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भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
Indian Institute of Technology Guwahati

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FNA, FASc, FNAE, FNASc, F-ASME, FIE
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March 28, 2016



Director's Message

It is indeed a great pleasure to know that the Association of Civil Engineers (ACE) and the Waste Management Research Group (WMRG) of IIT Guwahati are organizing an International Conference on Waste Management, entitled “Recycle 2016” during April 1-2, 2016. This is indeed a very appropriate initiative of the ACE which will help us in growing and exchanging knowledge in waste disposal techniques of various aspects environmental problems and the issues related to climate change. I believe that this conference will provide an opportunity to the participants to enhance their knowledge on waste management and recycling of wastes.

I congratulate the Organizing Team for making this event happen and wish all delegates professionally rewarding experiences during the conference.

I wish the event a grand success.

Gautam Biswas

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**Prof. Subashisa Dutta,
Head, Department of Civil
Engineering, IIT Guwahati**

Message from HOD

Increasing rate of population growth has put a challenging question to the humankind-how much population the earth can carry in a sustainable manner. In other words, what is the carrying capacity of the mother earth? The day is not far when we may find that we have exhausted all the available resources to support ourselves, and also the environment is not in a position to absorb the waste generated by us. Therefore, the technology that can turn waste into resources is perhaps the need of the hour and I sincerely feel that our young bright mind should put their effort to develop, disseminate and bring innovations in this direction. I am happy that Waste Management Research Group (WMRG) and Association of Civil Engineers (ACE) are organizing “International Conference on Waste management Recycle 2016” with the focus on WASTE MANAGEMENT to pave the path for sustainable development. Learn from “yesterday”, Plan for “tomorrow”, “Today” is the day-you can act.

Subashisa Dutta





Dr. Ajay Kalamdhad
Associate Professor
Department of Civil Engineering
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Message from Convener

One of the major environmental problems faced by India is solid waste management which is quite inappropriate. Likewise, in many other cities in the developing world, the municipal authorities are responsible for the collection, transport and disposal of municipal wastes. India lacks appropriate strategies, methods for mobilization of financial resources and the necessary infrastructure for organized waste management. This leads to low collection coverage, especially in poor or marginal areas of the cities, and to uncontrolled disposal. In India, approximately 60 million tonnes of solid waste is generated annually and only about 10-40% of the municipal budget is utilized for solid waste management. Up to 50% of the waste generated daily remained uncollected in the cities; the remaining waste is collected irregularly, dumped in an uncontrolled manner, or burnt on vacant plots or on the outskirts of cities. This widespread practice leads to significant health hazard to for the population and to a rapid degradation of the urban environment.

This conference on waste management “Recycle 2016” provides a unique platform for the academia to share the research and knowledge of municipal solid waste (MSW) management. The conference has been received around 300 abstracts from different part of the world on diverse field of waste management. Through conference, an attempt has been made to provide a comprehensive review of waste management for Indian cities to evaluate the current status and identify the problems of waste management.

We wish to thank all the authors, reviewers, invited speakers, members of organizing committee and all those who have contribute to successful completion of the conference. We are grateful to Prof. Gautam Biswas, Director, IIT Guwahati and Prof. Subashisa Dutta, Head Department of Civil Engineering for encouragement and providing the necessary infrastructure.

Wish you all a pleasant stay.

(Ajay Kalamdhad)

Convener, Recycle 2016



KEYNOTE SPEAKERS



Challenges & Opportunities in Solid Waste Management



Prof. Amiya Kumar Sahu
Founder and President,
NSWAI

Abstract: This presentation “Challenges & Opportunities in Solid Waste Management” outlines the review of current Solid waste management practices in India & future opportunities. Since solid waste consist of different types of waste such as municipal solid waste, e-waste, Industrial hazardous waste, biomedical waste etc., here in this presentation, we focus on all these types of waste generated across the country and their treatment in order to conserve the environment. As waste management is one of the major environmental problems of Indian cities, an attempt has been made to provide comprehensive review of the present status of Solid Waste Management, challenges in waste sector & opportunities in waste management in India.





"Collection & Recycling of Waste in San Diego USA"



Prof. G. Krishnamoorthy

San Diego State Univ.

USA

Abstract: Recycling is the best way to make the planet Earth a better place to live on. We should not think that recycling is not for our present, but for our future. The Environmental services of the city of San Diego is mandated to protect the environment and to provide residents with properly disposed municipal solid waste, along with an environment free of litter and illegal dumping.

The department pursues waste reduction and recycling; composting and environmentally-sound landfill management to meet the City of San Diego's long-term waste disposal needs. In addition, Environmental Services oversees the City's management of energy, pursues innovative energy independence goals and works to advance more sustainable practices within the City organization and the community. This presentation will examine all the aspects of Recycling and the associated efforts which make the city as the most desirable place to live in USA.





Sustainable Solution for Flood Damaged Bridge



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Abstract: Building new bridges generally consumes more money and time than repairing and retrofitting of damaged bridges. Therefore, the latter can be considered more sustainable. However, proper methods are necessary to assess the level of damages and to verify the fitness of such bridges prior to repair and retrofitting. In the assessment, there are two important criteria to consider. One is the amount of fatigue damage to the bridge due to usual past vehicle loading and hence the remaining fatigue life of the bridge. The other is the magnitude of damage caused to the bridge by the unexpected loading. In order to determine the fitness of a damaged bridge for reuse, condition surveys are usually carried out. Using a validated numerical model of the damaged bridge (a finite element model, FEM), efficient decisions are possible as such models can be loaded with past loading histories as well as future expected loadings and then the stresses and deflection can be obtained from the FEM. Then the fitness of the damaged bridge can be verified and elements which need to be replaced or retrofitted can be determined. The case study is about a 34 m long, 5.2 m wide, single spanned, double lattice girded, wrought iron railway bridge, located at Puttalam (Bridge No. 02 on the railway track between the Puttalam Cement Factory and Limestone Quarry, used for transporting limestone) which was built about 40 years ago and damaged and displaced from its abutments by floods. The bridge was then placed on temporary timber abutments for several years. With the increase in cement production, the owners of the bridge wanted to use heavier locomotives on this railway track and also increase the number of trips. Therefore, there was a need for an assessment of bridges on this track in order to determine whether the bridges can be used further or should be demolished and new bridges built in its place. In order to do the assessment, a condition survey was carried out on all the bridges on the track. One of the bridge was found weak as this had been damaged by floods. Then an analysis was done by modeling the bridge (FEM) by using general purpose SAP 2000 program and validating the FEM by using results of a field loading test (the bridge was temporarily erected on timber aboutments for several years). Both static and dynamic loading tests were carried out using an M2 locomotive with 6 numbers of 13.16 ton axles for 5 different loading cases to measure the displacement, strain and acceleration at pre-determined (critical) members of the bridge. The future fatigue life of the bridge was estimated using the prescribed last method. The future life was found as 30 years with a factor of safety of 3. Further, using the validated model, the ability of the bridge for higher loading situations was confirmed. The cost, estimated for retrofitting work and constructing new reinforced concrete abutments was much less than that for



constructing a new bridge. Therefore it was decided that rehabilitation of the bridge with necessary retrofitting work is more sustainable than demolishing it and constructing a new one. The bridge is now in use after being repaired, retrofitted and placed on new abutments.

Keywords: damage assessment, steel bridges, retrofitting, sustainability, fatigue damage



Waste To Energy: Options, Opportunities and Challenges



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Abstract: Municipal Solid Waste (MSW) generation in India has been steadily increasing over the years, with the per capita generation expected to reach about 0.70 kg/capita/day by 2025. While conventional management techniques like landfilling, composting and bio-methanation still continue to be widely adopted, limitation in the available land and slow treatment rates make them challenging to handle the huge quantities of waste generated. The properties of the MSW have also undergone noticeable variation, as far as both physical and chemical properties are concerned. The period from 1970 to 2005 alone showed an increase in plastic fraction by almost 90% and that of paper fraction by almost 50%, despite the high recycling rates. Inert fraction reduced by about 20% and further, the fraction of biodegradables also reduced marginally. These compositional changes resulted in a significant change in the calorific value of the MSW, from mere 600 – 700 kcal/kg of the 1980s to an average value of 1200 - 1400 kcal/kg at present. Thermal waste to energy technology, which had failed earlier owing to the low heat content of the generated MSW, may now perhaps help curb the issues due to the mounting MSW. Moreover, not only do they help manage the huge quantities of waste generated at a fast pace, but also recover energy from it. Thermal waste to energy units might hence play a substantial role in India's MSW management programs in the near future.

This key note address discusses the various thermal characteristics of MSW and the possibilities of energy recovery from it. It describes the options and possibilities in the Waste to Energy Sector along with the difficulties and challenges faced. A few case studies are also included to describe the present scenario.





Solid Waste Management in India-Some Case Studies



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Enhancement of environmental quality is an accepted national goal. There is growing realization by Central and State Governments regarding waste management. The goals of Solid waste management cannot be achieved through isolated or sectoral approaches. Sustainable waste management depends on the overall effectiveness and efficiency of management and the capacity of responsible municipal authorities. Within the overall framework of urban management, the scope of municipal solid waste management encompasses detailed planning and management where in strategic planning, legal and regulatory framework, public participation, financial management, institutional arrangements and disposal facility sites are various functions and concerns.

The choice of appropriate treatment technology plays a great role in the success of integrated solid waste management. Challenges for improving solid waste management in India and strategies to overcome them are discussed. The paper reviews the appropriateness of 8 technologies (mechanical waste sorting, aerobic composting, aerobic vermin composting, anaerobic composting, bio methanation for power generation, refuse derived fuel pellets, waste to energy and sanitary land filling) for Indian conditions in the context of some case studies.

India with a fast growing economy (having a large GHG reduction potential) with a favourable investment environment and with a strong CDM related organizational apparatus, is one of the most attractive non-annex 1 countries for CDM project development under Kyoto Protocol. Solid waste management projects which are eligible under this scheme should take advantage of this.



COMPOSTING

ICWM-COMP-01

Rotary Drum Composting of Flower Waste and Ranking Using Analytical Hierarchy Process

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Abstract: In India about 300 MT/day flower waste produced which are either mixed with municipal solid waste or thrown in river. Flower waste is good source of organic matter and nutrients which are beneficial for plants growth. Aim of the present study was composting of flower waste by using rotary drum technique. For composting flower waste were mixed with cow dung, saw dust and wheat bran. Cow dung acts as inoculum whereas saw dust and wheat bran as bulking agents. Four different trials were performed in which 0.5 wt% of saw dust and wheat bran was added in each trial. Different proportion of Flower waste and cow dung were 5:4, 6:3, 7:2, 8:1 in trial 1, trial 2, trial 3 and trial 4 respectively. Physico-chemical changes in different trials were evaluated for thirty days. At the end compost produced by all trials was found having pH 6.97-7.90, electrical conductivity 4.89-5.51 ms.cm⁻¹, percentage reduction of total organic carbon 29.81-36.27, percentage increase in total nitrogen 1.4-1.54, C: N ratio 15-19, Na 2.46-3.21 g.kg⁻¹ and Ca 25.16- 32.37 g.kg⁻¹. Analytical hierarchy process (AHP) was used for the ranking of trials to find the best proportions from different combinations performed in this study. 7:2 ratio of flower waste and cow dung was found as best combination among the all proportions.

Key-words: Rotary drum composting, Flower waste, C: N ratio, Germination index

ICWM-COMP-02

Comparative Study of Different Composting and Vermicomposting of Kitchen Vegetable Waste

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Abstract: The main objectives of the study were to compare the effects of the composting and the vermicomposting processes by kitchen vegetable waste were done in wooden boxes (52×53×21.5 cm³) by Windrow method. Three different mixtures of wastes (cow dung, rice straw, raw vegetable waste) were 15kg (1:2:4) combined were prepared and put into the wooden boxes (one purely anaerobic, one aerobic and another one vermicomposting). The nutrient status and microbiological enumeration of composting and vermicomposting were studied under laboratory conditions. Throughout the composting process, the temperatures of the mixtures were monitored and physicochemical, the degree of maturity and chemical properties and were determined. In all boxes, the temperature exceeded 60°C for more than 2 weeks, which ensured maximum pathogen reduction. Losses of organic matter followed a



first-order kinetic equation in all composting process. Economic analyses of composting and vermicomposting technologies are generally feasible except in some special cases. The differences are due to the wide range in local market value for organic fertilizer and differences in cost for the type of composting or vermicomposting system which could influence its economic feasibility. However, if organic fertilizer, nutrient value increases and carbon offsets are available for the nutrient recycling, it will affect the economic feasibility in a positive way.

Key-words: Agrochemical properties, Composting, Solid waste management, Vermicomposting.

ICWM-COMP-03

Possible Solution to Municipal Solid Waste (MSW) Management of Prospective Smart City Guwahati: A Comparison between Rotary Drum and Barrel Composting

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Abstract: Municipal solid waste (MSW) management is a challenging environmental concern of all the cities of India. Most cities are facing scarcity of land for MSW disposal. Guwahati, the nominated smart city, has neither adequate land nor any facility for MSW treatment. Keeping that in mind a comparative experimental study has been carried out to find a suitable way to reduce the load on the landfill by converting organic fraction into useful soil amendment before dumping. Two experimental set ups viz. static compost barrel and rotary drum composter were made using 200 ltr. capacity plastic drum. Both the composters were filled with segregated cooked and uncooked food waste collected door to door from the vicinity of the university. The barrel was filled in 4 days with household waste and dry leaves in layers in a ratio of 4:1 and left it to compost. But the waste was dumped into the rotary drum daily and mixed by rotation with dry leaves for four days and left it to compost. The result shows that the rotary drum composter took only 8 days whereas the static barrel took 28 days for composting and the compost parameters are nearly same. So, from this experiment it can be suggested that if the waste of Guwahati city are collected in some decentralized locations and processed through rotary drum technique the load on the landfill can be reduced to a great extent.

Key-words: rotary drum, barrel composting, decentralization, organic waste.

ICWM-COMP-04

High Rate Composting Of Toxic Weeds Eichhornia Crassipe and Parthenium Hysterophorus

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Abstract: Water-hyacinth (*Eichhornia crassipes*) and Congress grass (*Parthenium-hysterophorus*) are two aggressive uncontrolled weeds of tropical and subtropical



environments. These are having high concentration of N, P, K, Zn and Fe that makes them suitable for composting. Composting would be the best alternative way to control and utilization of these weeds green biomass. Studies were carried out on the physico-chemical and biological transformations during agitated pile composting of the harvested biomass with rice husk, Sawdust and cattle manure in different combinations (Trial T1, T2, T3). The maximum temperature of 44.8 °C during the composting process was monitored in T1 (15 kg-WH, 15 kg-CG, 20 kg-RH, 10 kg-CM). Three different types of compost viz. Waterhyacinth and Parthenium each alone as well as combined were prepared. Enzymatic and Biochemical analysis of the compost in addition to seed germination was performed. C/N and C/P ratios, Phenols, organic carbon were found to decrease significantly while N, P, K, polyphenol oxidase increased significantly in combined compost. It can be concluded that combined composting of Water hyacinth and Parthenium not only reduces the allelopathic effect but also increases its nutrient quality and thus it could be promising for organic farming and bioremediation.

Keywords: Eichhornia crassipes, Parthenium weed, Composting, Phytotoxicity, Solid waste management

ICWM-COMP-05

Vermicomposting of Food Waste for GLA University- A Case Study

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Abstract: Solid waste management has become one of the major muddle we all are facing today. Today is the time of urbanization. As the recent worldwide development with respect to rapid increase in the population growth which has resulted into production of huge quantity of organic solid waste. Most of the agricultural and kitchen solid waste is uncollected or dumped in open fields. Thus, it starts creating problems resulting unhygienic conditions. This organic waste is reported to have a high nutrient content suitable for use as a fertilizer. An effort was made to understand the effectiveness of vermicomposting in possibly solving the issue. The food and biodegradable waste was collected from hostels, faculty residences, blocks & guest houses of GLAU campus for the study. This project report is concentrated on the way of handling the problem in simplest, economical, user friendly and scientific way to transform the solid waste into compost through vermicomposting by using a tropical species of earthworms - red wigglers and Italian earthworms and investigating the effect of these earthworms on physicochemical and microbial properties during vermicomposting of fresh fruit and vegetable wastes (FVW) by contrasting two decomposing systems of FVW with and without earthworms for 5 weeks.

Key-words: vermicomposting, food and biodegradable waste, GLA University, earthworms



A Review: Food Waste Composting in India

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Abstract: Organic solid waste poses a serious threat to the environment as the world struggles to keep up with its rapid generation. Biological waste treatment technologies such as composting and vermicomposting are widely regarded as a clean and sustainable method to manage organic waste. Today, Indian government is focusing towards the various ways to utilize the food waste while 80% of the agricultural, kitchen waste is open dumped. Rather than land filling and composting which are enriching methods to decompose these waste. The objective of this study is to investigate the composting effectiveness of two effective processes, named anaerobic bio gas digester and vermicomposting. The investigations focused on acid-related process inhibition and the relationships between temperature, aeration, evaporation and the scale of the process. In the first exploration i.e. anaerobic bio gas digester, the food waste is pass through various methods and produces different kinds of gases such as methane, ammonia etc. These gases can be used for various applications. In the second exploration i.e. vermicomposting, all the waste is converted into compost with the help of special species of earthworms like Indian and Italian earthworms. This created manure can be used in irrigation, gardening and various applications etc. The environmental impact and economic potential of these processes are also discussed. This review shows that composting and vermicomposting are capable of degrading various types of organic waste, thus enabling them to be adopted widely. Economic assessments of composting and vermicomposting technologies show that these technologies are generally viable except in some cases. The differences are due to the wide range in market value for organic fertilizer and differences in cost for the type of composing or vermicomposting system which could affect its economic feasibility.

Key-words: vermicomposting, food and biodegradable waste, composting

ICWM-COMP-07

The Maturity and Stability Analysis of Vegetable Waste by Chemical and FTIR Method

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Abstract: The organic part of the Municipal solid waste (MSW) i.e. the vegetable waste (VW) has been considered to be the main source of composting in the study as its disposal in the along with the MSW in the landfills or dumping site is creating odour nuisance, leachate production and greenhouse gas emission adding to climate change. The locally available material like saw dust (SD), water hyacinth (WH) and garden prune (GP) have been used as bulking agent (BA) along with cow dung as



source of inoculants. Three samples are prepared in the ratio of 6:3:1 (VW:CD:BA), Trial I (SD) trial II (WH) trial III (GP) maintaining C/N under 25 and composted for 10 days in reactor followed by 30 days windrowing. The follow-up of different physico-chemical parameters (TOC, C/N ratio, CO₂ evolution, temperature) over 10 days showed rapid composting and greater maturation in trial I & III but total failure was observed in Trial II (WH) as the temperature plunged to 15 °C on third day and huge leachate production which was due to high initial moisture content. The FTIR analysis was conducted on compost end product of 30 days. Three indicator bands which provide the first quick evaluation of the progressing process of trial I & III: 1) the aliphatic methylene bands at 2920 and 2850 cm⁻¹ that reach a constant band height when organic matter becomes stabilized, 2) the C–N stretch vibration of amines at 1320 cm⁻¹ that disappears completely and 3) the C–O and C–N vibration of carboxylic acids and amides (1260–1240 cm⁻¹) that decreases to a weak shoulder. The phytotoxicity of the compost was determined by germination Index (GI) & total coli-form analysis. GI which showed above 90 % for trials I & III and trial II was found to be below 90%. The maximum total coli-form declined from 15.0 x 10⁸ to 4.5 x 10² (MPN/g) which is for trial III as it reached the peak at 55 °C in the thermophilic phase for two days.

Key-words: Vegetable waste, inoculants, garden prune, compost

ICWM-COMP-08

Rotary Drum Composting of Primary Paper Mill Sludge (PPMS)

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Abstract: Extensive research in accordance with the sustainability issues has shifted focus from exploiting routine substrates to utilization of potent waste resources which are most often not realized. Wastes resulting from any industry always pose a burning problem and stricter regulations have worsened the situation. Therefore there is always a search for alternative measures in dealing with these wastes which is either just disposed or otherwise relatively not much utilized. One such waste product is primary paper mill sludge (PPMS) which has great potential to be used as an organic feedstock but mostly is disposed in landfills or dumped in the vicinity of the industries. So the current study is focused on utilization of these organic wastes through rotary drum composting jointly with cow dung and saw dust, thus exploring its possibility to be applied as enriching soil amendment. Moreover composting is a widely established and cited technique in handling organic wastes. In this context, different trials were performed and the stability, physiochemical parameters along with nutrient, heavy metal content were evaluated and analyzed. All the tested parameters depicted PPMS to be a potential and safe source for composting and permitted its subsequent land application.

Keywords: Primary paper mill sludge, rotary drum composting, stability, nutrient, heavy metal.



Technology Developed to Accelerate Waste Decomposition using Thermophilic Microbes

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Abstract: Total MSW generated in urban India is estimated to be 68.8 million tons per year (TPY) or 188,500 tons per day (TPD) of MSW. Such a steep increase in waste generation within a decade has severed the stress on all available natural, infrastructural and budgetary resources. Therefore it is the need of hour to develop accelerated technique to decompose the waste to minimize the environmental pollution. In present study a technology has been developed to accelerate the process of decomposition time using consortium of ligno-cellulolytic thermophilic organisms. Wastes materials like crop residues, farm wastes and vegetable wastes are collected. For the preparation of 100 kg compost, 150 kg fresh biomass (waste material), 50 kg fresh cowdung, 50 g fungal inoculum (105 viable cell), 1 litre bacterial and actinomycetes (108 viable cell) respectively were used. The temperature was maintained about 55 to 70°C in this bioreactor for 20 days during composting period to activate thermophilic organisms. Biodegradable city wastes were collected, segregated and evaluated for the maturity and stability indices of compost. The manurial value such as total nitrogen increased upto 1.75%. C:N ratio and water soluble carbon decreased with increasing time to 14:1 and 0.5% respectively. However, CEC and lignin/cellulose ratio increased with decomposition and reached to 94 cmol(p+)/kg and 2.4% respectively. The results of this study have shown that biodegradable wastes can be recycled within 1.5 months and can be converted to quality compost.

Key-words: Composting; biodegradability index; bioinoculum; decomposition.



TREATMENT AND DISPOSAL OF SOLID WASTE

ICWM-TDSW-01

Application of Industrial Solid Waste in Making of High Performance Bricks

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Abstract: Different processes in the pulp and paper industry result in the formation of different solid waste and sludge. Solid waste mainly generated from pulping, deinking unit operation and waste water treatment. Utilization of the widely spread industrial wastes in the civil construction practice may lead to a real possibility of significant decrease in the environment pollution by paper and lime production waste and decrease the cost of civil construction. The use of paper mill residuals in concrete formulations was investigated as an alternative to landfill disposal. The cement has been replaced by waste paper sludge accordingly in the range of 5% to 20% by weight. To manufacture a high strength building bricks and blocks of precise dimensions and desired properties such as lacking brittleness, having energy absorbing ability, being light weight, shock proof and sound absorption. Also industrial uses gasket, speaker cone and friction.

Key-words: Paper waste, Cotton waste, spinning process

ICWM-TDSW-02

Biochemical Changes in Lantana Camara and Ipomoea Aquatica Growing in the Fly Ash Amended Soil

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Abstract: Fly ash is a minute air borne free particles generated from thermal power plant by the burning of bituminous coal. Proper disposal and recycling of this industrial waste is quite important due to its devastating nature. The present study evaluated the effects of soil amendment by fly ash using two local species of Jharkhand namely Lantana camara and Ipomoea aquatica. These two species is selected on the basis of prior field investigation. Fly ash was obtained from the Patratu thermal power plant, Jharkhand. Sequential extraction of metals in fly ash showed that result shows that exchangeable and soluble fraction has only Ni and Mn. Rest of the metals were high in Fe-Mn bound fraction, & Organic bound fraction. The two plants Lantana camara and Ipomoea aquatica were grown in soil amended with various concentration of fly ash and some organic fertiliser (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100%) a pot without fly ash is served as control study is conducted in the pots under normal condition. Physicochemical properties of soil, heavy metal uptake & biochemical changes in plants which were analysed. The results



of different stages of plants were compared with the control to understand the stress. ANOVA showed statistically significance with the different harvesting of the plants. So, these two plants can be successfully used to phytoremediate metals from fly ash. After implementing proper harvesting strategy and plantation cycle the easily available heavy metals can be removed and hence safe disposal of fly ash is possible.

Key-words: Fly ash, Lantana camara, Ipomoea aquatic, biochemical changes

ICWM-TDSW-03

Process to Solidify Arsenic-Waste Generated from Arsenic Removal Plant and Converting it into a useable Product

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Abstract: Arsenic a semi-metallic element found naturally in ground water in some areas of India, Bangladesh, Chile, China, Argentina, Mexico, Hungary, Taiwan, Vietnam, Japan, New Zealand, Germany, United States and many other countries. Due to differences in geochemistry, environmental conditions, and human activities, arsenic concentration in ground water aquifers varies widely which is several times higher than maximum contamination level (MCL) 10 μ g/l recommended by World Health Organization (WHO). Long-term exposure to arsenic through drinking water and/or food can results in adverse health effect Chronic Arsenic Toxicity (CAT) including dermal diseases such as melanosis (dark and light spots on the skin) and keratosis (hardening of skin on hands and feet), vascular diseases, birth defects, low IQ, cancer of lung, kidney, skin, and others. There are several well-known technologies available for removal of arsenic from drinking water. The most commonly used technologies are adsorption, precipitation, oxidation, absorption, coagulation, ion-exchange, lime treatment and membrane filtration. During removal of arsenic a large quantity of Hazardous Solid Waste Residue (HSWR) is produced which contains about 5-7 kg of arsenic per cubic meter of arsenic-sludge. The safe disposal method of this arsenic rich HSWR is of great concern as it posses high potentiality of arsenic leaching and recontamination of groundwater aquifers. The research was conducted to address this issue and determine a simple and easy method for solidification/stabilization of arsenic sludge and also bringing out a useable product. Arsenic sludge was incorporated into brick clay for making Indian Standard (IS 11650:1991) bricks. Number of bricks was prepared following standard procedure with different mix proportion of arsenic sludge to evaluate its structural and field applicability through converting it into a useable product . Standard tests like water absorption, moisture contain, efflorescence, leaching and compressive strength were conducted to ascertain its quality.

Key-words: Arsenic sludge, Drinking water, Stabilization, Brick clay.



Biogas Technology as Solid Waste Initiative for Source Sorted Organic Fractions of Municipal Solid Waste (SSOFMSW)

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Abstract: Faced with ever increasing accumulation of municipal solid waste (MSW) and improper interment of wastes in landfill, developing countries are turning their attention to meet the increasing demand for energy and rising cost of disposal of solid waste. Biogas Technology is one such technology with which energy can be derived from organic fractions of municipal solid waste in the form of methane and biodiesel. For the past twenty years and above, the research on this progressing on laboratory scale and being published in the peer reviewed journals. It is the time to wake up and academicians are limited by many constraints to implement such low cost technology at policy level. The nonchalant attitude towards the public cleanliness have started disappearing now with the revision of the Waste Framework Directive implemented the "waste hierarchy" and set an order of preference that has to be adopted for waste management, namely: prevention, preparation for re-use, recycling, other recovery and finally landfilling. Excellent results are progressing now by involving the community and private entrepreneurs to work with local government. One of the success story is No food waste group is monthly collecting from different counters where left out quality food from marriage halls, functions and feeds 200 people daily by preventing food waste entering into main MSW stream. The second step in hierarchy is also succeeding by provision of decentralized anaerobic digestion facility and composting for organic fractions of MSW by some of the NGOS, institutions and private sectors. Self groups in rural and few urban community have succeeded in implementing recycling and recovery of useful products. The bio-waste comprising garbage, fruit waste and yard waste from public places requires a solution and the demolition and construction wastes can reach the ultimate destination point as landfill. A study on engineered anaerobic digestion of organic fractions of municipal solid waste in conjunction with domestic sewage for biochemical methane potential was carried out in laboratory scale and evaluation of bio-kinetic coefficients. The other components studied for comparison represented broad classes of MSW components like garbage, kitchen refuse, yard waste, fruit waste and source sorted organic fractions of municipal solid waste.(SSOFMSW) The digesters can be operated in developing countries at ambient temperature ,methane production rate can be increased by increasing the feed concentration or decreasing the Hydraulic retention time(HRT) to optimize the process. Based on the experimental results obtained, optimum loading rate(L) kgvs /m³/d, specific methane yield (Y_m) m³/kgvs. Reaction rate constant K /d, methane yield coefficient (α) m³ CH₄/kg and methane production rate (R_m) CH₄ m³per day were determined using first order kinetics. From the studies, it is evident that Y_m is 0.45 at HRT of 25 days for SSOFMSW.

Key-words: municipal solid waste, biogas technology, kinetics.



Recovery of Heavy Metals from the Automobile Shredder Residue (ASR) Through a Precipitation Methods with the Support of Zero Valent Iron

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Abstract: The presence of heavy metals (HMs) in low-grade automobile shredder residue (ASR) makes it attractive for recycling. This study investigated the leaching and recovery characteristics of HMs (Zn, Cu, Co and Ag) from the ASR. The effects of acid concentration, amount of H₂O₂, temperature and liquid to solid (L/S) ratio on metal leaching were determined. The metal extraction rate was increased with increasing nitric acid concentration, amount of H₂O₂, L/S ratio and temperature. The extraction kinetics was examined by using a second-order reaction model. In the analysis of leaching kinetics, the metal leaching data were well fitted ($R^2 \geq 0.95$) with the second order reaction model. Metals were recovered by fractional precipitation with the application of advanced Fenton process (AFP). Metal recovery efficiency was increased significantly by the AFP. Recovery of the heavy metals from ASR using nitric acid is highly efficient.

Keywords: Automobile shredder residues, heavy metals, kinetics, recovery

ICWM-TDSW-06

Sustainable Solid Waste Management Options for Guna Town (Madhya Pradesh) using SWOT Analysis

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Abstract: Municipal solid waste management has been a major area of concern in India due to the increasing population, urbanization and industrialization. Increasing percapita solid waste generation and rising issues due to the environmental pollution, have been creating stress on the civic bodies in the country. In most of the places, commonly adopted disposal methods are landfilling and open dumping. Technologies such as composting, biomethanation, incineration, pyrolysis etc are in existence in very few locations. Solid waste has been used as a tool for sustainable development in many developed countries through power generation, resource recovery, recycling and fuel extraction. In the existing scenario, sustainable solution could be obtained in the solid waste management system, if it is economically feasible, ecologically viable and socially desirable. The present work discusses the sustainable options for solid waste



management using SWOT analysis, through the evaluation of strengths (infrastructure and local conditions), weaknesses (problems), options (technological) and threats (problems on disposal) in the present system. The area considered for the study is Guna town, having a population of 1,81,935, quantity of waste generated is 10 tonne/day; which is being managed through land filling at saketpur site (5 kilometers away from Guna). Guna Municipal Corporation is responsible for solid waste management in the town. Due to the unscientific mode of management, the disposal site has been polluting the surrounding areas. The study has identified certain key areas such as management of wastes from residential and vegetable market areas separately has the potential to yield greater benefits. Samples were collected separately from the residential areas and combined waste streams. The collected samples were analyzed for parameters individual composition, moisture content, fixed carbon, nitrogen, pH and calorific value; in order to understand the options for solid waste management. The results suggest that the fraction of biodegradables were found to be in higher portion i.e. upto 62%, in sample collected from the residential areas, analysis results of both the samples; suggest that composting could be the suitable method with a proper planning.

Key-words: Solid waste management, SWOT analysis, Composting, land filling, Sustainable solid waste management.

ICWM-TDSW-07

Characterization and Composition Study of MSW in Market Area of Kolhapur City

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Abstract: Municipal Solid Waste management is a chief challenge for many nations to manage increasing quantity of solid waste. There is a need for environmentally sound management practices of these wastes. Kolhapur is one of the growing cities in state of Maharashtra, in India having population nearly 549283 residents. (Census2011) The city is having main central market area around Mahalaxmi temple. Four major markets are placed in 1.5 km periphery. These markets are mainly of vegetable, fruit and flower market. The names of markets are, Kapiltirth market, Runmukteshwar market, Shingoshi market and flower market at Mahalaxmi temple. Major amount of organic waste of city generates here. The aim of this study is to determine the characterization and composition of solid waste generated in this area. It was found that the organic waste is sorted out separately in Kapiltirth market only. Daily analysis was made over these four markets for one week for physical and chemical analysis. The characterization studies for physical analysis was done on density measurement, moisture content and composition of waste whereas in chemical analysis the work was done for ph and volatile solids. In composition study of this solid waste, paper, cloth, plastic, glass and organic materials were found. No any



metals and biomedical wastes were found. The results showed that the organic content and pH of Kapiltirth market was found 88% & 7.9 of Runmukteshwar market was found 72% & 7.0, of Shingoshi market was found 78% & 7.8 and Mahalaxmi mandir flower market was found to be 81.2% & 8.0. The moisture content and volatile solids for Kapiltirth market was found 30% & 35% of Runmukteshwar market was 30% & 33% of Shingoshi market was 35% & 26.7% and that of Mahalaxmi Mandir flower market was found to be 40% & 32%. The average density of solid waste of four market places was found around 790kg/m³. The large amounts of organic wastes were found in these markets because of contents of vegetable matter, fruits and flowers in it. The sorting of non biodegradable material like plastic and glass can be possible here by manually as the quantity generated is very less. The characterization and composition study is important to know the quality of waste and from that to suggest the proper treatment methods for them. The characterization study proved that the peripheral area of Mahalaxmi temple markets contains much amount of organic resource which is good for composting process. If the organic waste is to be treated in that premises only then the cost of collection, transportation and treatment on dumping site would get reduced drastically. The final product gain after processing the said waste would be of good quality manure. As the cost of land is more in market areas it was suggested to adopt the new composting technologies like Rotary drum contactor for composting.

Key-words: Municipal solid waste, Characterization of MSW, Kolhapur, Composting

ICWM-TDSW-08

Effectiveness Study of Dolochar as a Filter Media in Slow Sand Filtration

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Abstract: The increase in water demand due to the continuous growth of human population has raised a strong interest in wastewater reuse as a way of industrial and municipal water supply. When appropriately treated and recycled, wastewater can become a feasible option as a water source. As conventional SSFs only can remove coliforms and turbidity, modification techniques such as changing filter media can enhance efficiency in removing pollutants from wastewater. The study was carried out to evaluate the feasibility of slow sand filter by using Dolochar a solid waste generated from sponge iron industry as a filter media & compared with the sand media. Effectiveness of filters assessed by two laboratory scale filter columns (10 cm diameter and 0.40 m media depth) one consisting sand media & other with Dolochar. The effective size of both Sand & Dolochar media used were 0.42 mm to study the performance at filtration rate at 0.06 m/h. For the 120 hour of run period, the Dolochar media showed higher removal efficiencies in all respect, especially Chemical oxygen demand (COD) removal up to 90 % compared to sand media filter 65 %, Turbidity removal of 97% compared to 85% of sand media filter. Phosphate & Nitrate removal also observed more in case of dolochar media filter specially the phosphate removal from the Dolochar media filter was upto 94.29 % compared to sand filter of 86 %. Only the microbial removal observed to be lower in case of Dolochar media filter.



Still more removal results can be expected from the further filter run. So the consideration can be made regard to the dual media filter consisting Sand & Dolochar can be the effective in wastewater treatment process. Since the Dolochar media filter exhibited to possess higher removal efficiencies, it supports the utility of Dolochar as a low cost and highly efficient filter media for slow sand filtration.

Key-words: Slow sand filter, Effective size, Dolochar, Chemical oxygen demand (COD)

ICWM-TDSW-09

Effect of Sludge Acidification on Speciation Behavior of Heavy Metals in Battery Wastewater Sludge during Electrochemical Remediation

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Abstract: The battery wastewater sludge (BWS) was collected and characterized through physicochemical analysis such as particle size distribution (PSD), electrical conductivity (EC), pH, COD, cation exchange capacity (CEC), volatile solids (VS), ash content (AC) and heavy metals. Heavy metal speciation following BCR extraction procedure was also carried out. Standard methods for analysis of solid waste were adopted for PSD, EC, pH, COD, CEC, VS and AC, whereas acid digestion procedure was followed for total heavy metal analysis. Electroremediation of hazardous BWS was attempted in a three-chambered membrane reactor using graphite electrodes. The nitric acid solutions were used for sludge acidification and also as catholyte. The BWS was found to be of hazardous nature containing Pb, Cu, Cd, Ni and Fe in concentrations of 5877, 262, 2578, 383 and 27890 mg/kg on a dry basis. Acidification of sludge changed species distribution of heavy metals and increased its mobility helping electrokinetic migration of heavy metals through sludge. The concentration and speciation of heavy metals after electrochemical treatment was measured at 4 normalized distances from the anode. The acidification of sludge remarkably improved removal of the bioavailable fractions of the heavy metals. The removal efficiency of the bioavailable fraction was in order Cu>Pb>Cd>Fe>Ni near the anode. The removal efficiencies were different at normalized anodic distances, and it was the maximum near the cathode. Development of acidic or basic front due to electrode reaction affected heavy metal migration. The acidification was found to be beneficial for the removal of the bioavailable fraction of heavy metals from BWS. Removal of 80 % of Pb was achieved for non-acidified sludge. However, it was 95.5 after sludge acidification.

Key-words: Battery wastewater, Heavy metallic sludge, Electro-remediation, Electrokinetic migration



E-WASTE AND MEDICAL WASTE MANAGEMENT

ICWM-EMWM-01

Elimination of Lead from Solder Alloys: Influence as Soldering Properties and Recycling

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Abstract: Lead has been classified as one of the seventeen most toxic elements for human life according to Environment Protection Agency (EPA). In e-waste material lead comes from Sn-Pb solders used in electrical & electronic assemblies. These lead and its compounds have harmful effect on the environment and human health, when disposed in solid waste landfills. These waste components come in contact with the ground water and lead oxide (PbO) converts to lead carbonate (PbCO₃) in presence of CO₂ and Cl. Moreover, recycling of e-waste, containing Pb in particular, is still a challenging task due to complexity of processes involved and possible evolution of toxic substances. Due to Environment concerns, European and Indian government legislation has compelled the researchers to promote research in development of novel alternative materials for soldering application, which can replace Pb bearing solders for electrical & electronic industries. Therefore, research on the development of alternatives to Sn-Pb solder alloy gained attention worldwide. A large number of alternative to Sn-Pb solder alloy have been studied by many researchers are Sn-Ag, Sn-Cu, Sn-Bi, Sn-Sb, Sn-Zn, Sn-Zn-Al, Sn-Zn-Cu, Sn-Ag-Zn, Sn-Bi-Ag and Sn-Ag-Cu. Different techniques are used to develop solder alloy such as Metal casting, sol-gel, chemical reduction, chemical vapour deposition, spark erosion, mechanical milling. However, many issues with above mentioned alternative solder alloys like higher melting temperature; higher corrosion rate, low wettability and recycling of these waste alloys are unresolved. Sn-9Zn, eutectic alloy, having melting point and mechanical properties comparable to Sn-Pb eutectic alloy and has relatively higher corrosion rate. In order to improve the integrity and reliability of eutectic Sn-9Zn alloy, the influence of minor alloying additions of Al and Cu and reducing the Zn amount have been investigated. Different composition Sn-7.5Zn, Sn-6.5Zn, Sn-8.6Zn-0.45Al, Sn-8Zn-1Al, Sn-8.6Zn-0.4Cu, Sn-8Zn-1Cu and Sn-3.5Ag-0.7Cu solders alloys using metal casting method were studied. The compositions of prepared alloys were determined using X-ray fluorescence (XRF). The microstructures of the prepared alloys were observed using Optical Microscope. Results indicated that with addition of Al into hypoeutectic Sn-Zn resulted in slightly reduced under-cooling and increased pasty range while maintaining its melting temperature close to Sn-9Zn level, whereas alloying with Cu into hypoeutectic Sn-Zn resulted in significant increase in melting temperature. Wettability significantly increased on reducing Zn-content and alloying with Al, but marginally on alloying with copper. Corrosion rate reduced when Zn-content is reduced and copper is added whereas, corrosion rate increased on alloying with Al. Elimination of Pb from the solder alloys and consequently from e-waste generated thereof, the recycling of resulting e-waste will be relatively simplified and free from evolution of toxic substances.

Key-words: lead free solder, Soldering properties, Recycling, Electronic waste.



New Method of Enhancing CBR Value of Subgrade of Rural Roads of E-Waste Plastic

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Abstract: Rural roads deteriorate frequently due to the continuous ingress of rainwater. Rainwater reaches subgrade due to gravity through the granular media and reduces its stiffness. Deformation of subgrade takes by traffic load, which reflects on the top surface resulting into complete structural and functional failure of the pavement structure. Indian Roads Congress (IRC) has specified to implement soil stabilization techniques and various unconventional materials (fly ash, rice husk ash, recycled concrete, iron slag etc.) to strengthen subgrade of rural road. However, plastic of e-waste has not been yet recommended by IRC and hence not recognized as road construction. After separating from important metal, e-waste plastic (EWP) is left as disposal in landfills and incineration due to its unknown composition that necessary for sorting at recycling plant. This has raised the threat the environment. Potential application of e-waste is although reported in many investigations, it finds hardly any relevance in strengthening rural road, where bitumen is used only to construct a thin layer wearing course above granular base. Therefore, present study was carried out to investigate the potential use of EWP to enhance the mechanical strength of subgrade soil using e-waste plastic. Plastics of e-waste were separated and shredded into small chips and then mixed randomly with soil sample in proportion of 0.25%, 0.50%, 0.75% and 1.00% by dry weight of soil sample to evaluate the compaction characteristics and CBR values at unsoaked and soaked condition. Soil and soil + EWP showed similar compaction characteristics, where maximum dry density and optimum moisture content of soil + EWP at all the proportions of EWP were close to that of values of soil. The reason could be the reorientation of e-waste plastic similar to that of soil grains during soil compaction process. However, CBR test of soil + EWP did not show any conclusive result at all the proportions of EWP with that of soil in both unsoaked and soaked condition due to random distribution and orientation of chips of e-waste plastic. Therefore, based on CBR test, it was concluded that chips of e-waste plastic could not be used to improve CBR value of soil by mechanical soil stabilization technique. However, a new method of using chips of EWP was studied in the present project by laying horizontally in proportion of 0.1%, 0.2%, 0.3%, 0.4% and 0.5% of dry weight of soil between the layers of soil in CBR sample. Horizontally laid rigid lightweight chips of e-waste plastic was used to provide slab action at the interface of soil layers to transmit load stress to a wider area below in CBR sample. The result of CBR test found improvement in CBR value soil + EWP by more than 100% to that of soil in all the proportion of EWP in both unsoaked and soaked condition.

Key-words: Bitumen; CBR; E waste plastic; Rural Roads; Subgrade.



ICWM-EMWM-03

E-Waste Management by Bacteria and Diatoms

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Abstract: Modern age is the age of semiconductor. The semiconductor industry is one of the fastest growing manufacturing sectors. Semiconductors are particularly useful as a basic material in the manufacturing of computer chips. However, semiconductors are not only used in computer, are also used for different important industries like, military, automotive, communications, and other consumer purposes. Computers only make up 44% of entire industry consumption. Today's semiconductors are usually composed of silicon, and they are manufactured in a procedure that combines the familiar with the bizarre. Some steps that are involved in the process are as everyday as developing a roll of photographic film while others seem as if they would be better suited to take place on a spaceship. Several semiconductor manufacturers have been cited in the past for holes in their safety procedures and have been ordered to tighten their handling of carcinogenic and toxic materials. These contains silicon, different toxic heavy metals and poisonous organic chemicals. These materials are not easily decomposable. In this study, silicon is decomposed by diatom isolated from east Kolkata wet land and heavy metals are removed by an isolated bacterial strain. So this method may be effectively used for treatment of toxic E-waste.

Key-words: Silicon waste, E-waste treatment, Heavy metal pollution

ICWM-EMWM-04

Characterization and Disposal of Ashes from Incineration of Bio-Medical Wastes

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Abstract: Thermal treatment by incineration happens to be the most commonly practiced method of disposal of bio-medical wastes (BMW) in India. This method has some important advantages such as pathogen destruction, volume reduction, etc. However, there are many issues of concern due to the potential for dislocation of pollution. For example, storage, handling and disposal of bottom ashes generated by the incinerators owing to the presence of heavy metals, inorganics and other refractory substances. Such ashes should be sent to engineered secured landfills meant for hazardous wastes. The present study raises a question whether is it happening? Effort has also been made to develop a set of alternate solutions that will keep such ashes out of hazardous waste landfills. The incinerator bottom ash samples were collected from



a biomedical wastes management facility (having incinerator capacity of 50 kg BMW/hr) located in the region of Greater Mumbai. Presently, the facility is sending the ash to a nearby hazardous waste treatment storage, disposal facility (HWM-TSDF). Characterization of bottom ash would include particle size distribution, morphology, mineralogy and chemical composition; particularly heavy metal composition (mainly As, Cd, Cr, Cu, Pb) by using analytical techniques such as Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES). The characteristics of bottom ash shall be compared and contrasted with the ashes encountered from BMW-incinerators worldwide. Finally the study shall discuss the potential impact on immediate environment – if the ashes are not disposed off in a HWM-TSDF. A set of alternate solutions are being developed –which shall also be presented briefly. Work is in progress.

Key-words: Incinerator, Bio-medical waste, Bottom ash, Heavy metals, Hazardous waste landfill

ICWM-EMWM-05

ACO Approach for Optimization of Infectious Medical Waste Collection and Transportation System

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Abstract: Collection and transportation of Infectious medical waste in an optimum, environmentally safe and sustainable manner is a challenging task. Optimal routing and scheduling of Infectious Medical Waste Collection and Transportation (IMWCT) system, is a critical problem which need a systematic and logical attention. The present paper proposes a meta-heuristic approach based on Ant Colony System (ACS) to optimize IMWCT problem. The major objectives considered are minimization of risk, minimization of total traveling time and minimization of the number of vehicles associated with IMWCT. An exhaustive cause-consequence analysis is carried out and a mathematical model is developed to determine the risk associated with IMWCT and developed a modified multi-objective Ant Colony System to provide optimum solution for multi-objective problem with time window constraint like IMWCT problem. Software based on this approach is developed in C programming and validated for standard Solomon benchmark problem. The proposed approach is also evaluated for its applicability for route optimization and usefulness in minimizing the risk associated with a real life IMWCT problem and found to be effective.

Key words: infectious medical waste; sustainable transportation; multi-objective; risk analysis; vehicle routing problem; ACS; safety; time window.



Assessment of Major Elements in Desktop Computer Monitors

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Abstract: The desired purpose of the study is to determine the major elements (mainly toxic and hazardous elements) in desktop computer monitors, both of which are old, out of warranty and discarded by their users. Personal computer (PC), one of the most essential and extensively used electronic products, adds a major portion in the e-waste inventory because of its limited life cycle. In this scenario, the study of composition analysis in one of the significant parts of desktop computer viz. the monitor is essential to develop an environmentally sound management scheme and to protect the civilization from the adverse effects of the presence of toxic and hazardous elements. In this paper, monitors from a variety of PCs with different levels of technologies such as Cathode Ray Tube (CRT) and Thin-Film-Transistor Liquid-Crystal-Display (TFT LCD) have been examined to find out the change of trend of elemental concentrations with the change of display technology of monitors. An experimental procedure involving disassembly, sample size reduction (crushing and grinding) and chemical analysis has been implemented. The composition analysis of obsolete monitors has been performed by using Wavelength Dispersive X-ray Fluorescence (WDXRF) Spectroscopy and Laser Ablation Inductively Coupled Plasma Mass Spectroscopy (LA-ICP-MS) methods. By performing the qualitative and semi quantitative estimation of major elements, a change has been found in concentrations of some major elements as a function of technology. The concentrations of Pb and Ba in CRT glass are higher as compared to the TFT LCD panel probably due to the high use of Ba in CRT front panel and leaded glass in the funnel shaped rear portion of CRT monitor. Moreover, Zn and S concentrations are higher in CRT monitor which indicate the use of zinc sulphide in the interior of CRT screen. On the other hand, concentrations of some major elements such as Al, Cu, Ni, Cr and Si are high in TFT LCD panel which confines their usage in electrodes of TFT layer and also in color filters of TFT LCD monitor. Moreover, a high concentration of In and Sn in TFT LCD monitor indicate the extensive use of indium tin-oxide as conductive electrode of TFT layer. Therefore, the variation of concentrations of different elements based on display technology will support us to monitor the change of toxic elements in the desktop computer monitors and may also provide us a guideline in e-waste segregation and end-of-life (EOL) disposal.

Key-words: E-waste, Desktop Computer Monitor, Major Element, Technology.



ICWM-EMWM-07

State of Art on Conversion of Waste Printed Circuit Board (Electronic Waste) into Commercial Economic Composites

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Abstract: Printed circuit boards (PCBs) are essential part of almost all the electrical, electronic information technology equipments. It accounts for ~3%-5% of the total E-waste generated globally. Waste printed circuit boards (WPCBs) are composed of nearly 70% non-metals, which are generally recycled as low-value filling materials or even directly dumped in landfills. Depending on the type of dumping, hazardous materials possess by PCBs causes potential environmental problems as well as proved to be detrimental for the human beings. The current paper reviews about application of the nonmetallic portion (NMP) of WPCB in the composite industry with different matrix materials such as polypropylene (PP), polyster, polyvinyl chloride, and epoxy. Various manufacturing processes of fabricating these composites and its mechanical properties as well as thermal behaviour is discussed. The study showed that the appropriate addition of (NMP) in thecomposites can significantly improve the mechanical properties and thermal behaviour. The optimum quantity of the NMF with the various matrix resins gives the best results. The maximum increment of tensile strength, impact strength, flexural strength and flexural modulus of the composites were reviewed. The effect of increment in the softening temperature, leachability of the Cu and Br in to composites was also discussed. These composites exhibit high performance and non-toxicity, offering a promising method to recycle WPCB with high-value applications with low cost.

Key-words: WPCB, NMP, Composite, Mechanical properties, Leachability

ICWM-EMWM-08

Extraction of Cu and Zn from High Grade Printed Circuit Board Scraps by Conventional and Hybrid Bioleaching

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Abstract: Waste electrical and electronic equipment (WEEE) or electronic waste (e-waste) is one of the fastest growing waste streams worldwide. Printed circuit board (PCB) is the core component of e-waste. PCB contains a complex array of metals in rich quantity, some of which are toxic to the environment and all of which are valuable resources. Therefore, the recycling of e-waste is an important aspect not only from the point of waste treatment but also from the recovery of metals as secondary source. The objectives of the study were two-fold: characterization of PCBs from electronic scraps, viz. mobile phone, digital video disc (DVD) player, inverter for their metallic contents especially and subsequent assessment of bioleaching of selected



metals from high grade PCB only. Chemical analysis of microwave-assisted digestate of PCBs revealed that Cu was the most abundant metal among the base metals with content more than 80 mg/g dw while other metals like Mn, Ni, Co were present in low concentrations in all the three PCBs. Waste mobile phone PCB contained Zn in rich quantity with content more than 30 mg/g dw. However, Cr was not at all detected in any of the PCBs. Owing to its rich metallic content of Cu and Zn, the mobile phone PCB was considered as high grade material and subjected to bioleaching studies for their extraction. Bioleaching of Cu and Zn from pulverized waste mobile phone PCB with particle size of <math><600\ \mu\text{m}</math> and pulp density of 1 g/L was assessed at 170 rpm. and 30°C using pure culture of *Acidiphilium acidophilum*, a strain of acidophilic alphaproteobacteria with and without the addition of lemon juice containing citric acid as active constituent to simulate hybrid and conventional conditions, respectively. Dissolution of Cu and Zn varied greatly under conventional and hybrid bioleaching conditions showing better solubilisation in hybrid approach. Metal dissolution of 0.416 mg/L was achieved for Cu at 12 days which asymptotically increased to 0.424 mg/L at 15 days of conventional bioleaching. Similar asymptotic bioleaching trend was also observed for Zn with an increase to 0.132 mg/L at 15 days from 0.130 mg/L at 12 days in conventional approach. However, increased bioleaching of both the metals in hybrid approach was observed as compared to conventional approach. Under hybrid condition, the maximum concentration of Cu and Zn leached was 2.419 mg/L and 1.272 mg/L, respectively at 15 days. Increased dissolution of the selected metals from the PCB in hybrid bioleaching approach can be attributed to the presence of citric acid as metal chelating agent in lemon juice along with the action of *A. acidophilum*. These findings highlight improved efficiency of hybrid approach of bioleaching over conventional approach for metals recovery from e-waste.

Key-words: E-waste, Printed circuit board, Metals, Conventional bioleaching, Hybrid bioleaching, *Acidiphilium acidophilum*

ICWM-EMWM-09

State of Art on Biodegradable Studies of Thermo Sensitive Injectable PEG/HAP Scaffolds for Orthopedic Applications

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Abstract: According to World Health Organization, a road traffic accident claims injury every two seconds. To cure these bone injuries, internal and external fixation devices are used. But, metallic internal fixations have some disadvantages such as it require additional surgery to take out, stress shielding and ions release from implant. Metallic bone fixation devices need secondary surgery to remove from surgery location. This increases healthcare cost and patient morbidity. Biodegradable polymer based bone materials are alternative to metallic and these degrade in the body by hydrolysis or enzymatic pathways. So, no secondary surgery required (reduces healthcare cost). Thus, the current study is motivated towards biodegradable



polyethylene glycol/Hydroxyapatite (PEG/HAp) based scaffolds. The main advantage of biodegradable polymer is it can degrade as the healing progresses (no secondary surgery). These scaffolds can be fabricated by additive process using bottom-up approach (Rapid prototyping and 3-D printing). Since the bone is brittle material and its breakage will be random in shape and size as well as its fracture orientation. So, developing the 3-D scaffolds for this type of complex 3-D geometry will be a big issue for 3-D printing. So in the present study, biodegradable polymers based hydrogel based injectable scaffolds are prepared along with artificial bone material (Hydroxyapatite) as reinforcement. This fluid based biocomposite can be easily injected with minimal invasive technique (Syringe) in the fractured region. Because of its thermo-sensitive nature, the fluid based biocomposite becomes porous solid orthopedic scaffold with required geometry on both sides of fracture. The complex geometry formations on both sides of bone fracture depend on the rheological properties of the PEG/HAP fluid based biocomposite. The rheological properties decide the flow (Flow of injectable scaffold to each nook and corner of the fractured region on both sides) and deformation (how much deformation will take place after thermal hardening takes place). The PEG is considered as base polymer to fabricate the hydrogel because it releases its formulation at low pace, thus it will give ample time to the fracture to strengthen the rejoining of both bones. It also releases the valuable elements (anti microbial and anti inflammatory) at controlled rate, as well as reduce uptake of harmful immunoglobins. This allows longer dosage and reduces immunogenicity of substances. PEG is non toxic, thus ideal for biological applications, and can be injected into the body without adverse effects (FDA approved materials). Partially degraded scaffolds should maintain their mechanical integrity until the newly formed tissues have sufficient strength to replace them. In addition to providing support for the tissue surrounding a defect, the scaffold can serve as a substrate for seeded cells, facilitating new tissue formation at the site of injury. The incorporation of drugs or bioactive molecules may also accelerate new tissue formation. This paper provides insights of how the bio-degradation of these injectable scaffolds inside the body using hydrolysis or enzymatic pathways. It also explains the bone regeneration rate with its biodegradation rate.

Key-words: Biodegradability, Scaffolds, Orthopedics, Hydrogels, Polyethylene glycol, Hydroxyapatite, Rheology

ICWM-EMWM-10

Hospital Waste Management: Issues & Challenges

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Abstract: Hospital Waste Management has always been an issue particularly in developing and underdeveloped economies. The nations differed in terms of the regulatory frameworks, the formulations of laws, and their enforcement whereas the practitioners differed in the ways they deal with such waste. Practitioners are observed to have been different in terms of the methods they practice and the challenges they face. However, the purpose for all the nations and practitioners remain same- to prevent the living human and non-human beings from any likely harm caused by any



reckless handling of such waste. Having observed some of these differences, the researcher has conducted a primary data based research focusing on the hospital waste management process of selected hospitals and nursing homes, awareness of dealing staff about various aspects of the process and related regulations, and the challenges involved therein. Suitable statistical tools have been used to deduce some meaningful results.

Keywords: Hospital waste; Bio-medical waste, Treatment of medical waste, Disposal practices of hospital waste



ANAEROBIC DIGESTION

ICWM-AD-01

Investigating the Effect of Anaerobic Co Digestion on Biogas Potential of Lawn Grass Cuttings and Poultry Manure

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Abstract: Anaerobic co-digestion of lawn grass cuttings with poultry manure at five different proportions of volatile solids (VS) 18.76%, 38.12 %, 58.11 %, 78.76 % and 100 % was evaluated to know the biogas potential. The Biogas potentials for a period of 30 days was determined with 120 ml closed glass vials and biogas volume measured by water displacement method. Biogas potentials for 30 days were found to be 41 ml/g VS, 37.9 ml/g VS, 45.8 ml/g VS, 47.1 ml/g VS, 57.2 ml/g VS, 28.5 ml/g VS for the lawn grass cuttings proportions 18.76%, 38.12 %, 58.11 %, 78.76 % and 100 % respectively. Lawn Grass proportion of 78.76 % has shown highest biogas production which is 39.5% and 100.7 % higher than that of mono digestion of poultry manure and lawn grass cuttings respectively. This study concludes the presence of synergistic effect between lawn grass cuttings and poultry manure for anaerobic co-digestion.

Key-words: Anaerobic co-digestion, Lawn grass cuttings, Poultry manure, Biogas potential.

ICWM-AD-02

Anaerobic Co-Digestion of Organic Fraction of Municipal Solid Waste (OFMSW) and Lignocellulose Waste (LW) in Presence of Inoculum Using Batch Reactor

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Abstract: Unmanaged pollutants from municipal solid waste (MSW) degrade the environment. Methane emitted from their decomposition contributes to global climate change. Under modern environmental regulations, in general, and MSW (Management and Handling) Rules, 2000 promulgated by MOEF, Govt. of India, in particular, these wastes are becoming difficult to dispose off using traditional means. There are various technologies to treat MSW at global level. However, in India, open dumping is most commonly practiced. Composting, one of the processing options, is being used in many of the municipalities in India. Inferior quality and high cost of compost have resulted in low-market demand for compost. Lands are becoming scarce for disposal of waste. This demands for an integrated approach for MSW management. Due to an increasing awareness of the true economic and environmental cost of conventional land filling, recent interest is to develop technologies that accelerate the degradation of the organic fraction of MSW. Anaerobic digestion (AD) has been, until now,



essentially applied to wastewater management. In connection with the utilization of renewable energies and the rising relevancy of climate protection, it can be affirmed that AD of MSW has relatively high potential for future development. Apart from yield of biogas, AD creates solid and liquid by products, which can have value as a fertilizer or soil amendment. The amount, quality and nature of the products will depend upon the quality of MSW feedstock, the method of digestion (wet or dry) and the extent of the post-treatment refining processes. Anaerobic processing of MSW for bio-energy results in residue, which can be converted to compost, rich in N, P, K and micronutrients like magnesium and iron. This paper incites the behaviour and performance of the digester at various organic loading rate (OLR) with particular regard to the gas (methane) production rate by varying the organic fraction of municipal solid waste (OFMSW) and lignocellulose waste (LW) in presence of inoculum in the reactor.

Key-words: Municipal Solid Waste (MSW), Organic Fraction of Municipal Solid Waste Lignocellulose Waste (LW), Anaerobic Digestion, Co-Digestion.

ICWM-AD-03

Integrated Bio-Energy Plant for Treatment of Municipal Solid Waste and Sewage Water in Coimbatore City

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Abstract: This research is a special focus towards the sustainable development of Coimbatore City (any city in India) targeting the problems in 2030 and beyond. At the current rate of urbanization, it has been proven that the surface of the planet and the biodiversity that is the essential part of it will undergo drastic changes. Over the next 40 years, the earth will undergo the largest and the fastest rate of urbanization in the human history. As per Waste-to-Energy Research and Technology Council (WTER), Coimbatore generates about 0.47 kg of garbage per capita every day. At present the waste disposal is by open dumping and partly covering with debris and there is no clear solution to handle the whole of the MSW in Coimbatore Urban as of now. And these are polluting and are expiring with a serious need for remediation of the landfills. This retro method is unsustainable and has been posing serious environmental threats to the city. We classified the waste into four types as follows, Biodegradable MSW, Public Toilet Complex For Chennai Corporation and the other sewage, Non-biodegradable MSW and Sewage Sludge, Noyal waste water. The concept of de-centralized treatment system, without affecting the atmosphere of the public can be established if we adapt an integrated bio-energy system of MSW+Sewage+Noyal treatment processing units. As a first phase we are working with treatment of sewage water. Waste Water is treated by anaerobic pre-treatment with Bulk Volume Fermenter. BVF is most often trapezoid in shape, length 10 feet, width 5 ft, and depth 8 ft. The top 2 to 6 meters of the pond are constructed as non corrosive high density polyethylene mesh. The rock filled compartments become an



integral part of the fermentation, rock providing a surface for the anaerobic bacteria to attach themselves providing a better degree of treatment. The biological breakdown of organic matter in the absence of oxygen gives off primarily methane, but also carbon dioxide and some traces of hydrogen sulfide, which altogether is labeled biogas. Although biogas-derived methane and carbon dioxide come from an organic source with a short carbon cycle, they do still contribute to increasing atmospheric greenhouse gas concentrations.

Key-words: rock filled, Bacteria, fermenter.

ICWM-AD-04

Anaerobic Digestion of Food Waste for High Rate Methane Production

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Abstract: The anaerobic digestion of microalgae is a prospective environmentally feasible option for creating a renewable source of energy for industrial and domestic needs. Microalgae anaerobic digestion is a key unit process that integrates efficiency and beneficially into the production of microalgae derived biofuels. Anaerobic digestion culminating in methane fermentation improves the economic viability of microalgae liquid biofuel production and presents an opportunity for power generation from wastewater derived microalgae. However the anaerobic digestion of microalgae biomass is not straight forward due to several technical restraints including low concentration of digestible biodegradable substrate, recalcitrant substrate constituents, cell wall degradability, and low carbon to nitrogen ratio, ammonia toxicity and effects from salinity and associated metal ions. Current production methods for liquid biofuel production from microalgae produce approximately 60–70% residual biomass that is currently a byproduct. Anaerobic digestion provides biogas, but it can also provide essential nutrient recovery from lipid extracted microalgae biomass. The biogas produced from the anaerobic digestion process can be used to generate onsite electrical power or thermal heat to offset biomass processing and extraction processes. When both of these processes are integrated and operated simultaneously, the benefits to microalgae biofuel production and wastewater treatment derived energy production are increased significantly. To consider the integration of anaerobic digestion into a commercial-scale integrated microalgae production and biofuel refinery facility or wastewater treatment plant we present a review of the literature, the current state of the art and future directions for research. Anaerobic digestion should be done for the mathura waste as waste is continuously increasing from which 15-20% methane and 15-25% CO₂ is produced. the waste should be used in the ratio of 1:1.

Key-words: methane, carbon dioxide, GLA University, biogas.



ICWM-AD-05

Effect of Hot Air Oven Pretreatment on Hydrolysis of Water Hyacinth

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Abstract: Water hyacinth, although a visually appealing plant owing to its lavender coloured flower and round glossy leaves but in reality it is a nuisance to the aquatic ecosystem and day to day human activities like navigation, recreation, irrigation and power generation. Due to the plant's astonishing level of growth and spread, it forms a thick and compact mat where various disease carrying vectors breed. Therefore the necessity to control this noxious pest brings forth anaerobic digestion. Anaerobic digestion is an effective, eco-friendly and low cost technology apt for converting the noxious pest into biogas in the absence of oxygen. Water hyacinth is predominantly comprised of lignin, cellulose and hemicellulose. Although lignin is present in a very small quantity in the pest, it firmly holds together cellulose and hemicellulose making hydrolysis the rate limiting phase during anaerobic digestion thereby restraining biogas production. Therefore, hot air oven pretreatment was done to speed up the hydrolysis process and enhance the substrate digestion. Both temperature and temporal study was done and parameters like sCOD and VFA were studied. Hot air oven pretreatment showed a hike in sCOD indicating a positive impact of the hot air oven pretreatment on the hydrolysis of water hyacinth.

Key-words: Water hyacinth, lignin, pretreatment, hydrolysis

ICWM-AD-06

Effect of Different Inoculum/Substrate Ratios on Anaerobic Digestion of Pulp and Paper Mill Sludge

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Abstract: Pulp and paper industry is considered as one of the most polluted industry in the world and also energy and water intensive. Paper industry produce huge amount of wastewater, hence sludge production is a major issue. Conventional sludge management methods such as landfilling produce leachate and incineration emits greenhouse gases, therefore public opposition and strict regulatory pressure have been perceived in many countries. Anaerobic digestion a versatile technology for alternative disposal options. The aim of this study was to evaluate the effect of different inoculum/substrate (I/S) ratio on the anaerobic digestion of pulp and paper mill sludge (PPMS). A laboratory scale reactor was used to analyse the four different I/S ratio varies from 1.0 to 2.5 plus control on VS basis were used for this study. The different parameter i.e. pH, volatile solid, soluble chemical oxygen demand and cumulative methane production from different I/S mixture was measured and it was



observed that the maximum methane production of 3479 mL was achieved in I/S ratio 2.0. Hence the study concluded that I/S ratio of 2.0 was good for better methane production.

Keyword: pulp and paper mill sludge, anaerobic digestion, inoculum/substrate ratio, methane.

ICWM-AD-07

BMP Studies on Flower Wastes in Anaerobic Digestion Process

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Abstract: Dawn of industrial era results in urbanization, cities, with more industries, are main centers of economic growth, trade, education innovations and employment and showed a rapid development of 50% population. This in turn increases the consumption of resources and production of wastes. Waste includes all items that people no longer have any use for, which they either intend to get rid of or have already discarded like household rubbish, sewage sludge, garden waste, unused vegetables fruits, used flowers etc., The type of waste generated depends on the country, culture and usage of resources. This paper discusses about the management of flower waste. In addition to facilitating the reproduction of flowering plants, flowers have long been admired and used by humans to beautify their environment, and also as objects of romance, ritual, religion, medicine and as a source of food. Flowers have been used since as far back as 50,000 years in funeral rituals also. In India basically people following Hindu religion, the flowers are offered to the deities in temples and are thus available in huge quantities as temple wastes. Especially flowers like Arali (Nerium oleander), Rose (Rosa species), and Marigold (Tagetes) flowers are used for worshipping God in huge amounts and are dumped outside after use. Most of these flowers are either dumped by the side of river or allowed to naturally decay and used as compost. Millions of temples in India are having nearly the same practices; hence, there has been a strong need for appropriate waste management systems for flower wastes produced from temples and markets especially in countries like India. The objective of the study is to find out the bio-methane potential of flower waste such as, Mariegold, Arali, Rose and mixture of all the three flowers. The digestion was carried out for a period of about 25 days under batch fed system at a constant temperature of around 34 ± 2 °C using VDI-4620 German standard method. The substrate to seed sludge ration used was 0.4 gVS/gVS. The specific biogas production was 0.4756, 0.329, 0.366, 0.401 L/gVS_{added} for the Flower wastes Mariegold, Arali, rose and mixture of all the three flowers respectively. Based on the experimental values kinetic parameter k was estimated using first order kinetic model as 0.159, 0.160, 0.135 and 0.149 respectively. The specific methane activity was found to be 0.05, 0.3, 0.3 and 0.4 g CH₄-COD/g VSS-day respectively for the flowers used

Key word: Bio-methane potential, kinetics, Specific methane activity, flower waste



Anaerobic treatment of organic fraction of Municipal solid wastes in two-phase semi-continuous reactor for recovery of energy

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Abstract: Currently, Municipal Solid Wastes (MSW) including organic fractions is disposed into the dumpsite leading to emission of methane one of green house gas response for climate change, contamination of groundwater and odour nuisance. In the present study, major organic fractions of MSW i.e., vegetable market wastes (VMW) was collected separately and subjected to anaerobic digestion in single and two-phase semi-continuous anaerobic reactors. The biogas production obtained from both single and two-phase semi-continuous anaerobic reactors are compared for different organic loading rates for 25 days HRT. In this study, it was found that the specific biogas production increased with an OLR from 1.5 to 4.5 gVS/L/d and maximum specific biogas production of 0.721 ± 0.010 L/gVS_{add} was obtained at OLR of 4.5 gVS/L/d and a 25-day HRT in two phase reactor compared to the maximum specific biogas production of 0.514 ± 0.010 L/gVS_{add} at OLR of 1.0 gVS/L/d at 25-day HRT in a single phase reactor. The potential methane emission reduction by implementation of anaerobic reactor in the place of current of dump site was estimated and it was observed that about 2500 tonnes CO₂ equivalent/year could be reduced.

Keywords: Municipal solid wastes, vegetable Market Waste, Anaerobic digestion, carbon emission reduction, biogas production

ICWM-AD-09

Study of Anaerobic Digestion of Organic Waste

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Abstract: Now a days, the excessive accumulation of organic solid waste (e.g., sewage sludge, organic farm waste, municipal waste, industrial and commercial waste) has become a matter of concern for engineers and environmentalists. These organic wastes need to be treated properly so as to minimize the risk of disease, to avoid the depletion of natural resources, to maintain a balance in the ecosystem and to introduce an alternative source of energy. There are a large number of methods available to treat these wastes. Anaerobic Digestion (AD) has been recognized as one of the best options as it results in dual benefit simultaneously. First the waste is treated properly and second, the power and manure can be obtained efficiently. The two valuable final products of AD, biogas and digestate can be efficiently used for power generation and manure production respectively. This paper illustrates few examples of new or broader applications of anaerobic digestion to the treatment of sewage, slurries, industrial wastewater, and solid wastes. This paper also focuses on the various aspects of AD such as the system microbiology, steps involved, parameters



affecting, role of microbes, advantages and disadvantages, wastes suiting to process etc . Hence, anaerobic digestion is a treatment solution for Organic waste as it can deliver positive benefits related to multiple issues including waste treatment, power generation, depletion of natural resources, cheap manure production etc.

Key-words: organic waste, anaerobic digestion, sustainable technology, sewage treatment, renewable energy



COLLECTION AND RECYCLING OF SOLID WASTES

ICWM-CRSW-01

Reusing and Recycling of Granite Slurry in Construction Industry

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Abstract: Characteristics of waste generated in stone processing industries, impact of its current disposal practices and waste recycling potential were assessed by field studies. The physical and chemical characteristics of waste are comparable to construction materials like sand and cement. Physical characteristics of the waste such as moisture content, bulk density, and particle size distribution were determined. The chemical composition was determined in terms of included Fe_2O_3 , MnO , Na_2O , MgO , K_2O , Al_2O_3 , CaO , SiO_2 expressed as the percentage weight of the dried waste and leachability of heavy metals. The environmental issues due to the disposal of waste including that on ambient air quality were identified at respective disposal sites. It was found that the waste can be used to replace about 60% of sand and 10% of cement in concrete. Similarly the waste can replace 40% of clay in clay bricks without affecting its compressive strength.

Key-words: stone processing waste, reuse, granite slurry, ambient air quality, compressive strength, waste management

ICWM-CRSW-02

Fly Ash not a Waste but a Very Useful Construction Material

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Abstract: In India, coal-based thermal power plants are the major source of electricity generation. This production of electricity brings along few problems i.e. generation of waste material which is termed as fly ash and its disposal problem as it is produced in a very huge amount. The fly ash disposal operation is very expensive and is also hampering the environment. So it is very important to come up with the technological concepts which will ensure consumption of fly ash in bulk instead of disposing it. Therefore, nowadays fly ash is considered as a raw material for civil engineering constructions because of its properties and chemical compositions. When the fly ash is used in structural fills or embankments, it offers several advantages over natural soil.

This paper demonstrates the utilization of fly ash waste in civil engineering constructions. Various laboratory tests have been conducted on fly ash to ensure its utilization. The unit weight of fly ash from experiment was found to be 11.98 kN/m³. Its relatively low unit weight makes it well suited for placement over low bearing strength of soil and its high shear strength compared with its unit weight, results in good bearing support and minimal settlement. The coefficient of consolidation was observed as 7.285×10^{-7} cm²/sec. Due to the presence of high void ratio, the fly ash possess low compressibility and hence, it can be used as embankment or structural fill



in order to minimize roadway settlement or differential settlement between the structures and adjacent approaches. In order to calculate the bearing strength of fly ash waste, CBR test was conducted and the value was found to be 11.23% and 16.27% at 2.5 mm and 5 mm. The permeability (k) values of well-compacted fly ash ranges from $3.93-3.30 \times 10^{-5}$. The main purpose of the permeability test was to modify the permeability value and hence to minimize the seepage of water through a fly ash embankment. The present study also highlighted the effect of different types of geosynthetics on fly ash waste in civil engineering construction. The addition of different types of geosynthetics to the fly ash acts as reinforcement and hence, improves the properties of fly ash waste. So the combination (i.e. fly ash waste with different types of geosynthetics) can be used as a structural fill material for civil engineering construction.

Key-words: Fly ash waste, embankment, Shear strength, Differential settlement, Geosynthetics, and Reinforcement.

ICWM-CRSW-03

Hydro-Mechanical Behaviour of Sand-Bentonite Mixture Reinforced with Scrap Tyre

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Abstract: Generally, mixture of sand-bentonite is used as a liner material at the waste disposal site. Due to desiccation of bentonite, it shrinks and the hydraulic conductivity increases and the shear strength decreases significantly. Hence, it is quite essential to reduce the desiccation shrinkage of sand-bentonite to achieve a durable landfill liner. Due to rapid urbanization and industrialization large amount of scrap tyre wastes are being generated and generally used as light –weight back fills material for construction purpose. The scrapped tyre wastes can also be used to reduce the desiccation shrinkage of the sand-bentonite mixture. However, the properties of the sand-bentonite mixture may get seriously affected due to the addition of tyre chips and may become unsuitable for the use as a liner material. Hence, it is quite essential to investigate the effect of addition of the tyre chips on the various geotechnical behaviour of sand-bentonite mixture. No studies have been carried out on sand-bentonite mixture reinforce with scrap tyre chips. This paper investigates the effect of the sand bentonite characteristics on the performance of waste tyre chips. In this study, a series of consolidated undrained, oedometer, and unconfined compressive strength tests have been conducted to investigate the hydro-mechanical characteristics of sand bentonite (SB) mixture reinforce with waste tyre chips. Bentonite-sand mixtures, mixed in the proportion of 70% sand-30% bentonite (SB30), were mixed with 10% and 15% of tyre chips. Result showed that effective internal friction angle (ϕ') and effective cohesion (c') value were increased by inclusion of 10% tyre chips, however, both parameter (ϕ' and c') decreased with the addition of 15% tyre chips. Excess pore water pressure (EPWP) was quite low for reinforced mixture as compared to unreinforced mixture. Additionally, it was also observed that EPWP was quite low at 10% tyre chips as compared with 15% tyre chips. Swelling pressure and swelling potential both were significantly decreased due to addition of 10% and 15% tyre



chips. Additionally, compression index was found to be decreased due to addition of 10% tyre chips and slightly increased with 15% tyre chips. It was noticed that the improvement factor not only increased at 10% tyre chips but also decreased with 15% tyre chips.

Key-words: Liners, Bentonite, Tyre chips, Swelling pressure, Hydraulic conductivity, Shear strength, UCS, Improvement factor, Excess pore water pressure.

ICWM-CRSW-04

Recycling of Fly Ash with Bentonite used as Compacted Landfill Liner Material

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Abstract: Compacted landfill liner is an integral part of engineered landfills which minimize the migration of contaminants to surrounding geoenvironment and groundwater. Bentonite is widely used for construction of liners along with other materials like fly ash because of its high absorption capacity and low hydraulic conductivity. The recycling of fly ash in waste management system can solve its disposal problem, which minimizes environmental pollution and also, reduces the cost of geoenvironmental projects. Therefore, the present study aims to propagate the bulk utilization of fly ash as a landfill liner material in combination with bentonite. Commercially available bentonite was mixed with industrial by-product fly ash in varying proportions (i.e. 0, 10, 20 and 30% by weight of dry soil) to assess the suitable combination of fly ash-bentonite mixtures based on criterion of low hydraulic conductivity (i.e. k), adequate unconfined compressive strength (UCS) (i.e. σ_c) and plasticity. The laboratory based falling head permeability test, UCS test and Atterberg's limits test were carried out. And, it was observed that 70% fly ash with 30% bentonite mixture satisfies all the universally accepted criteria. Therefore, fly ash with 30% bentonite can be used as a recycled material in MSW landfill liner construction.

Key-words: Fly ash, Bentonite, Landfill Liner.

ICWM-CRSW-05

Recycled Waste Polyethylene for Ground Improvement- Saving the Ecosystem and Enriching the Built Environment

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Abstract: It is often said that we live in the 'age of plastics'. The ubiquitous use of plastics in day to day consumer applications have been contributing to an unprecedented rise in the volume of plastic material in municipal solid waste generated across the globe. Plastic pollution is the agglomeration of huge quantity of



plastic products openly in the environment that adversely affects the flora and fauna equally. Plastic shopping bags, manufactured from polyethylene, a non-biodegradable polymer are inexpensive, lightweight, durable and water resistant which make them a convenient and dependable packaging material for consumers worldwide. The plastic bags are mostly used once and discarded which ultimately generates millions of tonnes of waste leading to environmental issues such as diminishing landfill space for disposal and marine and urban littering. Above all, plastic wastes seriously impact the biological aspect of the natural environment when disposed of inefficiently. This calls for an engineering solution to this problem. Suitable procedures need to be concocted in order to plummet the antithetical effects of plastic by transferring it in a useful and productive manner to the built environment. One of the popular definitions of recycling is- “to alter or adapt for new use without changing the essential form or nature of a thing.” In the spirit of this definition, the paper investigates the possibility of utilising polyethylene shopping bags waste which prove to be a nuisance to the organic environment to reinforce soils which can pave way for its use in civil engineering projects such as in road bases, embankments and slope stabilisation which fundamentally deal with the built environment. The non-biodegradability of plastic which may otherwise be seen as the main hazard to the organic environment can prove to be a boon when the same plastic is used in soil stabilisation. Of course, the minimum use of plastic bags should always be exhorted and plastic should be replaced as far as possible with more eco-friendly alternatives. But this project is a humble effort in order to recycle the plastic that has already accumulated as waste in the environment. It is tested that whether plastic, which is an active hazard for the bio-environment, can act as a passive agent for the betterment of the constructed environment or not. For this purpose, a series of direct shear tests have been performed on locally available soil sample collected from the banks of the ‘Brahmaputra’ by mixing it with finely shredded plastic bags to form a somewhat homogeneous mixture. The effect of varying dimensions of the strips are also investigated by using strip lengths from 15 mm to 45 mm and strip widths from 5 mm to 15 mm. Further, the concentration of soil strips are also varied from 0.3 % to 0.6 % by weight. Shear strength parameters are obtained for composite specimen from which analysis is done to identify the extent of soil improvement. Laboratory results obtained indicate that the inclusion of this material in sandy soils prove to be effective for ground improvement in Geo-technical engineering.

Key-words: Polyethylene plastic bags, Soil reinforcement, Direct Shear test, Shear strength, Biological Environment, Built Environment.

ICWM-CRSW-06

Recycling of Slag and Flux Dust in Submerged Arc Welding: A Review

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Abstract: Submerged Arc Welding (SAW) is one of the most attractive fusion welding processes because it serves inherent advantages like good strength of the joint, higher metal deposition rate and good weld surface appearance. Due to these



advantages, this process is widely used for the fabrication of offshore structures, pressure vessels, pipe lines and heavy machinery. Among several process parameters that can influence various aspects of submerged arc weldment directly or indirectly, one of the most important process variable is the chemical composition of the flux on which the performance and quality of weld depends. Submerged arc welding flux carries nearly half the total cost of the entire welding process. After welding the flux fuses over the molten puddle and is turned into the slag. The slag is generally discarded and thrown away as a waste material in the environment. Apart from this, during transportation and handling, an amount of submerged arc welding flux gets converted into fine particles that are not usable in welding and are discarded. Throwing away of the slag and unused flux dust is not only uneconomical but also can create a hazardous effect in the environment greatly affecting the flora and fauna. Due to non-biodegradability of the flux and slag, these wastes are mainly disposed in landfill sites, costing huge amount of money. It has been seen that processing cost to recycle the slag is lesser than the price of fresh flux. Many times, the saving due to recycling is more than 50%. There is an increasing interest in search of technological alternatives for the use of unused flux and slag. Researchers have investigated the effect of recycling the mechanical properties of the weldment. Changing the flux composition, adding of different mixture of chemicals with the flux dust and slag are some of the process for recycling the flux dust and slag. The cost effectiveness of recycling has been studied by several researchers. This paper present a review of the work carried out by various researchers for the recycling of slag as well as unused flux dust. It is concluded that effective utilization of flux is an important and upcoming area of sustainable manufacturing.

Key-words: Submerged Arc Welding (SAW), Slag, Flux, Recycle, Waste, Chemical composition, Sustainable manufacturing.

ICWM-CRSW-07

Plastics Waste and Recycling Prospects in North East India

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Abstract: Plastic is versatile, lightweight, flexible, moisture resistant, durable, strong and relatively inexpensive. It can be chemical resistant, clear or opaque, and practically unbreakable. These are wonderful useful qualities, and plastic plays many important roles in life on Earth. Plastic is all around us, it forms much of the packaging for our food and drink. For many of us, it is throughout our home, our workplace, our car, the bus we take to and from work. It can be in our clothing, eyeglasses, teeth, toothbrush, computers, phones, dishes, utensils, toys. The list goes on, especially when you look around and begin to notice the plastic in your life this is because it is user friendly and have become an integral part in our daily life as a basic need. As a consequence, the production of plastics has increased markedly over the last 60 years. On the other hand it is causing unprecedented environmental problems, and harbours serious health risks. Disposal of plastic waste in an environment is



considered to be a big problem due to its very low biodegradability and presence in large quantities. Although they are not intrinsically dangerous, they take up a huge amount of space in landfills and they are made from non-renewable resources, namely fossil fuels. Moreover, current levels of their usage and disposal generate several environmental problems. Around 4 per cent of world oil and gas production, a non-renewable resource, is used as feedstock for plastics and a further 3–4% is expended to provide energy for their manufacture. Growing environmental awareness and reduction in available landfill capacity have encouraged plastic recycling programmes in most developed countries. Currently, however only between 5 to 25% of plastic waste is being recycled. The paper discusses sources of generation, present practice of collection, transportation, disposal, prospects and requirements of plastic waste Recycling in North east India by evaluating the quantity of plastics produced in the Municipal waste and mechanism in-placed to recycle them. It is concluded that the existing rate of environmental worsening is likely to continue unless long term remedial measures are adopted for plastic wastes management in this part of country as much as the mainland of India. On the other hand people in North East India has the potential to tap the huge economic value of plastics waste, as a result of this, recycling of waste plastics can play a major role in providing employment.

Key-words: Plastics, Packaging, recycling, plastic waste management.

ICWM-CRSW-08

Recycling of Industrial and Municipal Solid Wastes in Cement Based Applications

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Abstract: For sustainable society, the management of wastes generated from various industries and municipality is an important task. The uses of these wastes as raw materials in cement productions or as granular additives in preparing various cement based materials are some major recycling options. Proper evaluation of physico-chemical properties of waste materials is important for determining their applicability. Moreover, for recycling in cement and concrete based applications, technical requirements such as strength and durability as well as environmental properties such as leaching of toxic elements from products must be fulfilled. Here, the author briefly presented some results of experiments those he conducted in last 12 years to evaluate the suitability of some municipal and industrial solid wastes as raw materials in various cement based products development. The municipality wastes considered for such applications were fly ash and bottom ash generated from municipal solid waste incineration (MSWI) plants and the plastic wastes generated in municipality. A slag sample obtained during melting of lead was also included. Considering the physico-chemical properties of fly ash generated from MSWI, the waste was considered as a raw material for cement clinker production. Results indicated that more than 44% of fly ash could be used to prepare raw mix. The washing of ash by water could be considered for improving technical properties of



clinker. The MSWI bottom ash samples and Pb-slag were considered as partial replacement of sand during mortar preparation. Presence of high amounts of Al metal, sulfate and organic matter in MSWI ash were the major difficulties. Depending on their physico-chemical properties, pretreatment of these wastes were also considered to improve their qualities. On the other hand, use of Pb-slag as partial replacement of sand can improve the various mechanical properties of cement mortar. Evaluation of leaching properties indicated that investigated waste materials could be considered as hazardous wastes because of leaching of substantial amounts of some toxic elements. On the other hand, leaching of negligible amount of toxic elements from waste cement based composites indicated the environmental suitability of these waste materials in such applications. Three types of plastic wastes were considered as granular substitutions of both fine and coarse aggregates in concrete production. Results indicated that all type of plastic waste aggregates deteriorated the strength and most of the other mechanical properties of concrete at any substitution level. Another important point for considering a waste for any type of application is the search of at least one inherent property that could be beneficial for some special applications. Since plastic has better energy-absorbing performance than that of natural aggregates, therefore use of plastic waste for developing ductile concrete structure can be an option. Similarly, calcium in MSWI fly ash is mainly found as minerals other than carbonate and therefore use of such ash in cement clinker production can reduce the CO₂ emission that normally observed during production of normal cement clinker. However, in any cases, it should not be compromised with the normative requirements that fixed for cement and concrete materials for various applications.

Key-words: Waste management, Municipal solid waste, Pb-slag, Cement clinker, Concrete

ICWM-CRSW-09

Optimization of Route for Municipal Transportation by Using Arcgis and Energy Retrieval from Municipal Solid Waste in Urban Kanpur: Perspectives and Future Challenges

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Abstract: Municipal Solid waste management, energy demand and improvement in the transport sector are the foremost concerns for the sustainable development at the global scale. Every year US \$102.5 billion has been spent for managing the billion tons of MSW. Transportation of MSW only constitutes about 55% of the total expenditure in the major cities of developed cities and more than 80% in the developing cities across the World. There is a need to improve the existing technology with the new one with least cost and time. From the past two decades, new technologies such as Geographical information system (GIS), related optimization software and self-modified algorithms have been used to optimize the haul route distances. As like other urban cities, Kanpur is also facing the problem of massive solid waste generation due to the migration of population from rural to urban areas.



The situation worsens for the administrators to manage the waste and to fulfill the electricity crisis. The area of Kanpur city has been extended from 302 to 605 km² in 2011 that leads to the solid waste transportation about 1600 tonnes per day. In this paper, the ArcGIS Analyst tool has been used for the identification of the optimal routes in the case of MSW collection and disposal for the Kanpur city. The GIS consider all the parameters including static and dynamic, such as the positions of waste bins, the road network and the related traffic, as well as the population density in the area under study. After developing the database for Kanpur with the 110 wards and 6 zones, the route optimization procedure has been run for 12 wards (generating nodes) to one dumping nodes (intermediate transfer station before landfill sites), using ArcGIS. The optimization process reduced the distances traveled by 12.35%. For the energy recovery from the MSW, the study has been conducted by collecting sample data from solid waste collection and disposal sites of Kanpur. The sample size of 5 kg has been taken from 20 collection and disposal points. Finally, electrical energy is calculated for all the Kanpur solid waste by using Dulong formula which comes out to be 44 MW per day which can fulfill 7.5% of electricity demand in Kanpur. It is found that electricity production from Municipal Solid Waste (MSW) could be an alternative way of power generation as well as the volume reduction of solid waste up to 90%. This study solves the problem of large volume of solid waste as the final product in ash of very less volume and improves the efficiency in terms of total distance, cost and transportation time.

Key-words: Municipal Solid waste management, Route optimization, Energy, ArcGIS.

ICWM-CRSW-10

Utilization of Thermal Power Plant by-Product Fly Ash in Waste Management

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Abstract: Landfill liners are used for the efficient containment of waste materials generated from different sources. In the absence of impermeable natural soils, compacted mixture of expansive soil and sand have found wide applications as landfill liners. In this study, attempt was made to replace sand with thermal power plant by-product fly ash. Annual production of fly ash in India is approximately 170 million-tons per annum out of which only 61% is being used in construction of road and embankments, production of cement, reclamation of low lying areas, agricultures, making bricks and tiles and others. There is limited literature on the utilization of waste product (fly-ash) for waste management applications. The major objective of this research work is to maximize the utilization of waste product (fly-ash) in waste management. The study clearly demonstrates the utility of fly ash in waste management as a substitute of sand.

Key-words: Landfill liners, Expansive soil, Sand, Fly ash, Waste containment



Effect of Reclaimed Asphalt Pavement Aggregates in Granular Layers

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Abstract: Reclaimed asphalt pavement (RAP) is a term given to removed and/or milled pavement materials containing asphalt and aggregates. This material is obtained from recycling the existing flexible pavements which have reached the end of their design life. Now a days the use of RAP has grown extensively reducing the use of virgin aggregates which leads to conservation of resources. RAP can be used in construction of base/sub-base of new pavement which results in huge savings. This study was carried out by using CBR for 5 mixes prepared in which 0, 25, 50, 75 and 100% are replaceable to that of fresh aggregates by RAP aggregates in Granular sub base for Grading III. The maximum dry density of reclaimed asphalt pavement aggregates was up to 50%, substitute level was about 0.035 g/cc and that is more than that of control mix of natural aggregates and CBR value of RAP aggregates is also more than that of control mix of virgin aggregates and this increase in strength due to the binder content in the RAP aggregates. And permeability also increased with increased percentage of RAP aggregates.

Key-words: Reclaimed Asphalt Pavement (RAP) aggregates, Granular Sub Base, Maximum Dry Density, California Bearing Ratio, Permeability, Recycling & Economy

ICWM-CRSW-12

Smart Systems

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Abstract: In this paper, we propose to design and develop prototype autonomous robots/drone which can segregate and collect recyclable plastic waste from land, water or river bodies and railway tracks across India. These solar powered robots can be tracked from anywhere using cloud and mobile apps. The prime technologies used include Internet of Things (IoT), Cloud Computing, Digital Image/Video Processing, Machine Learning and Robotics. As we know, recycled plastic produces about 3.5 kg less CO₂ compared to 6 kg of CO₂ for new plastic and 6,137 tonnes/day waste remain uncollected and littered across India viz. Delhi-690, Chennai- 430, Kolkata-425, Mumbai-408 ton/day. After collecting the waste, it can be sent to relevant industries for recycling. We believe these robots assist in realizing our Government's Swachh Bharath and Make in India schemes along with implementing Smart Cities.

Key-words: Internet of Things, Cloud Computing, Machine Learning, Robotics Image/Video Processing, Robotics, Swachh Bharath. Make in India.



Methods to Improve Mechanical and Durability Properties of Self-Compacted Recycled Aggregate Concrete

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Abstract: Huge amount of construction and demolition (C&D) waste are produced every year. The disposal and storage of this C&D waste creates serious environmental problems. Recycling of concrete is necessary from the viewpoint of environmental preservation, shortage of land for waste disposal and the effective utilization of resources. The use of recycled aggregate concrete (RAC) is widely adopted in all over the world. Use of RAC solves the problems of its disposal and the production of new material. Recycling of concrete involves breaking, removing and crushing existing concrete into materials with a specified size and quality. Recent research shows that with proper mixing approach, the recycled aggregate can attain required mechanical and durability properties. In the present study, the usage of RCA was investigated for making self compacting concrete (SCC). SCC flows under its own weight and passes through congested reinforcement without any need of compaction or mechanical vibration. The workability properties of SCC can be defined by three prime characteristics: flowability, passing ability and segregation resistance. These fresh properties are achieved by the addition of chemical additives to the concrete, such as superplasticizer, fly ash, silica fume, limestone and their combination on SCC properties. In this study, the performance of self compacted recycled aggregate is studied for mechanical properties and split tensile strength, and water absorption for durability property. For this purpose three different types of concrete mixes were produced, one of them is used as reference with 0% RCA and other two are prepared with 50% and 100% of RCA. The results show that the mechanical and durability properties of self compacted recycled aggregate concrete are sufficiently improved and can be by following two stage mixing approach.

Key-words: Construction and demolition (C&D), Two stage mixing approach (TSM), Self compacting concrete (SCC), Recycled aggregate concrete (RAC)

ICWM-CRSW-14

Review of Alternative Methods to Reduce the Generation and Improve the Disposal of Solid Wastes in India

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Abstract: Many cities in India face serious problems in managing solid wastes. The annual waste generation increases in proportion with the rise in population and urbanization. Places with greater rural populations produce more organic wastes such



as kitchen wastes and fewer recyclable items such as paper, metals and plastics. Improper management of solid waste is a threat to inhabitants and hazardous to the environment. Various studies reveal that about 90% of the solid waste is disposed of unscientifically in open dumps and landfills, creating problems to public health and the environment. Recycling is widely assumed to be environmentally beneficial, although the collection, sorting and processing of materials into new products also entails significant environmental impacts. There are different ways to recycle solid waste without causing any threat to the environment such as incineration (which can be adopted to some extent for recycling those wastes which on burning do not produce any harmful gases; further this heat can be converted into energy for other uses), by using the wastes (such as vegetable and fruit wastes, tea powder, etc) as manure, by transformation of the waste into other similar products (for instance, clothes can be modified into smaller garments and suitcases), etc. However, the focus should primarily be on trying to reduce the generation of wastes as much as possible. To achieve this, the most important step is to create awareness among people about the types of wastes and the ill-effects of not having them disposed of efficiently. This will help separating the various types of wastes and thus the disposal of the solid wastes in open places can be brought under control. Once the generation of wastes is reduced, recycling becomes easier, and solid wastes can be safely used again and again. Today, with the declination of space to store solid wastes the only remedy is to recycle those with a faster rate. This paper reviews about the literature on the issues concerning disposal of solid wastes, its impact on the environment and also the alternatives which can be implemented so as to minimize the generation of solid wastes.

Key-words: Solid waste, Recycling, India, Environment, Awareness



AIR AND NOISE POLLUTION

ICWM-ANP-01

A Review on GIS-Based Approach for Road Traffic Noise Mapping

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Abstract: Road traffic noise pollution, in the recent times, has been well recognized as one of the major trepidations that impact the quality of life in urban areas across the globe. This review paper highlights on how the different Geographic Information System (GIS) techniques have been applied for the noise mapping. The traffic noise produced by motor vehicles, as main sources in urban areas, is part of general environment problem which inflicts a serious damage to the health of human beings. In order to control acoustical sound level in urban areas, methods for prediction of the traffic noise are necessary. In the literature, many works have been devoted to the development of a predictive Traffic Noise Model (TNM). Noise emission levels have been calculated from many sound propagation models like ISO 9613:1996, Calculation of Road Traffic Noise (CoRTN 88), Harmonoise Noise Prediction Algorithm and Nord 2000. In road traffic noise studies, noise levels have been predicted with specially developed noise computer models. The results of the computer models can be served as input data for a GIS. Combined with other geographical information, such as locations of houses and buildings, areas sensitive to noise and traffic characteristics, noise effects can be quantified and visualised using functions available in GIS. GIS is only used as a pre- and post-processor in the study of noise pollution. GIS Database management system facilitates for storing, collecting, controlling and managing the noise data. Noise contours can be generated based on the interpolation techniques available in GIS. It is possible to generate a continuous spatial model of noise levels within GIS. The integration of GIS with noise prediction models provides a fast and accurate assessment of the environmental impact of noise and possible to increase the quality of noise effect studies by automating the modelling process, by dealing with uncertainties and by applying standardized methods to study and quantify noise effects.

Keywords: Road Traffic Noise, Geographical Information System, Prediction Models, Noise Mapping

ICWM-ANP-02

A Quick Review on Adoption of Fuzzy Logic in Prediction of Noise Pollution Effects

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Abstract: Adoption of fuzzy techniques in the field of environmental engineering is quite a popular these days. It is also discovered that fuzzy logic contributes good results in prediction and controlling uncertainties like noise pollution effects.



Depending on affectability the direct prediction methods may have a lot of deficiencies, but fuzzy logic gives more truthfulness as it is more important to assess real-life health effects. Observing this a quick review on adoption of fuzzy logic in the prediction of noise pollution effects is significant as its vast variety of usage. Many uncertain factors may influence in predicting an effect of noise due to the intricacy of considerable parameters. Wherefore soft computing methods and, particularly fuzzy logic occurs to be ideal for prediction of these unclear, fluctuating and nonlinear systems. Thus, understanding utilization of fuzzy logic is need of an hour. Noise pollution is a most significant origin of environmental annoyance as a result of globalization and industrialization. As per Environmental Expert Council of Germany, relentless annoyance over a continued period of time results in distress. Another important health effects of noise include hearing loss, decrease in work efficiency, interference with communication, the effects on sleep and social behavior. Thus, it is important to monitor and assess noise-induced health effects as it affects quality of life. Adverse effects of noise can be psychological or physiological. The effects of noise pollution are uncertain in nature because it changes person to person or situation to situation, especially psychological effects, for example, annoyance. Due to this, the fuzzy logic technique is one of most convenient way of representing health effects of noise pollution. Prediction models for noise-induced sleeplessness, effects on heart, performance deficiency, annoyance, speech interference have successfully been developed using fuzzy logic. These models have given satisfactory results as it depends upon human tendency and behavior.

Keywords: Fuzzy logic, noise pollution, soft computing, health effects, Noise Mapping

ICWM-ANP-03

Comparison of Plant Tolerance towards Air Pollution of Rural, Urban and Mine Sites of Jharkhand: A Biochemical Approach to Identify Air Pollutant Sink

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Abstract: Air Pollution is one of the most threatening challenges faced by humans now-a-days. The major issue is that air pollution cannot be contained. It is trans-boundary in nature, which further complicates the situation. Rapid industrialization coupled with increase in vehicular emissions have further intensified the situation leading to increased degradation of the air quality. Plants can be effectively used as filters for mitigating air pollution and as bio-indicators for indicating the air quality. Air pollution tolerance index (APTI) is a parameter to assess the tolerance or sensitivity of a plant towards pollution. In this study four biochemical parameters namely- relative moisture content, pH, total chlorophyll and ascorbic acid are monitored for monsoon and winter season. Reducing sugar and protein have also been monitored for the winter season to confirm the air pollution stress on plants. Ten common plant species have been selected from rural, urban and mine sites of



Jharkhand. *Mangifera indica*, *Dalbergia sissoo*, *Ficus religiosa*, *Artocarpus heterophyllus*, *Neolamarckia cadamba*, *Cassia fistula*, *Bauhinia sp.*, *Shorea robusta*, *Ficus benghalensis*, *Azadirachta indica* are taken for the study. Air pollution parameters like SO₂, NO₂, PM₁₀, and PM_{2.5} were monitored in the different sites in monsoon and winter season. ANOVA showed no significant variation between different sites for monsoon season at 0.5 level of significance. Pearson correlation showed significant positive correlation between ascorbic acid and air pollution parameters. Anticipated Performance Index of the plants has also been calculated to assess the overall performance of a plant in a particular region depending on the biochemical parameters as well as socio-economic value of the plant. *Cassia fistula* and *Mangifera indica* have been found to be the most tolerant species among the selected plants and *Artocarpus heterophyllus* to be the least tolerant species. Jharkhand being a forest rich region has lots of plant diversity. So far, air pollution tolerance index of plants of this region has not been reported. This type of study will be essentially helpful for plantation purposes in urban and rural development programmes and green belt development. Plants with high APTI values indicates more tolerance towards pollution and hence can serve as sink of pollutants. Finally, plants also serves as bio monitors of air quality which can be reflected from the APTI value of selected plants, without installing expensive monitoring equipment.

Key-words: Air Pollution Tolerance Index, Anticipated Performance Index, Bio-monitors, Biochemical Parameters

ICWM-ANP-04

Air Quality Indexing System: A Literature Review

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Abstract: In recent years the air pollutants effect on human health become a major health concern worldwide. Increased industrial pollution, vehicular traffic and other activities contribute towards increase in air pollution. In order to indicate the level of severity and disseminate the information on air pollution, Air Quality Index (AQI) is used. Air quality index (AQI) is a tool used to commune to the citizens how polluted the air is at present or how polluted it is forecast to become. In the past, a large number of methods were developed by various countries to determine the AQI but there is no globally adopted method which is suitable for particular situation. Different countries use different methods and terms for reporting Air Quality Indices like Air Pollution Index, API in China, Pollution Standard Index, PSI in Singapore etc. according to their local climatic condition and number of pollutants. This results in different indexing systems and air descriptor from one country or region to another. The present paper is a review of all the major air quality indices developed worldwide. The major differences among the indices in the literature are found in the number of index classes (and their associated colours), aggregation function, number and type of pollutants, and related descriptive terms. It was found that the guidelines are



consistently different from place to place in setting the threshold values and indicating the pollutants to be monitored. The review of various methods reveals that most of the methods do not have the flexibility of accommodating a new pollutant because the method is designed for specific number of pollutants. Furthermore, many indexing method are not based on health criterion and it was also found that in many of the indexing methods pollutants are not aggregated in index calculation, that is, the synergistic effects of the pollutants is not considered.

Key-words: Air pollution, Air Quality Index, Literature review.

ICWM-ANP-05

Performance of Rotating Biological Filter on Removal of Xylene from Waste Gas Streams

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Abstract: Both liquid and gaseous xylene is a major pollutant generated from paint manufacturing, chemical and petrochemical industries, designated as hazardous air pollutant by US environmental protection agency (EPA). The present study dealt with the biodegradation of xylene in batch, and continuous mode using rotating biological filter (RBF) to evaluate its performance at various operating conditions. Batch kinetic study was performed for biodegradation of xylene using an acclimatized mixed culture. Haldane model was found to be best suited for predicting the biokinetic parameters satisfactorily. This batch kinetic study was useful in the determination of optimum environment before operating the continuous rotating biological filter. The performance of sponge medium based RBF at different inlet loading rates (ILR), and its effect on elimination capacity (EC) and removal efficiency (RE) of gaseous xylene was investigated. RBF was operated at loading rate from 2.1–43.4 g m⁻³ h⁻¹, with an empty bed contact time (EBCT) ranges from 12.4 to 4.9 min. Removal efficiency was found to be more than 90% at a lower loading rate of 5.4 g m⁻³ h⁻¹ and decreased further with increase in loading rate. Studies indicated that concentration greatly influence the removal efficiency of gaseous xylene as compared to flow rate. Elimination capacity of xylene increased with increase in loading rate, but the removal efficiency observed to be decreased. Production of carbon dioxide (Pco₂) is an important indicator for the degree of xylene mineralization which increased with increase in elimination capacity. RBF simultaneously removed nutrients (NH₃-N and PO₄-P) from wastewater, found to have an inhibitory effect with increase in loading rate of xylene vapour. The results demonstrated that the RBF might be an efficient and promising option for removal of xylene in waste gas stream and nutrients from wastewater in industries using industrial sludge as a starter seed.

Key-words: Batch kinetics, Haldane model, Biodegradation, Rotating biological filter (RBF), sponge medium



A Major Greenhouse Gas “Carbon Dioxide” Capture by Polyethylenimine Impregnated KIT-6 To Renewable Source for Useful Hydrocarbons Synthesis

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Abstract: Today world is heavily dependent for energy on coal and subsequently petroleum oil and natural gas. It is a major source of greenhouse gas such as CO₂. Besides, CO₂ is a major raw material for production of hydrocarbon and artificial fertilizers. Carbon capture and utilization (CCU) is a promising option to mitigate the greenhouse effect as well as utilized as raw feed stock for production of hydrocarbons. Carbon capture is a primary stage of CCU. In the present study, a novel CO₂/N₂ selective sorbent were synthesized by wet impregnation of polyethylenimine (PEI) in templated mesoporous silica KIT-6. The synthesized adsorbents were characterized by N₂ adsorption/desorption (-196 °C), X-ray diffraction spectra, electron micrograph, TG analysis and IR-spectra. The CO₂/N₂ adsorption capacity was measured by volumetric adsorption apparatus. TEM micrograph indicated the PEI forms a layer in KIT-6. The P123 template present in KIT-6 played a great role in promoting the CO₂ adsorption capacity, which could be enhance from 3.0 to 3.4 mmol/g (adsorbent) when the amount of amine loading and the adsorption temperature were optimized as 60% and at 105 °C for the sample KIT/PEI-800. The mechanism of the template synergistic effect was elucidated by the result of CO₂ adsorption kinetic studies. However, KIT/PEI-800 has very high CO₂/N₂ selectivity at low partial pressure. It shows stable sorption capacity even after 20 adsorption/desorption cycles.

Key-words: Mesoporous silica, KIT-6, CO₂ adsorption, Template, Selectivity



INTEGRATED WASTE MANAGEMENT AND CLIMATE CHANGE

ICWM-IWMC-01

Green Banking: A Step Towards Environmental Sustainability

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Abstract: Climate change is the most serious issue the world is facing. Number of initiatives has been taken place to protect the environment from man's harmful actions. In the environment friendly society "Go Green" has become very important and useful tool in each and every aspects of business. The banks too are adopting this go green mantra to contribute to the cause of environment protection by funding the socially and environmentally responsible investment projects , using online banking instead of branch banking; paying bills online instead of mailing them and many more eco friendly banking practices which would also benefit our future generations. The term Green Banking is an integrated and innovative approach that ensures environment friendly practices in banking sectors and thereby reducing internal and external carbon footprints. Bank believes that every small "GREEN" step taken today would go a long way in building a greener future and that each of them can work towards to better global environment.

Key-words: Environmental Sustainability; Green Banking.

ICWM-IWMC-02

Layout Optimization of Sewer Network using Minimum Cumulative Flow in the Sewer Network

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Abstract: The optimal design of sewer network includes two sub-problems: (1) finding the feasible sewer layouts and (2) optimal design of sewer layout components. The topic of sewer network optimization has been broadly studied since the concept was first proposed in the late-1960s. Most of the design practices have focused on sewer network component sizing with a fixed-plan layout. The latter includes pipe diameters, slopes, and excavation depths, all of which is considerably influenced by the layout configuration. This work goals at introducing a method to solve the layout sub-problem. A new approach to the selection of feasible sewer layouts has been developed, in which generation of all spanning tree algorithm is introduced to generate all possible sewer layouts from the base sewer network. After that, these sewer layouts are sorted in ascending order of total cumulative flow and a cost function is applied to determine the optimal sewer layout. The proposed method has been applied to solve two test examples at different scales and the results



have been discussed. The results clearly reveal the efficiency of the proposed method which can effectively solve the problem of optimal layout determination of a sewer network.

Key-words: Sewer networks; Spanning trees; Layout optimization

ICWM-IWMC-03

Analysis of Waste Generation and Management of Dibrugarh District (Assam) from Sustainability Perspective

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Abstract: This paper deals with the major issues and concerns associated with the waste management in Dibrugarh district, Assam with a sustainability perspective and how inefficient waste management systems could degrade the natural resources and ecology of a place. The paper gives a broad view of the Dibrugarh district in respect to its geography and demography. It highlights the existing land use patterns of the district and also defines the key features of the Assam State Action Plan on Climate Change. The paper deals with the existing scenario of the solid waste management infrastructure in Dibrugarh. It also gives an idea of the potential sources of waste generation. It also analyses the strengths and weaknesses of the district based on its population, literacy and waste management. It explains the possible opportunities to develop the renewable sources of energy from the waste generated in Dibrugarh. Moreover, the paper also tries to discuss the threats to the district if no stringent steps are taken to improve the condition. To conclude, the paper describes how public participation, participatory governance and decentralization of power could help in resolving some major issues regarding lack of awareness and how they can be of great use to improve the current scenario.

Key-words: Demography, Waste, Solid Waste Management, Infrastructure, Environment

ICWM-IWMC-04

Municipal Solid Waste Management of Imphal City and Estimation of Resultant Green House Gases Emission

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Abstract: Managing municipal solid waste (MSW) around the world is a major environmental problem and challenge that needs to be properly addressed for holistic and amicable solution. Many urban settlement and cities in India are already in the grip of this problem due to unscientific and improper disposal system of the waste



and Imphal city is no exception to it. Apart from creating environmental hazards, pollutions, health problems, ecological damages, etc., improper management of solid waste can also contribute to emission of greenhouse gases. An investigation was carried out to assess the present status of MSW generation scenario of Imphal City with an objective to highlight the prevailing shortcomings in the management initiatives of the waste especially with the problems of collection, transportation, segregation and disposal. An effort was also made to estimate unregulated resultant greenhouse gases emission from various MSW management activities using IPCC model. As per the study it was found that Imphal City generates 100 tonnes per day (TPD) of MSW. The major portion of this waste is organic (56% by weight). The disposal site is within 8 km from the city and mostly 4 and 6 wheeler vehicles are involved for transportation. The collection and disposal of MSW of the city is outsourced to the local NGOs and they carried out door to door collection without segregation and processing of solid waste both at source and disposal site. Various shortcomings in MSW management of Imphal city viz-a-viz the Integrated Solid Waste Management System (ISWMS) and the Municipal Solid Waste (Management and Handling) Rules, 2000 are also highlighted in this paper. The present paper can be a tool for all stakeholders for an effective and sustainable MSW management initiative for Imphal city.

Key words: Characterization, Emission, Greenhouse Gas, Landfill, Segregation.

ICWM-IWMC-05

Calibration of Soil Moisture Sensor in Solid Waste Compost and Local Soil

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Abstract: Use of capacitance based soil moisture sensor has become quite popular in laboratory as well as field applications. These sensors can provide continuous measurement of volumetric moisture content in variety of soils. Agriculturist as well as horticulturist is increasingly using these sensors to plan the irrigation frequency and in soil water budget computations internationally. These sensors also provide real time continuous data in multiphase flow experiments. However the major disadvantage of this sensor is that customized calibration is required before using them in a particular soil. In this study we have used 5TE and 5TM (Decagon Devices Inc., Pullman, WA, USA) soil moisture sensors and determined their calibration to be used in solid waste compost and local red soil. As per the manufacturer, these sensors use Topp et al. (1980) equation to convert the di-electric sensor response to volumetric moisture content by default with an accuracy of 3%. This Topp's equation works well in some of the mineral soil, however, deviates considerably in high saline soils and organic soils. As per literature, however, there are further relations like Schaap et al. (1996) that can convert di-electric senses to volumetric water content. Therefore, in this paper, to determine the custom calibration for waste refuse soils, different equations



proposed in the literature are tried. Each soil was tested with three sensors. Overall the sensor output was highly consistent. Literature has suggested that sensor output is sensitive to electrical conductivity (EC) and temperature of the medium. EC of the solid waste and the local soil were found to be less than 2 dS m⁻¹ and the measurements were conducted at room temperature. Therefore the effect of EC and temperature has been neglected.

Key-words: Moisture sensor, Solid waste compost, Di-electric response

ICWM-IWMC-06

Integrated Water Hyacinth Control and Waste Management Plan: A Case of Futala Lake, Nagpur

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Abstract: Water hyacinth belongs to family Pontederiaceae and is a very remarkable and rapidly growing angiospermic plant, generally found in the fresh water bodies. Various studies have determined that besides having pernicious and inimical characteristics, it is a remarkable source of biomass and hence makes good organic compost. The present study identifies the effluents from upstream of surrounding area, immersion of idols of Gods during festivals and dumping of domestic garbage as the principal reasons for the growth of water hyacinth in Futala lake, Nagpur and proposes an integrated management plan to control the water hyacinth growth and eliminate the municipal solid waste being dumped in the lake at its source. The proposed integrated plan, explains the step-wise procedure to eliminate the water hyacinth problem and control the wild dumps of municipal solid wastes near the lake by using waste to compost machines working on the principle of thermophilic decomposition. The study also compares the effectiveness of the mechanical, environmental, chemical and biological water hyacinth control methods in conjunction with other waste to compost and waste to energy technologies in terms of volume reduction, ease of operations, restrictions and conservation on type of waste processing, quality of compost, odor control, ease of organizing human resources, financial feasibility and uses the technology specific emission factors in conjunction with the Intergovernmental Panel on Climate Change methodologies to determine the annual greenhouse gas (CO₂ eq.) emissions from them. Thus, with respect to the analysis of the efficiency and effectiveness of the proposed management and control plan for Futala Lake, the study proposes that similar plans could be used to check the growth of water hyacinth in any fresh water body.

Key-words: Water hyacinth, pollution, mesophilic decomposition, thermophilic decomposition, integrated management, compatibility.



Steel Slag as a Replacement of Natural Aggregate: A Review

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Abstract: India has the world's second largest road network in terms of length, a number which stands at a staggering value 4.24 million km. Flexible pavement contributes more than 85% of the road network. Large scale highway construction in India, emanating from rapid development, has caused massive depletion of scarce natural aggregate. The development of the highway construction industry in India under the aegis of National Highway Development Program (NHDP), has posed great demand of natural aggregates for road construction. As the resources for naturally occurring aggregates are diminished at an ever increasing rate, road industries are keen to utilize recycled and waste materials in road construction in harmony with sustainable development. Steel slag is a material, which is the byproduct of steel making industries, serves implicitly as a substitute for natural aggregates in road construction. As per American Society for Testing and Materials (ASTM), Steel Slag is a non-metallic product, consisting essentially of calcium silicates and ferrites combined with fused oxides of iron, aluminum, manganese, calcium and magnesium. Based on the production process steel slag can be classified into three categories namely basic oxygen furnace slag, electric arc furnace slag and open hearth furnace slag. Due to high strength and durability, steel slag can be used as an aggregate not only in surface layers of the pavement but also in unbound bases and subbases. Also, based on high frictional and abrasion resistance, steel slag has gained wide utilization on industrial roads, intersections, and parking areas where high wear resistance is required. Due to its suitable characteristics and reduction of high disposal cost steel slag is considered as a construction material and not as a waste by most of the developed countries. Researchers have evaluated the possible use of steel slag as an aggregate in the design of asphalt concrete mixes for use in road construction. The best management option for this by product is its recycling. This leads to reduction of landfills reserved for its disposal, saving the natural resources and attaining a potential environment. This paper present a brief review of work carried out by different researchers to judge engineering properties and suitability of steel slag in road construction.

ICWM-IWMC-08

Integrated Waste Management Plan for Indian Towns

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Abstract: Common problem for Indian towns and cities is providing quality services to citizens and maintaining cleanliness in surroundings. Source of the problem is collective action of the individuals who is not having civic sense. It is observed that



the educated are littering and uneducated are cleaning the streets of cities. Source correction is the best solution for any problem. But here source correction may really not be possible, so alternate systems are to be implemented for waste management. Earlier the problem is only in urban areas but due to developments and lifestyle changes, even towns are attracting population. Plans and measures were taken to tackle the waste management in metros and cities but very less focus was kept on towns which cumulatively hold more population than that of cities in India. With 4031 towns to be taken care of with making each of them a clean and tidy a great initiative taken by the government of India to make the country clean is “Swachh Bharat Abhiyan” (Clean India Mission). Many studies were conducted and solutions were made available to cities to handle the waste. But coming to the case of towns, no much research is done to handle the problem. The solutions proposed for cities are not feasible to towns due to the scale. An effort is made to integrate the systems and processes for waste management for towns with a population of 50,000 - 500,000. A detailed study is carried out understanding the life cycle of wastes that are generated and handled in the towns. Solid waste management, Sewage management, Storm water management, Public sanitation, Littering etc were taken along with socio-cultural and economic parameters in planning an integrated waste management. Condition analysis is carried out and the expectations of the citizens are taken into consideration. Best practices for waste management in towns across the globe and few practices of cities were adopted and a proposal is developed for Suryapet, a town in Telangana state for integrated waste management which can be adopted for any town in the country.

Key-words: Waste Management, Towns, Swachh Bharat, Clean India, Solid Waste.

ICWM-IWMC-09

Analysing the Strength Behavior of Cement Composites with Waste Glass Fibres

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Abstract: Cement composites fail due to tensile strains exceeding their limiting strain capacity. This results in the development of cracks and gradual loss of strength. The controlling of cracks is vital for better fatigue performance of concrete construction. In this paper an attempt has been made to study the suitability of waste glass fibers for utilization in cement mortar and concrete specimens in order to promote sustainable construction. These fibers were added to the composites by weight fraction and relevant tests were performed on them. Test results indicate that cement mortar showed an increase in strength and a pseudo ductile behavior due to the addition of fibers while concrete specimens showed loss in compressive and flexural strength.

Key-words: Tensile strain, Fatigue, Waste glass fibers, Sustainable, pseudo ductile.



WASTE TO ENERGY

ICWM-WTE-01

Characterization of Biomass Briquettes Derived from Pine Leaves and Cattle Dung

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Abstract: Briquetting of biomass has the potential of substituting the wood for heating application in the current scenario of energy crisis and environment degradation due to deforestation. Briquette, a densified form of biomass, can be prepared from any form of biomass such as grasses, tree leaves, saw dust, straws of wheat and paddy, rice husk, cattle dung, municipal wastes, etc. The best part of briquetting is that it increases in net calorific value per unit volume, eases the handling, transporting and storing of product, and solve the problem of residue disposal. In this investigation, an attempt was made to prepare the briquettes from cattle dung and pine leaves that are usually available in cold regions. Both of them have been considered to supplement the wood required for heating applications. Three samples of briquette, having the composition of 100 % cattle dung (CD100), 75 % cattle dung and 25 % pine leaves (CD75), 50 % cattle dung and 50 % pine leaves (CD50), by mass were prepared for study. The investigation reveals an increase in the average diameter and calorific value of the briquette with the increase of pine leaves content. CD100 has highest water resistance index of 37.67% while CD75 has highest compressive strength of 0.92 kN.

Key-words: Biomass, briquette, cattle dung, pine leaves, calorific value

ICWM-WTE-02

Improvement of Waste-To-Energy Technology- an Indian Senario

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Abstract: The paper present, the various phases of the development of Waste-to-Energy (WtE), and list down the reasons for which the WtE industry in India step on to a descending path. Based on that, the work gives the necessary recommendations for the future path. Most of the developed and developing countries having large population are making WtE as an integral part of their waste management approach (WMA) and investing more and more money in the development of the WtE industry. The WtE technology is still at an early stage of development in India, even though it is expected to grow at a fast rate due to integrated WMA along with significant and sustained growth opportunities of earning in future. But contrary, all the past WtE projects in India have got a very poor success rate. However, analyzing the various aspects of the past projects, one could find out that the greatest drawback for WtE



industry in India is its 'BAD TRAC RECORD'. Most of the earlier projects got failed because of: Lack of expertise of the plant operator, selection of the wrong set of technology, mismatch between waste characteristics and plant design, poor project development, lack of government support, pollution concerns and financial viability. It looks like the entire concept of WtE is mishandled in Indian context. With a view to increase the possibilities of using different type of technologies for converting WtE – live case studies have been studied to find practical solution for implementing WtE as a source of renewable energy.

Key-words: Bio-methanation, energy recovery, municipal solid waste (MSW), public private partnership (PPP), project development, waste-to-energy (WtE).

ICWM-WTE-03

Waste to Energy (WTE) by Incineration of Municipal Solid Waste

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Abstract: In this paper I will try to focus potential WTE capacity in metropolitan cities like Delhi, Mumbai, Kolkata, Bangalore & simple treatment of flue gases which may lead to the decrease the cost of the project. Principle of Waste to Energy Plant: Firstly MSW is transported from various places to the WTE plant. Then it is transferred from truck to mix bunker to mix it properly for getting uniform quality of MSW. Mechanically/electrically operated large gripper transferred this MSW to hopper. The waste is then incinerated in grates at high temperature (1000-1200°C). The heat produced from that is used to turn water into steam in the furnace walls. This steam is then passed through turbines which are in high pressure and the turbines drive the generator. This generator generates electricity. The part of the waste which remain incombustible (metals and other inert material) after incineration are called bottom ash. Metals are recovered from the bottom ash. Large amount of ferrous and non-ferrous metals like Al, Cu are returned as scrap metal trade for recycling. Rest of the bottom ash is cleaned further until clean sand and a stony granular remain. These are used in high quality building material like concrete and asphalt. The flue gases (consist of CO₂, CO, SO₂, NO_x, flying particles etc.) are then removed to fulfill the emission norms of CPCB or state PCB. Firstly flying particles are removed using electrostatic precipitator (ESP). This precipitated fly ash can be used as filling material in asphalt. Then the flue gas is cooled for further treatment. Removal of CO₂ & CO can be done in two chambers using KOH and Cu₂Cl₂ solution respectively. Water reservoir will be connected to control the flow of gas in two chambers. Removal of SO₂ can be done by wet scrubbing using alkaline sorbent like limestone or lime. NO_x can be removed by BioDeNO_x process. Otherwise both NO_x and SO₂ can be removed by SNOX process. Status of Delhi: Present quantum of MSW = 7000 t/d approx.(Delhi Pollution Control Committee) % of composition that will generate power (i.e. excluding the composition of metal, glass & inert material) as per 2002 data = 64.1 % (V. Talyan et al.).Year by year this composition is increasing. HCV = 1802 KJ/kg (CPCB 2000). Potential energy of MSW = 7000*1000*0.641*1802 KJ/d = 80.855*10⁸ KJ/d. Thermal generating efficiency of incinerator =



80-90%. This heat is used to generate electricity at gross efficiency of 17-30 %. The net efficiency cited around 27 %.(IPPC Reference document on Best Available Technologies for Waste Incineration, August 2006) For generating 1 MW electricity we require amount of energy (considering 27% efficiency) = 3.199×10^8 KJ/d. Potential electricity = $(80.855 \times 10^8) / (3.199 \times 10^8) = 25.27$ MW. If we collect only 50% MSW; then we can generate around = $25.27 \times 0.50 = 12.64$ MW electricity.

Key-words: Municipal solid waste, Calorific value, Incineration, Waste to energy, Flue gases

ICWM-WTE-04

Pyrolysis of Municipal Plastic Waste: Time Dependent Gas Generation Analysis at 500 C

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Abstract: Depleting energy supply and concern about global warming has emerged an attention towards renewable and alternative sources for energy generation. Worldwide the concern for the disposal of plastic waste has emerged as it is non-degradable and landfilling requires lot of space. Plastic waste is a viable source of energy which can be recovered via thermo-chemical process such as pyrolysis. This paper relates to the investigation into the pyrolysis of real world mix plastic waste for the energy recovery. The waste is primarily composed of thermoplastics such as polyethylene (HDPE and LDPE), polypropene (PP), polyethylene terephthalate (PET) and polystyrene (PS). Thermo gravimetric analysis (TGA) was done to determine the effect of temperature on waste at different heating rates of 10, 20 and 400C/min. Several experiments were performed at temperature ranging 450-5500C; optimum temperature for pyrolysis was obtained at 500 0C with max oil with zero wax percentage in minimum recovery time. The reactor was used to process 200 gram of sample per batch to represent homogeneous mixture. On a large scale pyrolysis, amount of gases obtained cannot be ruled out as they contain high heating value (HHV). The products were analyzed using Gas chromatography (GC), and GC-mass spectrometry (GC-MS). In addition, time dependent gas analysis was done to determine different composition of gases at different oil product recovery time. A large amount of H₂, C₁-C₄ hydrocarbons were found in gas product with a little presence of CO and CO₂ in the initial phase of the reaction. The effect of reaction temperature at formation of non-condensable gases was analyzed and presented for two different heating rates. It was analyzed that on increasing process temperature the paraffin component increases which increases the density of pyrolytic oil. On increasing the process temperature amount of gases increases with decrease in char quantity. It was concluded that the waste can be disposed off economically with generation of Fuel oil and gases via pyrolysis. The gases obtained having HHV can be collected and utilized for production of energy.

Key-words: Municipal Plastic waste, Pyrolysis, Gas chromatography, TGA, Fuel, Hydrocarbons



An Emerging Technology for Sustainable Disposal of Plastic Wastes and Energy Recovery

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Abstract: Rapid generation of waste plastics in this revolutionary era of industrialization and modernization is causing a global concern for their safe disposal since plastics pose a severe environmental threat due to their non-biodegradability and long persistence in nature. The current scenario of plastic waste disposal problem has led to the exploration of effective ways of energy recovery from high calorific plastic wastes. This has gained gradual attention of researchers as an effective solution of issues related to energy crisis and waste disposal. In the recent past, thermal Plasma Pyrolysis has been acknowledged as a feasible approach for the impending plastic waste management crisis while conforming to the laws of sustainable development and environmental protection. Plasma pyrolysis is a novel, eco-friendly, non-incineration state of the art technology for transformation of waste plastics into a valuable synthesis gas or 'syngas' by means of thermal plasma (torch or arc) at an extremely high temperature in oxygen-starved ambience. The intense and versatile heat generation capability of this technology facilitates disposal of all types of plastic wastes including polymeric, municipal, biomedical, electronic and other hazardous wastes in a safe and reliable mode. Plasma Pyrolysis technology offers unique advantageous features which include high waste volume reduction (> 99%), elevated reaction and heating rates, inhibited formation of toxic dioxins and furans (in case of halogenated waste) with their emission levels well below the accepted standards, increased efficiency (more than 99%) of conversion of carbonaceous plastic wastes into non toxic gases (CO, H₂) and destruction of stable pathogens due to extreme plasma conditions. The syngas product may be used for power generation using gas engines or processed to hydrogen and methane. The current review deals with sustainable utilization of the plasma pyrolysis technique in energy recovery from waste plastics. The aim is to provide a comprehensive summary of the current research progress of thermal plasma pyrolysis technology applicable to plastic waste disposal coupled with energy recovery on the basis of limited available literature. The research article also outlines the operational principles, process details, plasma characteristics in addition to advantages and limitations of this system which may throw a light on the future investigation trends. Plasma technology is finding its way as a plausible and commercially viable route in environmental plastic waste treatment that allow for significant energy recovery.

Key-words: Sustainable disposal, Plastic wastes, Plasma Pyrolysis, Syngas, Energy recovery.



Development of Waste-To-Energy Technology- an Indian Perspective Projects

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Abstract: Waste-to-Energy (WtE) is still at an early stage in the developing countries having large population like India. Even though WtE is expected to grow at a good rate due to integral parts of waste management program (WMP). Under WMP, government investing large amount of money for the development of the WtE technological industry. But from past WtE projects have got a low success rate. Most of the earlier projects got failed because of 'LACK OF EXPERTISE' of plant operation, selection of wrong set of technology, mismatch between plant design and waste characteristics, lack of government support, poor project development, financial viability and pollution concerns. Failure of WtE technology plant in India due to above mentioned reasons. This has made authorities and promoters conscious of taking up WtE projects. Based on that, the paper present, the several steps of the development of WtE, and appropriate reasons for which the WtE industry projects in India step on to a descending path. Also, the necessary recommendation for the future path.

Key-words: Air Pollution Control, Emissions, energy recovery, project development, waste-to-energy.

ICWM-WTE-07

Biodegradable Municipal Solid Waste to Bio-Ethanol using Surachi: a Traditional Rabha Yeast Culture, Assam, India

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Abstract: Municipal solid waste to bio-ethanol has its own stand in 20th century because of sharp increase in petroleum prices and its limitedness in earth crust. Bio-ethanol production is the environment friendly disposal method to mankind for a fuel alternative to petroleum. A disposal method of biodegradable municipal solid waste (BMSW) to ethanol using Rabha traditional starter culture Surachi was employed. The Rabha tribes mainly residing in North valley of river Bramhaputra, Assam prepare the local yeast culture Surachi from powdered *Oryzasativa* and some medicinal plants like *Ananascomosus*, *Artocarpusheterophyllus*, *Scoparia dulcis* L., etc. Collected BMSW fractions from three dumping areas of Kokrajhar district were hydrolyzed with HNO₃, HCl and H₂SO₄ mixture at 40°C. The hydrolyzed masses were analyzed for total carbohydrate content by phenol-sulphuric acid method. After hydrolysis powdered starter culture was mixed and placed in an aluminium utensil in anaerobic condition for 4-5 days. *Saccaromyces cerevisiae* is the main enzyme strain present in this



culture. A comparative study of ethanol produced from BMSW was done with absolute alcohol by UV- Vis spectroscopy for detection of its purity and content with a simple, cost effective colorimetric method. Approximately 70% ethanol was obtained by this procedure. Addition of Zn dust during fermentation procedure increased the ethanol content. The paper concentrated on the production of ethanol from collected BMSW to show better, simple cost effective and environment friendly disposal method of solid wastes.

Key-words: Biodegradable, Surachi, bio-ethanol, waste, colorimetric.

ICWM-WTE-08

Enzymatic Application in Anaerobic Digestion (AD) of Organic Fraction of the Municipal Solid Waste (OFMSW)

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Abstract: In the era of the 21st centenary, municipal solid waste management (MSWM) has become a challenging issue around the world. There is an urgent need to convert the generated solid wastes into stable end-products as early as possible. Although there are several technologies, including sanitary land-filling, composting and incinerations, for MSWM, the process of anaerobic digestion (AD) has been found to be an eco-friendly and energy producing method. The hydrolysis step in AD is where the insoluble polymers in the procured OFMSW are converted into simpler soluble monomers by the action of certain extracellular enzymes available from the fermentative bacteria. This being the rate-limiting step plays an important role in the anaerobic decomposition of the organic fraction of the municipal solid waste (OFMSW) to convert it into stable products. The substrates generally found in OFMSW include lignocelluloses, proteins, lipids and starch. There are three main types of fermentative bacteria that are responsible for the liquefaction of OFMSW and these are: the proteolytic bacteria, which produce an enzyme known as protease for the breakdown of protein and peptides into ammonia and amino acids, the lipolytic bacteria, which generate lipases enzyme for the breakdown of saponifiable lipids into fatty acids and glycerol's and the cellulolytic bacteria, which create hydrolysis enzymes for the breakdown of polysaccharides into monosaccharides. Hydrolysis reactions are carried out by extracellular enzymes called hydrolases, which catalyze all the reactions. From the chemical point of view, hydrolysis means the breakdown of long chain bio-molecules by the reaction with water. Biologically hydrolysis acts through the influence of enzymes. Products of hydrolysis are soluble smaller molecules. The present research reviewed the potential, functional routes and behavior of hydrolytic enzymes. It also highlighted the limitations and applicability of various enzymes to promote the hydrolysis process in the AD.

Key-words: Organic fractions, Municipal solid waste, Anaerobic digestion, Enzymatic hydrolysis, Application perspective.



Experimental Study on Tesla Turbine used for Power Generation by using Waste Flue Gas

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Abstract: Tesla turbine and test rig have been aimed and manufactured. Experimental study on tesla turbine used for power generation by using waste flue gas results is presented. The fluid flow field within tesla disc turbine have been investigated experimentally. The turbine is a bladeless centripetal and tangential flow turbine. The turbine runs by the principle of momentum transfer by developing a boundary layer on the smooth surfaces of the disks. Rectangular nozzles were analyzed using air as the working fluid and flow taken to be incompressible, turbulent and non-reacting. Resistance to fluid flow between the disc results in energy transfer to the shaft. High velocity working fluid enters the disc through inlet nozzle path tangent to the outer edge of the discs. Different inlet velocity ranging from 15.0 to 80.0 m/s has been investigated. In the range investigated the lower velocity did not influenced the performance. Paper will develop an adequate design of nozzles contribute to increase the overall yield of a Tesla turbine.

Key-words: Design, tesla disc, turbine, nozzle, velocity, power.

ICWM-WTE-10

Recovery of Energy and Calcium Oxide from Textile Sludge by Plasma Technology

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Abstract: Textile Industries produce effluent which is in turn treated in common effluent treatment plant. Effluent treatment plant generates textile sludge continuously. The sludge is in powdered form with some clinkers and moisture which appears white. Simple dumping on earth surface will result in large deposition and finally gets accumulated over a large area. In the long run it causes leachate flow and it contaminates the ground water as well as occupying a big portion of land. Plasma treatment has become a prominent technology because of the increasing problems with waste disposal and the opportunities to generate valuable co-products. Several benefits associated with plasma technology include high thermal efficiency (resulting in fast reaction kinetics); flexibility in choice of process gas environment; substantial waste volume reduction; high energy density, thus adequacy in utilizing smaller processing reactors; no material pretreatment is required; and the need for less pollution abatement equipment due to the lower demand for air and absence of fossil fuels. Since it is a thermal transfer process it is experimented to find the feasibility and it is analyzed in energy angle to find or develop a strategy for this issue. In any solid



waste disposal method the volume or mass reduction is the first step proving that Plasma Technology can give better result than the conventional methods. Calcium carbonate is reduced as Calcium oxide and carbon dioxide is the gaseous output. Lime can be further separated from vitrified slag and used as a raw material for cement industry. Calcium oxide recovery is major advantage and it is the raw material for many industries. The exhaust contains CO, CO₂, and hydrogen at high temperature (more than 100°C) and it can be used for thermal energy recovery. The exhaust gas can be further reformed to have better calorific value by addition of steam which will increase the reaction rate to improve the presence of carbon monoxide and hydrogen. Steam acts as a catalyst. Efficiency achieved in this process is 49%. This can be improved by steam reforming and catalyst addition to improve the reaction rate. Enthalpy calculations prove that the plasma torches can produce very high power in this test set up.

Key-words: sludge, energy, plasma technology.

ICWM-WTE-11

Biodiesel Production from Garbage Waste using Oleaginous Yeast *Lipomyces Starkeyi*

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Abstract: Biodiesel has become one of the renewable fuels in recent decades. Major obstacle for biodiesel production and consumption is the cost of biodiesel production. More than 70% of the production cost is consumed by the raw materials since biodiesel conventionally produced from edible oils and food crops. It is also getting criticism from food security point of view. Attempts have been made to produce biodiesel at lower cost by using solid waste (Garbage) waste as raw material. Vegetable waste was collected from the local market at Coimbatore, was dried and grinded. Garbage of varying solid loading ratio such as 2%, 4%, and 6% (w/v) were mixed with 3% (v/v) Sulphuric acid, autoclaved and filtered to obtain Garbage Hydrolysate (GH). These samples were detoxified by over liming process using calcium hydroxide. It was again subjected to detoxification using 3% w/v activated charcoal. The C/N ratios were analyzed using Shimadzu TOC analyzer. The Maximum C/N Ratio was obtained as 19.67 for the solid loading at 4% w/v of Garbage. Along with this, the pH and temperature was also optimized as 8 and 30°C respectively. The lipids accumulated by *Lipomyces starkeyi* in Garbage hydrolysate (GH) and standard Growth Medium (GM) was compared and it was found that GH produced 1.960g/L and GM produced 4.240g/L of lipids. The lipid thus obtained was confirmed through the Ethanol emulsion test. Lipid is then subjected to transesterification process to react with methanol and sodium hydroxide where the triglycerides are converted to fatty acid methyl esters (FAME) and glycerol. FTIR results confirm the presence of FAME (biodiesel) compounds such as butyl stearate, ethyl myristate, ethyl palmitate, methyl elaidate GC reference and methyl linoleate natural

Key-words: Garbage, *Lipomyces starkeyi*, C/N, Single cell lipid, Bio-diesel



Waste to Energy -A Review of Available Technologies

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Abstract: Energy is an essential part of economic growth of a country. According to the Central Electricity Authority (CEA), the per-capita conventional energy consumption of India reached 1010 kWh in 2014-15. However, India still faces an energy shortage with the peak power deficit of 6103 MW, as per recorded in the financial year 2013-2014. Coal has been the main conventional source of energy, accounting to 60% of the total energy produced. Hence, the import of coal, in addition to India's increasing dependence on imported oil, has led to an import of around 28% of India's total energy needs. In rural households, 85% depend on solid fuel for their cooking needs. Only 55% of all rural households have access to electricity, where most of them face issues with the quality and consistency of energy supply [1]. On the other hand, India generates approximately 100,000 MT of Municipal Solid waste per day [2]. If managed and processed efficiently, this can generate sufficient renewable energy that can be used for various purposes both in households and in industries. Energy can be recovered from waste in the form of electricity, heat and fuel using different technologies such as incineration, gasification, pyrolysis and anaerobic digestion (biogas generation). Current waste-to-energy generation in the country is 107.5 MW whereas we have the potential to generate 2554 MW (i.e., 2% of the renewable energy resources) as per Government's 2014-2015 annual report. In this paper, we review the present solutions available via waste-to-energy technologies in overcoming the glitches of conventional sources of energy, also shedding light on the challenges of the treatment of waste for energy production.

Key-words: Waste to Energy, Municipal Solid waste, Power, Energy crisis

Designing and Utilizing of the Solar Water Collector for Digestion of Lignocellulosic Biomass

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Abstract: The production of biogas from organic material under anaerobic condition involves sequence of microbial reactions. Anaerobic digestion represents one of several commercially viable processes to convert woody biomass, animal waste such as cattle dung, chicken litters, pig manure, agricultural wastes, municipal solid wastes etc. to methane gas. The process involves three stages namely hydrolysis, acid formation, and methane formation. However, processing and production of methane



highly depends on the temperature of digestion and pretreatment methods. Pretreatment involves removal of lignin and disruption of the crystalline structure of cellulose. The best and efficient way of digestion of lignocellulosic biomass is thermal pretreatment. Thermal pretreatment needs high Temperature (heat energy) for heating the lignocellulosic biomass in order to break down the lignin part and activate the enzyme reactivity. To achieve the required temperature for thermal pretreatment solar energy is used for this project. Flat plate solar collector is one of the known devices developed for harnessing solar energy and converting it to heat, particularly for applications requiring energy delivery at moderate temperature of up to 1000 C . Copper tube used for transferring fluid and glass wool for insulating back and side of the collector there by reducing the heat loss. The aim of the present work is to design a 2m² solar collector for heating water. The heated water is circulated to heat exchanger which heats the lignocellulosic biomass in an anaerobic digester. The Size and spacing between the copper tubes depend on temperature requirement of the system. The solar collector was tested experimentally for heating water before circulating in to the heat exchanger. The result showed that at the flow rate of 0.03 Kg/s the output temperature and the daily average instantaneous efficiency were 530C and 32.4% respectively. The efficiency and the output temperature can be increased further by using selective coating on the absorber plate and reducing total heat loss from the collector by proper insulation.

Key-words: Anaerobic digestion, Thermal Pretreatment, Instantaneous Efficiency, lignocellulosic Biomass

ICWM-WTE-14

Characterization and Utilization of Waste Rubber Seed Shell for Production of Biofuel and Mixture of Value-Added Chemicals

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Abstract: In this work waste rubber seed shell (RSS) comprises of 40–48% by weight of rubber seed was used for biofuel and value-added chemicals production through semi-batch pyrolysis reactor. Proximate, ultimate, extractive, thermal behaviors and crystallinity index analyses are important for biomass characterization. The ultimate analysis results revealed that the total organic matter content of RSS is around 96.67wt%. On average 3.53 wt% extractive (hexane and ethanol) were obtained in RSS sample and the crystallinity index was found to be 38.6%. Thermogravimetric analysis (TGA) of RSS was conducted at heating rate of 20°C/min to identify the active pyrolysis zone of temperature. R50 value of RSS at 20°C/min heating rate was found to be 12.72 %/min (376.5°C). The residual weight left after 800°C (0.8 wt%) was an indication of lignin and inorganic minerals presence in RSS. This result was confirmed by proximate and field-emission scanning electron microscopy (FESEM) with energy dispersive X-ray spectroscopy (EDX) analysis of RSS. Effects of pyrolysis temperature (350°C–600°C) and heating rate (10°C/min–40°C/min) on products distribution and heating value of bio-char were investigated. The result



showed that maximum liquid yield and carbon-rich bio-char can be obtained at 550°C pyrolysis temperature for heating rate of 30°C/min. With this condition the product distribution was found to be 46.14wt% (liquid), 30.42wt% (bio-char) and 23.44wt% (gas). Bio-char obtained at 550°C pyrolysis temperature has comparable energy content with anthracite (32–34 MJ/kg) solid fuel. Higher calorific value (34.5 MJ/kg), higher fixed carbon, lower ash and moisture content of bio-char produced from RSS pyrolysis can be used as a solid fuel. Value-added organic compounds such as acetic acid, phenolic compounds, creosol, Pilocarpine, benzene and 3-Hydroxy-4-methoxybenzoic acid presented in the liquid product were identified using gas chromatography with mass spectroscopy (GC-MS). The liquid product pH value (2.55–3.00) was fall within acidic pH range and this supports the presence of organic acids and phenolic fraction in liquid. Functional group presence also analyzed using Fourier transform infrared (FT-IR) spectroscopy. Dehydration reaction during pyrolysis of RSS increases the water content in the liquid product which is responsible for low quality of liquid fuel. The physico-chemical-thermal properties of RSS and obtained products (liquid and bio-char) suggest that RSS can be considered as a suitable feedstock for bio-chemical and fuel production.

Key-words: RSS,TGA, Pyrolysis, Bio-char, Liquid.

ICWM-WTE-15

Influence of Recycling on the Thermal Properties of Municipal Solid Waste for Incineration and Energy Recovery

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Abstract: A multitude of conventional and non-conventional techniques are adopted all over the world to handle the huge quantities of municipal solid waste (MSW) generated. Waste reduction, reuse and recycling are instrumental in curbing the issues related to MSW management and is being implemented in many countries including India. Most cities in India have active waste recycling programs. Not only do the recycling programs help in material recovery, but also aid the reduction in greenhouse gas emissions by replacing virgin items with recycled items. In the present study, the variation in the calorific values of the MSW generated in metros like Delhi, is investigated when recycling of various components is implemented. Biodegradables, paper, plastic, metals etc. from MSW are assumed to be recycled at different rates. Recycling of a combination of wastes is also considered to analyse the variation in heat content per kilogram of the MSW. Resultant changes in the combustibility of the MSW and its effect on the efficiency of thermal waste to energy facilities are examined. The tanner diagram and conventional thumb rules are used to interpret the results.

Key-words: Calorific value, Incineration, MSW, Recycling, Waste to energy.



Estimation of Energy Potential from Kitchen Waste Generated from Hostel Mess of an Educational Institute: A Case Study

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Abstract: Finding ways for harnessing bioenergy from waste is gaining importance. Substantial amount of Kitchen Waste (KW) is generated from hostel mess of institutional campus which can be converted into various forms of energy to achieve better environmental sustainability and management of waste. Kitchen waste when disposed along with the Municipal Solid Waste (MSW) or into sanitary sewers creates major nuisance due its putrecibility. But it has greater potential of energy recovery if converted into biogas, biofuels or bioelectricity. This paper deals with estimation of energy potential of KW generated from hostel mess of VNIT campus when converted to these valuable energy forms.

Key-words: Kitchen Waste, Bioenergy, Energy Potential.

ICWM-WTE-17

Performance Evaluation of Low Cost Microbial Fuel Cell Employing Earthenware Separator

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Abstract: The purpose of current study is allied to evaluate the performance of a low cost Microbial fuel cell (MFC) incorporated with earthenware separator; a potential device for effective conversion of waste to energy and treatment of wastewater simultaneously. Development of a state-of-the art technology for effective wastewater treatment and power production at low cost became so important. In some cases the technology becomes less reliable and affordable for sustainable wastewater treatment and power production due to its high cost of materials used. A variety of wastewaters containing high amount of nutrients could harness and possibly a device to be implemented for field applications. The current research is focused on studying the performance of MFC by varying the thickness of low cost modified earthenware separator. The separator composed of red soil (80 %) blended with montmorillonite (20 %), a soil mineral having high proton exchange capacity was used for the study. The separators were characterized by studying the proton conductivity, oxygen diffusion and also by energy dispersive x-ray spectroscopy (EDS) study. A comparative study employing different thicknesses of separator i.e. 4 mm and 5mm was established where separator having 4 mm thickness outperformed the separator having 5 mm thickness. The dual chambered MFC with inner anodic chamber and concentric outer cathode chamber showed appreciable performance with a maximum power density of 47.77 mW/m² and 33.44 mW/m² in 4 mm and 5 mm thicknesses respectively, normalized to anodic electrode surface area while fed with synthetic



dairy wastewater having chemical oxygen demand (COD) of 1920 ± 20 mg/L. The proton diffusion coefficients were 3.32×10^{-4} cm²/sec and 3.17×10^{-4} cm²/sec in 4mm and 5mm thicknesses respectively. The internal resistances (ohmic internal resistance) of each MFC devices were calculated by polarization study were 71 ohm and 95 ohm in 4mm and 5mm thickness respectively while the MFC shown a maximum COD removal efficiency of 89 % from both the reactors while treating synthetic dairy wastewater. The MFC incorporated with 4 mm earthenware separator shown a maximum working voltage of 600 mV and the MFC with 5mm earthenware thickness shown 470 mV when operated with a 150 Ω external resistance. The wastewater was treated anaerobically in the anode chamber and the effluent from the anode chamber was given aerobic treatment in the cathode chamber. The MFC has continuously supplied with synthetic dairy wastewater with a flow rate of 2.1 mL/min at hydraulic retention time (HRT) of 6 hours. The continuous aeration at bacterial bio cathode chamber helped in providing sufficient amount of oxygen to catholyte thus enabled to remove such an appreciable COD and acts as a best electron acceptor in the electrochemical process. The working voltage attained will help providing power to biosensors and other electrical equipments consuming less power. The low cost MFC showed promising performance in terms of conversion of waste to energy along with wastewater treatment.

Key-words: Microbial fuel cell (MFC); earthenware separator; chemical oxygen demand (COD); power density; proton diffusion coefficient; internal resistance.

ICWM-WTE-18

Rice Husk as Substitute Fuel for Food Processing Industry: Techno-Economic Investigation of an Industrial Biomass Gasifier in Assam (India)

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Abstract: Most of the food processing industries are thermal energy dependent and fossil fuels have been the traditional sources for it. The need for positive growth of food processing industries has been felt in all the nations for better economic prosperity. However, the uncertainties related with the uses of fossil fuel pose a serious concern in recent times. The food processing industry in Assam (India) is also facing such problems and it is unfavorable for economy. Rice husk is a major by-product of farming sector and it is abundantly available in rural areas of the region. Currently, application of rice husk, as a source of energy, is very limited and therefore, considered as a non-commercial commodity. The husk fuelled gasifier has been used in some parts of India and recently one 600 kWth system has been installed in one food processing industry in Assam (India). The diesel used in one of their biscuit ovens consuming about 50 liter per hour is replaced by producer gas generated from about 320 kg rice husk per hour. About 55% reduction of fuel cost has been reported by the user. However, there are certain techno-economic factors related to this fuel substitution technology which require in-depth analysis for extensive promotion of this renewable energy technology for industrial application. This paper



addresses such issues of gasifier application from social, economic and technological perspectives.

Key-words: Rice husk, Food processing industry, Agricultural waste utilization, Biomass gasifier, Techno-economic study

ICWM-WTE-19

Evaluation of Biogas Production from Waste Microalgae

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Abstract: The present work is carried out to evaluate the biogas production from anaerobic digestion from the algae biomass waste after the lipid extraction in the biodiesel production process in order to manage the waste biomass and prevent the environment pollution. Microalgae biomass has thick cell wall which results to less degradation reflects less biogas production, hence to enhance the biogas production, a pretreatment process is necessary to enhance the biogas production. Thermal pretreatment is done at low temperatures for disrupting the cells which consumes less energy than acid, alkaline, ultrasonic, microwave and biological methods. Response surface methodology by central composite design is used to optimize the interactions between the variables affecting the biogas potential. Batch assays with thermophilic digestion environment was investigated by optimizing the pretreatment variables such as temperature and heating time of 30° C to 110° C with an interval of 20° C and 1 to 24 hour with an interval of 6 hours for algae biogas production with co-digestion of corn husk and cow dung as an inoculum. Corn husk has high C/N ratio of 48:1 is used to balance the digestant as the microalgae has the C/N ratio of 6:1; where the lower C/N ratio causes for lesser biogas production. The optimal condition for the pretreated algae biomass were found as 70° C and 12 hours, resulting the cumulative biogas production of 230 mL/gVS than as 180 mL/gVS when the biomass at 30° C in 12 hours.

Key-words: biomass, biogas, microalgae, pretreatment, response surface methodology

ICWM-WTE-20

Waste to Energy

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Abstract: Introduction: Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of generating energy in the form of electricity and/or heat from the primary treatment of waste. WtE is a form of energy recovery. Most WtE processes produce electricity and/or heat directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels. Combustion, in which the residual waste is burned at 850 C and the energy recovered as electricity or



heat. WTE BENEFITS: 1. it helps the reduce its dependency on energy imports 2. It contributes towards reducing carbon emissions and meeting renewable energy targets when used for electricity generation, these technologies have a steady and controllable output, sometimes referred to as providing “baseload” power POLICY FRAMEWORK: 1. Applying 3Rs for achieving waste reduction & utilization. 2. Promoting the integrated waste management system to reduce the landfill areas and generate the renewable energy; 3. Encouraging the cooperation of adjacent Local Governments for establishment of waste management facility. 4 Endorsing public and private sectors to participate in waste management project. Reducing the environmental impacts then maximising the energy: The second principle is about ensuring that energy recovery is the best solution for the residual waste going to it, and then where this is the case that the most is made of the resource it represents. This means understanding and potentially manipulating the nature of the residual waste and ensuring it is suitably matched to the right type of process and energy outputs to minimise the environmental impact. Where this can't be done the impact needs to be mitigated. Energy from waste technologies: Incinerators: There are various types of incinerator. All involve direct combustion of residual waste in the presence of oxygen to produce energy. Advanced thermal treatments (ATTs): ATTs tend to use either gasification and/or pyrolysis, although there are a wide variety of technologies within these categories. WTE in INDIA: Scale of the problem: Lack of data and awareness, and qualified human resources are the biggest challenges for WtE in India. At some point, these will be overcome. The question is when and who will take the initiative? The government, industry or the public. If we wait until public demands reach the intensity that will move governments or the industry, we will have impacted many lives. Every day, urban India generates 188,500 tonnes of MSW 68.8 million tonnes per year and waste generation increases by 50% every decade. Solutions: India now has access to affordable WtE technology, thanks to numerous Chinese and South East Asian companies with operational plants. Further, a European WtE Company has recently established its office in India, and by sourcing their components indigenously and by standardising plant design is able to provide its technology at prices affordable to Indian cities. Municipal governments should practice caution in scoping projects, choosing private partners, and carry out transparent tendering processes by hiring knowledgeable consultants.

Keywords : Waste to energy, Energy from waste, Combined heat and power, Advanced thermal treatment

ICWM-WTE-21

Techno-Economic Analysis of Municipal Solid Waste Management for Madurai City

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Abstract: With the rapid industrialisation and migration of people from villages to cities, the urban population is increasing rapidly. Waste generation has been observed to increase annually in proportion to the rise in population and urbanisation.



According to ministry of urban affairs, government of India estimates that India is generating approximately 1 lakh metric tons of solid waste every day. The objective of this study is to critically examine the existing Municipal Solid Waste Management system in Madurai city to gain a better understanding of the situation, challenges and issues in the system. A comprehensive Cost-Benefit analysis was carried out using the present data collected in Madurai city that currently produces 680 tons of Municipal Solid Waste per day. The percentage generation of domestic solid waste is 65% followed by commercial waste of 20% and the per capita generation of solid waste is 450 grams per day. The combined solid waste contains about 44.15% of garbage, 13.31% of inert material and 42.09% of recyclables. Various economic cost and benefits associated with MSW Management are taken into consideration to check the feasibility of private sector participation by using Gross margin analysis. This study also includes a techno economic evaluation of the MSW system with emphasis on recyclable potential from waste interestingly the Madurai corporation waste has a good potential of recyclables and found that organic waste is the major component followed by mixed plastics and synthetics. The results show that the pyrolysis option is preferable than other options considered. Since the solid waste composition in Madurai contains calorific values are in the range of 1200-1600 kcal/kg the feasibility of RDF from the waste is low.

Key-words: Municipal Solid Waste, Cost Benefit Analysis, Economic evaluation

ICWM-WTE-22

High Energy Absorbent Sustainable Concrete Element from used Tin Cans

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Abstract: Large quantities of solid wastes being generated worldwide from sources such as household, domestic, industrial, commercial and construction demolition activities, leads to environmental concerns. One such major component is tin cans which are kept in the environment for long period of time. Tin compounds are accumulated on earth surface for many years. These are inorganic waste material, persistent and not fairly biodegradable so continuously increasing in the environment. Maximum tin cans which are directly thrown in environment contains food of low Ph which can cause toxic effects to the environment. Utilisation of tin cans wastes in making building construction materials can reduce the magnitude of many associated problems. 'ENERGY BLOCK' is a type of block which is able to resist impact load upto a great extent. It is mainly composed of cement, sand, fibres and tin cans. This paper which is based on energy block is proposed to develop an environmentally friendly, light weight building block from waste tin cans along with fibre (galvanised iron) without the use of coarse aggregate providing high energy absorption along with high tensile strength to the concrete. The paper conclude the results of laboratory tests and important research findings and the potential of using tin cans wastes in building construction materials with focus on sustainable and economic development. Instead of making a single block, multiple blocks with different properties and



parameters were constructed. About four primary cases or parameters were kept in mind before construction, whether block should be plain, reinforced with tin or fibres or a combination of all the three. The construction proceeds with casting of 12 cylindrical blocks and kept it cured for a period of 28 days to attain the strength. The energy absorption test has been conducted using universal testing machine and obtaining the graph between load on 'y' axis and CHT (cross head travel) on 'x' axis instantaneously. This graph is very crucial for finding the ultimate strength. While conducting the experiments, the results clearly showed that the energy absorbed using plain mortar, fibre, tin cans is very high. Hence, it can be concluded that there is a wide difference in the energy absorption between the plain mortar (fibres and tins cans) and the other three mixes. This paper also showcase the research gaps, which includes, the need to develop standard mix design for solid waste based building materials, the need to develop energy efficient method of processing solid waste use in concrete, the need to study the actual behaviour or performance of such building materials in practical application providing light weight and the usage of tin cans can be economical for conservation of environment.

Key-words: solid waste, energy block, high strength, economical, light weight, tin cans **Topics:** 8.Waste to energy

ICWM-WTE-23

Comparative Studies on Rheological Behaviour of Waste Cooking Oil, its Methyl Ester and their Blends

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Abstract: In this study, rheological behaviour of waste cooking oil (WCO) and its derivative methyl esters as well as its blends with diesel fuel were investigated. Rheological properties of oil samples were measured at temperature from 25–80°C and shear rate from 5–300 s⁻¹. Similarly, rheological behaviour for waste cooking oil, its methyl ester (WCOME) and blends (5 vol.%, 10 vol.% and 15 vol.%) with diesel fuel were also studied. Chemical modification of the oil sample by transesterification was found to be decreasing the rheological properties (viscosity). Power law model were used to investigate the flow behaviour of all the tested samples. The viscosity behaviour of oils (WCO), methyl ester (WCOME) and their blend with diesel fuel were studied for temperature range 25 °C–80 °C and found to be nearly Newtonian behaviour. However, slight deviations of Newtonian behaviour were found for WCO and its methyl esters within 5–100 s⁻¹ shear rate intervals. The dynamic viscosity of WCO was (49.91 mPa.s). The kinematic viscosity of WCOME at 40 °C was (3.36 mm²/s). The dynamic viscosities of tested samples were found to be fatty acids chain length and unsaturation dependent as well as temperature. According to fatty acid composition of the oils samples WCO are suitable for substituting edible feedstock and sustainability for biodiesel production.

Key-words: Rheology, dynamic viscosity, vegetable oil, methyl esters, blend, Newtonian fluid, power law model



Thermal Treatment of Tannery Solid Waste using Pyrolysis

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Abstract: Thermal treatment of Leather Finished Trimmings (LFT) and Chrome Shavings (CS) from tanneries using Pyrolysis were studied. Initial characterization of the leather finished trimmings and chrome shavings from the tannery industry indicated higher calorific value of both the samples which makes it suitable for thermal treatments. The TGA of chrome shaving and finished leather trimmings records a weight loss of around 80% and 69% at 800°C respectively. EDAX with SEM analysis for both the solid wastes was carried out. Pyrolysis of the waste was carried out using a fixed bed type Pyrolysis unit at a temperature of 500 ±10°C for both the leather wastes for a total reaction time of 30 minutes and three different by-products was obtained as a result of Pyrolysis. The product yield from the process as well as its physio-chemical properties and gas composition of the uncondensed gases resulting from the process were studied. Higher bio-oil yield of 52% from the leather finished trimmings and chrome shavings of 49% have been obtained which makes it suitable for Pyrolysis process. The calorific value of the bio-oil obtained for LFT and CS was found to be 28 MJ/Kg and 27.8 MJ/Kg respectively. The flame temperature of the gases burnt after Pyrolysis was measured and found varying in the range of 637±10°C and 665±10°C for LFT and CS respectively. Gas composition of uncondensed gases obtained from pyrolysis at 500 °C was determined.

Energy Recovery and Waste Disposal of Medium Vehicle Tyre Waste through Pyrolysis

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Abstract: Incessantly growing usage of automobiles, at a substantially higher rate than that of population growth, has created great concern world over on waste tyre utilization mechanism. In India nearly 0.6 Million Tons of scrap tyres are generated annually. The most suitable pathway for waste tyre management, universally accepted by the present day researchers, is undoubtedly the waste-to-energy conversion. Probably, the most economic and environment friendly route to achieve this objective, turning liability to asset, is the pyrolysis of waste tyre. Yield and composition of pyrolysis products: gas, liquid and char are reported to critically depend on a number of variables, viz., pyrolysis time, temperature and pressure, feedstock composition



(depending on car, truck or motor cycle tyre), carrier gas type and flow rate, feed particle size, type of catalyst, heating rate, volatiles residence time and catalyst to feed ratio. The present work is concerned with the experimental studies of the effect of temperature on yield of products of medium vehicle waste tyre pyrolysis in a fixed bed reactor. In this experiment 200 gram of sample per batch was taken for analysis. TGA was carried out at 10 and 20 °C/min to determine the thermal degradation temperature and behavior towards heating rate. Pyrolysis of medium vehicle tyre waste was carried out at 650°C for recovery of pyrolysis products. Characterization of pyrolysis gases was done using gas chromatography. Pyrolytic fuel oil physical properties were also determined. In addition, with the recovery of Pyrolytic oil the gases were analyzed at different oil yield. The product gases containing gas like H₂, C₁-C₄ hydrocarbons, CO with a little presence CO₂ due to oxides present in the waste tyres. It was concluded that as the process reaction precedes the amount of H₂ increases with decrease in amount of CO and CO₂. Other gases were also obtained a decreasing trend in volume percent as the reaction proceeds. The pyrolysis process can be used for the reduction of waste tyres and utilizing its gaseous products for energy generation which reduces its energy demand and make process energy sustainable.

Key-words: Waste tyre, Pyrolysis, Temperature, Fuel, Waste to Energy.

ICWM-WTE-26

Dehalogenation and Energy Recovery from Waste PVC Through Catalytic Pyrolysis

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Abstract: The demand of plastics is ever-increasing due to the rapid urbanization and industrialization. Along with increase in use of plastics due to their versatility and durability, the waste of plastic has also increased over time. Waste poly-vinyl chloride (PVC) or its presence in mixed plastic wastes cause a lot of environmental problems during disposal because of the presence of chlorine which releases halogenated undesirable compounds during incineration, combustion or which leach into the landfills etc. In addition to this rapid depletion of fossil fuels provide a strong need to look for alternate energy sources. In this context the feedstock recycling of plastic wastes have gained attention because fuel oil and other hydrocarbons can be recovered from these waste plastics, thus solving the problem of both disposal and fossil fuel crisis, together. Pyrolysis has been the most popular choice for feedstock recycling of many researchers. The oil obtained from direct pyrolysis of waste PVCs cannot be used until they are chlorine free, since the chlorine is corrosive and is therefore unwanted in reactors. In order to make the pyrolysis oil almost devoid of chlorine, dehalogenation of the waste plastic should be done during or after pyrolysis. The dehydrochlorination of PVC releases HCl gas. This dehydrochlorination can be done during pyrolysis using only temperature control which makes the pyrolysis a two-step process, or catalysts and sorbents can be used for dehalogenation during the pyrolysis. Co-pyrolysis of PVC with waste glass or coal also facilitates feedstock recycling and



has shown to produce high amount of liquid products. Dehydrochlorination of waste PVC using only temperature control seems to be a cost effective process since the use of catalysts or sorbents may bring a catalyst/sorbent recycle cost into the picture, after a certain number of cycles. Thermal Pyrolysis of waste PVC, the pyrolysis kinetics, and the various methods currently available for dechlorination of PVC and energy recovery has been critically discussed and reviewed in this paper.

Key-words: PVC, pyrolysis, dehalogenation, disposal, feedstock recycling.

ICWM-WTE-27

Construction of Microalgal-Bacterial Consortium for Effective Wastewater Treatment and Sustainable Bio-Diesel Production

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Abstract: Wastewater treatment with algal-bacterial consortium provides not only a convenient way in order to remove nutrients, heavy metals and pathogens from different kind of wastewater but also furnish sustainable biofuel which is an inevitable need to mitigate the challenge of fossil fuel demand and environmental pollution. The major disadvantages which are associated with conventional wastewater treatment practices are the handling and disposal of large amount of sludge from the waste water treatment plant, high energy requirements for aeration which is unsuitable for low per-capita energy consumption countries and the lack of complete nutrient removal efficiency process. But using the microbial consortium for wastewater treatment offers interesting advantages over conventional treatment system i.e. it is cost effective in a way to remove biochemical oxygen demand, pathogens, phosphorus & nitrogen than activated sludge process and other secondary treatment process. Low energy is required during aeration as algae provides an efficient way to consume nutrients and provide the aerobic bacteria with the needed oxygen through photosynthesis for degradation of hazardous pollutants such as polycyclic aromatic hydrocarbons, phenolic and organic solvents. It also helps in the utilisation of carbon dioxide released from various industries as algae effectively sequester carbon dioxide and reduce the GHG emission. Unfortunately, microalgae are quite sensitive towards hazardous compounds which include a wide range of toxic and persistent substances. However, in the present approach the characterisation of the indigenous microbial consortium in the enriched algal-bacterial system provides a new insight for the effective wastewater treatment and neutral lipid accumulation. Some processes will be developed for making the perfect consortium with better nutrient removal efficiency and heavy metal removal capacity effectively from artificial wastewater in laboratory scale. Then such a process can be implemented in outdoor condition with real wastewater. Such a typical propose can integrate the wastewater treatment from different wastewater with biodiesel production.

Key-words: wastewater, algal-bacterial consortium, Biodiesel



ANY OTHER ISSUE IN SOLID WASTE MANAGEMENT

ICWM-ASWM-01

Earthworm Technology- A Possible Option for Second Green Revolution

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Abstract: A package programme consisting of use of chemical fertilizers, pesticides, high yielding variety of seeds and proper irrigation was taken in mid-sixties of the last century in order to make the country self-sufficient in food grain production. Initially this programme led to dramatic increase in food grain production which was popularly known as green revolution. Although green revolution made India self sufficient in food grain production, indiscriminate use of chemical fertilizers and pesticides for the last five decades made the soil unproductive and environment polluted. Agricultural revolution of the past thus turned into present day's agricultural disaster. Environmental scientists are now planning for a second green revolution where rejection or reduced use of chemical fertilizers, recovery of soil health and increase in food grain production through organic farming and conservation of bio-diversity are the main objectives. Adoption of earthworm technology could be the best choice for second green revolution. Earthworm Technology is based on selection of appropriate species of earthworms with high fecundity and wide range of ecological tolerance and provision of adequate organic supplies to feed the worms. Earthworms, through their peculiar feeding, burrowing and casting activities, increase porosity, water holding capacities, aggregation and plant available nutrients of soil, thereby making the soil fertile. Earthworm Technology is of two types in- soil technology and ex-soil technology. In soil earthworm technology involves mass culture of suitable species of anecic (*Metaphire houlleti* etc.) and endogeic (*Pontoscolex corethrurus* etc.) earthworms and their direct inoculation in soil with proper organic input. Significant increase in tea production were observed at Sheikalmudi teas gardens of Tamil Nadu following adoption of in-soil technology (Lavelle et al.1998) and ex-soil technology in West Tripura, of India. Ex-soil earthworm technology, popularly known as Vermicomposting, allows quick transformation of organic wastes into plant-nutrient rich compost through synergistic actions of bacteria and epigeic species of earthworms viz. *Perionyx*, *Eudrilus*, *Eisenia* sp. etc. Presently, vermicomposting has gained momentum in India and abroad due to its established role in pollution abatement and sustainable agriculture. Field application of vermicompost shows an excellent response in production of different crops viz. cereals, spices, vegetables, fruits and ornamental plants. It is proposed that adoption of in-soil/ex-soil or combination of both the technologies (depending upon existing conditions) would be the best option for second green revolution.

Keywords: Earthworm technology, vermicomposting, *Perionyx*, *Eisenia*, *Eudrilus*, second green revolution



ICWM-ASWM-02

Waste Glass Powder as a Partial Replacement of Cement in Concrete-an Attempt to Bring a Paradigm Shift in Concrete Technology Through Recycling

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Abstract: The carbon dioxide emitted by the Cement manufacturing industry is one of the major contributors to the global carbon dioxide emission along with that emitted as an outcome of deforestation and burning of fossil fuels. It is known that global warming is one of the most dangerous repercussions of the emission of green-house gases like CO₂, CH₄, etc. to the atmosphere. Among all the greenhouse gases, CO₂ contributes about 65% to global warming. About 7% of the greenhouse gas emission to the earth's atmosphere is contributed by the emissions from the global cement industry. Hence there is a dire need of addressing the environmental effects associated with cement manufacturing. One of the ways to approach this problem is to develop or discover alternative binders which can replace cement in concrete. Hence, widespread research is being carried out in the field of finding cement replacement. The use of waste materials and industrial by-products is being given special importance considering the sustainability aspect. Earlier efforts have been made by concrete technologists to use waste glass as partial replacement of coarse or fine aggregates and to some extent of cement. To check the effectiveness of waste glass as an alternate solution to enable reduction of cement use in concrete, in this study, finely powdered waste glass is used as a partial replacement of cement in concrete and the various properties thus obtained is compared to those of conventional concrete. Thus, this work explores the avenue of recycling the refuse of various glass industries and the scope of reducing the amount of carbon footprint in the environment. In this study glass powder was replaced as 10%, 20% and 30% and tested for its compressive strength up to 7 days of age and the results thus obtained were compared with those of conventional concrete. It is thus found that glass powder can be used as a partial cement replacement material up to particle size less than 75 μ m to prevent alkali-silica reaction. Apart from waste materials, the use of natural admixtures in the place of chemical admixtures in concrete is also being advocated in the recent times. Also, observed to assess the scope of sugar which can be added as a natural admixture to concrete. The main functions found for usage of Sugar in concrete was to extend the initial setting time of concrete and as well as to increase the workability of concrete which is usually reduced due to the addition of glass-powder. Also it was evident from the literature that sugar when added in small amount helped to increase the compressive strength of concrete.

Key-words: Cement, carbon dioxide emission, fossil fuels, global warming, greenhouse gases, powdered waste glass, carbon footprint, compressive strength, sustainability, sugar, workability



Do Socioeconomic Parameters Govern the Generation Rate and Characteristics of Municipal Solid Waste?

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Abstract: Prediction of municipal solid waste generation rate plays an important role for scientific planning and management of solid wastes. Lack of complete past records of solid waste quantity and quality due to insufficient budget and improper management has resulted in a situation that makes the long term system planning for solid waste management intangible. The societal changes influence the composition and characteristics of solid waste. The solid waste generation rate is expected to vary in different socioeconomic groups due to many environmental and social factors. This study reports the assessment of solid waste generation rate based on various socioeconomic parameters such as education, occupation, income of the family, number of family members, fuels used in their kitchen, etc. for the city Dhanbad, Jharkhand, India. Socioeconomic groups were identified based on the questionnaire survey conducted in the study area which may affect the solid waste generation rate and composition. As per the survey, the study area was identified to have five different socioeconomic groups namely; higher socioeconomic group (HSEG), upper middle socioeconomic group (UMSEG), middle socioeconomic group (MSEG), lower middle socioeconomic group (LMSEG), and lower socioeconomic group (LSEG). The average waste generated in the study area was found to be 0.41 kg/capita/day in which the maximum waste was generated by LMSEG with an average waste generation of 0.46 kg/capita/day and minimum waste was generated by LSEG with average waste generation of 0.37 kg/capita/day which is contrary to the previous reported studies. Waste characterization indicated that there was no much difference in the composition of wastes among the different socioeconomic groups, but the amount of non-biodegradable waste was more (0.22 kg/capita/day) with compared to biodegradable waste (0.19 kg/capita/day). Ash residue and sweeping wastes were the major constituent of non-biodegradable wastes generated from households and ash residue was found to increase lower down the socioeconomic groups with maximum (31%) in LSEG. The study area is a coal based city hence use of coal and wood as fuel for cooking in the lower socioeconomic group is the reason for high amount of ash content. Plastic waste was found maximum (15%) in HSEG and minimum (1%) in LSEG. Food waste was a major component of generated waste in almost every socioeconomic group with maximum (38%) in case of HSEG and minimum (28%) in LSEG. In this study, it was found that the parameter education had the most significant impact on solid waste generation rate with compared to other socioeconomic parameters considered in this study.

Key-words: Municipal solid waste generation rate, Socioeconomic groups, Socioeconomic parameters, Solid waste composition.



Municipal Solid Waste Collection Time Optimization using AHP, GMDH and ANN

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Abstract: Municipal Solid Waste Management is now a global concern and need to be addressed with proper technological and scientific solutions. Municipal agencies spend a substantial amount of their budget on Solid Waste Management. Nevertheless, high capital investment in the solid waste management sector isn't necessarily leading to improvements in the quality of service. Collection and transportation forms a greater part of Solid Waste Management and the budget invested on it. In this study a model has been proposed using Analytical Hierarchy Process (AHP), Group Method of Data Handling (GMDH) and Artificial Neural Network (ANN) to determine an optimum time within which the collection of Municipal Solid Waste during each visit by each type of vehicle should be completed, this will economize the collection phase of Municipal Solid Waste Management. A case study was conducted on Agartala Municipality located in the state of Tripura in North eastern part of India. The optimum route length in terms of time is obtained as 3.84 hrs and 2.75 hrs for 14 m³ and 8 m³ garbage compactor respectively. Adoption of these optimum time estimates will lead to a cost effective SWM as all the garbage compactors need not have to work in two shifts, leading to savings in fuel and labour cost due to reduced labour hours. All the 447 bins can be cleared every day which will create a hygienic and disease free environment.

Key-words: Municipal Solid Waste, Collection time, Analytical Hierarchy Process (AHP), Group Method of Data Handling (GMDH), Artificial Neural Network (ANN)

ICWM-ASWM-05

To Study the Implementation Status of Pune Municipal Corporation rule on Segregation of Waste in the Housing Societies of Pune City

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Abstract: The work aims at Study of implementation status of Pune Municipal Corporation (PMC) Rule on segregation of wastes in the housing societies of Pune city. The Pune Municipal Corporation guidelines by the Government of India to housing societies under the Municipal Solid Waste (Management and Handling) Rules 2000 and Maharashtra Non-biodegradable Garbage Control Act 2006, reads that every society has to segregate their wastes into wet and dry wastes and dispose it off into two different bins provided by Pune Municipal Corporation (PMC) and societies which have been formed after 2001 should have their own vermicomposting pit to degrade



the wet wastes in their premises. The study was carried out in four different wards under two ward offices of Pune City. The methodology used semi structured surveys, interviews etc. By the analysis of the survey results various loopholes creating problems in proper implementation of the rule at Both PMC and Public level are evaluated. Pune is a city which is facing great crisis regarding waste management. Though proper rules for public are given regarding waste disposal, the results of the study shows that due to some drawbacks the rules are not being implemented properly. The next phase of the study was to create awareness among people. The methodology applied are making of posters describing the current waste management crisis going on in the city, the possible solution, guidelines of vermicomposting process as wet waste management are designed. The visual education through power point presentation regarding waste management scenario in the city are also formulated. The result of the awareness programme also describes the interest level among the citizen and their enthusiasms to take part regarding waste management issues going on in and around their surroundings.

Key-words: Pune Municipal Corporation (PMC) Rule, Solid Waste Management, Vermicomposting.

ICWM-ASWM-06

Statistical Optimization of Fermentation Parameters for 1,3-Dihydroxyacetone Production from Crude Glycerol by Immobilized *Gluconobacter Oxydans* MTCC 904

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Abstract: Fast depletion of fossil fuel and increase in greenhouse gases is a major concern recent years. To reduce the environmental effect of fossil fuel and promote the research in the area of renewable fuels, various bio-fuels such as ethanol, butanol, biodiesel etc. were implemented recent days. Among various biofuels, biodiesel has gained a specific interest due to its distinct advantages. Recently study shows that the global biodiesel production stood at 29.7 billion liters in 2014. Glycerol is a major by-product from biodiesel industry, where 1 Kg of glycerol is produced from each 9 Kg of biodiesel. As the glycerol from biodiesel industry is mainly contaminated with alcohol and alkali, this prevents its direct use in food, cosmetics, tobacco, pharmaceutical industries. Glycerol is an industrial important molecule used for production of various chemicals such as 1,3-propanediol, glyceric acid, citric acid, ethanol, 1,3-dihydroxyacetone (DHA). Among several products from glycerol, DHA is a commercially important chemical with various application in cosmetics, pharmaceuticals and food industry. The major route of DHA production from glycerol is microbial fermentation route using *Acetobacter* strains. Among various acetic acid bacteria *Gluconobacter oxydans* has been used industrially for DHA production. In present study, *G. oxydans* cells were immobilized over polyurethane support. Polyurethane has highly porous structure, and cells can get immobilized over the surface as well as inside the pores. This significantly increases the cell density in the fermentation mixture which leads to enhanced product formation. Three different



fermentation parameters viz. pH, temperature and initial glycerol concentration were optimized at five different levels using central composite design (CCD). Glycerol conversion (%) to DHA was recorded as response variable and a highest DHA conversion of 88.055% was obtained among 20 experimental runs. All three variables have individual effect on glycerol conversion, while the interaction effect was observed in case of pH & temperature and temperature & glycerol concentration. A maximum predicted conversion of 91.32% was obtained by response optimizer, while experimental result shows a conversion of 89.07%, which is close agreement to the predicted value. Experiments were carried out for both free and immobilized cells using the optimized fermentation parameters for pure/crude glycerol in order to study the comparative analysis. Optimization of fermentation parameters increases the DHA yield from crude glycerol significantly.

Key-words: Immobilization, *Gluconobacter oxydans*, Crude glycerol, 1,3 – Dihydroxyacetone, Response surface methodology.

ICWM-ASWM-07

Trend Analysis of MSW Leachate Characteristics

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Abstract: Landfill leachate is a liquid pollutant which unless properly managed and treated, would not only cause adverse negative impact on human health but also natural resources such as ground water and surface water. In order to monitor the landfilled vulnerability influences on the environment, determination of leachate quality and forecasting its behaviour is essential for proper management of landfill. The leachate generation data history demonstrated that significant changes in the leachate characteristics takes place throughout stabilization phases of landfilled during landfill operation and continuous even after closure. Thus, the spatial and temporal variation of leachate is challenging to predict its behaviours. In this paper the tendency of the landfill leachate characteristics noticed using the time series multiplicative decomposition techniques to forecast the forthcoming trend for proper planning and monitoring purposes of the landfill based on landfill leachate characteristics report. Results showed that there is initial increasing trend to peak and then followed decreasing trend projected for leachate parameters of BOD₅, COD, BOD/ COD ratio and conductivity due to maturation of the landfilled MSW. However, the leachate parameters such as pH, ammonia nitrogen and phenol showed increasing trend with increase of landfilled aged as the utilization of easily biodegradable organic matters. It can see that, time series prediction is an encouraging method for predicting trend of the future landfilled stabilization stages without further investigation of leachate parameters and thus helps to manage properly at the landfill site and easily communicates to the general public, field professionals and policy makers.

Key-words: Leachate Characteristic, Time series trend analysis, Forecasting



Estimation of Landfill Gas Using Genetic Programming

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Abstract: Disposal of Municipal solid waste in landfill generates large amount of greenhouse gases (CO₂ and CH₄). Methane is an increasing concern of greenhouse gas, as landfills are the principal source of anthropogenic methane emission. In order to plan and manage the landfill gas it is necessary to estimate it on daily basis. It has been observed that the complex processes taking place within the landfill leading to formation of landfill gas has been modelled by traditional hard computing techniques to modern soft computing techniques of ANN. The present study uses soft computing approach of Linear Genetic Programming to estimate the landfill gas emission for Pune City (India). Data from the simulated lab scale landfill has been used and the temporal models are developed. Landfill gas has been estimated using previous values of the gas recorded. The performance of the models was analysed using correlation coefficient (r) and root mean square error (RMSE). It was found that the model results are in good agreement with the actual values

Key-words: Landfill Gas, Genetic Programming, Pune City, Municipal Solid Waste.

ICWM-ASWM-09

Comparison between the Effect of Silica Fume and Fly Ash in High Strength Concrete using Concrete Mix Design

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Abstract: Concrete is the most important engineering material with cement as the basic ingredient. Concrete consumption is second only to water in terms of total volume consumed annually. With increase in trend towards the wider use of concrete for pre stressed concrete and high rise buildings there is a growing demand of concrete with higher compressive strength, thus driving up the concrete demand in the construction sector. The present per capita cement consumption is about 190 kg/capita and it will increase up to about 465 kg/capita to 810 kg/capita. Increased production of cement will have a strong impact on the overall energy utilization of the cement industry. More energy input will be required to meet the demand in various processes, which will result in increased fuel consumption leading to higher emissions of CO₂ and other green house gases. Enormous efforts are being made in the cement industries to bring down the carbon dioxide emission during cement production by using cement substitution. Clinker substitution by supplementary cementitious materials like silica fume and fly ash is being used as mineral admixtures to the cement. Both silica fume and fly ash are regarded as waste product produced in the industries. Silica fume is defined as very fine non crystalline silica produced in electric furnaces as a by-product in the production of elemental silicon or alloys containing silicon. Fly ash is defined as the by-product recovered from the gases of



burning coal during the production of electricity and also from boilers. The use of these by-products offer environmental advantages by diverting the material from the waste stream, reducing the energy investment in virgin materials, thus reduces the cost of construction and also improving the performance and quality of concrete. The comparative use of silica fume and fly ash as cement replacement and its effect in the production of high strength concrete has been studied in this project. We have used 5%, 10% and 15% by weight of cement as replacement by silica fume and fly ash in concrete.

Key-words: Cement, High Strength Concrete, Silica fume, Fly ash, Concrete Mix Design, Concrete properties.

ICWM-ASWM-10

Credibilistic TOPSIS Model for Evaluation and Selection of Municipal Solid Waste Disposal Methods

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Abstract: Municipal solid waste management (MSWM) is a challenging issue of urban development in developing countries. Evaluation and selection of disposal methods are very crucial in MSWM which are multi criteria decision making problems. A set of criteria including Net cost per ton, Technical reliability, Feasibility, Air pollution control, Emission levels, Separation of waste materials, Surface water dispersed releases, Number of employees, Waste recovery, Energy recovery are considered in evaluation of disposal methods. The disposal methods are Landfilling, Composting, Conventional incineration, and Refuse-Derived Fuel (RDF) combustion. A particular disposal method may not has best performance in all criteria. Each one have some advantages and disadvantages. So we go for compromise solution. In order to select the most preferred disposal method, an expert committee of three decision makers has been formed. They are from different expertize including an environmental engineer a field expert of waste disposal company and a professor of waste management studies. The decision makers often use different linguistic terms sets to express their assessments some of which may be imprecise, uncertain and incomplete. In response, a modified fuzzy TOPSIS methodology is proposed for the selection and evaluation of MSW disposal methods. Our proposed method is based on expected value of fuzzy variables. A particular disposal method might not be the best for different municipal area or country. The proposed method finds the RDF combustion is best among the alternative methods. A sensitivity analysis based on the weight preference of criteria is performed to visualize the expected most preferable disposal method. To determine the validity of the obtained ranking for this problem is also verified other MCDM methods. In order to verify the validity of our proposed method we perform a comparison with other methods like VIKOR, possibilistic TOPSIS.

Key-words: Multi criteria decision Making (MCDM), Fuzzy sets, Credibility. TOPSIS



Consolidation Characteristics of Bentonite in the Presence of Heavy Metals

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Abstract: Waste disposal, which is caused due to rapid increase in population and urbanization, has become one of the serious environmental problems in both developing and developed countries. Generally, these wastes are disposed off in sanitary landfills. Due to its high swelling capacity and lower value of hydraulic conductivity, compacted bentonite is used as a liner material in landfills. Existence of heavy metals in the leachates generated from wastes affects the pore fluid chemistry and influences the diffuse double layer of the bentonite which in turn affects the swelling and compressibility behaviour of bentonite. As such the durability and service life of a liner in waste containment facilities depends to a great extent on the leachates coming in contact with the liner. Consolidation is among the important properties of the liner material which need to be studied for settlement analysis. Volume changes in soils are important because of their consequences in terms of settlement due to compression which leads to changes in strength and deformation properties, which in turn influence stability. This study was carried out to investigate the effect of heavy metals of varying concentrations, on the consolidation behaviour of a compacted bentonite. The bentonite was studied in terms of changes in the coefficient of consolidation (c_v), coefficient of volume change (m_v), compression index (C_c) and time taken to complete 90% of consolidation (t_{90}) in presence of the heavy metal ions. Further, to study the effect of initial compaction conditions on the behaviour of compacted bentonite in the presence of these solutions, experiments were carried out on samples with different initial compaction condition varying in their initial water content. Of the various metal species detected in leachate, Cu, Zn and Pb are the major pollutants causing health hazards and thus these heavy metals were chosen for the study at varying concentrations of 100ppm and 1000ppm. The results showed that the C_c , m_v and t_{90} of the bentonite decreased, whereas, c_v increased with the increase in the heavy metal concentration. Results also showed that irrespective of the heavy metals present c_v decreased, whereas, t_{90} increased with increase in the consolidation pressure. However, with increase in the pressure, m_v increased initially and after reaching a peak value it decreased. It was also observed that samples compacted at dry of OMC (optimum moisture content) exhibited higher c_v and m_v values than the samples compacted at OMC. Since bentonite is widely used as a liner material at waste disposal sites, the results of this study may provide a general guideline for estimating the performance of liner in the presence of different kind of contaminants.

Key-words: Liner, Bentonite, diffuse double layer, heavy metals, compression index, coefficient of consolidation.



A Comprehensive Study on Domestic Sources of Municipal Solid Waste (MSW) in Guwahati City: Generation Trend and Characterization

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Abstract: Due to enhanced economic activities and rapid urbanization a significant increase in municipal solid waste (MSW) generation in Guwahati city has been noticed during the last few decades and its management has become a major issue. The poor waste management practices leads to unhygienic conditions which is the main reason for health related issues to the people. A survey has been carried out for Guwahati city through the collection of secondary data from the government agencies and field surveys. It has been found that approximately 600 tons/day waste is generated in Guwahati city, of which more than 50% waste is generated from domestic sources. The aim of this study is to quantify and analyse the domestic sources of waste generation in Guwahati city and suggest a suitable processing technology so that the total volume of waste can be reduced. To understand per capita generation of the domestic sources of waste, a sample survey was conducted taking into account for Low Income Group (LIG), Middle Income Group (MIG) and Higher Income Group (HIG) households. The household surveys were carried out for weekdays and weekends. Sample surveys being conducted in secondary point of collection as well to find out the gaps between source of generation and the secondary point. From studies it is found that the average per capita generation of domestic sources of solid waste in Guwahati city ranges from 306 to 360 g/day. Quartering method was adopted for physical characterization which indicated the fraction of organic component to be more than 60%. Chemical characterization shows high moisture content (more than 45%) and C/N ratio to be in the range of 14-30. Hence from the physical and chemical characterization of domestic sources of MSW, it can be concluded that the waste contains high organic components, high moisture percentage and C/N ratio indicates that waste is best suitable for biological processing (Composting and biomethanation). Since the domestic sources contribute to the 50% of the total volume of waste generated, of which 60% is organic matter, by adopting suitable technology atleast 180 tons/day waste can be reduced.

Key-words: MSW, Domestic sources of MSW, Characterization of MSW, Quartering Method.



Experimental Investigation for the Feasible Applications of Processed Recyclable Plastic Waste in Construction Sector

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Abstract: Plastics have become an integral part of modern life style due to its utilization as bottles, packing material, containers, shopping and garbage covers, house hold products etc; leading to increased generation of plastic waste. In India, the most common mode of solid waste disposal is through open dumping or land filling in the majority of areas. The major problem with waste plastics on disposal is, they are non biodegradable and stay in the environment leading to pollution. Recycling of plastics is the best practice to reduce the detrimental effects on environment. Options for the recycling are conversion into raw material for the industry, fuel production and utilization as construction material. Utilization of recycled plastics in construction sector provides ecological and economical solution, to the growing concerns due to the material shortage with increasing demand and associated burdens on environment in processing the building materials. The present work investigates the feasible applications for the utilization of processed recyclable waste plastic materials in construction sector. Materials such as plastic coarse aggregate (PCA) and plastic fine aggregate (PFA) were processed from the plastic bottles generated in the university campus. The application of these materials in areas such as concrete production (PCA and PFA), block manufacturing (PFA), pavement construction (PFA and PCA) and soil stabilization (PFA) has been studied. Experimental results suggest that PCA could be used as partial replacement in the preparation of light weight aggregate concrete due to its low specific gravity. The results of tests such as fineness modulus, water absorption, impact, crushing and abrasion values have also proved the conformance of PCA with properties of conventional natural coarse aggregate; for application in concrete production and pavement construction. The properties of PFA for the replacement of natural sand in pavement construction, block manufacturing and concrete production has been studied. The tests such as fineness modulus, water absorption, specific gravity, marshall's stability value, California bearing ratio (unsoaked) and compression value were conducted. Experimental results on PFA suggest that PFA could be used as a partial replacement for natural sand.

Key-words: Plastic coarse aggregate, plastic fine aggregate, waste plastics, concrete production, soil stabilization, construction sector.



Effect of Hazardous Waste Associated with Oil and Gas Projects in Onshore Region

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Abstract: Oil and gas projects within coastal region generate the large quantities of waste which are potentially very hazardous to the environment, micro organisms and human beings. Wastes can be generated from pipeline linking the platform to the shore, drilling of oil and gas wells, offshore platforms, building plants and usage of equipment. It deteriorates the environmental quality such as air, water and noise in the surrounding area belongs to the port and harbor and creates pollution from disposal of waste from both point sources and non point sources. It affects the lots of biological matter settles at the seafloor. During oil and gas projects, hazardous waste may release through the leaks and spills during transfer and storage and also by maintenance activities. The purpose of this paper is to provide an overview of environmental issues due to disposal of waste from oil and gas projects and to determine the effectiveness of measures to mitigate adverse effects on the environment. Findings were obtained from the interaction with experts working in these projects and secondary source of information. This paper concludes that recommended control measures can minimize the hazardous waste in oil and gas projects as per the guidelines of environmental aspects.

Key-words: Hazardous waste, onshore region, Oil and Gas Projects, Environmental issues

ICWM-ASWM-15

Significance of Presence of Asbestos in Construction and Demolition Wastes in India

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Abstract: Construction and Demolition (C&D) wastes, typically referred to as "debris", is continuously generated and is being seen as an urban nuisance in the last three decades in the developing world, particularly in India. Understanding the nature and composition of C&D wastes helps to optimize and manage the quantity of wastes produced. Since the advent of this century, the unrestricted use of asbestos, has lead to the generation of extremely high levels of carcinogenic wastes in the environment. In the Indian context, exposure to asbestos can be attributed to asbestos mining, asbestos cement (AC) industries, asbestos processing units and during the renovation and demolition of old asbestos cemented roof and other insulation materials. A major portion of C&D waste comes from the demolition of old buildings. It is feared that the construction workers, electricians, vehicle mechanics and other workers in the



building trades could potentially be exposed to the asbestos and inhales hundreds and thousands of asbestos fibres leading to the development of fatal diseases including lung fibrosis and mesothelioma. The present study deals with analysis of; current patterns of asbestos production, import and usage of asbestos, thus examining, quantifying and forecasting asbestos containing C&D wastes. Weathered 30 year old AC roof sheets and pipes were analyzed by using analytical techniques such as scanning electron microscope (SEM) fitted with EDAX prime energy dispersive analysis system and atomic absorption spectroscopy. The samples were collected from four demolition sites and analyzed in triplicates. The fibres found in all the bulk samples of construction material (asbestos roof sheets) had the characteristic morphology and appearance of "chrysotile asbestos". The very fine fibres (fibrils), when viewed at higher magnification, showed the characteristic tubular structure associated with chrysotile fibrils and showed no evidence of surface alteration. Individual fibres analyzed by energy dispersive X-ray (EDX) analysis showed chemistry similar to the reference standard of chrysotile studied in literature. The study points out that the asbestos fibres are encapsulated in cement matrix but the hazardous characteristics of the chrysotile is not altered and this can be a matter of great concern as these fibres are released into the atmosphere due to demolition activity or aging. The analysis shows that a considerable amount of chrysotile is being used in the manufacture of AC corrugated sheets. The asbestos containing construction materials when demolished after completion of their life span or due to climatic impacts, can undergo deterioration similar to the matrixes of other portland cement-based products such as concrete and mortars, and can also be attacked by chemically aggressive agents, or by mechanical stress due to stockpiling, transportation, assembling activities and exposure to wind, moisture, thermal cycles, thereby generating a massive quantum of wastes containing asbestos which comes under C&D wastes. The cementitious matrix of fiber-cement corrugated sheets can also suffer weakening through leaching of water. Quantitative analysis of the sample showed the presence of major components such as magnesium, silicon, aluminium, calcium, Iron etc.

Key-words: Asbestos, Construction and demolition wastes, Chrysotile, Fibres, SEM, Carcinogenic.

ICWM-ASWM-16

Role of Green Human Resource Management in Environment Sustainability and Waste Management

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Abstract: A worldwide environmental awakening is gathering force to save Planet Earth from man's harmful actions. Environmental protection has become a part of strategy in most organizations. The green movement has got attention and expanding rapidly in various organizations. In the field of human resources, the theme of "Green Human Resource Management" (GHRM) has emerged, establishing itself as a new



line of research. The GHRM is based on the green movement related to the protection of earth. GHRM will play an important role in industry to promote the environment related issue by adopting it, in management philosophy, HR policies and practices, training people and implementation of law related to environment practices. GHRM policies and practices transformed to incorporate a new way of work for people i.e., the 'green' way. In view of this, the paper intends to explain the concept of GHRM, the companies' approach towards GHRM, its advantages, policies and practices by presenting link between human resource management, environmental sustainability, waste management and economy. It also brings out the role of HRM function towards creating a 'green' culture in companies.

Key-words: Environment Sustainability, Green HRM, Human Resource Management, Practices.

ICWM-ASWM-17

Development of Sustainable Mortar using Ceramic Waste

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Abstract: There have been many studies in the recent past which have incorporated recycled materials as fine aggregate in mortar. This study involves replacement of fine aggregates with ceramic waste in mortar. Replacement ratios for the fine aggregate were selected as 50% and 100%. The mortar mixes have been tested based on their fresh properties (bulk density of fresh mortar and flow) and hardened properties (compressive strength and dry bulk density). Bulk density of fresh mortar have been found to have desired values. The compressive strength has been conducted at 3 days and 7 days and the results for both the 3 days and 7 days compression strength indicate that mortar incorporated as fine aggregate produces better results than the control mix (1:4 by vol.) at 50 % and 100% replacement. But the strength for both 50% and 100% were more than that of the control mix which instigates the need for further research for this material.

Key-words: Sustainable construction, Resource efficiency, Waste utilization, Sustainable development, Sustainable Habitat, Ceramic waste, Cement mortar.

ICWM-ASWM-18

Emissions Associated with the Transportation of MSW in Mumbai

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Abstract: Mumbai is the largest metropolitan city in India with an estimated population of 18.4 million (2011) which generates approximately 9000 metric tons municipal solid waste (MSW) daily with an average per capita waste generation rate of 0.45 kg/day. The generated waste is collected from the community bins and transported to the landfill sites. In addition to the greenhouse gas released from a



landfill site, emissions are also released while transportation of MSW by using diesel fuelled vehicles. The greenhouse gas emissions as well as other pollutants from heavy diesel vehicles used for transportation of MSW cannot be ignored as they may have considerable impact on the environment. The greenhouse gas emissions from transport sector for Mumbai metropolitan region (MMR) in 2011 was 15.71 lakh tons of carbon dioxide equivalent. Hence there is a need to determine the amount of emissions generated by these diesel vehicles into the environment if we want to curb these emissions. Objective of this work is to evaluate emissions from transportation of MSW for Mumbai City. An analysis was done to ascertain the emissions produced by the diesel vehicles while transporting MSW. The pollutants (CO₂, CO, HC, NO_x and PM) were evaluated based on the vehicle kilometres travelled (VKT) method. The results shows that CO₂, CO, HC, NO_x and PM were 104034.9 tons/year, 818.75 tons/year, 50.49 tons/year, 1269.07 tons/year and 169.21 tons/year, respectively. The results show that the transportation of MSW also plays an important role in the contribution of pollutants specially greenhouse gases to the atmosphere.

Key-words: Municipal solid waste, municipal solid waste transport, diesel vehicles, gas emissions, environmental impact

ICWM-ASWM-19

Leaching Behaviors of Heavy Metals, Distribution of PAHs and Pesticides in Coal, Fly Ash and Bottom Ash

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Abstract: Coal based thermal power plants are main power generation source in India which produce by products such as fly ash and bottom ash in large quantity. The utilization of ashes is major challenges in different sectors. The present research is an endeavor to evaluate the appropriate concentration of organic persistent pollutants in coal and ashes and leaching percentage of major, minor and trace element from coal, fly ash and bottom ash samples. These ashes residue contain inorganic elements and poly-aromatic hydrocarbon (PAHs) in their native composition due to conversion of coal to fly ash. Beside this, pesticides are also found in small quantities in coal and ashes. Present study is based on the leaching behaviors of heavy metals from coal, fly ash and bottom ash, PAHs and pesticides present in coal and ashes in coal fired thermal power plants in Uttar Pradesh. The 14 PAHs and 11 pesticides were analyzed separately in coal, fly ash and bottom ash using solid liquid extraction analyzed through GC-MS. Toxicity Characteristic Leaching Procedure (TCLP) had been



employed to identify leaching behavior of heavy metals (Mg, Fe, Mn, Zn, Al, Cu, Pb, Ni, Co, Mo, Cr, Cd, As, B and Se).

Key-words: Coal, Fly ash, Bottom ash, Leaching, PAHs, Thermal power plant.

ICWM-ASWM-20

Sustainability of Municipal Solid Waste Management PPP Infrastructure Projects: Lessons from the Indian Experience

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Abstract: The government of India has adopted the public-private partnership (PPP) procurement route for development of public infrastructure projects since last two decades. Consequently, infrastructure development goals relating to the provision of municipal solid waste management (MSWM) services have increasingly been fulfilled by local governments through a creation of privately built solid waste management (SWM) facilities through PPP route. Amongst the urban infrastructure sector, MSWM has been able to attract massive private investment through PPP route on account of its huge business potential. This procurement route gives major emphasis on economic and financial sustainability is being the major concern when looked into from sustainable development (SD) perspective. But there is no dedicated focus to assess the social and environmental sustainability of a project while claiming it to be economically SD. The main purpose of this research article is to study the various MSWM infrastructure projects in India procured through PPP route from the perspective of SD principles. This will help to identify the key areas in MSWM projects where SD principles can be integrated so as to ensure that PPPs are leading to holistic SD. The study has used analysis of case studies methodology through literature review as the approach in order to first study the PPP process in India and the core principles which should be followed in order to achieve holistic SD. Then the review of various MSWM infrastructure projects procured through PPP in India has been carried out to identify the shortcoming in PPP process. Finally, using the core SD principles, the PPP process currently in practice in India is analyzed to identify the key areas in PPP projects where the private sector can be incentivized to adopt sustainable practices and designs to promote SD. The study identifies the various areas which hampered the sustainability of MSWM infrastructure projects procured through PPP route in India.

Key-words: Municipal solid waste management, Public-private partnership, Sustainability, India



Physical Properties of Solid Waste- Comparison of Fresh Waste and the Compost

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Abstract: Proper understanding of physical properties is important for efficient handling of solid wastes. Composting is a method adopted in many solid waste management sites to decrease the severity of accumulation of wastes. In this study, properties such as Bulk density, Free air space (FAS), Water holding capacity, Total solids, Moisture content, Volatile solids, Fixed solids, Specific gravity, Electrical conductivity (EC), and pH were determined separately for a solid waste compost sample and a fresh solid waste. Standard procedures as described by ASTM (American society for testing and materials) codes and TMECC (Testing methods for the examination of composting and compost) were followed for determining these properties. Solid waste compost samples were obtained from Boragaon waste dumping site in Guwahati. Fresh solid waste was manufactured using the composition as determined earlier in the literature concerning Boragaon site. All the testing on fresh solid wastes was completed within 3-4 days of manufacturing. Therefore all the microbial changes taking places were ignored. To rule out experimental bias all the test were conducted in triplicates. There was inconsistency in the proper temperature selection while determining the moisture content. Therefore moisture content was determined at both 75 C and 105 C and values were found to be same. Electrical conductivity was determined using laboratory procedure as given in TMECC manual and using 5TE sensor (Decagon devices). The values were found quite comparable. 5TE sensor has been found to be quite robust in measuring volumetric moisture content, electrical conductivity and temperature. The values presented here has also been compared with the values reported in literature. Evaluation of these physico-chemical parameters is quite useful in understanding the product as well as process. Comparison of these properties have shown interesting trends. Since the measurement of some properties is not always practical, an understanding of the relationships among properties is useful in deducing them. Interaction of physical properties is very helpful in understanding the conditions of the system.

Key-words: Physical properties, Solid Waste, Solid waste compost

ICWM-ASWM-22

Granite Cutting Waste Concrete as a Turnkey Solution for Efficient Stone Waste Management

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Abstract: One of the biggest challenges being faced by mankind today is the efficient management of natural resources. The pace of development has strained the natural reserves of various resources on the other hand the world seriously facing the problem



of solid waste management. Once such noticeable solid waste is generated from the stone processing industries around the globe. The present paper seek to address both the aforementioned issues in one go. The aim of the study is to examine the feasibility of granite cutting waste substitution in concrete which is the second largest consumed material in the world and its annual global production is estimated at about 25 billion tonnes. Substitution for natural sand with granite cutting waste was made in steps of 0%, 10%, 25%, 40%, 55% and 70%. The study includes testing of granite cutting waste substituted concrete with w/c ratio 0.35 on mechanical as well as durability grounds which has not been attempted earlier. The tests carried out include compressive strength, flexure strength and behaviour under adverse condition test like Acid attack, sulphate attack, accelerated carbonation and chloride penetration. The test results showed that substitution of natural sand with granite cutting waste up to 40% by weight leads to significant improvement in the mechanical strength as well as durability when compared to the control concrete. Thus the use of granite cutting waste concrete will help tackle the problem of efficient disposal of stone waste and at the same time make concrete more sustainable and economical without compromising the performance.

Key-words: Granite cutting waste, concrete, strength, durability

ICWM-ASWM-23

Experimental Study of Stone Dust Cushioned Single Size Aggregate Confined in Plastic Cells as Sub Base Materials

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Abstract: Interlocking concrete block laid over the subbase confined in plastic cells increases the modulus of elasticity of the pavement, hence the thickness required for the pavement is less and lots of construction materials and money can be saved. Low density polyethylenes (LDPE) were used to make the plastic cell for the confinement of the subbase. The plastics used for making the diamond shape plastic cell were the recycled plastic with thickness of 0.26mm thickness. Different layers of the pavement were constructed in the laboratory. In the current study the plastic cells were used to confine the subbase only. Subbases with different pocket size cells are prepared in the laboratory by cutting the plastic sheet and are then heat sealed. Plate load test was carried out to obtain the deflection of each layer. To obtain the deflection from the subgrade layer, subbase layer and concrete block layer loads applied in each layer are 10kN, 30kN and 50kN respectively. The elastic modulus of the subgrade, Elastic modulus of subbase with different pocket size confinement, Elastic modulus of interlocking concrete block layer with jointing sand and without jointing sand were back calculated from deflection obtained from the plate load test of each layer. The deflections obtained were used to calculate the modulus of elasticity of each layer by back calculation with KENPAVE software and FEA model using ABAQUS 6.9. The modulus obtained for the subgrade is found as 45.161 MPa. The modulus of elasticity obtained from the different confinement size of subbase 150mm×150mm, 200mm×200mm, 250mm×250mm and unconfined subbase were found as 202.2 MPa, 154.83 MPa, 76.16 MPa and 60.23 MPa respectively. The elastic modulus of concrete



block layer with the same subbase confinement without jointing sand were obtained as 818MPa, 568MPa, 455.5 MPa and 378 MPa respectively and with jointing sand the modulus obtained with as 1947 MPa, 1650 MPa, 1570 MPa and 1512 MPa respectively.

Keywords: Concrete Block Pavement, Plate Load Test, ABAQUS, LDPE

ICWM-ASWM-24

Environmental Impact Assessment of Building Construction using RIAM Analysis

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Abstract: Rapid industrialization and population explosion in India has led to the migration of peoples from villages to cities which increase human settlement in world's growing cities and towns. This generates several issues with regard to the environment. Environmental impact assessment (EIA) is becoming a very important study before commissioning of any project plan or development in our country. In order to study either its beneficial or harmful effect; evaluation of any project through EIA has become a must; Indian construction industry is rapidly growing at an rate of 9.2% as against the world average of 5.5%. Undertaking EIA for construction industry and improving site management can reduce environmental impact both on and off site. The EIA study is necessary to prepare a detailed account of environmental impact of the proposed activity so that appropriate interventions could be taken. Rapid impact assessment matrix (RIAM) comes under one of the option for execution of EIA. This method is particularly advantageous over others as it provides a transparent and permanent record of analysis process while at the same time organizing the EIA procedure, which in turn considerably reduces the time taken in executing EIAs. Using this method of RIAM, EIA has been found that the negative and positive impact in this study. For that, we have adopted the various policies in order to reduce the considerable effect in present condition and future prediction of impacts, so as to create a eco-friendly building environment.

Keywords: EIA, RIAM, Building construction, Eco-friendly Building Environment

ICWM-ASWM-25

A Highly Efficient Solid Base Catalyst Derived from Waste Fly Ash

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Abstract: The present paper describes the utilization of waste fly ash to synthesize a highly efficient solid base catalyst (SBC) for crossed aldol condensation reaction between acetone with benzaldehyde to produce dibenzylideneacetone (DBA), an important compound used as a potential sunscreen component, as a medicine in treatment of oral cancer cells and as a reagent in various organic transformations. Using potassium hydroxide (30 wt.%) on thermally activated F-type fly ash, SBC was



prepared. FT-IR, BET surface area analyser, XRD and SEM-EDS were used for physico-chemical, mineralogical and morphological characterization of the solid base catalyst.

Keywords: solid base catalyst, acetone, benzaldehyde, dibenzylideneacetone, crossed aldol condensation reaction.

ICWM-ASWM-26

Municipal Solid Waste Characteristics and Management in Assam Engineering College, Guwahati

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Abstract: Municipal Solid Waste (MSW) is a major environmental issue in India. Waste generation increases with population expansion and economic development. Uncontrolled dumping, improper handling causes a variety of problems. It includes adverse environmental impacts, public health risk, other socio-economic problem etc. It also increases emissions of Greenhouse gases (GHG), which eventually leads to climate change. With proper planning and implementation of a suitable program for waste collection, transport and disposal, along with activities to recycle waste can eliminate these problems. MSW has widely been accepted as an important locally available renewable energy sources. Waste reduction and waste separation are two preferred practices that should be done. At many places including educational institutions, authorities are failing to install appropriate systems on waste management. The paper provides an overview of the present state of MSW, its characteristics, generation, collection, transportation and disposal in Assam Engineering College (AEC) located in Guwahati city, India. The waste (sample) generated from all the hostels of AEC were collected and analyzed properly to determine the characteristics of MSW. The waste management was found improper and there was also no servicing of MSW collection vehicles. Hence, the approaches of possible solution that can be undertaken to improve MSW services are also included.

Key-words: Municipal Solid Waste, waste management, environmental impacts, waste segregation.

ICWM-ASWM-27

Strength Characteristics of Sand-Bentonite Mixtures and the Influence of Sand Type

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Abstract: Landfilling is a necessary evil that needs to be dealt with while designing solid waste management schemes and engineered landfill liners form an essential part



of such a waste disposal scheme. Engineered landfill liners act as a barrier between the leachate formed during the decomposition of disposed waste and surrounding ground water. For effective functioning of landfill liner, materials used in making a liner should possess high contaminant adsorption capacity, lower hydraulic conductivity, minimum uneven settlement upon loading and be durable enough to last through design life of landfill. Sand-bentonite mixtures are a prime choice as landfill liner material because of their capacity for low hydraulic conductivity, lower shrinkage upon drying, higher dry density, shear strength and thermal conductivity. Bentonite is a commercially available high expansive clay soil and literature review indicated that most of the studies were undertaken and concentrated on finding the optimum quantity of bentonite to be mixed with locally available sands so as to minimize the project costs while fulfilling the desired engineering criterions. Research workers observed various proportions of bentonite fulfilling the engineering criterions depending upon the type of bentonite used and nature of waste being disposed. Very little information is available on the guidelines to be followed while selecting the other raw material i.e. sand, this study is an attempt to understand the influence of sand type on the engineering characteristics of sand-bentonite mixtures. Fine sand-Bentonite and Medium sand-Bentonite mixes were made with sand content ranging from 50% to 90% by dry weight of the mix. These mixtures were tested for compaction characteristics using standard proctor compaction. Fine sand mixtures were seen to be exhibiting higher optimum moisture content (OMC) and lower maximum dry density (MDD) compared to their medium sand counterparts. Compaction characteristics indicated that sand type definitely influences the attainable maximum dry density of sand-bentonite mixtures amongst other influencing parameters. Strength characteristics of fine sand-bentonite and medium sand-bentonite mixes were assessed using unconfined compressive strength (UCS). For each mix proportion, samples were made with 3 different water contents to confirm the extent of influence of mixing water content on the strength characteristics while observing influence of sand type. Results indicated that UCS decreases with increasing water content and mixtures with fine sand displayed higher strength compared to medium sand mixtures.

Key-words: Landfill liner, sand-bentonite mixture, standard compaction characteristics, unconfined compressive strength (UCS)



AGRICULTURAL WASTE UTILIZATION

ICWM- AWU-01

Utilizing Agricultural Waste: Coconut Fiber as a Humidifier Packing Material in a Solar Desalination Plant

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Abstract: Coconut coir, the waste obtained from coconut husk is one of the promising material was used as a humidifier packing material in this study. It comes under the category of natural fiber, having lightweight with high porosity, eco-friendly and freely available in India. In this work an experimental study has been performed to analyze the effect of coconut fiber as a humidifier packing material in a solar desalination plant. The affecting operational parameter like mass flow rate of water and air on the performance parameters of humidifier such as range, effectiveness, efficiency, Merkel Number, water evaporation rate, heat and mass transfer rate are analyzed. The inlet hot water temperature is kept around 35-60°C. It was found that the coconut fiber provide good contact surface for evaporation of water without much pressure drop and the yield of desalinated water was much satisfactory. It was clearly observed from this study that agricultural waste such as coconut coir have potential to replace the non-biodegradable materials and costly materials which are currently used such as pvc, asbestos etc. The proposed approach for the desalination plant by using coconut coir as a packing material is also helpful for developing new technologies which can utilize other agricultural waste in a very efficient way by providing sustainable, environment friendly approach. Also near future, this coconut coir which are considered as waste now can be a source of income for agriculturist.

Key-words: Coconut coir, Packing material, Humidifier, Effectiveness, Desalination, Humidity.

ICWM- AWU-02

Studies on Physico-Chemical Properties of a Freshwater Algal Bloom: Spirogyra Sp.

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Abstract: Spirogyra bloom in the aquatic ecosystem is a natural process which is triggered by different anthropogenic activity. Excessive nutrients particularly phosphorus is the accruing agents for such type of bloom. An investigation was carried out in the drainage basin of IITG campus to generate baseline information about physico-chemical properties of Spirogyra blooms. This is very common filamentous green algae that have high biochemical properties. The maximum total chlorophyll of 39.58 mg/g was uncounted with acidic pH of 5.98. This study revealed



that Spirogyra blooms possess high biomass concentration i.e. 94.91%. Nitrogen (1.54%), total phosphorus (0.351 g/kg) and other micronutrient also show promising result. Present study concluded that utilization of this green algal bloom as an alternative food source is possible.

Key-words: Algae, Biomass, blooms, ecosystem, pigments, Spirogyra sp.

ICWM- AWU-03

Utilization of Lemon Grass Agriculture Waste for Oil Recovery and Manufacture of Plywood

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Abstract: Lemon grass is a perennial fast-growing aromatic grass, growing to about 1 meter (3 feet) high with long, thin leaves and originally was growing wild in India. It produces a network of roots and rootlets that rapidly exhaust the soil. The main chemical components of citronella oil are myrcene, citronellal, geranyl acetate, nerol, geraniol, neral and traces of limonene and citral. Citronella oil is one of the major essential oils. It has a rose like odour and bitter taste. It is mainly used in the perfumery and cosmetic industry. Citronella oil is a raw material for production of geraniol, citronellal, hydroxy- citronellol and other similar high value perfumery bases. It is also widely used as a starting material for various automatic chemicals used in scented soaps, sprays, deodorants, detergents, polishes, mosquito repellants etc. After process, the remaining waste material of grass is used for manufacturing plywood and other packaging material.

Key-words: lemon grass, Steam distillation unit, Plywood maker unit, Dryer.

ICWM- AWU-04

Integrated Biorefinery Model of Bioethanol Industry Waste for Human Consumption

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Abstract: Biofuel Industries expansion is predicted to lead to food insecurity and food price hike. In the recent days there has been a significant expansion of the Ethanol distilleries globally. Studies conducted by International Food Policy Research Institute (IFPRI) suggested that the number of food-insecure people in the world will rise by over 16 million for every percentage increase in the real prices of staple foods. The utilization of bio-fuel by-products for human consumption can reduce the existing gap between the bio-fuels and food insecurity. Production of ethanol tripled in the last decade and recent estimates indicate a continued high growth. This major increase in the bio-fuel production has resulted in a substantial increase in the volume of distiller's dried grain solubles generated. Distiller's dried grain solubles (DDGS) is



the major by-product of the distilleries. Hence the utilization of DDGS for human consumption is becoming imperative. During the fermentation process starch is converted to alcohol and other fermented products, whereas nutrients such as protein, fiber, fat, vitamins and minerals remains in DDGS (Distiller's dried grain solubles). DDGS is hence hypothesised to have a potential to be used as a supplement and/or ingredient in human food products and in industrial sectors. Consumer acceptability of food products containing DDGS is one among the main issue. Therefore, poor flavor, darker color, oxidative rancidity, odor, poor texture and loaf volume of the food products developed are of a major concern for their marketability. When utilizing DDGS for human consumption distilleries must meet food safety standards and good manufacturing practices. Contamination of DDGS with mycotoxins is one of the concerns. The present investigational studies included strategic blending of processing techniques to address these challenges. It may be concluded from the present study findings that DDGS is having a good potential for commercial food uses, especially in baked foods. Incorporation of DDGS in human foods could add value to the traditional baked food market in terms of favorable nutritional profile, lower glycemic effect and higher dietary fibers. Its addition also effects the sensory characteristics of bakery products. The study showed that about 10 to 15 % DDGS can be added to the products without adversely affecting the appearance, flavor, and texture of the products. muffins without affecting the appearance, texture, flavor, and overall acceptability. Also it has been found that there are a number of nutritionally essential components present in DDGS, such as phytosterols, tocopherols, etc. These components can be extracted and can be used for industrial purposes or can be incorporated into various food items for nutrient enrichment. The economic value of DDGS can be enhanced by extracting the compounds from it to be used in food industries or other industries.

Key-words: DDGS, Biorefining, bakery, human consumption

ICWM- AWU-05

Comparative Study on the Adsorptive Removal of Methylene Blue by Dried Biomass of Banana Peel and Betel Nut Husk

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Abstract: Synthetic dyes are potential mutagens, teratogens and genotoxic in nature. When released into the environment as industrial effluents, they pose a serious threat by getting dissolved into the fresh water streams. Firstly, they obstruct the passage of sun-light, thereby barring aquatic photosynthesis and secondly entering the food chain; they accumulate at various trophic levels via bioaccumulation and pose a serious threat to the consumers at different levels. Thus removal of such dyes from the wastewaters is of utmost importance. We report use of Banana Peel (BP) and Betel nut husk (BNH), both ligno-cellulosic wastes, as an efficient adsorbent for the removal of basic synthetic dye Methylene blue (MB). The adsorption by BP and BNH was uniform in wide ranges of pH and temperature, suggesting its dye removal potential in diverse conditions. Physico-chemical studies e.g. Scanning Electron



Microscopy (SEM) and Fourier Transform-Infra Red (FT-IR) spectroscopy studies revealed changes in surface topology and available functional groups of BP and BNH post adsorption, implying dye interaction with the biomass surface. Kinetics and isotherm studies were carried out for understanding the adsorption mechanism. Both dyes followed pseudo-second order kinetics. While adsorption of MB by BP followed Langmuir isotherm model; and MB adsorption by BNH fitted Temkin isotherm model of adsorption. Based on these studies, we can conclude that BP proves to be an efficient candidate for removal of Methylene blue.

Key-words: Banana Peel, Betel Nut Husk, Methylene blue, Dye Adsorption, Adsorption kinetics, Biosorption, Waste Recycle, Waste Management, Wastewater Treatment, Agricultural Waste Utilization

ICWM- AWU-06

Comparative Study on the Enzymatic Hydrolysis of Alkaline Pre-treated Biomass of Sugarcane Bagasse and Spent Citronella for Reducing Sugar Production

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Abstract: Lignocellulosic biomass must be pretreated to cut down the fractions of the substrate in order to achieve high rate of enzymatic hydrolysis. Aromatic spent biomasses such as essential oil extracted biomass of citronella, mentha etc. are the most abundant and underutilized biological resources. These biomasses are non-cattle feed and hence discarded as waste or burn haphazardly leading to environmental problems. Hence, this study is an endeavor to evaluate the effect of subsequent alkaline pretreatment and enzymatic hydrolysis on production of total reducing sugar (TRS) from spent biomass of Java Citronella (after citronella oil extraction) and its comparison with standard lignocellulosic biomass (sugarcane bagasse) in order to determine the feasibility of aromatic Java citronella biomass for the production of bioenergy and bio-chemicals. Process parameters affecting the alkaline pretreatment and enzymatic hydrolysis of spent citronella biomass and sugarcane bagasse on TRS released were evaluated. TRS production decreased with an increased NaOH concentration (0.05 – 0.5 M NaOH), reaction temperature (80 – 120 °C) and time (20 – 60 min) for bagasse, whereas in case of citronella the released TRS increased from 0.05 M to 0.3 M NaOH and then decreased with further increase in the concentration. The maximum TRS obtained were 45.22 mg.g⁻¹ and 73.88 mg.g⁻¹ for sugarcane bagasse and spent citronella biomass respectively at lower temperature (80°C). The enzymatic hydrolysis (at 10 FPU, 50°C and 48 hr) using standard cellulase enzyme (*Trichoderma reesei* 26291) showed maximum TRS released of 396.70 mg.g⁻¹ and 345.49 mg.g⁻¹ for bagasse and spent citronella biomass respectively. Optimized NaOH pretreated biomasses were subjected to cellulase



production using *Phanerochaete chrysosporium* NCIM 1106 to evaluate enzyme activity of the biomass. The cellulase activity of sugarcane bagasse increased from 2.21 FPU at 24 hr to 16.17 FPU at 96 hr and then decreased to 13.52 FPU at 168 hr. On the other hand, the activity increased from 1.81 FPU at 24 hr to 14.48 FPU at 120 hr then decreased to 13.86 FPU at 168 hr for spent citronella biomass. The maximum crystallinity index (CI) of alkali pretreated bagasse and spent citronella biomass were 58.15% and 57.35% respectively. CI decreased to the minimum of 35.72 % and 36.53% for spent citronella and bagasse respectively, in the enzymatic hydrolysis process due to the conversion of crystalline cellulose to glucose. The porous surface of biomass samples after hydrolysis as observed in scanning electron microscopic analysis revealed de-polymerization of holocellulose and removal of significant amount of lignin.

Key-words: Aromatic spent biomass, Pretreatment, Hydrolysis, Cellulase, Reducing sugar, crystallinity.

ICWM- AWU-07

Utilization of Agricultural Residue for Energy Production Through Co-Firing

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Abstract: Agricultural residue is one of the prominent renewable energy options, both at present, as well as in the near and medium-term future. The use of this type biomass with coal as a fuel by adopting co-firing technology for energy generation has the potential to provide significant economic as well as environmental benefits. India is a fast growing country where the major source of energy are coal based power plants which emit large amount of harmful emissions. The environment around us at this hour is not similar to what it was some decades ago, but has only worsened. It can be visualized as a highly unsteady state open system with inputs more than its capacity to process leading to tremendous amounts of accumulations. Agricultural waste is suitable fuel for inclusion in a national energy network because it is a carbon-neutral form of energy that offers a potential source of energy. When it is co-fired with coal for energy production, it helps reduce green- house gas (GHG) emissions, CO₂ emissions, sulfur and heavy metals in the atmosphere and increases renewable energy share. The input of agricultural residue helps in sustainable development and also provides energy security for the growing population. At present, significant improvements in agricultural waste management are sought, especially in India, where the current waste management is in a poor condition; the use of the energy content of agricultural residue could be one of the leading ideas for such progress. This paper intends to build up on this idea and come up with strategies to put together co-firing agricultural residue with coal and CO₂ confiscation with the existing thermal power plants.

Key-words: Agricultural residue, Co-firing, Environment, Renewable Energy



Recycle of Agricultural Waste to Bio Energy by Various Technology Options

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Abstract: The purpose of this study is to examine and review the technology options that exist to convert biomass in the form of agricultural crop and forestry residues to bioenergy. It assesses the technological options, including the sustainability of the processes involved and its value addition. Currently, especially in developing countries, most of the waste agricultural biomass is left in the field to decompose naturally, which releases CO₂ plus the high global warming potential greenhouse gas – methane, burnt in the open, which releases gaseous emissions as well as black carbon which also has a high global warming potential. About five billion tons of agricultural waste is generated every year, thermal equivalent to about 1.2 billion tons of oil. Among Africa, Asia, and South America – Asia accounts for 77% of total waste agricultural biomass generation. Every tons of crop is on an average associated with almost equal amount of waste agricultural biomass, for some crops such as corn and cotton it could even be double. Converting waste agricultural biomass into energy has environmental as well as economic benefits. This is a clean source of energy, as the carbon cycle loop is closed (the carbon dioxide released by combustion is again sequestered in the next crop). There are usually no harmful emissions (such as sulphur oxides, heavy metals) and it is renewable. The material is available abundantly and is virtually free. Waste agricultural biomass can be an excellent source of energy to meet needs in rural areas. Commercial use of biomass can also provide additional income to farmers and poorer sections of society, helping in poverty alleviation. While agriculture is a major economic sector in most developing countries, the potential of using agricultural by-products remains largely untapped. Various technologies have been developed for converting waste agricultural biomass into a source of energy. There are concerns about their suitability and workability. This study aims to assess different technology options in order to select those which will be most suitable for local application of conversion of agricultural waste to energy.

Key-words: biomass, bioenergy, agricultural waste.

ICWM- AWU-09

Agricultural Waste Utilization in Sustainable and Resilient Construction

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Abstract: Today the world is suffering from some degree of climate change that is causing extreme weather events including frequent flooding followed by drought, cold wave, heat wave, landslides, cyclones etc. It is influencing need to adapt resilient



construction to mitigate the cause of climate change and to provide sustainable habitat to mitigate the aftereffects of climate change in future. The present work is a study on the use of agricultural wastes as fiber in improving the resiliency of earthen structures prone to flood damages. The straw bale and jute coir wastes were used to reinforce the earthen soil. The initial properties and a simplified flood resilient test as adopted from literature were observed. It was concluded that both natural fibers improve the resiliency of the material.

Key-words: Sustainable construction, Sustainable materials, Resilient construction, Agricultural waste, Waste utilization, Sustainable development, Sustainability, Sustainable Habitat, Natural fiber.

ICWM- AWU-10

Development of Sustainable Bricks using Agro-Industrial by-Products

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Abstract: The increasing demand for construction materials and waste management issues has created a need for the development of sustainable materials with the appropriate utilization of industrial by-products. Present paper investigates the feasibility of application of locally available agro-industrial by-products for the development of building masonry product. The study reveals the physical, mechanical and thermal property investigations for the developed bricks and was compared with the commercially available products. The study concludes that the development of masonry material using industrial by-products helps in efficient solid waste management and also proves to be sustainable construction material.

Key-words: Sustainable construction materials, industrial by-products, physico-mechanical properties.



WATER AND WASTEWATER TREATMENT

ICWM-WWWT-01

Effect of Different Coagulagulants on Pathogens Present in Greywater

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Abstract: Greywater can reuse, for applications such as toilet flushing and irrigation, represents a potential sustainable solution for water shortages experienced by regions of worldwide. greywater is not intended for potable use because the potential for transmission of waterborne pathogens by aerosol inhalation, topical contact, or indirect ingestion is a key concern for greywater reuse. Greywater can potentially harbor a range of pathogenic microorganisms, with opportunistic bacterial pathogens in greywater indicating a particular risk of greywater reuse for the vulnerable members of society. The treatment of greywater is therefore critical prior to reuse. Treatment of greywater, targeting the removal of large particulate material and pathogen removal, improves the efficiency of greywater, allowing compliance with stringent microbiological standards for urban water reuse. Present study is an attempt to find the effect of different coagulants (alum, ferric chloride and poly aluminium chloride) at pH 5.5, 6.5, 7.5 and 8.5 on pathogen density by analyzing the total coliform, fecal coliform, salmonella, heterotrophic plate count and E.coli. Fresh greywater was collected form Girls' hostel without including water used in kitchen. The result of the conclude that pH is a critical factor for optimum coagulant dose and pathogen removal and coagulation with different coagulants (alum, ferric chloride, poly aluminium chloride and lime) showed 1-4 log pathogen removal.

Keywords : greywater, pathogens, microorganisms, coagulation

ICWM-WWWT-02

Water Quality Index Assessment for Stormwater using GIS Case Study: Tapi River in Surat City

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Abstract:Water quality management is an important issue in the modern times. Water scarcity is increasing worldwide and pressure on the existing water recourses is increasing due to the growing demands in several sectors such as, domestic, industrial, agriculture, hydropower generation, etc. The River Tapi is one of the major rivers supporting agriculture, industrial application and domestic usage. It also carries the discharged wastes. The growing urbanization is typically associated with increasing stormwater runoff and non point source pollution. Since the latter is mismanaged and over exploited the river water needs constant monitoring for sustaining the quality.



The water quality was determined through the following parameters:- pH, Turbidity, Total Alkalinity, Total Solids(TS), Total Dissolved Solids(TDS), Total Suspended Solids(TSS), Dissolved Oxygen(DO), Chemical Oxygen Demand(COD), Biochemical Oxygen Demand(BOD), Chloride(Cl), Sulphate (SO₄) and Nitrate(NO₃), Phosphate (PO₄), Total Coliform(TC) and Fecal Coliform(FC). All these parameters were considerably affected by the discharge of Stormwater outfalls. The present study has proven that discharge Outfalls Stormwater has heavy impact on the river. Discharge Stormwater Outfalls is relatively more polluted than the main river itself. Protection and management of the river systems is warranted. Water quality index (WQI) was introduced with the aim of reducing great amount of parameters into a simpler expression and enabling easy interpretation of monitoring data. In this study, an attempt has been made to devise a methodology to integrate the WQI with geographic information system (GIS) for an effective interpretation of the quality status of the river. Remote sensing and GIS now-a-days have become inevitable tools for the analysis of stormwater at local, regional and global level. The main objectives of this study were to identify the point sources of discharged pollutant in to the river Tapi in order to aware and envisage the local authority toward careful management of water resources and to study the feasibility of reuse of stormwater (in agriculture or recharge).

Keywords: Stormwater runoff, Non point source pollution, Water quality standard, Water Quality Index, River Tapi

ICWM-WWWT-03

Degradation of 2,4-Dichlorophenoxy Acetic Acid by Advance Oxidation Process

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Abstract: Herbicide pollution occurs through the wastewater generated from equipments of pesticide manufacturing plants, agricultural fields and equipment rinsing operations. 2,4-dichlorophenoxy acetic acid (2,4-D) is a widely used plant growth regulator and weed controlling herbicide in the world. It is moderately toxic and potentially carcinogenic. The ester forms of 2,4-D is highly toxic to fish and other aquatic life. Removal of this herbicide is generally done using adsorption process. But this process only separates herbicides from wastewater and transfer it to solid phase. Thus, possibility of farther pollution from this solid form is present there. Other conventional process like bioprocess does not show significant degradation due to non-biodegradable nature of 2,4-D. Hence, complete degradation of 2,4-D is required. In the present study, UV-H₂O₂ advanced oxidation process (AOP) have been evaluated for degradation of 2,4-D from its contaminated wastewater. This AOP process relies on formation of free hydroxyl radicals from H₂O₂ under UV irradiation. The hydroxyl radical non-selectively oxidizes 2,4-D and convert it to biodegradable end product or minerals. Spectrophotometric method was used for determination of 2,4-D. This compound has two peaks at 230 nm and 282.5 nm.



Calibration curves were prepared for both the peaks and concentration of 2,4-D was measured using these two calibration curves. Direct photolysis and advanced oxidation experiments were conducted using batch UV reactor (M/s. Lab Tree) that emits monochromatic light at 253.7 nm. The photon flux of the instrument was found to be $1.9 \times 10^{-5} \pm 9.66 \times 10^{-7}$ Einstein/min/100 mL. The experiments on direct photolysis of 2,4-D showed that only 46% degradation occurred in three hours when 2,4-D concentration was 100 mg/L. But, UV-H₂O₂ process resulted in very fast degradation of the herbicide. For example, 50% of 2,4-D was degraded within 3 minutes when a molar ratio of 2.5 (moles of H₂O₂/ mole of 2,4-D) was used. Almost complete degradation was achieved within 10 minutes of irradiation. Degradation study was also carried out using wastewater spiked samples with a molar ration of 2.5 (moles of H₂O₂/ mole of 2,4-D). The 2,4-D concentration was 100 mg/L. It was found that the degradation for wastewater spiked samples was slower compared to distilled water spiked samples. The pseudo first order reaction rate constant for distilled water spiked samples was found to 2 times higher compare to wastewater spiked samples. This might be due to the presence of natural alkalinity in wastewater which acted as scavenger of hydroxyl radical.

Keywords: Herbicide, UV-H₂O₂ process, Wastewater, Reaction kinetics

ICWM-WWWT-04

Complete Degradation of the Cationic Surfactant by UV based Advanced Oxidation Process

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Abstract: Surfactants are widely used in many industries like pharmaceutical, cosmetic, detergent, textile, agriculture etc. These are the main constituents of commercial detergents. In domestic wastewater produced by households, surfactants exist in significant amounts due to the enormous use of detergents in washing purpose. However, due to its toxic nature they pose significant health hazards. Dermatitis is a common problem to human due to surfactant. Surfactants are harmful to human beings, fishes and vegetation. They create unpleasant taste and smell when present at certain concentrations. They are responsible for causing foams in river and effluent treatment plants. There are several methods for surfactant removal from wastewater such as adsorption, coagulation, chemical oxidation, biological process etc. Generally, physico-chemical processes of treatment are considered to be less environmental friendly, expensive and generate large volumes of chemical sludge and often require a pre-dilution of the detergent bearing wastewater to be treated. Due to the fact that conventional biological, physical and chemical treatment methods are not very effective in the removal of surfactants, alternative options need to be explored. In recent years, advanced oxidation processes (AOPs) have been developed and explored for the treatment of toxic and/or refractory pollutants and wastewaters. AOPs are based on the chemistry of hydroxyl radicals (OH•), which are non-selective reactive species and able to oxidize pollutants into mineral end-products, ultimately yielding CO₂ and inorganic ions. This work investigates the degradation of cationic surfactant



(cetyltrimethylammonium bromide (CTAB)) using UV irradiation and UV- H₂O₂ advanced oxidation process. UV irradiation and advanced oxidation experiments were conducted using batch UV reactor (M/s. Lab Tree) system that emits monochromatic light at 253.7 nm. The photon flux of the instrument was found to be $1.9 \times 10^{-5} \pm 9.66 \times 10^{-7}$ Einstein/min/100 mL. The experiments on direct photolysis of CTAB showed that only 55% degradation occurred in 6 hours when CTAB concentration was 100 mg/L. But, UV-H₂O₂ process resulted in very fast degradation of the CTAB. It was noticed that for molar ratio of 2 (moles of H₂O₂ / moles of CTAB), about 100 % degradation was achieved within 7 minutes when CTAB concentration was 100 mg/l. The rate constant for 2 molar ratio of H₂O₂ was determined by using pseudo first order kinetic model. The value of rate constant was 0.5987 min⁻¹. Experiments were also carried out to observe degradation of CTAB (100 mg/l) in municipal wastewater spiked sample. It was found that the CTAB degradation for wastewater spiked samples was slower compared to distilled water spiked samples. The pseudo first order reaction rate constant for distilled water spiked samples was found to be 2 times higher compared to wastewater spiked samples. This might be due to the presence of natural alkalinity in wastewater which acted as scavenger of hydroxyl radical.

Keywords: Surfactant, Advanced Oxidation, CTAB, Kinetics

ICWM-WWWT-05

Ultrasonication Integrated with Hybrid Biological Reactor for Treatment of Synthetic Textile Wastewater

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Abstract: Textile industry effluents contain different types of dyes, which because of high molecular weight and complex chemical structures, show low degree of biodegradability. Treatment of textile industry wastewater is considered to be difficult by the conventional processes. Therefore, the present study investigates the treatment of textile wastewater by an integrated process employing ultrasonication as pre-treatment and subsequent hybrid biological reactor as posttreatment. During ultrasonic experimentations, parameters such as sonication power and time were optimized for effective decolorization and COD reduction of synthetic textile wastewater containing different reactive di-azo dyes along with other chemical additives. Few of the least explored parameters such as effect of cow dung culture, sea microbial culture (halophiles), salt (NaCl) concentration, and pre-treatment were investigated individually and in combination as well for decolorization and COD reduction of textile wastewater in hybrid reactor containing anaerobic bottom and aerobic top zone. Major parameters such as volatile fatty acids (VFA), bicarbonate alkalinity (B-alk), total aromatic amines (TAAs) generation, COD, and color removal efficiency were monitored in a hybrid reactor operated at 32 h of hydraulic retention time (HRT). Out



of different combinations investigated in the study, a maximum 98% COD reduction efficiency was obtained, when ultrasonically pre-treated textile wastewater was further treated inside the hybrid biological reactor employing cow dung culture as the sole microbial source. Approximately 92% decolorization efficiency was achieved, when ultrasonically pretreated textile wastewater was further treated inside the hybrid biological reactor in presence of 50 g/L NaCl and halophiles as the sole microbial source. During anaerobic decomposition of dyes present in textile wastewater, significant concentrations (10 mg/L) of carcinogenic byproducts such as aromatic amines were resulted in the effluent. These aromatic amines were efficiently eliminated during aerobic zone inside the hybrid bioreactor. VFA/B-alk ratio in the anaerobic zone was found in the range of 0.21–0.28, indicating the adequate buffering capacity for stability of the bioreactor during the operation. The study demonstrates the importance of integrated process (ultrasonic pre-treatment in combination with hybrid biological reactor) employing different microbial cultures for effective mineralization of organic and inorganic impurities present in textile wastewater, and to enhance the treatment efficiency of the process.

Keywords: COD reduction; Decolorization; Hybrid reactor; Textile wastewater; Ultrasonication

ICWM-WWWT-06

Electrochemical Degradation of Reactive Red and Yellow in Continuous Flow Reactor

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Abstract: The Reactive Red & Yellow dyes synthetic solution of 60 mg/L concentration was studied over different operational parameter in continuous flow electrochemical reactor for decolourization. In this study, the effect of potential difference, electrolyte concentrations, initial dye concentration, inter electrode distance (S), cathode material, and discharges were examined independently. Initially, 20 volts was optimized for both dyes in range 10 – 30 volts through experiments and was kept constant for subsequent experiments. Results show that, colour removal efficiency increased from 61.44 to 96.53 % for yellow, whereas 88.32 to 99.07% for red. Similarly energy consumed was 1.269 to 14.95 and 1.52 to 13.57 kWh/m³ for yellow and red respectively. Reactive red showed higher removal efficiency than yellow on similar conditions with lower count of energy required. Furthermore, electrolyte concentration of 0.5 to 2.0 g/L was added to both dye wastewaters, to check decolourisation. The dose of 1.0 g/L showed 92.43 % and 98.91% decolourisation, consuming 6.22 and 5.57 kWh/m³ of energy for yellow and red respectively. In both cases color removal efficiency decreased from 92.43 to 27.45 % for yellow and 98.91 to 79.15 % with increase inter-electrode distance in range 1 to 2.5 cm respectively. In addition energy consumption was also reduced. In



addition, initial dye concentration was increased in range 60 to 120 mg/L at constant discharge and 20 volts. The decolourisation reduced from 92.43 to 49.36 consuming 6.22 to 6.42 kWh/m³ of energy for yellow. Contradicting with yellow, Reactive red decolourization increased from 98.91 to 99.18 for dose 60 to 100 mg/L respectively and then decrease to 98.60% at 120 mg/L. At constant experimental condition energy consumption increase with increase in initial dye concentration.

Key-words: Electrochemical, degradation, operational parameter, energy consumption.

ICWM-WWWT-07

Flow Characteristics of Multiple Plunging Jets

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Abstract: Due to rapid industrialisation urbanization and increasing population led to consumption of more water and directly release into the ground without any treatment. Therefore, it is very important for the sanitary engineers to stabilize the liquid waste to inoffensive and harmless substance to the degree required by regulatory agencies. The liquid waste is treated by aerobic and anaerobic biological method. In the last few decades there has been a growing interest in plunging jet aerators as they can significantly reduce the operating cost of wastewater treatment and other related processes, if operated under optimum conditions. Plunging jet aerator is simple in design, construction and maintenance and also free from operational difficulties encountered in other type of aerators. Further, the jet itself achieves aeration and mixing and no separate stirring device is needed. In this study, an effort has been made to investigate and analyse the multiple plunging jet of varied configurations were fabricated by drilling circular holes in the Perspex discs of 56 mm diameter and 6 mm thickeners so as to generate the plunging jets when water eject through the drilled holes. Two flow area namely 615.752 mm² and 452.389 mm² corresponding to 28 mm diameter and 24 mm diameter respectively are selected for carry out the experiments. For each flow area, the number of multiple plunging jets (n) is varied as 1, 4, 8 and 16. The experiments were carried out in an aeration tank having transparent wall made up of Perspex. A transparent graphical sheet was fixed on one side of the aeration tank so as to measure the width of rising bubble shown in the pool water. The observation and measurements were made out by image analysis. The images used the photograph taken during the operational conditions of plunging jet aeration system for various configurations and at four different flow rates (0.72 l/s, 0.85 l/s, 1.28 l/s and 1.62 l/s). The analysis revealed that the penetration depth and bubble swarm width are directly proportional to rate of flow. However, at a given rate of flow, both decreases with increases in number of multiple plunging jets under similar conditions. In this study a new term “composite Froude number, Fr(c)” is carried for better understanding and analysis of the flow characteristics of multiple plunging jet aeration system. The result of the study revealed that the gas-liquid mass transfer in the



multiple plunging jet aeration is controlled mainly by the optimal utilization of composite Froude number.

Key-words: Multiple plunging jets, Composite Froude number, Image Analysis, bubble swarm width

ICWM-WWWT-08

Removal of Chromium from Synthetic Sample by Electrocoagulation

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Abstract: Recent urbanization and industrialization of the Agra city resulted in the toxic heavy metal pollution. Among them Chromium(III) in one of the pollutant industries such as leather tanning, glass, ceramics, inorganic pigments, textile & photography utilize chromium in manufacturing process. Precipitation, adsorption, ion-exchange & membrane separation are the common technique for removal & recovery of heavy metal from industrial effluents. However, most methods suffer from technical & economics shortcoming, so alternative technologies are still under development. Recently various works have been investigated. Electro Coagulation for the removal of heavy metals (Cr, Zn, Cu, Pb, etc.) from wastewater. This paper focuses on removal of BCS by electro coagulation for removal of Cr³⁺. The process parameter investigated includes operating time, current density, pH, initial Cr³⁺ ions. Starrer rpm, and sludge generation, metal electrode (Fe, Al). The optimal conditions for maximum chromium efficiency by Fe electrode are pH 8.5, current density 5AS/m², time duration 25min, removal efficiency 79.91%.

Key-words: Electrocoagulation, Chromium, Tannery Waste Water.

ICWM-WWWT-09

Preparation of Solid Fertilizer from Secondary Treated Wastewater

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Abstract: Since phosphorus poses threat to aquatic life by causing reduction in biodiversity due to eutrophication, its removal is essential from water as well as wastewater. Also, phosphorus is a finite and non-renewable resource and is an irreplaceable mineral needed by all biotic regime. Thus, recovery of phosphate from phosphorus containing wastewater is essential for developing an alternative source of phosphorus to overcome the global challenge of phosphorus scarcity. This study has been carried out to recover phosphorus in the form of solid fertilizer using Magnesium Ammonium Phosphate (MAP) crystallization process as it ensures removal as well as recovery of phosphorus from wastewater. Synthetic sample was prepared with N:P:Mg molar ratio of 8:1:1.4. Experiments were carried in the pH range of 8-11 and reaction time of 1-4 hours. 1.2 gm of precipitate from 1 ltr. of sample was formed at pH 10 and reaction time of 1 hour, with phosphorous removal efficiency of 84%. With



pH and reaction time of other combinations, the amount of precipitate formed wasn't significant and the settling ability was reduced considerably. Scanning Electron Microscopy (SEM) analysis confirmed needle-shaped crystal formation in the precipitate.

Key-words: Wastewater, Phosphorus, Magnesium Ammonium phosphate (MAP) crystallization, Solid fertilizer

ICWM-WWWT-10

Bio-Degradability and Machining Performance Comparison of Mineral Oil and Bio Cutting Fluids

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Abstract: The main functions of cutting fluids in metal cutting industries are cooling, lubrication as well as assisting the chip evacuation. Mineral oil based conventional cutting fluids possess dominating lubricating properties but poor cooling properties. To enhance the cooling properties and enhance the other functional performance, other additives are blended. Mineral oils are basically one of the crude petroleum derivatives. So, this cutting fluid's biodegradability is low so, it has lot of chances to pollute environment (Air, soil and water). A major issue lies in their inappropriate disposal, which results in surface water and ground water contamination, air pollution, soil contamination depending on the type of disposal. The consequence of these pollution leads to contamination of agricultural products and food. In present research work, potential of biodegradability nature has been compared through aerobic degradation between bio-cutting fluid (BCF) and commercially available mineral oil (CMO) based cutting fluid. Two aerobic reactors (1Litre reactor capacity) Reactor-BCF (R-BCF) and Reactor-CMO (R-CMO) were operated in fed batch mode with bio-cutting fluid as well as mineral oil based cutting fluid as carbon source with initial chemical oxygen demand (COD) 1200 mg O₂/L respectively along with ammonia - N (200 mg/L) as nitrogen source. Reactors were operated at different hydraulic retention time (HRT-6h, 12h, 18h and 24h) for 21 days. COD and Ammonia-N removal increased in both R-BCF and R-CMO with increase in the HRT from 6h to 24h. COD and Ammonia-N removal was 81% and 69% respectively for R-BCF as compared to 57% and 53% respectively for R-CMO at 24h HRT. Degradation of Ammonia-N led to the formation of nitrite-N and nitrate-N in both the reactors. Analysis of food to microorganism ratio at 24h HRT revealed more degradation at lesser ratios in both R-BCF and R-CMO as well as optimum ratio of 1.48 was achieved for R-BCF. The results indicate that micro-organisms present in environment are able to consume disposed bio-cutting fluid in much better way as well as degradation potential of bio-cutting fluid is higher as compared to mineral oil based cutting fluid. The machining performance (cutting force, feed force and surface finish) of bio-cutting fluid is higher compared to conventional mineral oil. Around 12.8% (cutting force), 16% (feed force) forces were reduced and 10.31% workpiece surface roughness improvement were



observed using bio-cutting fluid compared to conventional mineral oil based cutting fluids.

Key-words: Bio-cutting fluid, Aerobic degradation, Wastewater treatment, Hydraulic retention time, Chemical oxygen demand.

ICWM-WWWT-11

Treatment of Effluent Sewage for Recreational Purpose

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Abstract: Water is one of the basic needs to survive. It is also used for some recreational purposes like swimming and also for gardening purposes. About 80% of supplied water has been reproduced as waste and discharged as unusable. The focus of this study is to treat the effluent water using three different treatment methods which was collected from a waste water treatment unit located in IIT Guwahati and to find whether the treated water obtained after few series of methods is suitable for recreational purpose. After addition of chlorine and coagulant dosages studies were carried out on the physicochemical and biological parameters like pH, TS, DS, SS, Turbidity, COD, BOD₅. The three treatment methods involves direct chlorination, clariflocculator followed by chlorination, aeration followed by clariflocculator and chlorination. Based on this study, the final characteristics of clear water obtained after different treatment methods is found to be within the permissible limits as taken from IS 10500-1991. But in Method I the COD value of the clear water is more that the permissible limit of 76 mg/l. Thus except this water the other two clear waters obtained in Method II & III can be used for recreational purposes.

Key-words: chlorination, clariflocculator, Turbidity, COD, BOD₅.

ICWM-WWWT-12

Surface Water Quality Modeling by Regression Analysis and Artificial Neural Network

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Abstract: The growing problem of polluted drinking water in our ground and surface water systems has necessitated the monitoring of drinking water quality of various sources to evaluate their primary quality, utility potential and to plan restorative measures. The major objective of the present study is to develop water quality prediction models after evaluation of water quality to predict water pollution of two lakes situated inside Tezpur University, using mathematical simulation techniques. The correlation was developed to predict the water quality using statistical techniques – linear regression analysis and artificial neural network (ANN). Linear regression examines the relationship between single depended variables and a set of independent



variables to best represent relationship in water quality parameters. ANN modeling has the potential to reduce the computation time and effort and the possibility of errors in the calculation. Therefore, this study illustrates design of a neural network model for rapid, direct calculation of the water quality. Water sample for the experimental purpose was collected from two lakes situated inside the Tezpur University and analyzed in the environmental engineering laboratory in civil engineering department of Tezpur University. The present study has been made to evaluate the current status of pollutants and an effort has been made to study the inter-relationship between different components of surface water using statistical techniques. Ten parameters were analyzed for each of the two lakes over a period of four months (January 2015 – April 2015). Various water quality parameters were estimated and statistical analysis were carried out. Correlation studies suggested a highly positive correlation between Total Solids (TS) with turbidity and Electrical Conductivity (EC) for both the lakes. pH shows correlation ranges from 0.5 to 0.7 ($0.5 < r < 0.7$) with Dissolved Oxygen but poor correlation with other parameters. Modeling of Total Solids and Biological Oxygen Demand (BOD) by Regression analysis suggests a good correlation between actual and predicted TS but a very poor correlation between actual and predicted BOD, suggesting regression model cannot be used to model BOD for the present case. Modeling of TS and BOD by Artificial Neural Network (ANN) shows a very good correlation between the actual and predicted values for both TS and BOD (R-square value ranges from 0.69 to 0.82) for both the lakes studied. The error between the experimental and estimated ANN model is less than regression model. Thus it can be concluded that ANN can be best described model for prediction of studied parameters. **Key-words:** Artificial neural network; BOD; Regression analysis; Total solid; Water quality

ICWM-WWWT-13

Feasibility of a Hybrid Bioreactor to Recycle Domestic Wastewater

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Abstract: In most of the developing countries like India and in low income group countries domestic wastewater collection, treatment, and disposal scenario is very pathetic. Especially in rural as well as extended urban areas disposal of domestic wastewater has been an issue. Mostly such area lack in sewerage network and central treatment facilities. In this context most of the habitat has to rely on onsite treatment methods. Out of the available onsite treatment options, septic tank and/or DEWATs are popular. However at many places the treatment potential of such onsite treatments is still questionable. Hence a study had been undertaken in the premises of Walchand College of Engineering, Sangli, Maharashtra. An attempt had been made to devise an onsite treatment option which will be adoptable for small waste producers, work on natural mechanisms, would not employ moving mechanical parts, and will provide reasonably good treatment. The main intention was to have treated domestic wastewater to recycle within the premises safely. The domestic wastewater arising out of the residential premises was characterized to know its quantity and quality aspects.



The wastewater generation rate found to be 105 l/person/day. The wastewater has initial COD of 600 ± 150 mg/l, BOD₅ of 350 ± 60 mg/l and TSS of 390 ± 50 mg/l and hence it was recognized as medium-high strength wastewater. The BOD: COD ratio was found to be in the favourable range of biological treatment. Though not accounted for in above values, there were occasional peaks in the concentration of COD, BOD and TSS hampering in general strength of wastewater. Hence the treatment chain was designed to have combination of inlet sump (for equalisation), Settler compartment (for the sedimentation of solids) and a hybrid bioreactor (for biological degradation). In general bioreactor is an encompassing term used for the reactor employed for the biological treatment to take place. Here the term "hybrid" has been intentionally induced to show that, the reactor was expected to support both attached as well as suspended growth of bacteria simultaneously. To facilitate the treatment, a pilot scale model was developed comprising settler compartment modified to have slanted baffles and a hybrid bioreactor compartment. The slanted baffles were useful to have desired vertical up-flow restricting entry of suspended solids as well as improving the gravitational settling of the same. Solid waste products such as human hair, corn nutshell (corn cobs) and coconut coir were used as media in the hybrid bioreactor. The reactor was run in batch mode under anaerobic conditions with varied detention time. The results revealed that the model is more effective in treating the wastewater than that of conventional popular onsite options. The performance was found to be more or less stable after stabilisation period of thirty days. The treatment efficiency observed throughout the experimentations was 58-67%, 63-73% and 80-85% for COD, BOD and TSS removal respectively indicating the feasibility of the system to treat domestic wastewater effectively. The treated wastewater can be recycled for land application after disinfection.

Key-words: DEWATs, COD, BOD₅, TSS, land application.

ICWM-WWWT-14

Fluoride in Groundwater: Causes, Effects & Mitigation

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Abstract: Fluoride contamination in groundwater is a burning global environmental issue today. Fluoride is a naturally occurring compound derived from fluorine, the 13th most abundant element in Earth. It is found in rocks, soil, fresh and ocean water. Fluoride is present naturally in almost all foods and beverages including water, but levels can vary widely. It is added to drinking water to provide public protection from dental caries. Fluoride pollution in the environment occurs through two channels, namely natural and anthropogenic sources. Natural sources are associated with the geological conditions of an area. Fluoride which is present in high concentration in volcanic ash is highly soluble in water, forms another natural source. Apart from natural sources, a considerable amount of fluoride is also contributed by anthropogenic activities like burning of coal, extraction of aluminium, use of



phosphate fertilizers, steel industries leading to encounter of fluoride containing aerosols, dust, wastewater in the surrounding environment. Fluoride is frequently encountered in minerals and in geochemical deposits and is generally released in sub-soil water sources by slow natural degradation of fluorine contained in rocks. The U.S. Environmental Protection Agency (EPA) has set a maximum contaminant level (MCL) of 4.0 mg/L for fluoride for drinking water for public water systems. EPA has also set a secondary standard of 2.0 mg/L. The U.S. Public Health Service has established the optimum level for fluoride content in drinking water in the range of 0.7 mg/L to 1.2 mg/L. Fluoride is beneficial to health if the concentration of the fluoride ion (F⁻) in drinking water is less than 1.5 mg/L (WHO). A higher concentration causes serious health hazards. The disease caused manifests itself in two forms, namely, dental and skeletal fluorosis. Besides skeletal and dental fluorosis, excessive consumption of fluoride may lead to muscle fibre degeneration, low haemoglobin levels, excessive thirst, headache, skin rashes, depression, abdominal pain etc. The fluoride removal has been classified in two parts dealing with membrane and adsorption techniques. In the membrane techniques, ultrafiltration, nano-filtration, reverse osmosis, dialysis and electro-dialysis have been discussed. The adsorption technique deals with different adsorbents such as soils and clays, alumina, calcium and carbon based materials, synthetic compounds etc. Studies on fluoride removal using red mud, zeolites, ion-exchanged resins, limestone and activated carbon are reviewed. Fluoride contamination, being a prominent and widespread problem in several parts of the world makes defluorinating the groundwater essential before consumption for a healthy world.

Key-words: Fluoride, Fluorosis, Groundwater, Wastewater, Treatment.

ICWM-WWWT-15

Waste Stabilisation Pond

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Abstract: Water, the most important resource on earth is declining day by day due to various reasons. In present time, humans have still not learnt the economical use of water. Hence, generation of waste water has been increasing. In this regard, the reuse of greywater (waste water) for non-potable applications has become a positive solution for atleast the deprived portions of the world. In the present study, a spread sheet model has been formulated to design a waste water stabilization pond for treating waste water of KING'S PALACE (Boys Hostel of KIIT UNIVERSITY) - 1,2,3,4,8,10(A),10(B) and reusing it for irrigation purpose. In this design, three distinct cases- aerobic, anaerobic and facultative have been considered. Input of the spread sheet model was temperature, BOD, DO, discharge of water and evaporation rate. This study attempts in finding the appropriate design for treatment of waste water.

Key-words: Waste Stabilization Pond, BOD, Irrigation, Evaporation Rate, Anaerobic Pond, Facultative Pond, Aerobic Pond.



Treatment of Slaughterhouse Wastewater by Advanced Oxidation Process

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Abstract: Industries are growing at a fast rate and so is the rate of waste generation. India is one of the largest exporters of meat in the world, credit to its large number of slaughterhouses. But huge production leads to the production of large quantities of slaughterhouse waste as well. The main pollutant in slaughterhouse effluents is organic matter which is due to the presence of paunch, faeces, blood, urine, fats, proteins, loose meat, manure, grit and colloidal particles. Therefore this wastewater has large values of biological oxygen demand and chemical oxygen demand. A number of treatment technologies including physic chemical and biological methods are used to treat slaughterhouse wastewater. As the wastewater is of high strength more than one unit operations are preferred for achieving significant BOD/COD removal. Attempts have been made to evaluate the efficacy of using Fenton's reagent for treating slaughterhouse wastewater. Fenton's reagent is an Advanced Oxidation Process and it uses H₂O₂ and FeSO₄ which results in the formation of free radicals and these radicals then attack and remove the organic matter. Studies were performed to evaluate the optimum pH and dose of Fenton's reagent for COD removal. Experiments were conducted at different pH and doses using Jar test assembly. A contact time of 30 minutes was used. The optimum dose of Fenton's reagent and pH was worked out to be (4ml H₂O₂ + 0.5 g FeSO₄) and pH 4 respectively. At optimum conditions, a COD removal efficiency of 81% was achieved. It was concluded that advanced oxidation process can be used as a post treatment option to biological treatment.

Key-words: Treatment, Slaughterhouse Wastewater, Advanced Oxidation Process, Fenton's Reagent.

ICWM-WWWT-17

Bioremediation of P-Nitrophenol (PNP) in Textile Dye Wastewater using Isolated Soil Bacterium Strain

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Abstract: The huge amount of use of nitroaromatics as a synthetic product in the process of manufacturing of dyes, pigments, pharmaceuticals, plastics and industrial solvents leads to accumulation of nitrophenol out of which P-nitrophenol (PNP) is the most important mono nitrophenol in terms of toxicity and amount of usage. PNP are often found in the effluents released by textile dye industries and is detected in wastewater stream, rivers, soil, ground water and it reaches to living organisms and gets accumulated in the food chain. Soil sample was collected from near the outlet of



the textile industries and a soil bacterium strain, capable of using p-nitrophenol (PNP) as its sole carbon and energy source, was isolated from textile dye industries peripheral area by enrichment of minimal salt medium (MSM). On the basis of phylogenetic analysis of 16S rRNA gene sequences the bacterium was found to be closely related to *Pseudomonas taiwanensis* ECA e22. The strain showed PNP degradation of more than 90% upto PNP range of 85 ppm in 96 hours. Optimum temperature and pH for the bacteria to survive was found to be 30°C and 8.5 (slightly alkaline pH) respectively. Effective degradation rates slowed as the concentration increased. This Bacterial strain can thus be used in process of bioremediation for any effluent which releases <10 mg/L (limit for PNP release).

Key-words: Bioremediation, p-nitrophenol (PNP), Mineral salt medium (MSM), phylogenetic analysis, 16S rRNA, *Pseudomonas taiwanensis* ECA e22, textile dye wastewater

ICWM-WWWT-18

Trihalomethanes Occurrence in Chlorinated Treated Effluents at Sewage Treatment Plants of North-Indian Region

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Abstract: Chlorination of treated wastewater generally leads to formation of disinfection byproducts (DBPs) which are matter of great concern because of their carcinogenic nature. Trihalomethanes and haloacetic acid are two major classes of these DBPs. Chloroform being the predominant THM has also been classified as group B2 or “probable human carcinogen” by US Environmental Protection Agency. Total trihalomethanes (TTHM) concentration were determined in 7 treated effluents from sewage treatment plants in North-Indian region (Haryana and Utrkhand) over a span of 10 months (July 2014-April 2015). 3 STPs operated on Up-flow anaerobic sludge blanket (UASB) treatment technology, 2 STPs operated on sequential batch reactor (SBR), 1 STP operated on activated sludge process (ASP) and 1 on oxidation pond (OP). Low TTHM concentrations were obtained in all the samples analyzed (as per international standards for drinking water) though higher concentrations were seen in UASB plants (lower than the standard limits). The samples were evaluated only for winter season, effect of warm season on TTHM formation was not evaluated.

Key-words: Wastewater treatment, Disinfection, Disinfection by-products.

ICWM-WWWT-19

Industrial Effluent Treatment by Bacterial Laccase

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Abstract: Pyridine raffinate is a residual reaction mixture after pyridine extraction and contains large quantities of pyridine, formaldehyde, phenolics, and picolines with high alkalinity (pH 12.0) and water solubility. It is released by many chemical



industries as effluent waste. It is reported to be toxic for human as well as for many bacterial species. Bioremediation of such a harmful compound is essential before its exposure to environment. In present study an enzyme known as laccase was used to treat pyridine raffinate. Wide application of microbial laccase has been reported in degrading both phenolic and non-phenolic compound. Most of the laccases used in pulp and paper mills, are thermo stable having optimum activity in range of 45-95⁰C and stable at pH range 9-12. These properties of laccase was exploited to degrade pyridine raffinate and it was a new approach. Pyridine raffinate was collected from a chemical industry in Gajraula (U.P.). Laccase producing bacteria were isolated from different habitats including timber soil and garden soil. Laccase activity was determined using substrate named guaiacol. Laccases (benzenediol: oxygen oxidoreductases) are extracellular blue color multi-copper enzymes that use molecular oxygen to oxidize wide variety of aromatic and non-aromatic compounds following a radical catalyzed reaction mechanism. In present study we isolated a bacteria pyridine raffinate. This approach can be an effective way to avoid expensive and harmful use of chemical methods. A bacterial species named *Budvicia aquatica* was reported to have laccase activity and was successfully able to degrade pyridine raffinate biologically. This species has been identified on the basis of biochemical tests performed (HiMedia Laboratories Pvt.Ltd.Mumbai,India). COD analysis can be performed to check degradation of of chemicals that will ultimately lead to an eco-friendly degradation of pyridine raffinate. Since this raffinate has also been reported to have some cancerous properties in animals, this work can also be taken to a big level by checking gene toxicity of pyridine raffinate.

Key-words: Pyridine, Raffinate, bioremediation, laccase.

ICWM-WWWT-20

A Review on Nitritation Process

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Abstract: Due to the growing population and increased discharge of waste water, the nutrient concentration is increasing in the surface water bodies. The effluent standards are now more stringent to reduce nutrient load in receiving water sources. Nitrogen removal is achieved through nitrification followed by denitrification in waste water treatment plants. Recently, nitrogen removal via nitrite pathway i.e. nitritation has caught the attention of researchers as it helps in reducing aeration costs by 25% without the need to add an extra carbon source in the de-nitritation step. In the present paper biochemistry of nitrogen removal process, microbiology of nitrification and factors affecting nitritation are discussed. A summary of studies involving Sequencing Batch Reactor (SBR) for nitrite accumulation is also presented.

Key-words: waste water treatment, ammonia oxidizing bacteria, nitrite oxidizing bacteria, nitritation.



Novel Antifouling and Hydrophilic Ultrafiltration Membrane for Humic Acid Removal

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Abstract: The present study invokes the removal of humic acid (HA) which can be found in both the ground as well as surface waters. HA is a prominent part of the organic dissolved matter. For the removal of HA from the water, polysulfone (PSF) antifouling and hydrophilic ultrafiltration (UF) membranes were prepared by using the phase inversion method. In membrane preparation poly(2-acrylamido-2-methylpropane sulfonic acid) (AMPS) and polyethylene glycol (PEG) were used as the hydrophilic additive and pore former, respectively. The membrane casting solution was prepared by using N-methyl-2-pyrrolidone (NMP) as the solvent. 5 different kinds of membranes were prepared by using different wt% of AMPS in the membrane casting solution. Various permeation and morphological studies were carried out to check the authenticity of the prepared membranes for their role in the successful removal of HA from the feed. Pure water flux (PWF) and hydraulic permeability of the membranes were analyzed. Equilibrium water content (EWC) and water contact angle (CA) of the prepared membranes were measured to ensure an increase in the hydrophilicity of the prepared membranes. The antifouling nature of the prepared membranes was analyzed with the help of bovine serum albumin (BSA) solution. A synthetic feed solution of HA was made to use as a feed in the permeation experiments so as to check the successful removal of HA from the feed. Techniques like field emission scanning electron microscopy (FESEM), atomic force microscopy (AFM) and Fourier transform infrared spectroscopy (FTIR) were utilized for the morphological as well as confirmation of the presence of the additives in the membranes. UV-Vis spectroscopy was utilized to analyze the permeation results of BSA and HA. The results show that there is eminent decrease in the CA of the prepared membranes from 62.63° to 49.83° to confirm the increase in hydrophilicity of the prepared membranes. Also the BSA flux study shows that the prepared membranes are antifouling in nature and can be utilized to effectively remove HA from the contaminated water. 99.43% HA removal was obtained with the best PWF giving membrane. The obtained results prove that the prepared membranes are a better solution for removal of HA from the contaminated water.

Key-words: Polysulfone, Ultrafiltration, Antifouling, Hydrophilicity, Humic acid.



Wastewater Purification from Organic Dyes by rGO Wrapped Hollow Spherical Tin Oxide

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Abstract: SnO₂ hollow sphere and solid sphere composed of SnO₂ nanoparticles was synthesised by reaction between hydrated stannic chloride (SnCl₄·5H₂O) and sodium hydroxide (NaOH) under high pressure and temperature i.e. by hydrothermal process, both of the material has bandgap 3.6 eV. Graphene oxide (GO) had been synthesised by modified hummers method and reduced by Hydrazine Hydrate to get reduced graphene oxide (rGO), XRD pattern of GO shows a very sharp peak at 10° which confirms that there are only one crystalline plane, FTIR absorption spectra shows lower intensities of ketone, hydroxyl, Carboxylic and various organic groups for rGO compared to GO as well as from RAMAN spectroscopy IG / ID ratio increases for rGO which confirms less defect levels in rGO. The transmission electron microscopy (TEM) and scanning electron microscopy (SEM) images show the spherical and hollow spherical structure of Tin Oxide (SnO₂) from FESEM images shows the diameter of spheres around 900 nano meter and the smallest grain which builds the spheres has diameter around 4 nano meter which is similar to the crystalline size of the SnO₂ nanoparticles by XRD analysis, diameter of the hole of the hollow sphere is around 400 nano meter which determined from FESEM image. The hollow spherical SnO₂ takes 60 minutes to degrade methylene blue almost 99.2 percent where solid sphere takes 110 minutes for the same purpose under UV light in room temperature. The same operation can be done in visible light if the bandgap of the catalyst is under 3.1 eV. Surface of hollow spherical SnO₂ was modified by (3-Aminopropyl) triethoxysilane (APTES) and wrapped by reduced graphene oxide by placing the mixture solution in Teflon lined autoclave at 180° C for 24 hrs. From XRD and RAMAN spectra analysis it can be concluded that the property of the SnO₂ and rGO both are present in the composite material which has 1.5 eV bandgap so theoretically capable for photo degradation of organic dyes from water in visible light. 10⁻⁵ molar methylene blue solution had been taken for photocatalysis experiment by rGO wrapped SnO₂ hollow sphere and degraded almost 99.1 percent in just 85 minutes in visible light where normal SnO₂ hollow sphere takes 330 minutes to degrade the same solution to 97.66 percent in room temperature. The composite material is also reusable as rGO wrapped SnO₂ hollow sphere due to less absorption of methylene blue at their surface for less porosity compared to the normal SnO₂ hollow sphere.

Key-words: Tin Oxide, hollow sphere, photocatalysis, wastewater, RAMAN spectroscopy.



Significance of Addressing Persistence of Pathogens and Micropollutants to Enhance Reuse of Treated Sewages in India

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Abstract: Presence of pathogens and micropollutants are inevitable part of the sewage generation train and is observed to be persistently exhibited in the reuse of treated sewages. Thus, existence of pathogens and micropollutants in the wastewater is the real challenge. The micropollutants comprise of pharmaceuticals, surfactants, personal care products, industrial chemicals, pesticides, steroid hormones etc. which are found in the varying concentration range in several kinds of wastewaters. The persistent release of micropollutants with wastewater effluent may cause destructive effects including long-term toxicity, antibiotic resistance of microorganisms, carcinogenic or teratogenic and endocrine disrupting effects even at trace concentrations. These effects may be individualistic, synergistic or antagonistic. Owing to multifaceted structures and bio-accumulating nature, the micropollutants possess an ecological challenge for their degradation leading to negative effects on human health and the environment. However, for the removal micropollutants, none of the technologies i.e. existing biological wastewater treatment plants or mechanized are specifically designed. Therefore, the primary objective of this paper is to discuss “significance of addressing persistence of pathogens and micropollutants to enhance reuse of treated sewages in India”. This study addresses the occurrence, monitoring and treatment of micropollutants as well as pathogens. However, the investigation of undetected micropollutants requires more advanced analytical instrumentation and procedures due to their occurrence at trace concentration. The mechanized treatment technologies including sequencing batch reactor, activated sludge process and extended aeration are less effective for the removal of the pathogens. On the other hand, significant removal of pathogens is exhibited by the natural treatment systems. If one intends to subject the treated effluents to reuse, there is a need for effective monitoring as well as elimination of pathogens and micropollutants from secondary and especially tertiary effluents. For the removal of micropollutants and pathogens, the natural treatment systems have been found to be highly efficient. Undoubtedly, due to numerous cost advantages (both, capital and operation and maintenance costs), the natural treatment system might prove to be the outstanding technological substitute. Use of the horizontal subsurface-flow constructed wetland is stated in the literature for the elimination of micropollutants and pathogens. Therefore, highly efficient treatment technologies comprising constructed wetland can be executed for the removal of micropollutants and pathogen as their partial removal takes place in conventional wastewater treatment. The consistent removal of pathogen in the constructed wetland is already reported in the literature for different types of wastewaters. Constructed wetland acts as biofilters for the effective removal of pathogenic bacteria and viruses from wastewater through a combination of physical, chemical and biological



processes. Hence, the constructed wetland is of distinctive importance among the natural treatment systems for the treatment as well as reuse of sewages and sullages in rural and peri-urban communities.

Key-words: Pathogens, Micropollutants, Detection, Treatment.

ICWM-WWWT-24

Preparation of Faujasite (FAU) Zeolite Membrane on Low Cost Porous Tubular Ceramic Substrate for Removal of Chromium from Wastewater

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Abstract: In this work, faujasite type zeolite membrane was prepared by hydrothermal treatment technique on low cost porous tubular ceramic substrate for the removal chromium from synthetic wastewater. The tubular substrate was fabricated by the extrusion method from locally available low cost clay materials. To formulate zeolite layer on the porous substrate, the reaction mixture was prepared by mixing of silicate and aluminate solutions. The synthesized faujasite zeolite was characterized by thermogravimetric analysis (TGA), X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR). The fabricated ceramic substrates as well as zeolite membrane were characterized by porosity, field emission scanning electron microscopy (FESEM), and water permeability. The porosity, pore size and water permeability of the zeolite membrane were significantly decreased after hydrothermal crystallization of faujasite zeolite on the porous ceramic substrate. The porosity, mean pore size and water permeability of the ceramic substrate and zeolite membrane were evaluated to be 53%, 0.309 μm , $5.93 \times 10^{-7} \text{ m}^3/\text{m}^2\text{s.kPa}$ and 43%, 0.179 μm , $1.62 \times 10^{-7} \text{ m}^3/\text{m}^2\text{s.kPa}$, respectively. Moreover, the potential of the fabricated faujasite type zeolite membrane was investigated by chromium removal from an aqueous stream at various influencing parameters, such as applied pressure (69-345 kPa), initial feed concentration (250-3000 ppm) and the cross flow rate (5.55×10^{-7} - $1.66 \times 10^{-6} \text{ m}^3/\text{s}$). The results clearly indicated that the percentage removal of chromium increases as the feed solution concentration increases. The maximum removal of chromium (82%) is obtained at applied pressure of 345 kPa and the initial feed concentration of 1000 ppm. Besides, the potential of the membrane on the chromium removal is evaluated by comparing its performance with other membranes reported in the literature.

Key-words: chromium removal, tubular membrane, zeolite membrane, hydrothermal.

ICWM-WWWT-25

Mathematical Modeling of the Upflow Anaerobic Sludge Blanket Reactor System (UASB)

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Abstract: Mathematical modeling of Upflow Anaerobic Sludge Blanket (UASB) reactor is useful for understanding the complex conversion of organic matter into the



biogas. It may facilitate the prediction of the effluent concentration as well as the amount of biogas generation in this high-rate anaerobic treatment. The present paper overviewed both the steady-state and dynamic models on UASB system available so far. The primary focus is on identifying the origin, scope and shortcomings of various mathematical models in this regard. Some important models on UASB reactor system are also illustrated with relevant conceptual diagrams and equations. Then comparison is made to explore the applicability as well as compatibility of different mathematical models. The final outcomes of all individual models have also been analyzed in order to find out the most versatile one. In addition the solution procedure for various models is also carefully scrutinized to arrive at a relatively simple mathematical relationship. Critical evaluation of all the relevant issues on the mathematical model of UASB reactor system is made to find out the research gap in this field. Necessary measures required for developing a simplified model to describe the anaerobic conversion of the organic substrate in the UASB reactor system have been highlighted. The performance of various UASB models has been explored with respect to important outputs and on the basis of available data. The scope of integration of individual mathematical models on UASB has also been tested for the sake of a comprehensive model. The limitations of such models are also discussed from their perspective features. Subsequently, the feasibility of various mathematical models for describing the conversion process in both the conventional UASB and the Hybrid UASB (HUASB) has been explored. The process design aspect of some common UASB models is also highlighted in order to find out the evolve the reactor configuration.

Key-words: Mathematical Modeling, UASB Reactor, Origin and Scope, Model Solution, Model Performance, Process Design.

ICWM-WWWT-26

Improving the Hydrophilicity of Polysulfone Membrane by the Addition of Imidazol with Polyvinyl Pyrrolidone for Crystal Violet Dye Removal

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Abstract: Asymmetric polysulfone (PSn) ultrafiltration membranes were prepared using polyvinyl pyrrolidone (PVP) of three different molecular weights with imidazol (IMZ). Phase inversion technique was adopted for fabricating the PVP and IMZ blended PSn based membrane. Morphological analysis of membranes was done by field emission scanning electron microscope (FESEM) and atomic force microscopy (AFM). Liquid-liquid displacement porosimetry (LLDP) method was used for determining the average pore size, number of pores and permeability of membranes. Hydrophilicity was found to be increased with increasing molecular weight of PVP from 24000 Da to 360000 Da with IMZ, as compared to the plain membrane. Investigation was done in terms of permeation and rejection behavior of fabricated membrane for crystal violet dye (CVD), with and without an anionic surfactant sodium dodecyl sulphate (SDS) from aqueous media.

Key-words: Polysulfone, Membrane, hydrophilicity, dye removal, contact angle.



ICWM-WWWT-27

Assessment of Various Produced Water Treatment Methods Applied in Oil Fields of Assam

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Abstract: Produced water management is one of the major challenges in the present oil & gas exploration industry. Produced water comprises of the water injected during fracture stimulation process or as natural formation water during fuel extraction. Each year, thousands of new oil and gas wells are drilled around the world and thus generates millions of barrels of produced water. Oil field produced water contains substantial quantity of oil and Grease and other suspended particles and therefore, it cannot be disposed off directly or cannot be injected to the sub surface for secondary recovery purposes considering stringent disposal norms set by environmental regulation policies. Moreover among 3% of all water on earth, only 0.29% of World's freshwater are easily accessible (USGS, 2005). If this waste water from oil wells can be recycled and reused, it can effectively reduce the produced water disposal volumes by approximately 85% to 100%. Although, studies were conducted pertaining to its beneficial reuse and potential environmental risk assessment in connection to toxicity and known contaminant concentration. This study focuses on the study of the available water treatment methods applied in the various oil fields of Assam to meet the regulatory norms for disposal and re-injection of produced water as Assam being most potential oil and gas producer in India. The study also highlights some of the advanced technologies that can be used to treat the produced water considering not only the safe disposal norms but also as a source of fresh water.

Key-words: Produced water, Fracture stimulation process, natural formation water

ICWM-WWWT-28

Utilization of Water Treatment Plant Sludge for Pretreatment of Dyeing Industry Wastewater using Coagulation and Flocculation

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Abstract: Water treatment plants generate huge amounts of sludge during the coagulation and flocculation of raw water, which poses a challenge in disposal even after drying. Potential savings in coagulant dosage can be achieved through recovery of coagulant from sludge or reuse of the sludge in treatment. Due to high contents of



metal hydroxides, use of water treatment plant (WTP) sludge in wastewater treatment may also be an economic option. This work presents a study on reuse of WTP sludge for treatment of dyeing wastewater. The study area, i.e., Varanasi is famous for its Banarasi Saree industries, most of which are small to medium scale in size and they keep on polluting the nearby rivers like Ganga, Varuna and Assi with their effluents containing various dyes. Direct disposal of the colored effluents into the receiving water bodies is hazardous to the exposed lives and therefore, it becomes imperative to treat the effluents economically to reduce the adverse environmental impacts. Commonly applied methods for the color removal are costly and therefore, cannot provide an economical treatment option for such small and medium scale industries. At present, there is an urgent need to develop low-cost methods for treatment of the colored wastewater and therefore, use of a low-cost material like WTP sludge for pretreatment can be a feasible option to achieve better results after final treatment. This study was conducted applying coagulation and flocculation using WTP sludge for treatment of Acid Red 94, Acid Yellow 1, Direct Green 26 and Reactive Blue 21 dyes because these are frequently used in dyeing industries in and around Varanasi city. The maximum removal for Acid Red 94, Acid Yellow 1, Direct Green 26 and Reactive Blue 21 dyes were found to be at the sieve size of 90-125 μm and the corresponding values were 41.5%, 27%, 43.5% and 26.2% respectively.

Key-words: Coagulation/flocculation, water treatment plant sludge, dyes, colour removal

ICWM-WWWT-29

Energy Utilization in Activated Sludge Process Based Sewage Treatment System in Gujarat

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Abstract: Wastewater handling is sort of financial hassle in India. For years, it has been found there is an issue regarding treatment of generated as well as management of sewage treatment plant, which could be due to relatively higher maintenance cost and lower returns from it. The treatment of sewage is energy demanding operation. Although primary treatment is similar and standard in all types of sewage treatment plants (STPs), there are different alternatives for secondary wastewater treatment as well as solids treatments produced during the secondary treatment process. The energy utilization in these treatment systems varies significantly depending upon the type of treatment used. This study aims to quantify energy consumption in different unit processes of sewage treatment and also explore options of reduction in energy use in a full- scale conventional STP. In this study, an Activated Sludge Process (ASP) type STP in Ahmedabad, Gujarat having 180 MLD treatment capacity is considered. Based on discussion with plant engineers and personal level observation of each components of STP, which included rating of mechanical and electrical equipment, their time of operation and daily average flow of the wastewater, It was found that in a well operated STP the major energy consumption (>50% of total energy use) was in the



aeration process. There are opportunities to generate energy within the STP boundary; the one of the options being proper utilization of sludge produced during sewage treatment, which may lead towards sustainable STP operation. As the fossil energy consumption is a serious concern in terms of economic as well as environmental impacts, this study will likely give insights to the decisions makers and environmental professionals with respect to energy use reduction as well as renewable energy utilization in sewage treatment plants.

Key-words: Municipal wastewater, activated sludge process, energy consumption, sustainability energy generation, secondary treatment, sludge utilization

ICWM-WWWT-30

Batch Studies on Removal of Pb²⁺ from Aqueous Solution using ZnO Nanoparticles as Sorbent

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Abstract: Contamination of groundwater by heavy metal, originating either from natural soil sources or from anthropogenic sources is a matter of paramount concern to the public well-being. Remediation of contaminated groundwater is of highest importance since billions of people all over the world use it for drinking purpose. Adsorption as the widely used method plays an important role in water & wastewater treatment, which is based on the physical interaction between metal ions and sorbents. In recent times, nanotechnology has been given great scope for the production of desirable nanomaterial with large surface-to-volume ratios and unique surface functionalities to treat these pollutants. In this study, production of Zinc Oxide nanoparticles at pre-determined reaction conditions was carried out using sol-gel technique. The present study was conducted to evaluate the feasibility & ability of these prepared nanoparticles to reduce Pb²⁺ in aqueous solution. The nature and morphology of adsorbent was characterized by XRD and SEM analysis. The XRD analysis revealed the procurement of nanoparticles effectively. The SEM results showed the diversified growths of morphologies on nano-scales. Batch experiments were performed to investigate the effects of variation of concentration of Pb²⁺, pH of solution and contact time on the removal efficiency. Batch experiments reported that ZnO nanoparticles presented an outstanding ability to remove Pb²⁺ due to high surface area and high inherent activity. The extent of Pb²⁺ reduction was increased with increasing the dosage of adsorbent and inversely with initial Pb²⁺ concentration as well as with decreasing pH. At optimum pH, Initial Pb²⁺ concentration of 10 mg/L & adsorbent dose of 2.5g/L removal of Pb²⁺ was found to be 91%. The high adsorption capacity of ZnO NP's suggests that it may be used as a suitable material for lead removal.

Key-words: Groundwater Removal, Pb²⁺, Zinc oxide, Nanoparticle, Adsorption



Removal of Arsenic Using Lemon Juice by Solar Oxidation Method

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Abstract: Arsenic contamination in groundwater in the Ganga and Brahmaputra fluvial plains in India, Uttar Pradesh (UP) situated in the upper and middle Ganga plain has an area and Arsenic contamination, considered so far endemic to the eastern part of Uttar Pradesh bordering Bihar. Its consequences to the human health have been reported as one of the world's biggest natural groundwater source calamities to the mankind. In India, seven states namely- Assam, Bihar, Jharkhand, Uttar Pradesh, West Bengal, in the flood plain of the Ganga River and Manipur in the flood plain of the Brahmaputra and Imphal rivers have so far been reported affected by Arsenic contamination in groundwater above the permissible limit of 10 µg/L. The permissible limit of As (arsenic) concentration in groundwater is 0.05 mg/l and the suggested the limit of arsenic in potable water has been lowered to 0.01mg/l by the BIS. Removal of Arsenic by Solar Oxidation and is a low-cost non-hazardous technique for the removal of As (arsenic) from groundwater. In this research, we tested the efficiency of natural citric acid sources extracted from lemon and alum to promote the technique for As removal at the household level. The experiment was done in the laboratory using both synthetic solutions prepared and natural groundwater samples collected from arsenic polluted areas in Uttar Pradesh. The role of molar ratios As to Fe and citrate doses on As removal efficiency were examined in synthetic samples. The results demonstrate that Lemon juice (as citric acid) was more efficient to remove As from both synthetic sample, the percentage of removal: (42.50–100%) and natural groundwater (80–95%) samples compared to alum (20% respectively) without using sunlight and lemon juice. The molar ratios As to Fe and the citrate dose display an 'optimized central tendency' on As removal. Anti-oxidants, e.g. 'hydroxycinnamates', found in lemon juice were shown to have a higher capacity to catalyze the removal of Arsenic by Solar Oxidation photochemical reactions compared to 'flavanones' found in other juice. The application of this method has several advantages, such as eco- and user- friendliness and efficient at the household level compared to other cheap techniques.

Key-words: Arsenic, Anti-oxidant activity, Citric acid, Groundwater, Solar oxidation

ICWM-WWWT-32

Sustainability Studies on Abrasive Water Jet Cutting Process

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Abstract: Sustainability is an increasingly important requirement for human activity, making sustainable development a key objective in human development. At its core, sustainable development is the view that social, economic and environmental concerns



should be addressed simultaneously and holistically in the development process. Sustainability has been applied to many fields, including engineering, manufacturing and design. Manufacturers are becoming increasingly concerned about the issue of sustainability. Appropriate trade-offs are often necessary, given the diverse interests of manufacturers and society. Relevant, meaningful, consistent and robust information on sustainable manufacturing must be available and utilized by organizations and their managers if sustainability is to improve in manufacturing. In this perspective an effort has been made by conducting experimental studies on waste water obtained by machining mild steel plate using abrasive water jet cutting machine to examine the traces of metallic bodies and their impact on the environment. Studies were also conducted to calculate the embodied product energy of the process. Results from the experiment confirmed the presence of metallic particles and proved the necessity of treating these particles.

Key-words: Sustainable manufacturing, Waste water treatment, Biodegradable organics, Suspended solids

ICWM-WWWT-33

Improving Industrial Water Use: Case Study for the Distillery in Karnataka

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Abstract: Effluent originating from distilleries known as spent wash leads to extensive soil and water pollution. Elimination of pollutants and colour from the spent wash, as mandated by law, is an extremely essential but awfully challenging process. In Karnataka there are about 40 distillery units, permitted by the Karnataka State Pollution Control Board, to operate. In the present study a detailed questionnaire has been prepared and data from each industry file has been compiled with respect to capacity, pollution control measures, including present status of pollution control equipment, comparing with stipulated norms. Due to the large volumes of effluent and presence of certain recalcitrant compounds, the treatment of this stream is rather challenging by conventional methods. Indian distilleries employ various types of primary, secondary and advanced treatments for spent wash. The typical treatment sequence is screening and equalization, followed by bio-methanation. Ferti-irrigation, bio-composting with sugarcane pressmud, and eventually Reverse Osmosis, Ultrafiltration, or Multiple Effect Evaporators are the some of the most widely used options. The land application of the spent wash is also being explored since the effluent, generally is free of toxic heavy metals and rich in nutrient concentration. In this article distillery processes, spent wash, and its treatment have been widely discussed.

Key-words: Distillery; Spent wash; Water use; Conservation; Wastewater; Recycling; Reuse



ICWM-WWWT-34

Treatment of Sugar Mill Wastewater using Hybrid Upflow Anaerobic Sludge Blanket Reactor

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Abstract: The performance of a lab-scale Hybrid reactor with Upflow Anaerobic Sludge Blanket was studied for the removal of organic matter from sugar mill wastewater. The working volume of the reactor was 1.1 litre. Polyvinyl chloride (PVC) rings were used which provided the advantage of fixed film system in addition to the sludge blanket. The reactor was operated at an HRT of 48 hours. The wastewater had an influent Chemical Oxygen Demand (COD) of 1792 mg/l. The ratio of influent Biochemical Oxygen Demand (BOD) to influent COD was 0.3. A COD removal efficiency of 85% was achieved after 55 days. The PVC rings provided a greater surface area for solid retention and the biofilm development aided in faster COD removal.

Key-words: Hybrid reactor, Upflow Anaerobic Sludge Blanket, Polyvinyl chloride rings, Chemical Oxygen Demand, Sugarmill wastewater.

ICWM-WWWT-35

Co-Treatment of Landfill Leachate and Municipal Wastewater by Combined Sequencing Batch Reactor (SBR) and Electro-Coagulation Process

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Abstract: Feasibility of combined sequencing batch reactor (SBR) and electro-coagulation process was assessed for co-treatment of landfill leachate and municipal wastewater. Chemical oxygen demand (COD), ammonia, nitrate, phosphate, turbidity and total suspended solids (TSS) removal were used to assess the combined process's treatment efficiency. SBR, one of the conventional treatment technologies, is a well defined process for municipal wastewater treatment while its co-treatment with landfill leachate is comparatively less investigated. In electro-coagulation process, metal ions produced during the reaction are subjected to fast hydrolysis by decomposing the electrodes. Products of hydrolysis neutralize the charge of the suspended particles, driving them to rapid coagulation and sedimentation process. In this study, a 3 L lab scale SBR was fabricated to be used as an initial step for co-treatment of 20% (v/v) of landfill leachate with municipal wastewater. SBR was operated in post-anoxic condition to achieve denitrification. SBR effluent was subjected to electro-coagulation treatment for increasing COD, TSS, turbidity and



nutrient removal efficiency. Aluminum plate was used as sacrificial anode and stainless steel plate was used as cathode at 5 cm spacing while DC current density was fixed at 257 A/m² during the electro-coagulation process. Results showed that SBR was effective to remove 64% COD, 82% ammonia, 73% nitrate, 54% phosphate and 72% TSS of the initial concentration whereas further treatment by electro-coagulation led to an overall 97% COD and 98% TSS reduction in 60 minutes of reaction. Electro-coagulation also led to maximum 99% ammonia, 99% nitrate and 97% phosphate removal along with 100% turbidity removal in 30 minutes of reaction. Except TSS the final effluent concentrations for all other parameters tested were within the Indian standards for discharge of treated wastewater in inland surface water. Overall results of coupled SBR and electro-coagulation process indicated that the process has potential for landfill leachate and municipal wastewater co-treatment. Further studies on HRT and OLR variations in SBR and variations in current density for electro-coagulation will help to optimize the co-treatment process.

Key-words: Landfill leachate, Municipal wastewater, SBR, Electro-coagulation

ICWM-WWWT-36

Adsorption of Cu(II) and Cr(III) by High Carbon Ferromanganese (H.C.Fe-Mn) in Aqueous Medium

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Abstract: The removal of toxic and heavy metals contaminant from waste water stream is one of the most important environmental issues. High carbon ferromanganese (H.C.Fe-Mn) was used as an adsorbent to remove Cu(II) and Cr(III) ions from aqueous medium. H.C.Fe-Mn was prepared as standard reference materials by CSIR – National Metallurgical Laboratory (Jamshedpur) and supplied as an adsorbent for this study. Batch adsorption experiments were conducted. The adsorption were studied on variation with adsorption dosage, contact time, mixing frequency, medium pH, initial adsorbate concentration in aqueous medium in detail for the remediation of Cu(II) and Cr(III) in aqueous medium. Experimental adsorption data were successfully modeled with modified and conventional Langmuir and Freundlich isotherm equations. Fe and Mn leaching from the adsorbent at lower pH was an issue which, however, could be satisfactorily addressed above pH 7.0. X-ray diffraction (XRD) techniques was applied for characterization of adsorbents. The study also inferred that H.C.Fe-Mn can be used as an adsorbent for removal of Cu(II) and Cr(III) ions.

Keywords: High carbon ferromanganese, Cu(II) and Cr(III), Aqueous medium, Adsorption.



Biosorption of Pb (II) by *Bacillus Badius* AK Strain Originating from Rotary Drum Compost of Water Hyacinth

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Abstract: Presence of heavy metals in the environment due to the industrial activities is of serious concern because of their toxic behaviour towards the humans and other forms of life. Biosorption of Pb (II) using dry bacterial biomass of *Bacillus badius* AK, previously isolated from water hyacinth compost has been undertaken in batch system. The optimum conditions of biosorption were determined by investigating the initial pH, contact time, initial biomass dosage at constant temperature of 40 °C, initial metal concentration of 100 mg/L and rotational speed of 150 rpm. The optimum pH was found to be 5 and equilibrium contact time was 2.5 h. The maximum biosorption capacities of Pb(II) on *Bacillus badius* AK was 138.88 mg/L at an initial concentration of 100 mg/L. Kinetics study revealed that the adsorption process followed pseudo second order rate kinetics. The experimental data was fitted to Langmuir isotherm. Characterisation of the biomass indicated the presence of several functional groups. The results indicated that the bacterium *Bacillus badius* AK is efficient for the removal of Pb(II).

Keywords: Biosorption, heavy metals, Langmuir isotherm, *Bacillus badius* AK

ICWM-WWWT-38

Water Footprint Reduction in Masonry Mortar Production Utilizing MBBR Assembly Treated Wastewater

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Abstract: Water footprint for masonry mortar is the quantity of fresh water required in preparation of mortar utilized in placing of bricks and plastering work in masonry constructions. Surface water and ground water are the only resources of water for masonry construction works which are adversely affected by fast growing infrastructure developments and it results in the depletion of fresh water resources. It may become more significant, especially in water deficient areas. To provide a sustainable solution, there is need to look for alternative sources of water. In present scenario, most of the treated waste water (TWW) is discharged in to natural water bodies and used for horticulture purposes, through proper assessment and management such discharge can be used in construction activities, such as, masonry constructions. However, composition of the TWW can affect the properties of mortar when used for mixing in mortar. This paper investigates the effect of using TWW on the properties of mortar. The sample of TWW was collected from a local domestic



waste water treatment plant in Jaipur. The waste water in the treatment plant is biologically treated by an assembly of moving bed bio-film reactor (MBBR) and filtered through dual media filter (DMF) and activated carbon filter (ACF) for maintaining high quality output water. The collected TWW sample and controlled potable (tap) water sample were analyzed for physical, chemical, and biological properties as per construction water quality requirements prescribed by Indian Standards. Fresh and mechanical tests were performed on mortar specimens. The results confirm that the type of water used for mixing did not affect mortar slump and final setting time. Cube compressive strength was also determined at 7 and 28 days of curing. Results indicated that the strength of mortar of the mixture prepared using TWW was comparable with the strength of the control mixture.

Key-words: Sustainable construction, Sustainable materials, Sustainable mortar, Resource efficiency, Water footprint, Recycled water, Wastewater utilization, Water scarcity, Sustainable development, Sustainable habitat.

ICWM-WWWT-39

Tertiary Treatment of Waste Water by using Algal Photobioreactor

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Abstract: Due to recent advances in illumination technology, artificially illuminated algal-bacterial photo bioreactors are now a potentially feasible option for simultaneous and comprehensive organic carbon and nutrients removal from secondary treated domestic sewage. The experiments described herein were designed to determine the extent of nutrient uptake in photo bioreactors through algal assimilation. Accordingly, quasi steady state data on algal photo bioreactor performance was obtained under 20 different conditions. Results indicated that irrespective of influent N and P levels, algal biomass recycling resulted in superior performance of algal photo bioreactors in terms of both N and P removals. Further, both N and P removals were positively related to the growth of algal biomass in the reactor. Conditions in the reactor favouring greater algal growth also resulted in greater N and P removals. N and P removals were adversely impacted in reactors with low algal concentrations due to the inability of the algae to grow fast enough under the conditions provided. Increasing algal concentrations in reactors over a certain threshold value through higher algal biomass recycling was also not fruitful, since algal growth slowed under such conditions due to reduced light availability due to algal 'self-shading'. It was concluded that N removals greater than 80% at high influent N concentrations is not possible with the present reactor configuration. Greater than 80% N removals may however be possible in similar reactors if higher light intensity is provided. High P removal is possible only if the influent N: P ratio in the reactor is aligned closely with the algal stoichiometric requirements for P.

Key-words: bioreactors, quasi steady state, self-shading.



Removal of Fluoride from Groundwater by Adsorption onto Brick Powder-Alum-Calcium Chloride Infused Adsorbent

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Abstract: Presence of fluoride in drinking water may be beneficial (1.0 – 1.5 mg/L) or detrimental (> 1.5 mg/L) depending on its concentration and total amount ingested. Consumption of fluoride at levels beyond those used in fluoridated water for a long period of time causes skeletal fluorosis. Several techniques like membrane filtration, precipitation, nanofiltration, ion-exchange, electrocoagulation flotation, and adsorption have been used for fluoride removal. Among all the methods, adsorption has been proven to be a low cost and effective process, and is applicable for the removal of fluoride even at low concentrations. Although various methods, materials and techniques are available for fluoride removal, but very little or none has find its place in the rural parts of the country due to (i) poor economic conditions of rural masses, (ii) non-availability of developed technologies, (iii) costly filtering media used, etc. Therefore, the need of the hour is to assess and improve low cost, socially acceptable, locally available adsorbents, to produce water of potable quality by removing fluoride from the drinking water. In the present study, removal of fluoride by adsorption onto BAC – an adsorbent made by infusing brick powder, alum and calcium chloride was carried out. Individually the three materials namely brick powder, alum and calcium chloride can take up fluoride or can destabilize fluoride in the water in the form of calcium fluoride, but in very low concentration and therefore these have been selected and fused together to enhance the overall fluoride removal capacity. Brick powder passing through 150 μm sieve and retained on 75 μm sieve is used, but calcium chloride and alum were used as purchased for the study. The three materials were taken in the ratio of 1:1:1, fused together with 20% conc. HCl, oven dried at 105°C for 24 hours. The material was then crushed and powder was kept in airtight container. Fluoride removal was evaluated through a series of batch experiments as a function of different parameters such as contact time, adsorbent dose and rpm. The impact of different experimental conditions such as solution pH, initial fluoride concentration, adsorbent dose, and contact time was well studied and optimized for the maximum fluoride removal from water. For initial fluoride concentration of 4 mg/L, an equilibrium time of 100 min. was observed at dose of 0.3 g of BAC at 280 rpm shaking speed. The experimental data were fitted by the Freundlich and Langmuir isotherm models and the related equilibrium constants were calculated. The results of the isotherm studies showed that fluoride removal by both adsorbents followed the Freundlich isotherm model. Kinetic studies were conducted and the results demonstrated that the experimental data were fitted well with the pseudo-second order kinetic model.

Key-words: Adsorption, Alum, Batch studies, Brick powder, Low cost.





Poster Presentation



Preparation & Characterization of Eco-Efficient Concrete Using Ceramic Waste

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Abstract: Recent decades have seen a marked increase in the worldwide industrial growth but every production system creates by-products and wastes which may affect the environment harmfully. Worldwide social concern has raised for waste management due to the growing quantity of industrial, construction and demolition waste. Ceramic waste may come from two sources- The first source is the ceramics industry, and this waste is classified as Non-hazardous industrial waste (NHIW). The second source of ceramic waste is associated with construction and demolition activity, and constitutes a significant fraction of Construction and demolition waste (CDW). The present investigation is based upon the possibilities to re-use these ceramic waste aggregates in the production of concrete without any pre-processing requirements so that it can be economically efficient and environment friendly. Different formulations were prepared replacing both the natural aggregate and cement usage with Ceramic waste coarse aggregates (CWCA) and fine powder due to their mechanical and pozzolanic properties. After the preparation, Ceramic waste composed concrete samples were tested and compared with the conventional standard concrete for their characterization in physical and mechanical terms. These tests were carried out for 7, 14 and 28 days. A small gain in compressive strength has been observed while increasing the amount of ceramic waste up to a maximum limit of 25%. In addition to help protecting the environment, use of such waste offers a series of advantages such as a reduction in the use of other raw materials, also including benefits in terms of energy, primarily when the waste is from kiln industries (ceramics industry).

Key-words: Re-use, Ceramic waste, Concrete, Eco-efficient, Environment friendly.

Histological Responses and Metal Sequestering Potential of Eisenia Fetida when Exposed to Heavy Metal Contaminated Solid Waste: A Fluorescence Probe Based Study

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Abstract: Rapid industrialization and population explosion has led to the generation of tonnes of solid waste thereby releasing a significant source of metals into the environment. To explore more about the metal detoxification and accumulation potential of earthworm species metal rich municipal solid waste (MSW) were fed to Eisenia fetida and various metal fractions were studied. Compost and biocompost



samples were obtained periodically to determine various quality parameters. Fascinatingly, ample amount of toxic metals were observed to be transformed from exchangeable to recalcitrant (organic matter and mineral bound) fractions. This indicates that the ingestion of metals bound to solid waste components is likely to be a more important uptake route than the dermal uptake of dissolved ions for metals entering the body tissue of earthworms. Hence, ion-induced, metal impregnated fluorescence chemosensors were used to investigate the synthesis of protein-metal complexes in earthworm intestines and navigate the biological process. Interestingly, the earthworms were observed to synthesize a distinct metal binding high molecular weight gut protein more than 100KDa molecular mass when fluorescence-probe Cd and Zn were fed up with cow dung (CD) and MSW. Inspiringly, in supplement to these findings, histological analysis have also shown transparent exposure of Cd and Zn in the chlorocogenous tissue of the earthworm (*Eisenia fetida*) body.

Key-words: Solid waste, *Eisenia fetida*, Heavy metal accumulation, Fluorescence chemosensors.

ICWM-PP-03

Municipal Solid Waste Management in Bhubaneswar: Practices and Challenges

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Abstract: India, the second most populous country in the world, is classified as a newly industrialised country. Over the past two to three decades, industrialization and economic development have caused a tremendous increase in solid waste generation. Rapid economic development and population growth, inadequate infrastructure and expertise, and land scarcity make the management of municipal solid waste become one of India's most critical environmental issues. Improper management of municipal solid waste causes hazards to inhabitants. In present day, management of such wastes is very necessary for a healthy and safe living. In India, solid waste management is taken care by the municipal corporations, municipalities and other local bodies. The main aim of this study is to assess the solid waste management in Bhubaneswar, one of the planned cities of India. Bhubaneswar, being a well-planned city, has an inefficient, outdated and unscientific waste management system. The waste generated per day is about 300-350 tons and collection and disposal is taken care by the municipal corporation. Each ward has its own dumping site, which has its own pros and cons and some private agencies are also given the responsibility of collecting and disposal of wastes. The budget allocation is also insufficient for management of solid wastes is also less comparatively. An attempt to explore the problems of inefficacy has been represented in this paper.

Key-words: Municipal solid waste, collection efficiency, disposal.



Anaerobic Digestion of Kitchen Waste

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Abstract: Worldwide increase in population is generating large amount of kitchen wastes. Kitchen waste from household usually contains high levels of organic matter, moisture and nutrients that make the waste unsuitable for disposal in municipal landfills. Kitchen waste comprises of vegetable, cooked food and fruit waste which are easily biodegradable. These wastes require to be managed in a sustainable way to minimize the risk of human and animal health, reduce the environmental impact, balance the eco-system and moreover use it as an alternating source of energy. This review focuses on anaerobic digestion, the process where microorganisms break down biodegradable material in the absence of oxygen, generating biogas using kitchen waste as substrate and cow dung as inoculum. In aerobic digestion F/M ratio plays an important role for maximum biogas production. Kitchen waste collected is mixed in different proportions with inoculum to know their bio-methane potential. Anaerobic digestion is a well-known and broadly accepted methodology for converting kitchen wastes into biogas which will meet the world's ever-increasing energy requirements in the future.

Key-words: Anaerobic digestion, kitchen waste, Food to Mass ratio, Bio-methane potential

Recycling of Municipal Solid Waste: a Case Study in Guwahati City

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Abstract: In the modern era, as a result of unplanned development and population explosion the waste production becomes uncontrollable. Due to vast quantity of waste generation and scarcity of disposal sites, an efficient municipal solid waste management system becomes obligatory. In this scenario, Recycling stands as an effective method to minimize the quantity of waste being disposed. Recycling is the process of converting waste materials into reusable products, to prevent the waste of potentially useful materials. A recyclable material in it's a raw form can be used to create a new or different product. These efforts significantly reduces additional waste that will not only harm the planet today, but future generation as well. In this paper, we have briefly mentioned the history of recycling and the current industrial practices. Site visits were conducted to various recycling centers including CIPATE. Presently India is generating about 960 million tonnes of solid waste annually as by-products during industrial, mining, municipal, agricultural and other



processes. Managing of these much amount of waste is economically and socially very difficult in developing country like India. So the best option is Reduce, Reuse and Recycle the wastes.

Key-words: recycling, municipal solid waste, Guwahati

ICWM-PP-06

E- Waste Management and Recycling in India

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Abstract: Electronic waste or e-waste is one of the rapidly growing problems of the world. E-waste is a popular and informal name for electronic products which have completed their useful life. Discarded computers, televisions, VCRs, stereos, copiers, fax machines, electric lamps, cell phones, audio equipments, batteries etc are some examples of e-waste. This waste also includes non biodegradable plastics which possess serious threat to the environment. Basel Action Network estimates that the 500 million computers in the world contains about 2.87 billions kgs of plastics, 717.67 kgs of lead and 286700 kgs of mercury. A single 14 inch monitor contains about 2.5-4.0 kgs of lead. This may have a drastic effect on the environment, if left untreated. In India, e-waste management assumes greater significance not only due to the generation of its own waste but also due to the dumping of e-wastes by the developed countries. Many of these products can be recycled, reused in an eco-friendly manner. A comprehensive methodology that provides e-wastes regulation, management and proper disposal as well as recycling techniques is the need of the hour. This paper highlights the hazards of e-waste, their effects and the various recycling methods to get rid of them in context of Indian scenario. The proper handling methods of harmful, toxic materials produced from e-waste are also focused in the paper.

Key-words: E Waste, biodegradable, Non biodegradable, recycled

ICWM-PP-07

Beneficial Conversion of Domestic Bio-waste

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Abstract: Rapid urbanization has led to the steady increase of waste generation in the recent years and it is a major issue due to poor management system of municipal solid waste. From survey reports, we came to conclude that 50% of solid waste is generated from domestic sources. All households produce kitchen waste at some level which includes peels and remains of fruits, vegetables, bone, meat etc. and is rising at an alarming rate. The current practice of disposing kitchen waste at landfills is not sustainable and environmentally undesirable as there is limited landfill space, creates odour nuisance, generates leachate and landfill gases that require further mitigation



measures to deal with, and squanders the useful organic contents. Therefore an effort has been made here to utilize domestic bio-waste for the production of some useful material. Based on the study conducted in IIT Guwahati, the wastes found from hostels were mostly kitchen wastes, which include peels and remains of fruits, vegetables, egg shells etc. It was observed that the waste generated from the IIT Guwahati campus were collected by the municipality workers and unloaded in the dump site without processing. Experiments were carried out separately on orange peels, egg shells, rotten part of potato and onion peels. In our present study, we extracted the essence of orange peels and used it as room freshener; starch from rotten potato; calcium carbonate from eggshell and dye prepared from onions peels. The experimental procedures are cost effective and eco-friendly because these processes are done without using chemical or required less chemical. The present work was carried out at laboratory scale. It may be advantageous to encourage the researchers to work towards further improvement of the present study.

Key-words: kitchen waste, landfills, bio-waste, leachate

ICWM-PP-08

Investigation and Characterization of Solid Waste Disposal Site and its Impact on Soil and Water in Selected Taluks of Hassan District, Karnataka

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Abstract: In order to study the solid waste disposal and its impact on soil and water, the study was made for 4 taluks (Belur, Alur, Sakleshpura and Hollenarsipura) of Hassan district, Karnataka. Questionnaire for study was prepared by the help of experts, scientists, lecturers in the field of solid waste management. The investigation and characterization of solid waste disposal site and its impact on soil and water in Hassan district is made to check the contamination of ground water and soil at the dumpsite. The tests conducted for water samples of locations nearer to dumpsite were carried out as per test procedure given by AWWA manual. The results were compared with IS 10500-1991. The technical and general information on waste management was collected by the respective taluk municipal office. Using total station the existing profile of the dumping was prepared. The experimental results were compared with the IS standard values and the values obtained were within desirable limits. Only in one taluk (Arsikere) the fluoride content was more than permissible limit, however this was not due to the impact of solid waste this was due to the geographical features as it prevails in Arsikere taluk.

Key-words: Solid waste, Dumping site, Ground water, Waste management, Hassan district



ICWM-PP-09

Assessment of Bio-Medical Waste Management in Different Hospitals in Aligarh City

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Abstract: This study reveals that most of the hospitals are lacking bio-medical waste management system. Most of the hospitals do not properly segregate the waste no treatment and no proper disposal of the bio-medical waste. Hospital should have vigilance cells especially to monitor the handling and treatment of the waste but not working well. Waste should be segregated and treated as bio-medical waste management and handling rules, 1998. A series of programs should be organized for general public awareness and to make the employee of the health care facilities aware in the handling and management of bio-medical waste. It is observed that most of the hospitals have no management system in place. The hospital does not give priority to the proper disposal of the waste. There are several methods of disposal of medical waste are burning, burial, selling, dumping, reuse and removed by municipal trucks without any treatment. On the basis of data collection, it can be assessed that total quantity of biomedical waste generation in Jawaharlal Nehru medical college and other hospitals in Aligarh is about 750-850 kg/day.

Key-words: Hospitals, Bio-Medical Waste, Waste management

ICWM-PP-10

Nutritional Parameteric Study of Vermicompost Produced by Piggery Waste

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Abstract: Management of solid waste has become one of the biggest problems that the whole world is facing now a day. The degradable solid waste can be managed by composting. The easiest and traditional way is to compost using earthworms, which can also be called as vermicomposting. It not only conditions the soil but also serve as environment friendly and cost effective technique for solid waste management as easy and cheap availability of earthworms. Along with the waste generated by human beings, waste generated by animals is also an issue of waste management. In northeast region of India piggery waste has been generated in huge amount and difficult to manage. To manage such kind of waste some try is being made to convert the waste into a useful product. In this paper the study of nutritional parameters (N, P, K) of vermicomposting of piggery waste has been done. Vermicomposting produced by pig dung with combination of pig & cow dung using a mixed culture of earthworms like Eisenia foetida, Eudrilus eugeniae, Perionyx ceylanesis has been studied for its N, P, K values.

Key-words: Piggery Waste, Vermicomposting, NPK



ICWM-PP-11

Effective Use of Natural Coagulant with Chemical Coagulant in Turbidity Removal

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Abstract: Water is indispensable component for human kinds for their healthy lives. Turbidity imparts vital problem in direct use of water from natural resource. So we use many coagulants in treatment of raw water but in the convention method of treatment we are using chemical coagulant for turbidity removal. Due to use of chemical coagulant like alum we are facing many hazardous diseases like Alzheimer. So in this study an attempt has been made that use of natural coagulant like tamarind seed has a better removal of turbidity. It was found that its efficiency is 77% in turbidity removal. The analysis is carried out on two sample. One is lake water and other is on synthetic water. In this optimum ratio of alum and tamarind seed was found. For this different ratio of tamarind seed with alum were used and it shows that better efficiency with respect to cost of coagulant and turbidity removal. It also help in reduction of the effects of the chemical coagulant on people. Use of locally available coagulants was found cost effective, easy to use and eco-friendly for water treatment.

Key-words: Coagulation, turbidity, Tamarind seeds, Natural Coagulant, Raw water.

ICWM-PP-12

Medical Waste Management with Case Study

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Abstract: The main purpose of this study is to give view of Medical waste management and their consequences in environment. The objective of this study is to analyze health care management system including practices and compliances. There are many institution which pollute the environment but recently the ignored field which produce pollution by the way of hospital wastes and attracts the attention of environmentalists are the hospitals, dispensaries, medical stores, medical clinics of doctors and other paramedical staff. Most of the countries, especially developing countries, are facing grim situation arising out of environmental pollution due to pathological waste arising from increasing population and the consequent rapid growth in number of hospital units. In India, there are about 6 lakhs hospital beds, over 23k primary health care centers, more than 15k small and private hospitals. In India, The Biomedical Waste Rule, 1998(management & handling) makes it mandatory for hospitals, clinics, and other medical and veterinary institutes to dispose bio medical waste strictly according to the rules. Our area of study is major hospitals of Guwahati including Sanjeevani hospital, IITG hospital and Guwahati Medical College. The mode of study is case study to have a view of disposal mechanism is



being followed by these institutes. Safe handling, segregation, storage, subsequent destruction and disposal of hospital waste ensure mitigation and, minimization of concerned health risk involved through contact with the potentially hazardous material, and also in prevention of environmental contamination. Mismanagement of health care waste disposal causes dangerous infections and poses a potential threat to surrounding environment, persons handling it and to the public. In the past, medical waste was often used to mix with household waste and disposed of in municipal solid waste landfills. In recent years, increased public concern over improper disposal of health care waste have led to a movement to regulate the waste more systematically and stringently.

Key-words: hospital waste, health care waste, pathological waste, Bio-medical waste rule,1998

ICWM-PP-13

Waste Water as Feedstock for Production of Biodegradable Plastic

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Abstract: The concern regarding non-biodegradable material had been ever growing in the public domain especially in the case of petroleum derived plastics as these plastic are derived from a depleting hydrocarbon source. To combat this issue, biodegradable plastic from various renewable sources is considered to be a viable solution. Microbial derived biodegradable polymers using waste water as feedstock are an alternative and sustainable replacement of petroleum derived polymers. These are linear polyester compounds called Poly-Hydroxy Alconates (PHA) having similar properties to polypropylene and polyethylene. Bioplastics are expensive as compared to petroleum derived plastic owing to high operational cost, cost of carbon source and downstream processing. Several methods have been investigated for PHA production. Aerobic Dynamic Feeding (ADF) is a potential method among them that requires non-sterile condition, lesser process control and has higher productivity being aerobic process. ADF uses alternating feed/fast regime to enrich the Mix Microbial Community (MMC) present in activated sludge with PHA accumulators. The process utilizes pretreated waste water with high Volatile Fatty Acid (VFA) content. The enriched culture in pretreated waste water is used for batch/fed batch production under nutrient limitation. By this process activated sludge is enriched with PHA accumulators having these lipophilic inclusions that can be visualized by suitable dye which can be then extracted, characterized and concentrated. Highly enriched and acclimatized MMC after several cycle of operation can provide high yield of PHA. Properties of PHA depend on the composition of monomers which in turn depends on the type of VFA present in the culture medium. The type of VFA produced and accumulated can be regulated during pretreatment of waste water. This process enables bioplastic production with simultaneous treatment of waste water. Some products like biosurfactants, biohydrogen, biomethane can also be derived through this process further reducing the cost of production. This review deals with the cost



effective way to produce bioplastic using MMC from waste water that is applicable at industrial level.

Key-words: PHA, ADF, MMC, VFA, Wastewater.

ICWM-PP-14

Aerobic Granulation: An Encouraging Environmental Technology for Wastewater Treatment

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Abstract: Aerobic granules are the microbial aggregates contain millions of organisms per gram of biomass with a regular round shape, a distinct outline and a compact structure formed via self-immobilization process under aerobic condition by applying controlled loading and operating conditions. The formation, structure and development of aerobic granular sludge were influenced by several factors such as substrate composition, organic loading, hydrodynamic shear force, settling time, hydraulic retention time, aerobic starvation, presence of ion in feed, seed sludge and reactor configuration etc. Aerobic granulation has become an emerging approach to biological wastewater treatment because of several advantages over conventional treatment systems. Various industrial wastewaters have been treated by using the aerobic granulation technology such as dairy, brewery, slaughterhouse papermaking and petrochemical wastewater etc. This paper describes a review on factors affecting aerobic granulation, granule characteristics, granule formation and their stability. The applications of aerobic granules for treating toxic industrial wastewaters are also covered. This study attempts to focus on the fundamentals and applications of aerobic granulation technology in wastewater treatment.

Key-words: Aerobic granulation, Selfimmobilization, Hydrodynamic shear force, aerobic starvation, Granule characteristics, Stability.

ICWM-PP-15

Anoxic Treatment of Petroleum Refinery Wastewater: A Review

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Abstract: Aqueous effluents from petroleum refineries generated by different intra-industrial processes, contain a diverse range of pollutants including oil, phenolics, sulphides, ammonia, dissolved solids, suspended solids, toxic metals and BOD exerting biodegradable organics. Biological treatment is the most inexpensive one to convert several toxic pollutants from toxic form to non-toxic form by microbial action. However, refinery wastewater as a combination toxic multi pollutants makes the whole treatment process difficult and challenging. Aerobic reactors can be employed for the treatment of organic compounds in a very efficient way but the volatile properties of the compounds (sulphide, BTEX, diesel) in refinery wastewater leads to their escape prior to biodegradation and hence polluting the surrounding air.



Anaerobic reactors are not able to treat the petroleum hydrocarbon to the desired discharge limits and also needs longer hydraulic retention time and anaerobic biomass is sensitive to sulphide toxicity. A recent technology includes the treatment of petroleum refinery wastewater with nitrate or nitrite as electron acceptor (anoxic condition) maintained in anaerobic environment can achieve similar efficiency as those of aerobic processes. Abiotic losses of the volatile compounds can be avoided and release of nitrogen gas as by product of denitrification can be suitably utilized by these processes.

Key-words: Anoxic, Denitrification, Refinery wastewater, Sulphide, Diesel, Nitrate.

ICWM-PP-16

Application of Receptor Models for Source Apportionment

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Abstract: Air quality monitoring, identification of pollution sources and their quantification needed to implement air pollution control strategies. Air quality is a serious concern for India and become one of the most important problems of megacities and has serious impacts on public health, visibility, and can cause heat island effects on the urban scale. Most of the urban city of India has high concentrations of airborne particulate matter therefore; application of effective abatement measures is a high urgency. This case study is reviewing the application of receptor models for source apportionment. Previous studies applied multivariate receptor models including principal components analysis (PCA), chemical mass balance (CMB), positive matrix factorization (PMF), and back trajectory receptor models for source apportionment. This comprehensive review study found that interpretation of the multivariate model output to sources found subjective and challenging. The many studies were revealing a very wide range of conclusions, even for the same city. These deviations may be the result of using different sampling locations and/or seasons, but to a large extent differences probably arise from methodological weaknesses. The assignment of factors from multivariate receptor models to specific source categories is in many cases highly uncertain, this uncertainty in terms of presence of tracer elements may be the result of genuine collinearity of diverse sources, or more probably arises from methodological problems. The proper markers for wide range of source are still required to remove the ambiguity in source interpretation. Implications: This review focuses on receptor-based source apportionment methods for particulate (PM) pollution. Efforts have been made from the many years to use air quality data to estimate the influence of air pollution sources. These methods are now relatively mature and many are readily accessible through openly available software. This article reviewed the development of receptor models and the current state of the art in extracting source identification and apportionments from ambient air quality data.

Key-words: air quality, source apportionment, multivariate receptor model.



Utilization of Agricultural Waste as Potential Adsorbent for Water Treatment

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Abstract: In today's world, day by day agricultural waste is increasing tremendously. Pearl millet husk is commonly found agricultural waste. Recent studies have shown that pearl millet husk can be used for water filtration because of its significantly good adsorption quality. In the present study pearl millet husk has been used as filter media for making of low cost water filter for the domestic use. The analyses are carried out on two variants of media i.e. the naturally available pearl millet husk and the chemically modified pearl millet husk. The effective sizes of both variants of filter media are kept same for the analysis. The results of analyses are different for both the variants of filter media used. The naturally available husk shows a turbid, odorous and little yellowish filtrate, but was helpful in making the raw water in moderate pH range. Whereas the chemically modified pearl millet husk improves the adsorbent capacity of the filter. Further the water which passes the chemically modified filter media was considerably good in keeping the odor, color and turbidity with in permissible range, which in conjunction with reduction of other physical and chemical perimeter was helpful in increasing the efficiency of filter.

Key-words: Pearl millet husk, filter media, turbid, yellowish filtrate.

ICWM-PP-18

Immobilized Sulfate Reducing Bacteria for Heavy Metal Removal from Wastewater

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Abstract: The contemporary approach for the elimination of heavy metals from wastewater relies primarily on the use of microorganisms. Sulfate reduction aided by sulfate reducing bacteria (SRB) enables the recovery of metals as sulfides in treating the metal containing wastewater. This study was aimed at evaluating the potential of sodium alginate immobilized SRB for heavy metal removal under sulfate reducing condition. The immobilized SRB beads showed complete removal of metals at a low initial concentration and showed better tolerance to metals even at a high initial concentration compared to the metal removal by freely suspended SRB biomass. The metal removal followed the order: Cu > Fe > Pb > Cd > Zn > Ni. The activity of SRB was not inhibited by high metal concentration except that high metal concentration



resulted in extended lag periods of the SRB activity for sulfate and chemical oxygen demand (COD) reduction. Immobilized SRB beads were further characterized using field emission scanning electron microscopy (FESEM) equipped with energy dispersive X-ray spectroscopy (EDX). The results confirmed that the metal precipitates were confined to the exterior surface of the beads and the precipitates formed during the process consist of mainly the metal sulfides.

Key-words: Sulfate reducing bacteria, wastewater, immobilization, metal sulfide precipitation, heavy metals

ICWM-PP-19

Nanoparticle Mediated Enhanced Biological Carbon Monoxide Conversion Using Anaerobic Microbial Consortia

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Abstract: Carbon monoxide is emitted in large amount by incomplete combustion of fossil fuels during domestic and industrial processes. For example blast furnace gas contains 25% (v/v) CO, whereas automobile exhaust gas contains CO in the range 0.5 to 12%. CO can also be utilized for producing a wide range of products, such as ethanol, butanol, acetic acid, hydrogen, etc. Though, the conventional thermo-catalytic processes mainly the Fischer-Tropsch synthesis, water gas shift reaction, methanol carbonylation can be used. These methods have their own disadvantages, such as very high operating cost, restricted choice of metallic catalyst, perishable nature of the catalyst, high energy requirement, etc. From an environmental and economical point of view biological CO conversion methods are of great interest. In the previous study, a mesophilic hydrogenogenic carboxydrotrophic anaerobic sludge biomass isolated from upflow anaerobic sludge blanket reactor treating sewage was successfully used for simultaneous CO conversion and biological sulphate reduction. In this study in order to improve the CO solubility in aqueous phase and enhance the gas liquid mass transfer coefficient, biologically reduced iron nano particles were used. The results showed that even at low concentration of 0.2% (w/v) the nanoparticles were able to enhance CO solubility by 41%. The hydrogen as a product of CO conversion was also increased considerably. The enhancement of CO solubility was attributed to grazing effect, in which smaller particles transport additional amount of gas to the liquid bulk through adsorption in the gas-liquid diffusion interface layer and desorption in the liquid. For a better application potential of these nanoparticle in CO bioconversion, further research aimed at optimizing various parameters and reactor experiments currently underway.

Key-words: Carbon monoxide conversion. iron nanoparticle, biohydrogen production, waste gas treatment, carboxydrotrophic bacteria.



Analysis and Design of an Institutional Wastewater Management Scheme

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Abstract: Environmental pollution has become a burning issue in today's world. Water is becoming a rare commodity and many believe that future wars might be for drinking water. Recycling and recovering of waste water becomes very important, especially in urban localities. Like many educational / research institutions, IIT Delhi also generates both domestic waste water and laboratory waste waters. Laboratory waste waters contain different chemicals used in the various laboratories of the Institute. Presently both kinds of waste waters are getting mixed up and this mixed waste water is going to the municipal sewerage system. With a view to treat and recover water from the sewage, IIT Delhi is planning to separate these two waste waters and construct a STP for its sewage and another ETP for its laboratory waste water. This paper describes the details of the analysis carried out recently on the waste waters and present a design for the STP based on Sequencing Batch Reactor (SBR) concept.

Key-words: Sewage treatment plant(STP), Sequencing batch reactor(SBR), Design.

ICWM-PP-21

Fungal Chitosan Production Using Kraft Black Liquor as the Feedstock

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Abstract: Chitin is a homopolymer of N-acetyl glucosamine. Chitosan is a deacetylated derivative of chitin which plays a structural role in crustacean carapaces and insect shells. Several fungal species have chitin and chitosan as principal components of their cell wall. Chitosan extraction from fungal sources required milder physicochemical treatment as compared to commercial chitosan extracted from marine sources, thereby making this process environment friendly. In this study, fungal chitosan production using abundantly available kraft black liquor (KBL) as carbon source was studied. Three strains of fungi, namely, *Aspergillus niger*, *Absidia glauca* and *Cunninghamella elegans* lendner were first screened for chitosan production by growing on Potato Dextrose Broth (PDB). Prior to the experiment, kraft black liquor was obtained from local paper and pulp mill having chemical oxygen demand (COD) of 90 g/L (maximum) and delignified by acid precipitation for use as fermentation medium. Both *A. glauca* and *C. elegans* showed comparable chitosan yields with degree of acetylation (DAC) 3.11% and 4.34% respectively. *A. glauca* was further chosen for nitrogen source optimization in the kraft black liquor based medium. A total of ten nitrogen sources (five organic and five inorganic sources) have been explored for chitosan production in this study, with organic sources showing better chitosan yield as compared to inorganic sources.

Key-words: chitosan, kraft black liquor, fermentation, waste feedstock.



ICWM-PP-22

Chitosan Production by *Aspergillus Niger* Using Cheaply Available Domestic Wastewater

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Abstract: Marine sources have been extensively explored for the production of chitosan. However, limited availability as well as the variation in the properties of the derived chitosan is a serious drawback for utilizing marine sources for chitosan production. Fungal sources are therefore gaining more focus as an alternative to the production of chitosan derived from crustacean wastes. Also, inexpensive feedstock for the fungal chitosan extraction helps keep the process economically viable. Hence, in this study domestic wastewater was tested as a cheap substrate for fungal chitosan production due to its abundant availability and the presence of simple sugars. First, three different strains of fungi, viz. *Aspergillus niger*, *Cunninghamella elegans* and *Absidia glauca*, were screened for chitosan production from domestic wastewater with or without supplementation of mineral salts. Among the three strains, *A. niger*, yielded a maximum chitosan production of 35 mg/L and maximum COD removal of 50-60% within 24 hours. A higher chitosan yield was however obtained when the experiments were carried out under agitated conditions than under stationary conditions. The degree of deacetylation of chitosan obtained was 72%. These results indicate a very good potential of *A. niger* for chitosan production from cheap and abundantly available domestic wastewater.

Key-words: Chitosan production, Domestic Wastewater, *Aspergillus niger*, *Cunninghamella elegans*, *Absidia glauca*, fungal fermentation

ICWM-PP-23

Analysis of PM10 Concentration inside a College Campus

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Abstract: Indoor air pollution represents the most important health risk factor after malnutrition, unsafe sex, and unsafe drinking water and sanitation in the developing world (WHO 2009). Indoor air quality refers to the quality of air in and around the buildings, which directly affects the health of the occupants. Since women and children spend most of their time indoors, it's very much important that the indoor air quality is within the standards set by the regulatory agencies. Pollutants present in indoor air are particulate matter, volatile organic matter, carbon monoxide, polyaromatic hydrocarbons, among many. In addition to transfer of air pollutants from outdoor, the main sources of indoor air pollution include cooking, smoking, building and furniture finishing, and construction activities. The pollutants from construction



activities mainly include suspended particulate matter which when inhaled leads to various respiratory diseases like asthma and chronic bronchitis (Samet, Dominici et al. 2000, Brunekreef and Holgate 2002, Pope and Dockery 2006). IIT Guwahati is one of the premier institutes of the country; due to increasing student rolls in its campus the administration have started many new projects inside the campus. It includes new hostels, labs and other necessary extensions. Lohit hostel is one of the new hostels under construction, when fully completed it is expected to have 6 blocks in total making it the largest hostel in Asia. The students in Lohit hostel were allotted rooms as and when the blocks were completed, meanwhile the construction of other blocks were still in progress. Extension of Chemical engineering department is also in progress to add another storey to the already existing structure. The faculty members and students worked in the subsequent floors while construction work was carried on. Experiments were carried out in the hostel mess and room, chemical engineering lab, faculty quarter and IIT main entrance gate to measure the inhalable fraction of particulate matter with maximum aerodynamic diameter of 10 micro meters, PM₁₀. Average concentration of PM₁₀ was found to be 680.84 ($\mu\text{g}/\text{m}^3$) in Lohit hostel mess, 85.5 ($\mu\text{g}/\text{m}^3$) in a room in Lohit hostel, 142.0 ($\mu\text{g}/\text{m}^3$) in Chemical engineering lab, 103.4 ($\mu\text{g}/\text{m}^3$) in a room in faculty quarter and 120.2 ($\mu\text{g}/\text{m}^3$) in IIT main entrance gate. The experiments were conducted at different times of the year: Lohit hostel mess in March, Lohit hostel room, Chemical engineering lab, Faculty quarters and IIT main entrance gate in December. Barring PM₁₀ concentration of a room at Lohit hostel, concentrations at other sites were found to be above satisfactory level of 100 ($\mu\text{g}/\text{m}^3$) as mentioned by CPCB (CPCB, 2014). This study deals with the analysis of PM₁₀ concentration inside IIT Guwahati campus, its variation and possible sources.

Key-words: Indoor air pollution, Construction activities, PM₁₀ Concentration

ICWM-PP-24

Anthracene Biodegradation by *Bacillus Pumilus* Strain KPLG Isolated from Biomass Gasification Effluent

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Abstract: Biomass gasification effluent primarily consists of polycyclic aromatic hydrocarbons (PAHs). The toxicity, mutagenicity and carcinogenicity imposed by PAHs require necessary treatment prior to its discharge into the environment. PAHs degradation has been well reported for actinomycetes, such as, *Rhodococcus* and



Mycobacterium. This study examined anthracene biodegradation, a model low molecular weight (LMW) PAH compound by *Bacillus pumilus* strain isolated from biomass gasification effluent. Specific biomass growth rate (μ) in the range of 0.094–0.0215 h⁻¹ could be achieved over the initial anthracene concentration range 50–500 mg L⁻¹ were tested in this study. 10% (v/v) inoculum size showed more positive effect than 5% (v/v) inoculum size on anthracene biodegradation efficiency by *B. pumilus*. Overall, this study revealed a very good potential of the bacterium for treating PAH containing wastewater.

Key-words: Biomass gasification effluent, polycyclic aromatic hydrocarbons, anthracene degradation, *Bacillus pumilus*

ICWM-PP-25

Batch Biodegradation of PAHs in Mixed Pollutant System Using Oleaginous *Rhodococcus Opacus*

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Abstract: Naphthalene, phenanthrene and fluoranthene (low molecular weight polycyclic aromatic hydrocarbons) are enlisted as the primary pollutants by US Environmental Protection Agency. There is no detailed investigation carried out so far on the biodegradation of these compounds in mixed pollutants system. Therefore, this study examined the simultaneous biodegradation of these model pollutants along with lipid accumulation by *Rhodococcus opacus* in batch shake flasks. A 23 full factorial experimental design was employed with these three pollutants at two different initial concentration levels, i.e., 50 and 200 mg L⁻¹. PAHs biodegradation by *R. opacus* decreased, in general, with an increase in their initial concentration in the mixture. The biomass growth followed a tri-auxic growth profile in comparison to the individual PAH containing system, which was well fitted accurately the Haldane kinetics model. In addition, the removal of chemical oxygen demand, PAHs biodegradation rate, biomass growth and lipid accumulation by *R. opacus* were examined in detail. Furthermore, the intermediates formed during the PAHs biodegradation were analyzed using gas chromatography-mass spectrometry (GC-MS).

Key-words: Biodegradation, polycyclic aromatic hydrocarbons, mixture biodegradation study, *Rhodococcus opacus*, lipid accumulation.



ICWM-PP-26

Bio-Inspired Facile and Green Synthesis of Au@Ag@AgCl Nanoparticles using Benincasa Hispida Peel Extract and their Photocatalytic Activity for the Removal of Toxic Dye Under Solar Irradiation

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Abstract: This study reports a green process for the fabrication of Au@Ag@AgCl (Gold@silver@silver chloride) nanoparticles was synthesized by using using Benincasa hispida (ash gourd) peel extract without using any external reagents and external halide. The phytochemicals present in the peel extract were responsible for the formation of the nanoparticles. The starting materials were of AR grade Silver nitrate (AgNO₃), Hydrogen tetrachloroaurate monohydrate (HAuCl₄.3H₂O) and Malachite green oxalate (MGO) was purchased from Sigma– Aldrich Silchar. All solutions were prepared in double-distilled water and all apparatus were rinsed with aqua regia (3:1 solution of HCl: HNO₃) and then washed with double-distilled water before use. The biosynthesis of Au@Ag@AgCl nanoparticles were synthesized by using 20 ml 10% Benincasa hispida peel extract with HAuCl₄.3H₂O: Ag NO₃ (1:1 ratio) by heating at 70°C for 20 minutes. The solution was then allowed to stabilize for 1 days. After 1 days, the solutions were centrifuged, filtered and the residues were washed several times with double distilled water to remove unbound polymers. The synthesized nanoparticles were characterized by using UV-spectroscopy, FTIR, XRD, TEM and EDX analysis. The degradation of toxic dye like malachite green oxalate (MGO) in aqueous solution was also investigated by Au@Ag@AgCl nanoparticles as a photocatalysis under solar irradiation. Emphasis was given on the effect of operating parameter on the degradation effectiveness, such as catalyst loading (.05 - .1 mg/L). Optimum loading amount of the catalyst was found as 0.08g. The plausible degradation mechanism, photolysis products of under solar irradiation were also reported in this study. It was observed that 98% of the MGO was degraded using Au@Ag@AgCl NPs as a photo catalyst.. The photodegradation of MGO dye followed the pseudo-first order reaction and its kinetics rate constant (k) was found to be 3.7×10⁻² min⁻¹. For the best known of the authors, it was the first time, we report the synthesis of Au@Ag@AgCl using Benincasa hispida peel extract and the photo degradation MGO using Au@Ag@AgCl as a photo catalyst. The reactive species, such as .O₂- and ClO are mainly responsible for the degradation of MGO under solar irradiation.

Key-words: Au@Ag@AgCl, biomaterials, nanostructures, toxic dye , Photodegradation.



Regeneration and Reuse of Tradescantia Pallida Biomass for Cr (VI) Removal from Wastewater by Biosorption

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Abstract: Phytoremediation is an efficient method for the removal of heavy metals from contaminated systems. A proper disposal of metal hyperaccumulators following phytoremediation is a major issue. An efficient solution to this problem could be reuse of the plant biomass as biosorbent for removal of the same metal from constituent wastewater. Hence, in this study, Cr(VI) accumulating Tradescantia pallida plant parts were investigated for its reuse as a biosorbent for the removal of Cr(VI) ions from aqueous solutions. The effect of solution pH, contact time, sorbent dosage, Cr(VI) initial concentration, temperature and number of reuse cycles on Cr(VI) sorption by Cr(VI) exposed/unexposed T.pallida biomass was evaluated. Results showed that Cr(VI) exposed/unexposed T. pallida biomass could remove 94% of chromium and Cr(VI) biosorption kinetics followed pseudo second-order kinetics. The maximum adsorption capacity of T. pallida biomass according to the Langmuir model was found to be 64.672 mg g⁻¹ at 323 K. The changes in the free energy (ΔG°), entropy (ΔS°) and enthalpy (ΔH°) were found to be -5.276 kJ mol⁻¹, 0.391 kJ mol⁻¹ K⁻¹ and 11.346 kJ mol⁻¹, respectively, suggesting the process to be spontaneous, feasible and endothermic in nature. FTIR spectra of the T. pallida leaf biomass revealed the presence of ligands, such as -NH, amide, hydroxyl and sulphonate groups in the biomass for Cr(VI) binding. Further, Cr(VI) sorption-desorption experiment using different inorganic solutions (0.1 M KOH and NaOH, 0.1 M H₂SO₄ and HNO₃) and distilled water were carried out, which revealed and that the biosorbent could be regenerated for further reuse

Key-words: chromium(VI) removal, Tradescantia pallida, reuse, biosorption-desorption, phytoremediation

ICWM-PP-28

Production of Bioethanol from Agricultural Waste

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Abstract: Agricultural wastes are produced during the production of agri products at pilot scale. These wastes are daily produced and get accumulated into the environment and these wastes contain different types of toxic compounds which could disturb the ecological balance by elevating the emissions of green house gases. Non renewable sources of energy are depleting at a very faster rate so these agriwastes could be an alternative source for the production of renewable energy (green energy). These wastes could be used as a primary raw material having less cost for the development of other products having a demanding economical value. Various processes like



physical treatment and chemical treatment methods are involve in the production of bioethanol from agriwastes. The production of bioethanol has positive merits but still the researchers are focusing on different methods and techniques to offer bioethanol more economical value.

Key-words: agriwastes, Bioethanol, renewableenergy.

ICWM-PP-29

Harvesting Exhaust Waste Heat Energy from Small Diesel Engine using Thermoelectric Generator (TEG)

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Abstract: An energy harvesting system is proposed where waste heat coming out of exhaust pipe is converted into electricity with the help of Thermoelectric Generator (TEG). Depending upon the engine's exhaust operating conditions, it has been found experimentally that the exhaust temperature of I.C. engine varies with the load. The detailed experimental work has been carried out to study the performance of TEG under various engine operating conditions. Single thermoelectric module of Bismuth Telluride (Bi_2Te_3) has been used to produce direct current with the help of temperature difference between ambient and exhaust pipe. A spiral type heat exchanger has been fabricated and thermoelectric module has been placed on heat exchanger for the performance analysis. This study shows that the exhaust waste heat energy can be utilised in the future. TEG can also replace alternator for small electric load on small diesel engine. This will improve further the efficiency

Key-words: Thermoelectric Generator (TEG), waste heat recovery, small diesel engine.

ICWM-PP-30

Study on Glucose Yield from Sweet Lime Peels using Different Pretreatment Conditions with Respect to Various Time Profiles

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Abstract: The present study focuses on the glucose yield from sweet lime peel, which is otherwise considered as waste that can be derived from juice, squash, perfume industries. The peels were dried and grinded and various pre-treatment conditions were applied. The resulting substance after each pretreatment process was subjected to filtration for separating the extract. The extract were collected and then analysed for the glucose yield using high performance liquid chromatography (HPLC). The pre-treatment processes were carried out with respect to different time profiles (20, 40, 60, 80 and 100 minutes). This was compared against the glucose yield of non pre-treated peels and it was found that pre treatment can increase the glucose yield of the peels significantly.

Key-words: Glucose, Pretreatment, Peels, Extract, Time.



Valorization of Waste Soda Bottles by Co-Pyrolysis in a Semibatch Autoclave Reactor

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Abstract: Soft drink bottles are one of the major components of plastic waste stream. Polyethylene terephthalate (PET) is the major component in the manufacturing of soft drink bottles. The bottle caps are generally made from Polypropylene (PP). Thermal degradation kinetics of both PET and PP were calculated from non-isothermal TGA data. In the current study PET and PP pyrolysed in a semibatch autoclave reactor which is heated externally with electrical tubular furnace. The experiments were conducted for both individual samples and mixed samples of different mixing ratio. Effect of three pyrolysis conditions like temperature, heating rate and sweep gas flow rate has been studied. The liquid products were analyzed with GCMS, FTIR and ¹H NMR and gaseous products were analyzed in GC-TCD and FTIR. Solid or char samples were analyzed with FTIR spectroscopy and XRD. The variation of product composition was observed at various pyrolytic conditions.

Key-words: pyrolysis, plastic waste, degradation kinetics

ICWM-PP-32

Biomethanation: a Sustainable Solution for Tapping Energy from Municipal Solid Waste

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Abstract: Diverse stream of waste is generated by human population living in urban and industrialized background. Improper disposal of municipal solid waste has potential to harm the environment and pose potential risk to human health. Accumulation of large amount of waste is reaching critical level all over the world. This has led the scientific communities to adopt innovative methods for tapping energy from waste. Since, more than half of the waste composition is organic in nature; they are required to be managed in a sustainable way. A number of technologies are available for tapping energy from waste. Out of them, biomethanation proves to be most promising technology for treatment and management of organic fraction of waste. Biomethanation provides energy production in the form of biogas and manure as a by-product through a range of feedstock and digester configuration that achieves the required yields. Process of biomethanation involves wide array of microorganisms, co-substrates and other operational parameters that decides the efficiency of the process. Generating power from waste via biomethanation has greatly reduced the environmental impact and dependency on fossil fuels for electricity generation. Economically also it is an optimal solution for



recovery of heat and power. Therefore, biomethanation technology holds a promising future for sustainability of both environment and agriculture, with generation of energy as an additional benefit.

Key-words: Industrialized, Biomethanation, microorganisms, sustainability.

ICWM-PP-33

Experimental Investigation on Exhaust Emission of Direct Injection Diesel Engine Fueled with Jatropha Methyl Ester, Mahua Methyl Ester and Diesel Oil

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Abstract: Fuel crisis because of increase in vehicular population and environmental concerns have led to search for an alternative fuel which is renewable and sustainable. The best substitute for diesel is biodiesel. With no or fewer modifications, Diesel engines can be made to run on biodiesel which leads to sustainable reduction in exhaust emissions (PM, HC, CO). In this paper, investigations were carried out to study the exhaust emissions of diesel engine using ternary blends of Jatropha methyl ester, Mahua methyl ester and Diesel oil. A single cylinder, four stroke, water cooled diesel engine fitted with eddy current dynamometer was used. Initially the engine was run with Diesel fuel (B0) and then with ternary blends (B10, B20, B30, B40, B50). Exhaust emissions (CO, HC, NO_x and CO₂) were measured by a flue gas analyzer. Test was conducted over entire range of engine operation at varying conditions of load. The experimental results prove that the ternary blends of Jatropha methyl ester, Mahua methyl ester and diesel oil can be used in diesel engine as fuel to reduce emission.

Key-words: Diesel engine, Biodiesel, Jatropha methyl ester, Mahua methyl ester, blending

ICWM-PP-34

Waste To Energy: Feasibility Study of Dry for Combustion

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Abstract: This paper aims to quantify, characterize and to analyse the suitability of dry waste that are generated from the Faculty Residential Apartments, IIT Guwahati per day for energy generation through combustion. Waste to Energy industry nowadays has proved themselves to be an effective process in addressing the problems generated by the overwhelming amount of municipal solid waste. Advancement made in technology and research had made the WTE process as a cleaner, greener and sustainable source of energy. The energy content assessment of dry solid waste



collected from the Faculty Residential Apartments is discussed in this paper. The household of 15 families was selected and was classified into subgroups – Low, Medium and High-Income groups based on their annual income. The residents were given guidance on the importance of waste segregation and dry waste was collected physically on a daily basis from each household for a sampling period of 7 days. The collected weight was further segregated on the basis of their physical composition and weighing was done to find the percentage of contribution to the total waste generated. A sample representing the solid waste was prepared by quartering method. The sample was used for the proximate analysis at the Institute lab, Ultimate analysis at Biotech park, IITG and the calorific value was estimated using Bomb Calorimeter at Centre for Energy, IITG. The suitability of dry waste for energy generation through combustion was decided upon the conducted tests.

Key-words: Municipal Solid Waste, IIT Guwahati, Energy, Calorific Value, Dry Waste, Sampling, Waste to Energy, Proximate Analysis, Ultimate Analysis

ICWM-PP-35

Enzymatic Hydrolysis of Waste Bread by *Aspergillus Niger* to Produce Glucose and Subsequent Production of Bioethanol using *Saccharomyces Cerevisae*

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Abstract: In this study, waste breads have been utilized as the only nutrient source for the production of glucose using *Aspergillus niger* and subsequently bioethanol production from glucose by *Saccharomyces cerevisiae*. Solid state fermentation of waste bread by *Aspergillus niger* resulted in the production of a multi-enzyme solution containing amylolytic and proteolytic enzymes. The glucoamylase and protease enzymes are then extracted and enzyme activities are quantified. This crude enzyme extract was used for the hydrolysis of waste bread at 55 °C at 300 rpm. After hydrolysis, the amount of glucose was determined using high performance liquid chromatography (HPLC) and the free amino nitrogen (FAN) was determined by ninhydrin colorimetric method. The resulting solution contains above 100 g/l of glucose. The bread hydrolysate was then further used to produce ethanol having concentration of 55±5 g/l measured by HPLC. The result depicts the production of about 0.4 g ethanol per gram of bread. This process is important in the sustainable chemical industry because it converts the waste food into a value added product like ethanol.

Key-words: glucose production, bioethanol, solid state fermentation, enzyme extraction, waste bread



ICWM-PP-36

Coal Combustion Residues from Pulp and Paper Mill and its Potential Utilization

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Abstract: Coal combustion power stations generate huge quantities of ash annually, thus utilization of such waste residues is an important and essential component for sustainable disposal and management. This paper summarizes an investigation carried out on the Coal Combustion Residues (CCR) collected from Cachar Paper Mill, Assam, India. A thorough characterization of ash has been carried out with respect to its physico-chemical, mineralogical and morphological features by using density determination, LOI determination, FTIR, XRD, XRF, SEM-EDX etc. The coarser fraction appears to contain a high percentage of char, semi-coked/coked carbonaceous particles and exceptionally high LOI (86%) values. The carbonaceous matters contain some aliphatic carbon which implies incomplete combustion. For correlating the total characteristics features, various experiments were performed based on which a number of possible potential utilization directions were suggested. Further, the coarser particles showed excellent water holding capacities (400%) and good adsorption capabilities, due to presence of micro and macropores.

Key words: Coal Combustion Residues, Physico-chemical properties, Adsorption

ICWM-PP-37

Projection of Landfill Gas Emissions from Metro Cities in India

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Abstract: The anaerobic activities in the landfill degrade organic portion of the refuse results into various gases such as methane and carbon dioxide, hydrogen sulphide. However, monitoring stations are not available in most of the landfill sites to check the emission of these gases. Field studies so far accounts gas generation for short duration of time and predict average value of production only. Prediction of gas generation is very important to design the gas vent or gas extraction systems for energy recover facility. Thus, the objective of this paper is to estimate the temporal gas generation from various metro cities in India. For this purpose six landfill sites from three metro cities were considered in the present study. The models suitable for Indian scenario were studied and found First order model, Modified first order model, Multiphase model, and LandGem models could be best suitable for Indian conditions. Gas emission was calculated considering for both the pre-closure and the post-closure period of the landfills for a period of 30 years. It was found that that First order model and the LandGem model would give higher result if the coefficients not taken into account. Also variation of density has taken into account to estimate the gas emissions



from various landfills. This study would help in the waste to energy project for the proper management of landfill sites.

Key-words: Model, Landfil, gas generation.

ICWM-PP-38

Impact of Silver Nanoparticles on Earthworm Health and Soil Quality

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Abstract: Nanotechnology is one of most valued technology owing to its huge industrial applications. Recently, silver nanoparticles have captured a significant position at consumer's level products i.e., cosmetics, packaging material, disinfectants etc. Therefore, the probability of their predominance in soil and water resources is increasing day by day. Taking this into consideration, here in this present investigation we are interested to assess the efficacy of silver nanoparticles (AgNPs) on earthworm health and proliferation and soil health status. Five different concentrations of the synthesized AgNPs have been taken for this ecotoxicity study (100, 75, 50, 25, 10 mg kg⁻¹). Two different species of earthworms *Eisenia fetida* (Savigny) and *Metaphire postheuma* (Vaillant) were selected for earthworm incubation study and no detrimental effect was observed for a long period of time (60 day). We further extended our study with above mentioned treatment combinations in soil through periodical analysis of various soil physico- chemical attributes viz. bulk density (BD), water holding capacity (WHC), pH, Total organic carbon (TOC), easily mineralizable nitrogen (Avl N), total nitrogen (TKN), available phosphorous (Avl P), exchangeable potassium (Exch K). The effect of AgNPs on soil physical health status was further analysed through scanning electron microscopy (SEM) study. Activity of important soil enzymes (urease and phosphatase) was also evaluated. This soil study indicated no probable hindrance of AgNPs on soil health status. Soil physical health, nutrient availability and enzymatic status was not affected due to application the synthesized compound in the lab scale study (a periodical study for 90 days). This study also included evaluation of leaching and solubility pattern of soil by analysing different cations and anions (PO₄³⁻, NO₃⁻, SO₄⁻, Cl⁻, total alkalinity, Ca, Mg and Fe) through titrametric method and ICP analysis. Throughout the whole study we were mainly trying to evaluate the response of the AgNPs on earthworm health status, soil quality and solubility dynamics through various analyses. Although in this study short term detrimental effects of the AgNPs on soil and earthworm health was not observed, this area warrants long term and large scale research in future.

Key-words: Silver nanoparticles, *thuja occidentalis*, *eisenia fetida*, *metaphire postheuma*, soil health.



Plastic Waste in Bituminous Mix for Rural Roads: Status in India

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Abstract: Now a day's disposal of plastic waste is a predominant issue worldwide. The enormous amount of waste that is generated from plastic is to be treated and disposed properly considering the environmental, health and global warming problems. The best way is to adopt resist, reduce, reuse and recycle approach. One of the technique is to mix the plastic waste with bituminous for rural road construction. As an emerging and developing nation India is also focusing on this aspect. The aim of the paper is to emphasize the benefits of this sustainable approach and its utilization, construction, implementation status in India. The paper will also discuss about the different types plastic wastes generated and their processability with bituminous. India generating over 5.6 million tons of plastic waste annually out of which about 40% is dumped without any treatment. The polymer coated bitumen enhances the property of the mix in addition to its disposal in a useful way. Comparison was made between convention bituminous concrete mix and the mix modified with waste plastic. The results indicated that the strength properties of the mix with waste plastic were better when compared with a conventional mix. The fatigue life was doubled using waste plastic in the mix. The construction process of road laying using waste plastics is designed and implemented successfully at various places in India. India is having a rural road network of 19, 38,220 km with a road density of 621.58 km per 1000 Sq.Km area which further need to be improved as per the infrastructure statistics of GOVT of INDIA, 2014. To dispose the plastic waste, to enhance the life of the road and to reduce the economic burden of the upcoming nations this technology will be better if adopted in a massive way.

Key-words: Plastic waste, Bituminous mix, Rural road.

Use of Stakeholder Analysis to Design Waste Management Process to be Employed in the Construction Industry in Reference to Guwahati City

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Abstract: The construction industry in Assam is growing very rapidly with the growth focus in the entire north-eastern region. But like every coin has two sides, the growth has some negative effects also. Improper wastes treatment and disposal of



wastes have led to many serious effects which if left untreated can be detrimental for the future. An example can be cited of the deplorable condition of Deepor Beel which is a wetland located in the south west of Guwahati city. The wetland has been severely damaged due to the rapid construction activities along its periphery. The improper waste treatment can be due to two major reasons. Firstly, due to the lack of proper treatment facilities and secondly due to the indifferent attitude of the different stakeholders involved in the process. Lack of proper treatment facilities can also be traced to the attitude of the different stakeholders. To analyze the stakeholders involvement, a primary survey has been conducted. The different stakeholders include the government, people residing nearby, builders, construction workers etc. The survey tried to find out the deterrent reasons from the perspective of stakeholders. After going through the qualitative and descriptive analysis of the survey, a proper waste management process has been designed for the proper disposal of the wastes. The process identified is a 7 step process viz. planning the project, Requirement analysis, stock controlling, environmental education of the workers involved, assortment, recycling and waste auditing. The process identified caters to the concerns of the stakeholders and thus it pushes them to adopt this methodology for the waste management process.

Key-words: Construction, waste management, stakeholders analysis, design.

ICWM-PP-41

Surface Rearrangement of PVC for Selective Separation in WEEE Plastics by Activated Carbon Coating and Heat Treatment

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Abstract: Polyvinyl chloride (PVC) is one of the plastics which have been widely used in electrical and electronic equipment (EEE) and is a main component of Waste EEE plastics. PVC containing chlorine can release toxic materials and persistent organic pollutants (POPs) upon disposal. The combination of powder activated carbon (PAC) coating and mild heat treatment was investigated for selective separation of PVC from WEEE plastics. The heat treatment combined with PAC coating could rearrange and change molecular mobility to more development of hydrophobic moiety on the PVC surfaces. The treated PVC was settled down with 100 % recovery and 96.8 % purity by optimizing flotation characteristics. Finally, the combined treatment of PAC coating with mild heat and the froth flotation can be used as an economical and reliable technology to separate PVC selectively and facilitate plastic recycling.

Key-words: Heat treatment; PVC; Separation; Recycling; Hydrophobicity.



Role of Informal Sector in Solid Waste Management

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Abstract: Solid Waste Management (SWM) is one of the major concerns in environmental issue, in that role of informal sectors is acting as a part of private sector to increase attention due to the continuous insanitary and health threatening condition in spite of government activities. In this project, the study explains the term 'informal waste workers' which designates people who make a living from waste, but are not formally tasked with providing the service by the responsible authorities. We have also shown the hierarchy in which way the "informal sector & informal waste workers" involves in SWM for collecting and segregation of recycle materials from the dump site or different locations of dustbins for waste storage and collection, and thereby how the recycle material is being transported from waste workers to recycle industries in Guwahati. The findings show that the practice has become an employment for thousands among the urban poor as a survival strategy and that, the proper integration of the NGO's and CBO's sector into the existing solid waste management policies can lead to sustainable management practices and possibly help alleviate poverty.

Key-words: Informal Waste Workers, NGO, CBO, Sustainable management

ICWM-PP-43

Heavy Metal and Pathogen Contamination in Ground Water and Surface Water Sources near Boragaon Dumpsite, Guwahati

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Abstract: This study was conducted to evaluate the effect of Municipal Solid Waste dumps on water quality near Boragaon dumpsite in Guwahati. In order to achieve this, water samples were obtained from hand dug well, tube well, hand pump for ground water quality and from Deepor Beel for surface water quality. Sources of water were selected in close proximity to the dumps site. The area near dumpsite comprises of rag picker dwellings, schools and many private houses, which are directly dependent on the ground water and surface water sources of the area. Hence, this study aims at knowing the risk of contaminated water consumption to the inhabitants of the area near the dump site. The contamination is mainly due to the leachate generated from the solid waste accumulation on the dumpsite which seeps through the soil and reaches the nearby sources of water. The samples collected were analysed for pH, Heavy metal contamination and Coliform count, which were determined using standard methods.



Key-words: Municipal solid waste; Dumpsite; Heavy metals; Leachate; Rag Picker; Contamination.

ICWM-PP-44

A Case Study of Facing Challenges in Management of Municipal Solid Waste in Greater- Guwahati City, Assam, India

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Abstract: In developing countries Municipal solid waste management has faced the big challenges in environmental protection. This study reveals in facing the challenges from current solid waste management practices in Greater Guwahati city. In this study, Geographic Information System (GIS) is used for analyzing and displaying spatial data for investigating the solid waste generation rate. Solid waste management is characterized by lack of proper collection methods and lack of proper disposal technology in the Guwahati city. Due to rapid urbanization the populations are going to increase day by day within a short period of time. In 1991, solid waste generation rate per capita for Guwahati was 0.30 kg/day/person for 6.46 lakh population, in 2001 the solid waste generation rate was found to be 0.35 kg/day/person for 8.9 lakh population, in 2010 the rate was increased upto 0.60 kg/day/person for 12.4 lakh population (GMDA, 2009-estimated). One of the major threats facing the city is lack of scientific disposal technology of municipal solid waste and lack of awareness for solid waste management among people. Bharalu the most polluted tributary of river Brahmaputra carries the city's whole sewage, waste materials, and industrial effluent into the river Brahmaputra. Many people can't follow the proper use of dustbin. They dumped wastes along the road side or in the Bharalu tributary which pollute both surface water and ground water. Another facing problem is all the biologically degradable or biologically non degradable materials are dumped together. Due to increased government and non- government institutions and rapid population growth together with the development of markets and new industries resulted in the release of huge amount of hazardous organic and inorganic waste daily. There is no proper management of drainage system in the city for carrying the whole sewage, effluent or other wastes. There are different types of waste generation sources are identified, but there is lack of scientific source reduction technology, as a result of it; the environment is gradually polluted day by day.

Key words: Municipal solid waste, GIS, population growth, waste generation rate



Waste Practices in Guwahati City

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Abstract: Our environment is facing potential threat from unhealthy waste disposal practices prevailing in almost all the urban centers in the country. Though the living standard has significantly changed, the method of public health and sanitation still remains primitive. Vast quantities of waste generation by the cities are one of the serious outcomes of unplanned development. Guwahati is the capital city of Assam is also not exception on it. Due to rapid population growth within a short period of time, the city faces many problems. One of the major problems of the city is improper disposal of municipal solid waste. The management of municipal solid waste has become an acute problem due to enhanced economic activities and rapid urbanization. Urban population grows together with the development of markets and new industries resulted in the quantum of a huge amount of hazardous organic and inorganic waste daily. Proper management of the waste is a challenging issue that must be addressed adequately. The sources of waste are multiple and disposal method is not a scientific, as a result of it; the environment is getting polluted day by day. In this poster, the waste management system has been studied from the cooperation point of view

ICWM-PP-46

The Municipal Solid Waste Management of Indore City, (M.P) India

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Abstract: Municipal Solid Waste (MSW) management is now a solemn problem due to unruly increasing in human population and rapid globalization. On increasing human population day-by-day, it is very complicate to handle myriad of solid waste in an efficient manner. Wastes are being generally generated from residential, industrial and commercial land uses. Wastes are the mainly unavoidable by-product of the human activities. The solid and liquid waste generated in the urban areas is considered a burden on a society and vicinity's environment. The unsuitable placement of dumping yard at inappropriate areas is another obstacle found in a case of Indore city as it is growing very fast. Various studies reveal that about 90% of MSW is disposed of unscientifically in open dumps and landfills, creating problems to public health and the environment. As per census 2011, the population of this city was 3,276,697 with density of 9,718 sq/km. During 2012-13, on an average 641.85 metric tons of waste was generated per day; in 2013-14 it has grown to 796.26 metric tons per day and further to 967.16 metric tons per day, in 2014-15. It is observed that the people living near dumping site having health and hygienic problems such as allergic, asthmatic and other diseases. This paper contains the details about waste transportation, collection,



current scenario of solid waste management and technologies used by Indore Municipal Cooperation (IMC) for managing waste.

Key-words: Waste Composition, Collection Procedure, Transportation, Technologies for Handling Waste, Inimical Effect, Municipal Regulations, Schemes by Governments.

ICWM-PP-47

Public Awareness for Solid Waste Management at IITG Campus

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Abstract: Any substance which is discarded after its use when it becomes defective or useless for human is considered as Waste. Solid waste management is affected by its nature and quantity; it is hazardous to environment if not properly managed, even the economic cost of managing waste is very high. There is an effective role of public in solid waste management, since everyone operates waste and can be affected directly or indirectly. A huge amount of waste generation takes place at IITG campus at hostel as well as institute level. It contains recyclable waste as well as vegetable waste which are needed to be reduced. Various methods and techniques are adopted which is effective in creating and enhancing the initiative of public awareness. Thus the paper gives a public consultation approach for solid waste reduction in order to come up with detailed environmental laws along with the rules and regulations for the reduction, resource recovery, proper handling, packaging and transportation of generated waste.

Key-words: Solid Waste Management, IIT Guwahati, Public Awareness

ICWM-PP-48

Strategies of E-Waste and Bio-Medical Management

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Abstract: Every year around 40 million ton E-waste produced globally and 0.8 million ton is contributed by india. There are 4 main categories of E-waste-telecommunication waste, electrical waste, electronic waste, cable waste. Three ways of treating E-waste are landfills, reusing and recyclingand incineration. Dumping E-waste in landfills are dangerous like computer waste reduces contaminated leachates and leads to pollution of ground water. Sludge and acids from melting computer chips make us acidification of soil. In other hand incineration of e-waste can emits toxic gases. Therefore door to door collection of e-waste is significant. Recycling of old strategies may increases public awareness on e-waste management. Generally e-waste consist of 70% of heavy metals and 40% of led in landfills. This paper discusses various strategies of burying e-waste. Most of the developed countries collects e-waste



for donating it to under developed countries or developing countries. For instants USA donates e-waste to Uganda (Africa). Statistics of conservation through recycling- 95% conserved through recycling of aluminum, 60% conserved through recycling of newspaper, 70% conserved through recycling of plastics, 40% conserved through recycling of glass. E-waste management in Malaysia has been regulated since 2005 where the programs includes collection of e-waste from various communities and distributed the refurbished e-waste to the needy community. Medical waste management is major concern because of high risk to human health and environment. Medical waste are generated during treatments, diagnoses, immunization of animals or human beings. Globally countries which are developed generates 1 to 5 kg/bed/day and countries which are developing generates 1 to 2 kg/bed/day. Site visits, interviews, and surveys are significant to collect information regarding different medical waste management aspects, including medical waste generation, separation, collection, storage, transportation, and disposal. Bio medical risk waste are of 10-20%. Where area 80-90% are of non-risk waste. This paper discussing about Tabriz's (Iran) hazardous-infectious medical waste strategies.

ICWM-PP-49

Assessment of Greenhouse Gases Emissions from a Municipal Solid Waste Landfill in Guwahati, India

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Abstract: The rapid urbanisation and economic growth has led to significant increase in municipal solid waste generation in India during the last few decades and its management has become a major issue because of poor waste management practices. Mostly in India, solid waste generated deposited into open dumping sites without any segregation and processing. Due to the biodegradability of solid waste, excessive amounts of gases are released from landfills. Carbon dioxide, methane and nitrous oxide are the major greenhouse gases. Landfills are recognised as one of the major sources of anthropogenic methane, of all the landfill gases global warming potential of methane is 21 times higher than that of carbon dioxide and it has highest emission rate. Therefore, there is an increase in demand for its estimation and better utilisation as an energy source. After a detailed review of literature on the methodologies used for estimation of methane emissions, flux chamber method was chosen in the present study. Boragaon municipal solid waste landfill was selected in this study. It is the only disposal ground of city, where the municipal trucks simply carry the wastes and dispose it without any processing. The average methane and carbon dioxide emission rates from the selected landfill using insitu methodology (chamber method) were 6.11 Gg/year and 9.45 Gg/year, respectively. The US EPA uses LandGEM model to predict greenhouse gas emissions from landfills. LandGEM determines the mass of methane emitted by using methane generation capacity, mass of deposited waste, methane generation potential and methane generation rate. Using default values of methane generation potential and methane generation rate suggested by the model,



emission rates of methane and carbon dioxide from solid waste as 3.69 Gg/year and 11.02 Gg/year, respectively from the landfill. These values are 40% lesser and 17% higher than estimated emission rates of methane and carbon dioxide, respectively from this study.

Key words: MSW, Landfill, Climate change, Greenhouse gases, Methane emission, LandGEM model.

ICWM-PP-50

The Best Management Practices of Agricultural Wastes

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Abstract: Agriculture is the largest contributor of any resource sector, to the economy of a country. Agriculture may include some activities such as Horticulture, Fruit growing, Seed growing, Dairy farming and livestock breeding and keeping as well as use of land as grazing land, meadow land, market gardens and nursery grounds and use of land for woodlands where that use is ancillary to the farming of land for other agricultural purposes. It is a large generator of waste materials. Agricultural practice covers all activities that can occur on a farm or croft and includes activities such as slurry spreading, chemical and waste storage, silage making and waste pesticide disposal. The waste stream may include a range of items and materials that are not specific to agriculture such as packaging waste, tyres, batteries, scrap machinery and oil. In addition there will be waste that is more specific to the sector such as pesticide containers, silage wrap etc. The present study deals with how best management practices can be used on the farm to protect, conserve and reuse resources while minimizing negative impacts on environment. Many farm by-products can be economically valuable resources when managed correctly. Horticultural waste can be economically recycled. Farm plastics can be recycled and reused. Composting of poultry and other small agricultural animals is considered a low cost, environmentally acceptable method of disposal of dead stock. We can recover Methane gas (Biogas) from manure waste. Potato and vegetable waste which pose a plant health issue for industry as diseases such as Ring rot, Blight and Virus can be spread from culls that are not properly disposed of should have proper storage and disposal to protect ground and surface water. Hence management that put into practices the principle of the four Rs of Reduce, Reuse, Recycle and Recover is the best first option to be more environmentally responsible and gain maximum return from the waste resources.

Key Words : Agricultural waste, Farm waste, Horticultural waste, Reuse, Recycle.



Adsorption of Lead Ions from Aqueous Solution by Functionalized Polymer Aniline Formaldehyde Condensate Coated on Silica Gel and other Support Materials

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Abstract: A resinous functionalized polymer, aniline formaldehyde condensate (AFC) coated on silica gel as well as coated on eggshell, sand, tealeaves and flyash separately as support material was used as an adsorbent to remove lead (Pb^{+2}) from aqueous solution by varying the various parameters affecting adsorption like reaction pH, adsorption time, initial Pb^{+2} ion concentrations and dose of adsorbent. The adsorption continuously increased in the pH range 3.0-6.0, beyond which the adsorption could not be carried out due to the precipitation of the metal. The optimum pH for lead adsorption onto AFC coated silica gel was 6.0 with 80% removal and 19.34 mg/g of lead uptake. Similarly the optimum pH for Pb^{+2} removal by AFC coated tealeaves, fly ash, eggshell and sand was observed to be 6.0 with maximum Pb^{+2} removal of 91.88%, 91.36%, 74.54% and 65.79% respectively. Removal of Pb^{+2} by AFC coated silica gel decreased from 98% to 44% with increase in initial Pb^{+2} concentrations from 10 mg/L to 200 mg/L. However the uptake of Pb^{+2} increased from 5.56 mg/g to 40.25 mg/g with increase in initial Pb^{+2} concentrations from 10 mg/L to 200 mg/L. For the AFC coated adsorbents, the kinetics of adsorption followed second order model. Lead adsorption followed Langmuir isotherm with Langmuir monolayer isotherm uptake of 96.15 mg/g, 46.73 mg/g, 13.62 mg/g, 8.87mg/g and 7.07 mg/g for AFC coated on eggshell, tealeaves, flyash, silica gel and sand respectively. During desorption studies, almost 47%, 42% and 37% of adsorbed lead ion by AFC coated silica gel were recovered by mineral acids viz. HCl, HNO₃ and H₂SO₄ of strength 1 N. Further studies are recommended on regeneration and reuse of AFC coated silica gel as well as AFC polymer coated on other support materials like eggshell, sand, tealeaves and flyash.

Key words: Functionalized polymer, solution pH, lead adsorption and desorption, Amine group, second order kinetics



Degradation of Lignocellulosic Fractions during Drum Composting of Vegetable Waste

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Abstract: The study aimed to characterize the microbial population involved in lignocellulose degradation during drum composting of mixed organic waste i.e. Vegetable waste, cattle manure, saw dust and dry leaves in a 550 L batch scale rotary drum composter. Lignocellulose degradation by different microbial populations was correlated by comparing four different trials i.e. Trial 1 (5:4:1), Trial 2 (6:3:1), Trial 3 (7:2:1) and Trial 4 (8:1:1) of varying waste combinations during 20 days of composting period. Due to proper combination of waste materials and agitation in drum composter, a maximum of 66.5 and 61.4°C was achieved in trial 1 and 2 by observing a temperature level of 55°C for 4 to 6 days. The study revealed that combinations of waste materials had a major effect on the microbial degradation of waste material and quality of final compost due to its physical properties. However, trial 1 was observed to have longer thermophilic phase leading to higher degradation of lignocellulosic fractions. Furthermore, FTIR and fluorescent spectroscopy confirmed the decrease in aliphatic to aromatic ratio and increase in polyphenolic compounds of the compost.

Keywords: Lignocellulose waste; thermophilic composting; rotary drum; microbial dynamics; FTIR and fluorescent spectroscopy.

ICWM-PP-53

Climate Change and its Impact on Agriculture

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Abstract: Global climate change has become one of the major issues of discussion and considered within the academic policy of communities including general public. Tremendous impact to the environment has been well documented and about one-third of greenhouse-gas emission is contributed by human activities by combustion of fossil fuels and also non-energy emissions including from agriculture and land-use changes. Climate change directly or indirectly affect agriculture, especially on developing countries in which agriculture depend on climate in conjunction with poverty and rapid increase in population which is greatly vulnerable. Intergovernmental panel on climate change (IPCC) Fourth Assessment Report concludes that, by 2020, crop yields could increase by 20% in east and south-east Asia, but decrease by up to 30% in central and south Asia, and that rain-fed agricultural output could drop by 50% in some African countries. This paper discuss about the impact of climate change on agriculture and vice versa.



Key-words: climate change, agriculture, green gas emission

ICWM-PP-54

Solid Waste Management of Tezpur Town, Assam- An Initiative

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Abstract: Rapid increase of human population and their life styles, solid waste is also in extemporaneously increasing manner. Tezpur is one of the major important historical, commercial and business places of Northeast India which holds 58,559 populations in a density of 365 per square kilometer. Due to rapid growth of urbanization and outgrowth of human population, 27.7 metric tonnes waste is generated daily from the entire Tezpur city and is dump in Mora Bharali without proper scientific management. Management of municipal solid waste is most often the responsibility of municipal/urban local body (ULB) or other governmental authorities. This paper is emphasizes on Management of Solid Waste in Tezpur city. The survey is done in the every household of Tezpur city to know about the lack of management of solid waste. House to house collection and segregation at source point is the better option to understanding the solution of waste management to applying the scientific method for waste management. Community participation and Awareness among the community to every house hold and their helping hands is one of the major way to making waste is useful modus. Tezpur is planning to use two Dustbin systems (collection of dry and wet waste) in every house hold for making the Tezpur zero waste city. House to house waste collection is done daily basis for Tezpur town for assembling composting from waste, recycle material etc. Composting of wastes which will not only reduce the volume of waste to dispose but also maintain a healthy environment and low risks to public health.

Key words: solid waste, waste management, urbanization, community participation

ICWM-PP-55

Biosorption of Cadmium Metal through Bacterial (*Bacillus Badius* AK) Dry Mass

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Abstract: Biosorption of Cadmium using dry *Bacillus Badius* AK bacterial mass isolated from water hyacinth compost has been studied in a batch system. Heavy metals are defined as metallic elements that have relatively high density as compared to water. With the assumption that heaviness and toxicity are inter related, heavy



metals also include metalloids that are toxic even at lower concentrations. Criteria used to define heavy metals have included density, atomic weight, atomic number, or periodic table position. Heavy metals are found naturally in the earth, and become concentrated as a result of human caused activities. Common sources are from mining and industrial wastes, vehicle emissions, Cadmium batteries, fertilizers, paints, ammunition and treated woods. Cadmium is the most prevalent heavy metal contaminant.

Keywords: Cadmium removal, *Bacillus Badius* AK, Biosorption.

ICWM-PP-56

Biomass - an Alternative Source of Energy

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Abstract: Biomass generally refers to the renewable organic matter generated by plants through photosynthesis. a term used to describe all organic matter produced by photosynthesis on the earth surface. They include all water-and land-based vegetation and trees, and all waste biomass such as municipal solid waste (MSW) ,municipal bio-solids (sewage), and animal wastes, forestry and agricultural wastes . In recent year , a great deal of efforts has been made to increase the production and utilisation of biomass as a source of renewable energy. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country population depends upon it for its energy needs. The biomass resources is very large , the amount stored annually worldwide is equivalent to ten times the total world energy use. Biomass can be turned into solid, liquid and gaseous energy sources through different conversion processes. Generally the prominent bio-power technologies are comprised of direct combustion, co-firing, gasification, prolysis ,anaerobic digestion and fermentation . Numerous technologies have been developed for the generation of energy from biomass. With the expanding world population, increasing energy demand and diminishing stock of fossil fuel ,most of the countries have paid much attention on the bio-energy programme .Among the various non-conventional source of energy , biomass plays a significant role in solving the world fuel crisis. In recent years, to meet the demand of energy , plantation of energy plants has been re-emphasized. Energy plantation is the practice of planting fast growing trees purely for their use as fuel. A number of plants belonging to families Euphorbiaceae, Asclepediaceae, Apocynaceae etc. possess photosynthetic products (hydrocarbon) of high molecular weight in their sap and latex. These can be used to produce liquid and gaseous fuels and used just as petroleum products are used. In India attempts are also being made to cultivate energy plants and petro-plants on denuded wasteland to provide a more convenient form of energy.

Key-words: Biomass, Renewable energy, Bio-energy.



Prospects of Utilization of Biogas Residue as Growth Supplement for Mushroom Cultivation

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Abstract: Biogas residue or biogas digestate is the by-product of 'Anaerobic digestion' process that produces biogas as the main energy. Since digestates are the inevitable commodities of the conversion process, means of their appropriate management is essentially required for sustainability of bio-energy system. In developing countries, with faster adoption of biogas technology, a simultaneous increase in biogas residue is also expected drawing attention for their immediate and effective utilization. Biogas digestate retains nutrients from input feedstock with enhanced bio availability and minimum variation; hence these could be potentially used as growth supplement for mushroom. Present study discusses the prospects of utilization of the liquid fraction of biogas residues as a substrate along with rice straw for enhancing the production of white oyster mushroom (*Pleurotus ostreatus* spp.) under laboratory conditions. Enhancement of yield and growth parameters of mushroom with digestate application showed its potential utilization for successful commercial production of white oyster mushroom. Utilization of biogas residue in mushroom cultivation would help to enhance overall economic and environmental profitability of biogas technology through value addition of by-product.

Key-words: Biogas residue, Digestate, Anaerobic digestion, Mushroom

ICWM-PP-58

Stability Check of Biosolids Generated in Sulfidogenic Arsenic Removal from Drinking Water

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Abstract: Solid waste management in developing nations is often unsustainable, relying on uncontrolled disposal in waste dumps. Disposal of arsenic bearing wastes generated during arsenic (As) removal from drinking water, imposes a greater risk for human and water environment. The As can be highly mobile and has the potential to recontaminate back to ground and surface waters by leaching out. A promising arsenic remediation approach is microbial reduction to insoluble sulfide. An important question that must be addressed before this technology can be implemented is the stability of these sulfidic phases. This work evaluated the stability of reduced arsenic and sulfide precipitates produced in a sulfidogenic biological system. Anoxic solid-phase were taken from anaerobic batch bioreactors previously used to treat As contaminated groundwater. The precipitates were subjected to anoxic aging test and leached by the toxicity characteristic leaching procedure (TCLP) and American society of testing and materials (ASTM) test. The release of arsenic in aging

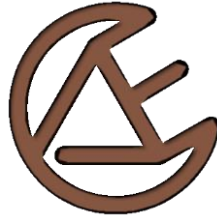


experiment was 58 ppb after 60 days. The results from TCLP and ASTM experiments showed that the concentration of As leached from solid phase samples after an 18 h extraction time was 29.5 ppb and 23 ppb respectively. The results demonstrated that the As concentrations in the leachate were below the current Australian and United States environmental protection agency (USEPA) guideline concentration for non-hazardous waste. The results suggest that, arsenic bearing solid waste generated in reactor systems were stable and would be classified as non-hazardous waste, which is safe to dispose in municipal solid waste landfills.

Key-words: Sulfidogenic, Arsenic, Leaching, TCLP.



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About



Waste Management Research Group was established in December 2010 as a means of addressing Sustainable and Environmental Research. It soon attracted to others who wished to create and promote strategies that secured environmental in a rapidly transforming India. Our grassroots experience informs all of our work, right up to advocating for better future through research on waste management. Our focus is on ensuring equitable and sustainable waste management and Research.

Vision:
To reduce ecological footprints and environmental burdens through systemic change brought about through partnerships, capacity building at the grassroots, advocacy and research, and sustainable, scalable models on the ground. [more](#)

Mission:
To reduce ecological footprints and increase environmental justice through systemic change brought about through partnerships, capacity building at the grassroots, advocacy and research, and sustainable, scalable models on the ground. Our initiatives include research, campaigns, policy interventions, by which building a better waste management among the Society.