INTERNATIONAL SYMPOSIUM ON Sustainable Urban Environment

23rd -24th June 2017
Tezpur University
Assam, INDIA

Tezpur University
(a Central University)
Tezpur 784 028, Assam, India

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Professor Madan M. Sarma
Vice-Chancellor (Acting)

Prof. Madan M Sarma
Vice-Chancellor

MESSAGE

It is indeed my pleasure to welcome you all to the International Symposium on Sustainable Urban Environment" (ISSUE) 2017, during 23-24th June 2017.

We at Tezpur University really feel proud to host this significant international event and hope that this venture would provide a platform for teachers, students, research scholars, industry personnel and policy makers all over the globe to discuss and share knowledge on site-specific problems/solutions to achieve a sustainable urban water environment.

I sincerely hope that your stay in the University campus will be a pleasant and fruitful one.

Madan M Sarma

Date 20 June 2017

तेजपुर विश्वविद्यालय / TEZPUR UNIVERSITY

(संसद के अधिनियम द्वारा स्थापित केंद्रीय विश्वविद्यालय)

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(Awardee of Visitor's Best University Award, 2016 and 5th among India's Top 100 Universities, MHRD-NIRF Ranking, 2016

Dr. Biren Das
Registrar

MESSAGE

I am glad to note that Department of Environmental Science is organizing an International Symposium on Sustainable Urban Environment (ISSUE) 2017, during 23-24th June 2017 and bringing out a proceeding to mark the occasion.

ISSUE-2017 has its origin embedded in three nations, India-Japan-Sri Lankan, Collaborative project on "Development of New Water Supply Strategies in Two Watersheds of India and Sri Lanka in the Context of Climate Change, Rapid Urbanization and Population Growth. A Vulnerability Assessment Approach" funded by the Asia-Pacific Network (APN)-Global Change Research (GCR). The symposium is cofounded by Research Centre for Water Environment Technology (RECWET), The University of Tokyo, Department of Science and TechnologyScience and Engineering Research Board (DST-SERB) and DST-JSPS initiative under IndiaJapan Science Cooperation Program (JSCP).

I therefore, take this opportunity to thank the convener, organizing committee, sponsoring organizations involved in hosting such an International forum at Tezpur University that brings scholars, researchers and policy makers in the area and water issues and climate change to share their knowledge, expertise and latest research findings.

Hope you all will find this place as a hospitable and pleasant environment for the Symposium. I wish all the delegates, attendees, sponsors of ISSUE-2017 a pleasant stay at Tezpur University to lead rewarding Outcomes.

Sd/-
Mr. Hriday Saikia
Registrar

MESSAGE

Prof. Hiroaki Furumai

In Asian countries, rapid economic growth in recent years has brought about better living conditions and greater opportunities for global market integration. However, climate change and diverse activities of the rapid growth trend have also caused damages of the natural resources and degradation of environmental quality. Especially, degradation of water environment has proportionately impacted the health and livelihood of the inhabitants. In order to meet the challenges imposed by climate change and rapid urbanization and population growth, sustainable management of water environment must be addressed intelligently.

Since 2016, we have conducted the collaborative research project with Tezpur University since 2016, which is titled with “Development of new water supply strategies for Brahmaputra watersheds of India under climate change regime” under the India-Japan Science Cooperation Program (IJSCP). From the above background and through this research cooperation, it is an honor to be able to jointly organize “International Symposium on Sustainable Urban Environment” (ISSUE) 2017, with Tezpur University, Kanazawa University and University of Ruhuna. We believe that the ISSUE-2017 can provide an international platform for water professionals to discuss and share knowledge and experience for strengthening our network.

On behalf of the Research Centre for Water Environment Technology (RECWET), the University of Tokyo, we would like to express my gratitude to all the symposium participants and we sincerely hope that this symposium turns out to be a productive and inspiring event to contribute to sustainable management of urban water environment.

Prof. Hiroaki Furumai

MESSAGE

Dear Colleagues and Peers

It is my pleasure and honor to present this proceedings of International Symposium on Sustainable Urban Environment (ISSUE) 2017. ISSUE-2017 has its origin embedded in three nations, India-Japan-Sri Lankan, collaborative project on ""“Development of New Water Supply Strategies in Two Watersheds of India and Sri Lanka in the context of Climate Change, Rapid Urbanization and Population Growth: A Vulnerability Assessment Approach” funded by the Asia-Pacific Network (APN)-Global Change Research (GCR). The sympsoium is cofunded by Reserch Centre for Water Environment Technology (RECWET), The University of Tokyo, *Department of Science and Technology-Science and Engineering Research Board (DST-SERB)* and DST-JSPS initiative under India-Japan Science Cooperation Program (IJSCP). I would like to thank all funding partners for believing the collaboration and funding the activity.

As mentioned ISSUE-2017 targets to explore an emerging need of active and science-policy interface contributing to human endeavor to achieve resiliency against climate change, urbanization and population growth. The main objectives of this communication are to understand the expert's view, stakeholder's perspectives,organizational role and site-specific problems/solutions to achieve the sustainable urban water environment. ISSUE-2017 is third tier of the activities after the previous editions occurred last year when Indian and Sri Lankan collaborators visited University of Tokyo and Kanazawa University, Japan and one-day brainstorming workshop in March, 2017. On behalf of the symposium organizing committee, we are looking forward to fruitful discussion time and resounding take home messages. I am sure the outcome of this symposium will have long lasting impacts. At the end of the symposium, there will be a field excursion to the wettest place on the planet earth “Cherrapunji” which also exhibit karst aquifers.

Finally, I would like to thank all invited speakers, participants, volunteer, administration, faculty & staff of Tezpur University (India)and other members connected directly or indirectly to this event. Last but not the least, this event would not have been smooth without the help of research scholars and WET Lab members of the Dept of Environmental Science, Tezpur University.

Thanking you

Dr. Manish Kumar
(PI- APN & IJSCP) Conference Convener
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KEY NOTE

Challenges to sustainable urban water use adapted for climate change

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Abstract

Climate change and increased water demand through rapid urbanization have caused water scarcity in mega cities in Asian countries. Concern about the sustainability of urban water use is the strong motivation to understand the potential use of rainwater and reclaimed water in urban area. Rainwater and reclaimed water have been applied to meet the increased water demand in urban area in Japan. This requires information on available amount and detailed quality of various water resources in a watershed. We are pursuing possible strategies for sustainable urban water use adapted for climate change.

Keywords: Climate change,rainwater, reclaimed water, urban water use

1. Introduction

In Japan, with rapid industrialization, urban water demand has been continuously increasing. To respond to the increased demand, many dams have been constructed and rainwater and reclaimed water use has been promoted in urban areas for several purposes such as toilet flushing (Furumai et al., 2008). In the 21st century, we are faced with series of drought, flood, water pollution, and new consequences caused by global warming and climate change.

It is meaningful to discuss on possible urban water use considering available water resources on a watershed basis. Since an extensive water use has been conducted in a watershed supporting water demand in Tokyo and Saitama, we conducted a research on sustainable urban water system. In this research, we predicted availability of rainwater considering the future climate change and evaluated water quality of reclaimed water. We integrated new findings on rainwater use potential and biological stability of reclaimed water in order to explore a strategy of sustainable urban water use adapted for climate change.

2. Material and methods

The study area is the Arakawa watershed, which has the catchment area of 2,940 km2, the river length of 173 km, the population of 9.3 million people and the population density of 3,100 people/km2. There is very extensive water use for irrigation, industry and domestic water supply.

3. Results and discussion

Rainfall prediction in the future

In order to design water use system in the future, it is necessary to estimate the frequency and severity of drought. We predicted future drought condition compared to the current situation using output at the global warming scenario of RCP4.5 from five Global Circulation Models (GCMs). The outputs from the GCMs were dynamically downscaled with the combination of pseudo global warming method and the Weather Research and Forecasting model.

Figure 1 shows the frequency of annual rainfall below 75% of the current average in the Kanto Region using outputs from the five GCMs. Higher frequency of drought is anticipated in the future for the Arakawa watershed. During the period from 2060 to 2070, annual rainfall below 75% of the current average is likely to

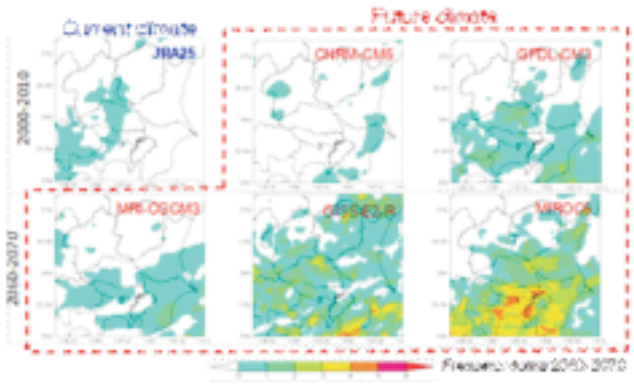


Figure 1. Frequency evaluation of annual rainfall below 75% of the current average in Kanto Region using outputs from the five GCMs. increase.

Estimated rainwater use potential

Rainwater harvesting is expected to contribute to the preservation of water resources. We estimated how much rainwater can be utilized in a watershed, considering residential and non-residential buildings. Figure 2 shows that the rainwater use potential can be estimated as 295 million m3 in the whole watershed, which corresponds to 85mm rainfall equivalent in the current climate. Comparison with the current condition, the potential will be reduced by 15 %

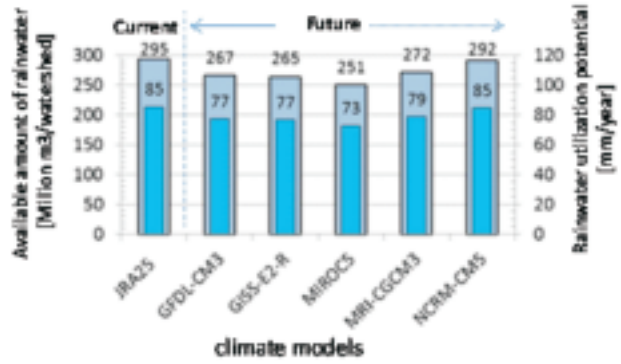


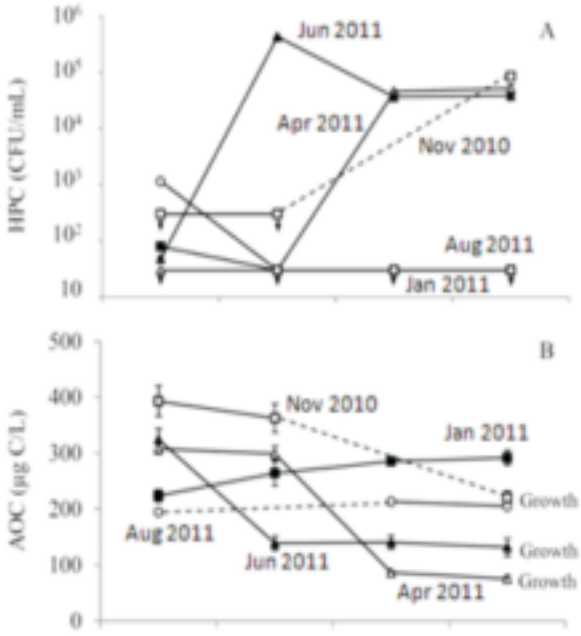
Figure 2. Frequency evaluation of annual rainfall below 75% of the current average in Kanto Region using outputs from the five GCMs. at the maximum case among the 5 GCMs.

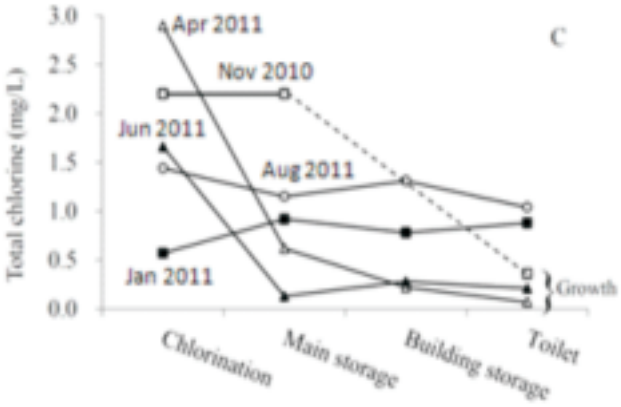
Biological stability of reclaimed water

We investigated a biological stability of reclaimed water with ozonation. As shown in Figure 3A, the Heterotrophic Plate Count (HPC) differed among the five different sampling occasions in the reclaimed water distribution system from Plant A. An increase in the HPC was observed significantly ($p<0.05$) in November 2010, and April and June 2011. In June 2011, the HPC increased in the distribution pipe or main storage tank. In November 2010 and April 2011, an increase in the HPC was observed after the main storage tank.

The reduction in the AOC concentration (approximately 100-200 ?g C/L) was observed significantly ($p<0.05$) in parallel with the HPC increase in these samples (Figure 3B). The AOC level did not decrease throughout the distribution and storage in January and August when the HPC increase was not observed; moreover, the AOC was rather increased in January ($p=0.017$). When microbial regrowth was observed in the distribution and storage in November, April, and June, a reduction in the total chlorine was also observed (Figure 3C). On the other hand, microbial regrowth was not observed when the total and free residual chlorine concentrations were maintained at greater than 0.62 mg/L and 0.10 mg/L, respectively. To secure biological stability in reclaimed water, the placement of biological filtration after ozonation is worthy of consideration. With increased biological stability, reclaimed water can be stored longer with less change in water quality.

Figure 3. Changes of HPC (A), AOC (B), and residual total chlorine (C) in the distribution system of Plant A.





4. Conclusions

Rainwater and reclaimed water should be properly allocated to urban water use by considering the balance between water supply and demand in cities. This requires information on available amount and detailed quality of various water resources in a watershed. Based on the information, possible strategies could be constructed for sustainable urban water use adapted for climate change.

5. References

(1) Furumai, H., 2008. Rainwater and reclaimed wastewater for sustainable urban water use. Physics and Chemistry of the Earth, Vol. 33 (5), 340-346.

Speaker's profile:

Dr. Hiroaki Furumai

Professor, Research Center for Water Environment Technology, Graduate School of Engineering, The University of Tokyo, Japan International Water Association, Board of Director (2012-), IWA Fellow (2010-), Japan Society on Water Environment, President (2015-), Water Research, Editor (2008-).

Field of Interest:

Sustainable urban water management focusing on water pollution control and water environment conservation. Urban nonpoint source pollution, modeling water quality dynamics, urban drainage management and rainwater & reclaimed water use.

Development of new water supply strategies in two major cities of India and Sri Lanka in the context of climate change, rapid urbanization and population growth: a vulnerability assessment approach

Manish Kumar[1]
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ABSTRACT:

This project aims to re-examine the current urban water use system and propose a new one to cope up with the future climate change, rapid urbanization and population growth in two South-Asian Cities. In the new system, each water resource will be properly allocated to each water use by considering the balance between water supply and demand. This requires information on available amount, and chemical and biological quality of various water resources, recharge zone identification for sustainable planning as well as people perception and willingness to pay. Two of main cities in South Asia; Guwahati (India) and Colombo (Sri Lanka), are selected as research fields. Both locations fall under Asian monsoon region but are on different phases in economic and demographic growths. Henceforth, suggested water supply strategies are going to be an integral part of infrastructure development of urban area especially in developing countries. Climate change and related uneven rainfall distribution cause water shortage. In such areas, safe water supply might become unsustainable, because water pollution becomes severer by decrease of water recharge and unintentional shift of water resources. We intend to evaluate urban water use strategies suitable for each city from various angles and develop Water Quality Information Platform (WQIP) and new strategies of sustainable water supply under climate change scenario. The research will have an impact not only on the critical scientific understanding of emerging chemical and biological pollutants issues posing threat on water potable use, but also on the development of a sustainable water management in urban and agriculture sectors.

Introduction:

Alteration in the global climate pattern can lead to societal impacts with the increasing demand on natural resources which are undergoing depletion due to unsustainable resource utilization. To address these problems, an integrated approach is required. With the varying global precipitation pattern as a result of climate change, managing water resources and their sustainable use is also becoming a burning global issue. Water availability and its quality have been deteriorating day by day as a consequence of climate change. Climate change evidently leads to societal conflicts. Hence the need of the hour is to adopt mitigatory approaches which can at least diminish the effect of climate change to a certain extent.

For sustainable water resource management, we need to adopt efficient water supply operating systems according to the availability and quality of water of that particular area. Aim of the proposed research is to achieve sustainable water resource management by understanding the governing processes of water storage and water supply on large scale followed by developing integrated efficient operating systems. We genuinely believe that the proposed research is not only a need of the hour, but also a first step to accomplish a sound and sustainable water environment in both thickly populated countries of Asia.

Assessing vulnerability of urban water systems is a major task considering the high complexity of such system. Decision-making needs to consider several aspects of health, environment, economy, socio-culture and technical function within a framework that includes interactions between users, organizations and technology and policy makers. To manage water resources, the most crucial step would be an extensive, in-depth study of the impact of climate change on water resources on watershed scale (Almeida et al., 2007; Brilly et al., 2006; Ouyang et al., 2006; Kumar et al., 2013). In the present era of high population growth, rapid urbanization and climate change, uncertainty of natural phenomenon and landuse pattern are rapidly increasing and posing serious threat on drinking water supply from both quantity and quality perspectives in many urbanized cities. Another aspect is to contamination threat to groundwater recharge as well as to reduce the non-point pollutant loads from urban surfaces to surface waters (Chaminda et al., 2005; Hara et al., 2010; Kumar et al., 2011). Urbanization results in severe environmental deterioration (Honda et al., 2010) because

countermeasures, which need to wait for policy-makers' decision, cannot catch up with the change (Bausch et al., 2014; Hsu et al, 2014).Much advancement has been made in this field but the difficulty lies in the application of the existing information to arrive at a solution for this.

The project addresses a very important issue concerning sustainable supply of water to the increasing urban population in a situation where overall water availability is reducing due to climate change and increasing demand from the agriculture sector. The competing demands for water to meet the needs of increasing urban population and the increasing demand of the agriculture sector have to be kept in view while planning for sustainable water supply to the increasing urban population.

Relevance to APN's Fourth Strategic Plan

Climate change evidently affects the global precipitation pattern which can lead to societal conflicts. Hence the need of the hour is to adopt mitigatory approaches which can at least diminish the effect of climate change to a certain extent. Managing water resources using an integrated approach would be critical to mitigate social, economic and environmental impacts. IPCC in 2007 said that "water and its availability and quality will be the main pressures on and issues for societies and the environment under climate change". When planning future water supplies, the global picture becomes less important than the effect of climate change on safe water availability in individual regions and seasons. Also, the mitigation strategies should be considered keeping the increasing demand of safe water in mind. The aim of the proposed research is to achieve sustainability in the water resource management by understanding the governing processes of water storage and supply on watershed scale followed by developing integrated efficient operating system. As both countries are in developing phase and modernization of infrastructure are eyeing on meeting the demand of employment and basic amenities for people residing in urban area. Thus proper research is the need of time as outcome can be easily incorporated and can enhance the life sustenance capacity of both cities of the Asia Pacific region.

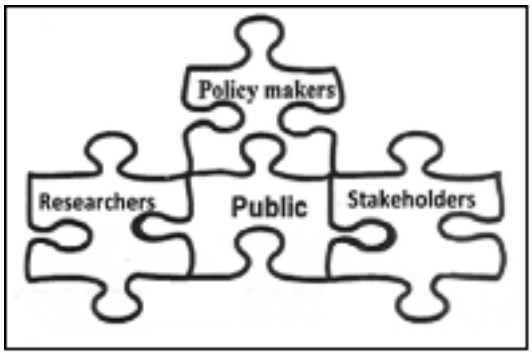

Figure 1 Bridge between scientific community and public.

Further, the collaboration and idea of the proposed research is such that strong science-based response strategies/ measures with effective linkages between science and policy, as well as scientific capacity building will occur. The outcome of the project can be rationalised only through an interface of natural, social, economical, behavioural and political sciences and as a bridge to fill the gap between scientists and policy makers by creating opportunities for them to interact effectively and by providing robust scientific input to policy decision-making and scientific knowledge to the public, civil society and other non-science communities (Fig.1).Thus outcomes of this study will be relevant to and/or mainstreamed into policy processes. These issues are kept in the priority list of APN agenda and very much on the line of APN goal and policy process.

Objectives and Deliverable

Objectives of the Project

The aim of the proposed research is to achieve sustainability in the water resource management in an urban area by understanding the governing processes of water storage and supply (quantity and quality) on cities followed by developing integrated efficient operating system scheme for sustainable water supply. The main objectives of the proposed research can be summarized point-wise as follows:

- To evaluate the current urban water use system and people perception of future drinking water issues in two major cities of Asia Pacific region (Guwahati, India andColombo, Sri Lanka).

I. To assess the risk from the current water sources considering the expected quality change by climate change. It includes understanding of the vulnerability of water supply system from various traditional biological and chemical pollutants with a special emphasis on intestinal enterococci (*Enterococci sp.*) and heavy metals.

II. To understand the holistic water cycle of the particular cities by tracing water recharge source and zones through isotopic tracers, water quality assessment, multivariate statistical analyses and HYSPLIT modelling.

III. To propose a new water supply system more adaptive to the future climate change where each water resource will be properly allocated to specific water use by considering the balance between water supply and demand.

Expected Deliverables/Outputs

The proposed research will have an impact not only on the critical scientific understanding of emerging chemical and

biological pollutants issues posing threat on water potable use, but also on the development of a sustainable water management, in general. It will further help to understand the vulnerability of drinking water supply system dependent on two major cities of two developing countries subjected to rapid urbanization and population growth. One of the expected outcomes is to educate and knowledge transfer by providing easily understandable water quality information of various water resources in two major cities (Guwahati, India andColombo, Sri Lanka) to promote general public to use alternative waters such as rainwater and reclaimed water for sustainable management of available fresh waters. The uniqueness of study lies in the integration of approaches and techniques. Moreover, in order to sustain rapid population growth, developing countries are being forced to develop immediate and immense infrastructure that must withstand long term water demand, where watershed protections especially recharge zone will be the key part of urban water supply system.

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Field of Interest:

Pathways of contamination in Freshwater System, Sources of the urban pollution and sustainability of urban water cycle under changing climate regime, Development of pollution assessment tools, remediation technique and management.

Health of Himalayan glaciers in changing climate scenario and its implication on water resources and livelihood

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ABSTRACT:

Climate variability and change has been affecting glacier/snow melt water dependent hydrological systems in densely populated large glacier fed river basins of Himalayas. The changing glacier mass and volume continue will affect livelihoods in these basins adversely by altering water resources, impacting farm and non-farm sectors, health, tourism etc., The Indian Himalayan region occupies a special place in the mountain ecosystems of the world. Among the global mountain system, the Himalaya is the most complex and diversified, and separates the northern part of the Asian continent from South Asia. This young mountains are not only important from the standpoint of climate and as a provider of life, giving water to a large part of the Indian subcontinent, but they also harbor a rich variety of flora, fauna, human communities and cultural diversity.

The Himalayan region has largest number of glaciers. Major perennial rivers and their tributaries such as Indus, Ganga, Brahmaputra originates from the glacier bound terrain. The contribution of glacier melt in annual stream runoff is found to higher in Indus basin as compared to Ganga and Brahmaputra. In Indus the well-developed canal network in the Indus basin produces almost 96% and 26% of food production of Pakistan and India respectively .The runoff pattern in Indus basin due to melting glaciers is significantly influencing the water and food security of the region. In Himalaya, extensive investigations have been carried out to estimate the loss in glacier length and areal extent. The region being a discrete geographical and ecological entity, figures prominently in major biophysical settings of the planet earth. The vast mountain range produced a distinctive climate of its own and influences the climate of much of Asia. Temporal and spatial variations caused by diversity in geological orogeny have resulted into a marked difference in climate and physiography and consequently in the distribution pattern of biotic elements. In view of growing threat to biological diversity, conservation and rational use of biodiversity in the Himalayan resource could bring enormous economic benefits to the local populations and can indeed contribute to sustainable development.

Long term (fifty years) glacier mass balance and runoff were simulated for the small catchment in Chhota Shigri Glacier (Western Himalaya) help to understand the linkage using gridded data from three regional climate models in Himalayas. The mass-balance model calculates daily snow accumulation, melt and runoff. The model parameters are calibrated with available mass-balance measurements and results are validated with geodetic measurements, other mass-balance model results and run-off measurements. Monthly runoff increases are greatest in July, due to both increased snow and glacier melts, whereas slightly decreased snowmelt in August and September was more than compensated by increased glacier melt. It is expected to remain a complex phenomenon impacting livelihoods and triggering the need for adaptation. The region is known as glaciers cover water tower of Asia-approximately 1020% of the area, ?while 3040% remains under seasonal snow cover. Despite the vast water resources trends such as diminishing regulatory effects of glaciers, streams and rivers are gradually occurring in the region. Development of societies is shaped to a large extent by their resource base. Water resources projects provide the basis for regional development with significant direct and indirect benefits for poor people. Pressures on water resources are growing with continuous population growth, inefficient groundwater infrastructures and landscape changes. The problem is compounded with global climate change adversely affecting the availability of groundwater. Future scenarios show an increasing temperature in the Ganges and Indus basin with higher precipitation variability.

Managing the increasing demand and competition is a concern for planners and policy makers. To effectively respond to the effects of climate change, climate resilient development with water management systems incorporating the priorities of poor people in a sustainable

manner is required. There is a need to strike a balance between the provisioning, regulatory, cultural and supporting services and having a multifunctional modeling approach to improve food, livelihood, and its pristinely nature. Though there are issues pertaining to conducting local-level assessments and modeling the dynamic nature of climate change, livelihoods and adaptations by community and livelihood based adaptations being practiced showcase strategies that serve in enhancing resilience. Collaborative adaptation research is required to aid evidence-based decision-making by demonstrating scalable adaptations informed by local and scientific knowledge relevant to stakeholder needs.

Speaker's profile:

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Field of Interest:
Glacier, climate and water resources, Ground water As, F and U pollution studies and Mangrove biogeochemistry

Water and Wastewater Management in Urban Cities: Challenges and Solution Pathways

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Abstract :

Managing water and wastewater in most urban cities is becoming a daunting task for the planners, engineers and decision makers. The interest of various stakeholders in this subject domain is gaining momentum in view of sustainable development of a city and enhancing liveable city conditions. The objective of this paper is to present challenges that are encountered in managing water and wastewater in urban environment and identifying solution pathways to overcome from these challenges. The findings are supported based on the data evidences and scientific analysis for the urbanized cities in Ganga river basin of Indian subcontinent. The study shows that the land use land cover is changing at a rapid rate due to urbanization and development of cities, and consequently the impervious surfaces is increasing. The increase in impervious surfaces influences the hydrological cycle which results into the increased surface runoff and reduced groundwater recharge that lead to several new water challenges in urban environment. These new water challenges in urban environment include water drainage, urban flooding, groundwater decline, water and wastewater infrastructure, demand-supply mismatch and climate change implications. Further, the growing water demand leads to increase in the wastewater generation also. The wastewater generation from domestic and industrial sources is increasing manifold day by day because of urbanization, increased population, changing lifestyle and industrialization. These wastewaters find some pathways to contaminate groundwater and surface water because of inadequate infrastructure of efficient wastewater disposal system and inefficient and inadequate wastewater treatment plants. The study reveals that there is need to develop implementable sustainable technologies, smart water and wastewater infrastructure, intelligent urban water management system, optimal water management policy, and sustainable land use pattern to effectively address water and wastewater challenges encountered in real life urban environment.

Keywords: Water Management; Wastewater Infrastructure; Urbanization; Hydrology; Groundwater; Sustainable Development

1. Introduction

The urban population is increasing continuously worldwide. The expected growth in the world population will be concentrated in the urban areas of the less developed regions, whose population is projected to increase from 2.5 billion in 2009 to 5.2 billion in 2050. Over the same period, the rural population of the less developed regions is expected to decline from 3.4 billion to 2.9 billion. In the more developed regions, the urban population is projected to increase modestly, from 0.9 billion in 2009 to 1.1 billion in 2050 [1]. In turn, the water demand and wastewater generation have also increased, and they are expected to increase further at a rapid rate as the effect of population increase will be accelerated by the industrialization and changes in the lifestyle. On the other hand, the availability of freshwater reduces because of increased impervious surfaces resulting from urbanization and water pollution resulting from urbanization and industrialization. The urban water quantity and quality problems are closely linked to the development taking place in the city [2]. The dependence on groundwater resources is significantly going up in urban areas due to limited fresh surface water. The water demands from groundwater resources for agricultural, municipal and industrial sectors are becoming very competitive. However, the increased impervious surfaces, changing land use land cover in urban environment and exorbitant groundwater draft are causing decline in groundwater resources in many regions, particularly in arid and semi-arid regions. This complicates and brings great challenge in the management of water and wastewater in urban environment.

2. Material and methods

A large number of published literature and study reports were reviewed to identify the challenges in water and wastewater management. The scientific analysis was also carried out based on the data [1, 3] for a number of urbanized cities in Ganga river basin of Indian subcontinent to support the observations and findings obtained in this study. The groundwater resources assessment is based on the GEC methodology (Groundwater Estimation Committee's methodology) which is based on the water table fluctuation and is widely

accepted in India for assessing groundwater resources on a watershed or block/city/district/state level. The area of impervious surfaces and land use land cover were obtained using satellite imageries of optical band.

3. Results and discussion

Fig. 1 shows the variation of sewage treatment capacity available in metropolitan cities and class I and class II cities of India. The metropolitan cities are those that have population more than 1 million. The class I city has population more than 1 lakh (0.1 million) and class II city has population less than 1 lakh. It is evident from this figure than metropolitan cities are having only 51% installed capacity for the treatment of wastewater generated in these cities. The conditions of class I and II cities are very poor in terms of infrastructure facilities for sewage treatment, considerably less than 50%.

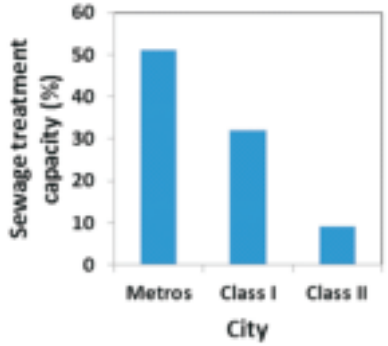

Fig. 1 Sewage treatment capacity in cities

To examine the wastewater infrastructure facilities in Ganga river basin which is a lifeline for millions of people, the study was conducted for a number of class I cities located in this basin. Fig. 2 shows major urbanized cities located in this basin. Fig. 3 shows the sewage generation and treatment capacities available in the selected metropolitan cities of Ganga river basin. It is evident from this figure that sewage treatment capacities available in Delhi, Kanpur, Allahabad, Varanasi, Patna and Kolkata are 61%, 41%, 34%, 44%, 38% and 24%, respectively.

Fig. 2 Locations of major urbanized cities in Ganga river basin

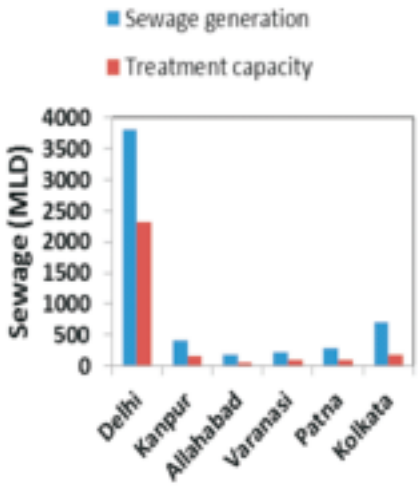

Fig. 3 Sewage generation and treatment capacity in metropolitan cities of Ganga basin

It is also observed that many treatment plants do not operate at the maximum efficiency and many become non-functional because of some operative problems. Thereby, the untreated wastewater finds some pathways to join rivers to contaminate it. Besides, they contaminate groundwater also in their course of travel through seepage. Such situation has been observed in the Delhi stretch of Yamuna river which is one of the major tributary of Ganga river. For more details on the wastewater disposal to river Yamuna, its effect on water quality and interaction between groundwater and river in terms of major ion chemistry can be found in reported literatures [4, 5]. The optimum waste load allocation to the Yamuna river and management strategies involving a combination of wastewater treatment at different levels and flow augmentation have been obtained to restore the river quality [6].

Fig. 4 shows the variation of annual replenishable groundwater and annual groundwater draft in a number of States of Ganga river basin. Among these states, Uttar Pradesh, Bihar and West Bengal are located on the downstream side and have large geographical area that comprises of large and very thick alluvium aquifer system. Uttarakhand is a hilly area and head streams along with the originating point lie in this region. Delhi is a small state and characterized by alluvium and quartzite subsurface systems. It is evident from this figure that Uttarakhand, Bihar and West Bengal are exploiting groundwater resources about 50% from the dynamic zone, whereas Uttar Pradesh is exploiting nearly two third and Delhi is over exploiting groundwater resources. These results are based on the data available to carry out evaluations in year 2013. The excessive groundwater draft and increased impervious surfaces have resulted into the reduced groundwater recharge in the Delhi region, which is reflected in the decline of groundwater table. A number of sustainable

technologies have been proposed for accelerating groundwater recharge and to bridge the gap in the water demand-supply mismatch for the Delhi region [7].

4. Conclusions

The study reveals that the level and complexity of water and wastewater challenges vary greatly depending upon the city landscape, changing land use land cover, urbanization and industrialization patterns and its linkages with the hydrology and human interventions. The growing water demand from various sectors and the rise in water pollution problems from urbanization and industrialization are complicating the scenario of wastewater management. The wastewater generation from domestic and industrial sources is increasing manifold day by day, and find some pathways to contaminate groundwater and surface water because of inadequate wastewater infrastructure.

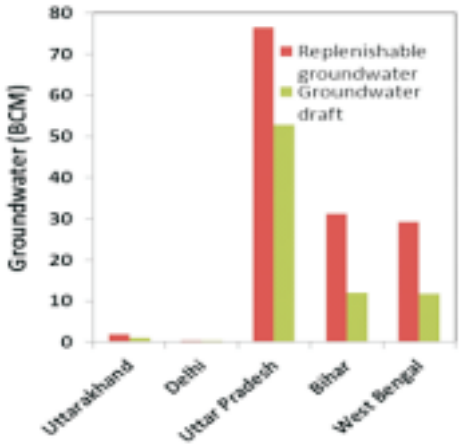

Fig. 4 Variation of replenishable groundwater and groundwater draft in selected States of Ganga river basin

The wastewater disposal from municipal as well as industries is becoming a major challenge in view of environmental regulations, environmental impacts in irrigation command and advocacy or compliance of Zero Liquid Discharge (ZLD).The increase in impervious surfaces influences the hydrological cycle and results into the increased surface runoff and reduced groundwater recharge that lead to several new water challenges in urban environment. The study reveals that there is need to develop implementable sustainable technologies, smart water and wastewater infrastructure, intelligent urban water management system, optimal water management policy and sustainable land use pattern to effectively address these challenges encountered in real life urban environment.

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Field of Interest:

Water Resources Engg., Groundwater Modelling,, Environmental Modelling, Hydrology &Hydrogeology,Remote Sensing & GIS, Urban & Snow Hydrology, Smart-Water, EIA & Sustainable Development.

Relating characteristics of Regional Climate and Droughts in India

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Abstract :

Much of human settlements and economic activities are concentrated in the mid-climatic regions of the earth. The life, environment, agriculture, and native economic activities in these regions are exposed to a wide variety of climatological, meteorological, and hydrological hazards. The spatial and temporal scales of these hazards vary from short-lived violent phenomena, such as flash floods, cyclones, and heavy floods to widespread and prolonged droughts. Among all other natural disasters, drought affects maximum number of people and highest extent of land areas for a period of several months to years causing severe water scarcity, famine, mass migration, desertification and loss of life in different parts of the world from time to time. The climate of the region governs the frequency of occurrence, severity and persistence of drought events. The regions with greater inter-annual variability of precipitation are more susceptible to frequent and severe drought. India has diverse range of climatic regions ranging from hyper arid, arid, semiarid, to sub-humid, humid and hyper humid areas. The frequency of occurrence, magnitude of severity and its prolongation in successive years vary greatly in above climatic regions in India depending on mean annual precipitation, evapotranspiration, temperature variation and length of wet season. In India, drought is linked to the amount and distribution of monsoon season (June-Sept) rainfall. The major causes of droughts are late onset of monsoon, less than normal amount of rainfall, long dry spells during rainy season and early withdrawal of monsoon. This paper presents analysis of drought characteristic in different climatic regions using 113 years (1901-2013) rainfall and temperature data for 526 stations across the country and the strategies for drought management in different climatic regions in India. The arid and semi-arid regions in India face more frequent droughts with an average return period of 3 and 4 years, respectively. It is 5-6, 7-8 and 8-15 years, respectively, in dry-sub-humid, sub-humid and humid regions. The magnitude of severity and socio-economic impacts are much higher in arid and semi-arid regions compared to other climatic regions. The occurrence of persistent drought events for 2 or 3- consecutive years are more in arid regions followed semi-arid and dry sub-humid regions. The persistent drought events in sub-humid and humid regions are rare. Therefore, region specific drought monitoring, assessment and mitigation approaches are essentially required for precise assessment of areas vulnerable and to droughts. This paper presents possible alternatives of drought mitigation in different climatic regions in India.

Speaker's profile:

Dr. Rajendra Prasad Pandey

Currently working as 'Scientist G' in the National Institute of Hydrology, Roorkee in India. He is Member- Secretary of Indian National Committee on Climate Change (INCCC) of Ministry of Water Resources. Also, he is member of Science-Policy-Interface (SPI) of the United Nations Convention to Combat Desertification (UNCCD). He has bachelor degree B. Tech. in Agricultural Engineering, a master degree M.Tech. in Soil and Water Engineering. He did is PhD degree on Drought from Dept. of Hydrology, IIT Roorkee, India

From last 27 years--Dr Pandey has been conducting basic and applied research studies on various aspects of climate change and drought. He has authored and published 60 research papers in peer reviewed international / national journals and 7 chapters in edited books. He has authored and presented 65 research papers in conferences and symposium. He has completed 4 sponsored projects, 29 internally funded research projects and 5 consultancy projects. Some of his important research contributions are:

Development of relationships between climatic parameters and the average drought frequency,
Revised classification of Standardizes Precipitation Index (SPI) and Effective drought Index (EDI) for their applicability in different climatic regions of India,
A new index for quantification of vulnerability to drought
Developed stream flow drought severity index (DSI) etc.

He has authored a book entitled “the new drought products: transforming drought information to facilitate decision making in 2015. He is also working as “Secretary” of Indian Association of Hydrologists.

Can bio-treatments of solid waste minimize the water contamination risk?

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Abstract:

World Bank records reveal that 50% of world's population is living in cities and the growth in percentage of city dwellers is rising. Moreover, solid waste generation is increasing at faster rate than the rate of urbanization. Consequently, the size of the dumping sites in cities is increasing, thereby severely contaminating the land and water resources. Therefore, sanitization of solid waste should ensure cleaner and healthier city ambience. Under such perspectives, meaningful application of biocomposting technologies can be a useful proposition because of their simplicity, cost effectiveness, and diversified utilities. The immediate benefits are substantial reduction in volume of solid waste and recycling in agriculture as organic nutrient source. Among several techniques, vermiculture technology has been proved to be the most flexible because the earthworm mediated reactors are not only capable of sanitizing solid wastes but also works as a successful effluent filtration system. As such, this earthworm mediated system is far more efficient than conventional composting in regard to particle size and density, nutrient enrichment, time, microbial diversity, and water holding capacity. A wide range of complex industrial and urban wastes can be treated and stabilized through vermicomposting. However, the major benefit of vermicomposting lies in utilizing the metal removal potential of earthworms to remediate waste materials. The immense importance of earthworm in the domain on pollution remediation would be evident from two recent publications in Nature Nanotechnology and Nature Communication; where it is emphasized that exploration of the stress management and protection mechanisms in earthworms can help to utilize this unique creature to remediate and stabilize toxic sludge and effluents Conventionally, metallothionein protein are known to be responsible for metal removal as they bind metals and transform them into insoluble or non-toxic forms. Interestingly, our recent study revealed that there may be one or more high molecular weight, non-metallothionein proteins that also efficiently detoxify toxic metals.

Speaker's profile:

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Research Professor in Hanyang University, Seoul, Republic of Korea

Field of Interest:
Biocomposting techniques; soil health management; solid waste utilization; biofertilizers; nano-fertilizers; plant bioactive compounds and their use.

Managing land and water under changing population and climatic conditions in India

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Abstract:

Today, the international community realizes that climate change and disaster vulnerability has everything to do with poverty and development, and vice versa. Poorly-planned development and inappropriate poverty reduction measures can increase vulnerability to external natural shocks. In the case of developing economies, climate change and its economic consequences presume vital importance in the process of realizing sustainable development in the longer timeframe. Land and water are the two major ingredients of the successful realization of this process. It is needless to say that land and water can't be disconnected while addressing the issue of sustainable development. This paper would concentrate on the issue of water where many issues would be equally relevant to the issues of land. It has been concluded in the Natural Resources Defense Council report that, the global warming may increase the risk of floods, so an efficient and conservative water use will be of paramount importance for future water supply. The main motivation of this paper is to discuss the water management challenges that can handle the threats or stresses like Global Environmental Change (GEC), climate changes, natural disasters like flood, drought or even an extreme climatic event like cyclone. This paper focuses on the broad area of water management issues such as the major river system of India, condition of ground water resources, the current water utilization, water losses, water under stress, water pollution and increased population & its impact on the problem of scarcity of water. It also focuses on the current water policy, land and water rights and act, Interstate Water Dispute Act etc. An attempt has been made to illustrate the environmental interface between land, water and climate in an interdisciplinary manner.

Speaker's profile:

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Fields of Interest:
Climate change-Vulnerability & Adaptation (V&A); Community based Watershed Management; Greenhouse gases (CH_4, N_2O, CO_2) management & Carbon Cycling in Agro-ecosystems; Soil Pollution and Solid Waste Management through indigenous materials and methods.

Challenges in the geomorphic management of a river system in response to urbanisation expansion around a mega city: Case study from Yamuna River around Delhi NCR

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Abstract

Larger river systems may have been significantly affected by rapid urbanisation in India. However, geomorphic studies on the interaction between large rivers and megacities are still limited in India. The Himalayan rivers will be more sensitive to these changes, because their hinterland area is already among the most ecological fragile region. The rivers in downstream region may be further affected by expansion of megacities along its bank. These conditions pose critical challenges for sustainable management of the Himalayan rivers in present and near future. This work highlights such challenges and complexity of processes in the Yamuna River at different spatial and temporal scales around the National Capital Region (NCR), Delhi.

Keywords:*channel morphology; urbanisation; sediment connectivity, stream power, Yamuna River, Delhi*

1. Introduction

Understanding of morphological dynamics and management of channel morphology is one of the fundamental aspect of sustainable stream management. Channel morphology at any given location acts as a proxy for the processes operative in the system. Hence, morphological appearance of a channel provides information about dominant processes and connectedness of different sub-system in a river system. Further, the physical state of river system also defines its ecological health.

Channel morphology is governed by variability in fluxes and energy condition in the channel. The liberation rate of potential energy during downstream flow of water defines the energy state, whereas sediment characteristics and channel roughness defines resistance again flow energy. Channel morphology is an equilibrium stage between driving and resisting forces in the system (Jain et al., 2012).

Anthropogenic impacts and urbanisation significantly affect flux variability and flow energy in a river system, hence, it can change channel morphology in a significant way. Changes in channel morphology in response to external disturbances is a nonlinear and complex process as it is further governed by threshold condition and connectedness between different geomorphic compartments (Jain et al., 2010; 2012). The change in channel morphology will be far reaching impact on river ecosystem and its overall health. A detailed study on these aspects has been presented for a large Himalayan river around a megacity.

The Yamuna River is the largest tributary of the Ganga River having basin area of 3.4×10^5 km^2. It flows through the northern part of India covering 1370 *Kms* and finally merges with the Ganga River at Allahabad. There are two barrages around NCR Delhi area, which has affected flux movement and morphological dynamics in this area.

2. Material and methods

Hydrological data were obtained from Central Water Commission (CWC), Government of India, for the period of 1980 to 2010. The daily discharge and sediment concentration data were analyzed for two hydrological stations located at upstream and downstream of the National Capital Region. Sediment concentration values were converted into sediment load data to analyse channel morphological processes and pattern of sediment connectivity across NCR. The stream power patterns were derived using topographic and hydrological data. Sediment connectivity was analysed at different temporal scale and reaches were classified in four different classes of Disconnected, Partly Disconnected, Partly Connected and Connected on the basis of flux transfer (Jain et al., 2010).

3. Results and discussion :

The Yamuna River is characterised by significant geomorphic diversity (Fig. 1). The upstream and downstream reaches are characterised by well distributed bars in the channel area, however midstream reaches show less geomorphic diversity with few bars in the channel area (Bawa et al, 2014). Downstream variability in channel morphology was analysed using stream power and unit stream power distribution pattern. The upstream and downstream reaches of the Yamuna River are higher energy reaches. Stream power is sufficient to transport sediment and create complex geomorphic system. However, midstream

reaches are characterised by very low energy condition, where river doesn't have sufficient energy to transport the sediments. The lower value of stream power is due to disconnection created by barrages.

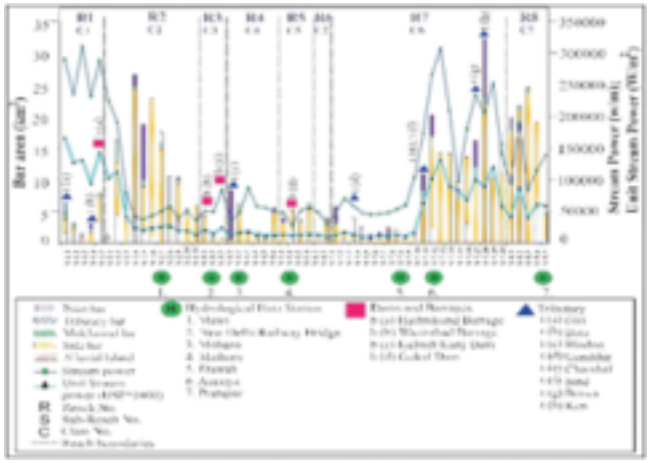

Figure 1. Distribution of channel bars and Sediment distribution pattern (Bawa et al., 2014)

Impact of barrages was further analysed through sediment connectivity analysis. Results show that from the mountain front to NCR, Delhi sstretch of the Yamuna River is geomorphologically disconnected. Around 5 Million Tons of sediments have been trapped in the Yamuna river near NCR Delhi. Peak discharge data also reveals that flood events were unable to connect the system with downstream station in terms of water and sediment fluxes. Extensive siltation between stations at upstream and downstream of Delhi NCR highlights major disconnection of downstream reaches with the upstream processes in the Himalayan area. Further, it is highly unlikely the any erosional signal from the Himalayan terrain will move downstream at modern time scale, because increase in sediment supply from upstream station pushes the system towards disconnectedness. The resultant aggradational processes are responsible for significant degradation in channel morphology and biodiversity.

Sediment transport relationships were further used to define environment-flow (E-flow) condition for the Yamuna reach for four different seasons. E-flow values were estimated for different cross sections. Specific stream power values were further estimated on the basis of higher resolution topographic data. Our study shows that E-flow values in the Yamuna River will be around 40-50% of total flow volume in river system.

4. Conclusions :

The present set of work thus showcases the scenarios in the megacity where excess pressure on river is resulting in an unhealthy river. Such process based approach using the concept of stream power will be very much useful for planning sustainable development in future, as it can act as a tool to identify the impact of urbanisation on the physical state of river system. Thus effective management plans must be aim at maintaining the lost connectivity for hydrological and geomorphic processes.

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Fields of Interest:

Earth surface processes, River science, External forcings and river's future, Glacio-fluvial coupling, Geomorphic applications in stream management.

Toward a Food-Energy-Water-Ecosystem Services Nexus for Rapid Growing Cities in a Changing Climate

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Abstract

The rainfall variability is most important for any national economy as it is predominantly involved in agriculture and food production. As most of the population lives in urban areas, a change in rainfall or temperature extreme events would have a strong impact on the growing economy of any country. The most prevailing consequences of climate change are not the changes in mean conditions but the overall increase in the behavior of extreme events. The objective is to study the historical trends in climate extremes to evidence possible physical vulnerabilities and eventually aid adaptive measures.

Keywords: Climate Change; Climate Extremes; RCLIMDEX; Urbanization;

1. Introduction

Rainfall is arguably the driver of the hydrologic cycle and the Food, Water, Energy, and Ecosystem Services (FEWES) infrastructures around the world. Precipitation deficits and surpluses affect within hydrometeorological and climate influences FEWES sustainability at local to global scales, altering natural and human-modified processes on the physical (e.g. streamflow generation and water storage), Biological/Biogeochemical (e.g. water use efficiency and nutrient loads), socioeconomic (e.g. virtual water trades and water rights) dimensions. In rapid growing cities, dynamically changing boundaries of urban areas and FEWES production areas are affected by extreme precipitation as well as droughts. However is unclear if those changes are occurring at the same rate and under the same intensity in the historical record or in the future climate changes. The goal of the present work is to characterize the sensitivity of changes in indices of Extreme Hydrometeorological and Climae Events (EHCEs) in two contrasting mid-size urban centers. A multidimensional and interdisciplinary system, complex and dynamic, of naturally-driven and human-modified process requires robust analyses of EHCEs to make more informed decisions leading to more sustainable growing cities.

The most prevailing consequences of climate change are not the changes in mean conditions but the overall increase in the behavior of extreme events. A slight change in the frequency of extreme events such as floods, droughts, heat waves will have severe impact on both human society and natural environment (Easterling et al., 2000). An increase in the number and magnitude of extreme climate events is observed in the recent past in most parts of the world causing huge loss of lives, extensive damages to crops, properties and immeasurable misery to millions of people (Hartmann et al., 2013). The Intergovernmental Panel on Climate Change (IPCC) in its fourth Assessment Report (AR4) stressed on more persistent extreme weather events in the future (IPCC, 2007). Such extreme events will be predominant for rapidly urbanized cities in the context of climate change under the stress of population growth. The study of climate extremes has progressed enormously over the last few decades (e.g. Zhang et al., 2005; Curry et al., 2014; Razavi et al., 2016) due to the international coordinated efforts led by the Expert Team on Climate Change Detection and Indices (ETCCDI). Specifically, a team was formed by the commission on Climate Variability and Predictability (CLIVAR) under the World Meteorological Organization (WMO). Study of such extremes may be critical for any urbanized centre as it can directly impact the flash floods, heat waves etc and can be more intense under climate change. Further, the understanding of climate extremes is essential for urban water management and adaptive decision-making. The objective is to study the historical trends in climate extremes to evidence possible physical vulnerabilities and eventually aid adaptive measures. To this end, the present study mainly emphasis on the assessment of extreme climate indices developed by ETCCDI in the context of rapidly urbanized cities. In this context, the study considered two rapidly developed cities in a developed country in the Northern hemisphere (Lincoln NE) USA and an emerging-economy country in the tropics (Hydaband) India to compare the historical trends in the climate extreme indices of precipitation and temperatures.

2. Material and methods

2.1 Data

To study the climate extreme indices of precipitation and temperatures, long time series of observed station data at daily time scale is essential. The daily precipitation, maximum and minimum temperatures data for a 69-year

period from 1948 to 2016 is obtained from High Plains Regional Climate Center, Lincoln, Nebraska. The daily precipitation, maximum and minimum temperatures data for a 51-year period from1965 to 2015 for Hyderabad is obtained from Agricultural Research Institute,Professor Jayashankar Telangana state Agricultural University, Hyderabad, India. Hyderabad is the 4th most populous city in India with a population density of 18,480/km2. Whereas, Lincoln is the 2nd most populous city in Nebraska with a population density as 1,119/ km2 (Figure 1).

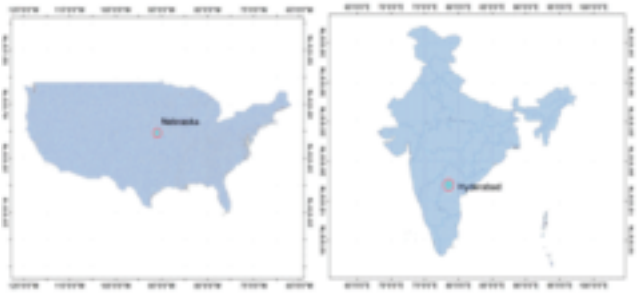


Figure 1. Location Map of Lincoln, USA and Hyderabad, India

2.2 Methods

The climate extremes considered in the study are adopted from World Meteorological Organization-Commission for Climatology (WMO-CCI) and the research program on Climate Variability and Predictability (CLIVAR) which are widely used in determining the weather extreme events. The CCI-CLIVAR Expert Team for Climate Change Detection and Indices (ETCCDI) made efforts to estimate climate extreme indices based on daily temperature and precipitation data through the free standardized software for data analysis and quality control. One such standard software developed by ETCCDI is RCLIMDEX software packages (http://etccdi.pacificclimate.org/software.shtml). The precipitation, maximum and minimum temperatures are processed using RCLIMDEX software package to detect and monitor extreme climate events. The ETCCDMI recommended a total of 27 core extreme indices which can be derived from station daily data. All 27 climate extreme indices are estimated for both Lincoln and Hyderabad with the daily-observed data of available period. For instance, the hottest or coldest days of a year, frost days or tropical nights, or the annual maximum 1-day or 5-day precipitation rates and percentile based threshold indices, which estimate the exceedance rates above or below a threshold derived from the considered base period of 1961-1990.

Next, the trend analysis was performed on 27 core indices to study the trends exists in precipitation, maximum and minimum temperatures extremes using Mann-Kendall test, Sen's slope and Pettitt Tests. The Trend analysis was performed using the Mann-Kendall non-parametric statistical test (Mann, 1945; Kendall, 1955) on precipitation and temperature indices. Mann-Kendall is a non-parametric test, to assess if there is an upward (positive) or downward (negative) trend of a variable of interest over time. The Sen's slope test is performed on all 27 core extreme indices of precipitation, maximum and minimum temperatures to estimate the magnitude and to characterize the trend as increasing or decreasing. Sen's slope trend analysis is similar to linear regression trend analysis in terms of both magnitude and direction of the trend in a time series (Sen, 1968).The positive and negative sign of the sen's slope represent increasing and decreasing trends respectively. Pettitt (1979) is a non-parametric change point detection test, generally applied to detect a single change-point in the mean of a continuous climate data. The change-point in the extreme events are identified for all 27 core indices for both Lincoln and Hyderabad.

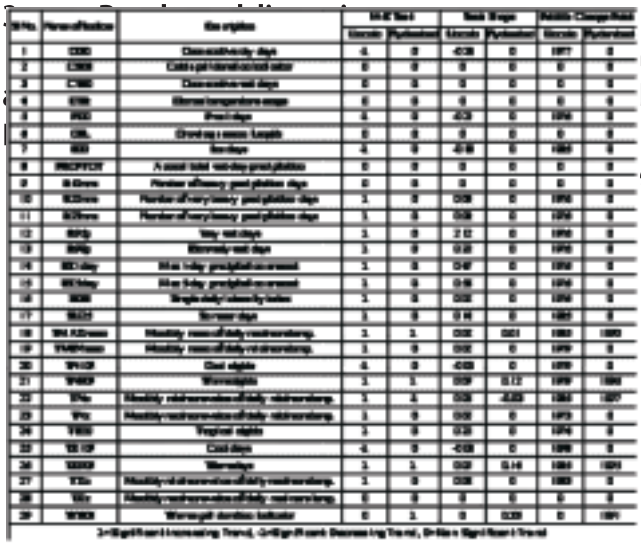
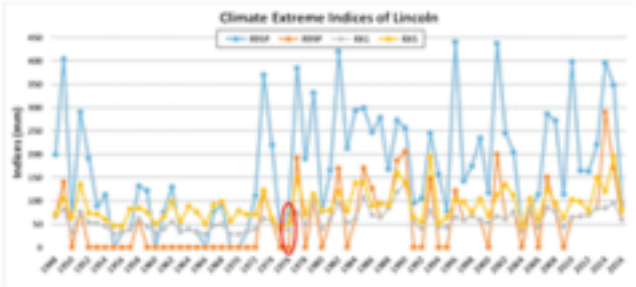


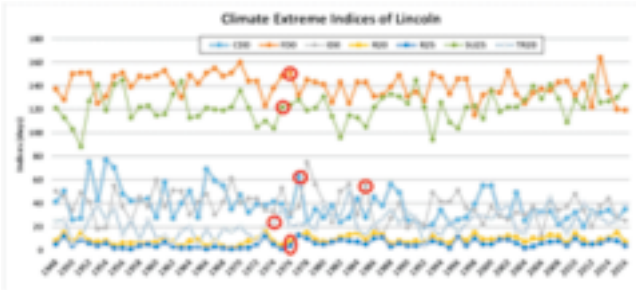
Table 1. Description and trends of extreme indices with change points.

The Consecutive dry days (CDD), Frost days (FD0) and Ice days (ID0) are found to be significantly decreasing trends for Lincoln city with slopes of -0.24, -0.21and -0.18 respectively. Cool days (TX10P) and Cool nights (TN10P) are also found to be decreasing in nature with magnitude of slopes of -0.04 and -0.06 respectively. The other temperature based indices like Warm nights

(TN90P), Warm days (TX90P), Monthly minimum and maximum of daily minimum temperatures (TNx &TNn), Tropical nights (TR20) are found to show significantly positive trend. Precipitation dependent indices like Number of very heavy precipitation days (>20mm &>25mm) (R20mm & R25mm), Very wet days (R95P), Extremely wet days (R99P), Monthly maximum 1 day and 5 days precipitation amount (RX1day & RX5day), Simple daily intensity index (SDII) are found to depict significant positive trends with magnitude of slopes of 0.04, 0.04, 2.12, 0.2, 0.47, 0.54, 0.02 respectively. From Figure 2, it can be found that the precipitation based extreme indices show significantly increasing trend after the change point of 1976. The other temperature dependent indices are found to show significant trend in between 1973 and 1998.



(a)



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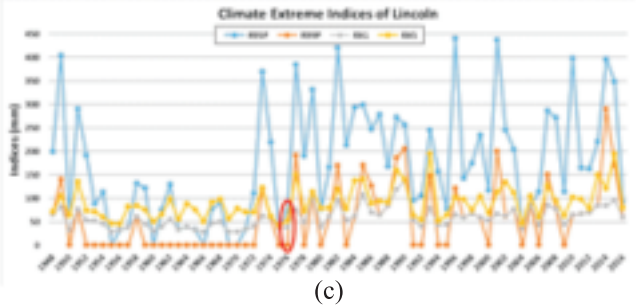

(c)

Figure 2. Trends of extreme indices and corresponding change points for Lincoln city.

The variability of precipitation is found to increase after the change point of 1976. The mean and variance are found to be 738.04 mm and 48.74 respectively for the time period of 1977-2016 as compared to 674.49 mm and 29.68 for the time period of 1948-1976 for precipitation.In case of Hyderabad, there is no significant trend has been found for precipitation dependent indices whereas significant increasing trend has been found for some temperature dependent indices. Significant increasing trend has been found for indices like Monthly mean of daily maximum temperature (TMAXmean), Warm nights (TN90P), Warm days (TX90P) and Warm spell duration indicator (WSDI) with magnitude of slopes of 0.01, 0.12, 0.14, 0.33 respectively whereas significantly decreasing trend has been found for Monthly minimum value of daily minimum temperature (TNn) with slope of -0.03. From Figure 3, it can be seen that the temperature dependent indices has started to show significant trends after the change points which are in between 1990 and 1997.

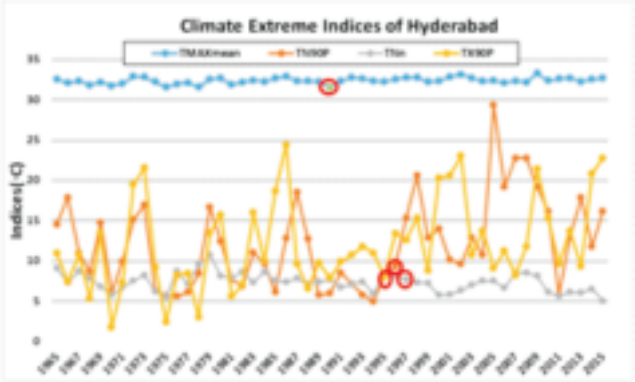

Figure 3. Trends of extreme indices and corresponding change points for Hyderabad city.

4. Conclusions

Trend analyses provided insights of changes in the sensitivity of indices due to historical changes in temperature and precipitation. Differences between mid-latitudes and the tropics emerge and are also present on the identification of the "break" of changes in climate conditions usually identified in the mid seventies. The need for additional records in Hyderabad evidence the need to explore numerical and statistical techniques further. In growing cities climate trends and population and FEWES trends have to be coupled and require more robust data and integrative techniques.

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Fields of Interest:
Hydroinformatics, Integrated Hydrology, Water Resilience Predictability of Hydrometeorological and Climate Extremes Risk, Nexus Water-Food-Energy in a Changing Environment, Hydroclimatology, The Global Water System.

Environmental Education and Water: Implications for Sustainable Development Goals

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Introduction

Stockholm Declaration, adopted at the first United Nations Conference on Human Environment, which was held in 1972 in Stockholm, declared "environmental education is essential". Later, in Belgrade, (capital of then Yugoslavia) in 1975, a charter was adopted which for the first time considered the goals, objectives, and guiding principles of environmental education programs. Importantly, Belgrade Charter made general public as the audience for environmental education. The first Intergovernmental Conference on Environmental Education (IFEE) was held in 1977 in Tbilisi, Georgia (then part of Soviet Union), which laid out the role, objectives, and characteristics of environmental education, and provided several goals and principles for environmental education.

India also took definite steps in the matters of environmental education. The National Policy on Education (1986) stated that the protection of environment is a value which, alongwith certain other values, must form an integral part of curriculum at all stages of education. It states, "There is a paramount need to create a consciousness of the environment. It must permeate all ages and all sections of the society, beginning with the child. Environmental consciousness should inform teaching in school and colleges. This aspect will be integrated in the entire educational processes."

Later, Hon'ble Supreme Court of India, in a judgment in 1991 on a public interest litigation, observed that "… if the laws are to be enforced and the malaise of pollution has to be kept under control and the environment has to be protected in an unpolluted state it is necessary that people are aware of the vice of pollution and evil consequences". It further declared ". through the medium of education awareness of the environment and its problems related to pollution should be taught as a compulsory subject." (http://www.greenteacher.org/images/File/Supreme%20Court%20EE/22_11_1991.pdf) . Later, in 2003, the Hon'ble Supreme Court directed the NCERT to prepare a module (model) syllabus and observed that *"We accept on principle that through the medium of education awareness of the environment and its problems related to pollution should be taught as a compulsory subject. The University Grants Commission* will take appropriate steps immediately to give effect to what we have said, i.e. requiring the Universities to prescribe a course on environment. So far as education upto the college level is concerned, we would require every State Government and every Education Board connected with education upto the matriculation stage or even intermediate college to immediately take steps to enforce compulsory education on environment in a graded way." On 13th July, 2004, the Supreme Court directed that the " syllabus prepared by the NCERT for Class I to XII shall be adopted by every state in their respective schools". It further directed that "NCERT be appointed as a nodal agency to supervise the implementation of this Court's order". Since then NCERT has made requisite changes in school syllabus on the lines of Hon'ble Supreme Court Order. One of the important policy initiatives has been the 'infusion'

Decade of Education for Sustainable Development (DESD-2005-14)

United Nation's Decade of Education for Sustainable Development (2005-2014) ended with a World Conference on Education for Sustainable Development in Japan (Aichi-Nagoya) in November, 2014. Its report, "Shaping the Future" has listed following key findings:

ESD, an enabler for sustainable development

- 1. Education systems are addressing sustainability issues
- 2. Sustainable development agendas and education agendas are converging

Importance of stakeholder engagement for ESD

- 3. Political leadership has proven instrumental
- 4. Multi-stakeholder partnerships are particularly effective
- 5. Local commitments are growing

ESD is galvanizing pedagogical innovation

- 6. Whole-institution approaches help practice ESD
- 7. ESD facilitates interactive, learner-driven pedagogies

ESD has spread across all levels and areas of education

- 8. ESD is being integrated into formal education
- 9. Non-formal and informal ESD is increasing
- 10. Technical and vocational education and training advances sustainable development.

This Conference adopted a Global Action Program (GAP), which seeks to generate and scale-up ESD action.

The overall goal of the GAP is to generate and scale up action in all levels and areas of education and learning to accelerate progress towards sustainable development.

The GAP has two objectives:

- to reorient education and learning so that everyone has the opportunity to acquire the knowledge, skills, values and attitudes that empower them to contribute to sustainable development and make a difference;
- to strengthen education and learning in all agendas, programmes and activities that promote sustainable development.

The GAP focuses on five priority action areas:

1. Advancing policy; Integrating sustainability practices into education and 1.training environments (whole-institution approaches);
2. Increasing the capacity of educators and trainers;
3. Empowering and mobilizing youth;
4. Encouraging local communities and municipal authorities to develop community-based ESD programmes.

ESD and Water

That "water is an elixir of life" requires no further elaboration and emphasis. Access to safe and clean water to world's population remains the central concern of the humanity. Climate change only aggravates the situation. Any solution to water woes in cities cannot be rolled out effectively without taking children on board from planning to execution of strategies. Taking cues from the learnings of the DESD, following 3 key approaches can be identified for promoting water sustainability as part of environmental education.

i) Whole-institution approaches
ii) Learner-driven pedagogies
iii) Increasing the capacity of educators and trainers;

And therefore I propose following action plans for promoting water sustainability through children by invoking key features of environmental education. They are suggestive in nature.

1. Just as contextualization of social issues are important, contextualization of environmental issues are also crucial as environmental issues differ, their treatment differ as one move from one place to another. We should bring this loudly in our text books.
2. However, merely focusing on immediate context without understanding the regional, national and global ramifications of a local' issue would be like missing wood for tree. Therefore, when contextualizing, the holistic understandings should not be missed.
3. More and more materials (both print and digital) using local examples in local languages may be developed. And these materials must be widely disseminated. Often discussions should follow such exposures.
4. The focus should be not only to create mere awareness among school children but also to bring an enhanced understanding of the issues leading to informed decisions on the matter.
5. We should also concentrate on pre-service and in-service teachers. I suspect that pre-service teachers' trainees do not give proper attention on this aspect of curriculum. If we want children to be the harbinger of change then teachers must change first. Whatever it takes to bring this change must be done.
6. In North East, the community living robust and their shared wisdom on issues of culture, environment and livelihood is a heritage which needs to be not only conserved but further built on. Eco-friendly practices of communities having cultural sanctions need to be identified. Such programs/projects may be undertaken.
7. Managing water from the standpoints of both wasteful expenditure and pollution need to be given prominence in projects. Even the best conceived scheme can go awry in the absence of a sound management. Therefore, an efficient system for managing EOSE may be put in place.

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Fields of Interest:

Dr. Abhay Kumar has been working as Assistant Professor in Central Institute of Educational Technology (CIET), National Council of Educational Research and Training (NCERT), Chacha Nehru Bhawan, Sri Aurobindo Marg, New Delhi-110016 since June, 2016. Before transfer to New Delhi, he was working in the same capacity at North East Regional Institute of Education (NERIE), NCERT, Shillong for more than seven years. A Ph.D. in Environmental Sciences from JNU, his interests include environmental education, educational technology, science education, climate change, water quality, etc.

Sustainable Approach to Urban Hydrological System: A Case Study of an Emerging City of Assam

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ABSTRACT

Sustainable urban hydrological system is key to the future development of urban habitat, particularly tropical cities of Asia of sub humid climate. Concentration of people in these continuously developing urban areas significantly alters landscape and particularly the hydrological cycle, one such city is Guwahati city. The objective of the present study was to assess the anthropogenic impacts of the city on the urban aquatic environment, including processes and interactions in the urban water cycle. The impacts vary in time and space, and need to be quantified with respect to the local climate, urban development, environmental and other socio-economic factors.

The main issues of water quality degradation of water bodies and flooding of Guwahati city have been addressed in this study. Weather analysis has been done for a period and city master plans on public utilities were studied. Integration of SUDS method with storm drainage plan has been suggested for flood mitigation. Sanitation plan has been suggested for informal population in the city. Mapping of legislations and institutional mechanisms has been done & a methodology has been proposed for implementation. Sanitation plan for informal population as well as for hilly areas has been given along with SWOT analysis.

The study reinforced that integrated strategic planning to storm water, waste water and potable water along with conservation of existing water bodies is the key to sustainable development of hydrological system of Guwahati city. Rain water harvesting and Grey water reuse can optimize the water demand. The successful conservation & restoration of water bodies can mitigate the flood and can also bring range of ecological benefits to the Guwahati city, as demonstrated by the study.

Keywords: Urbanization, flood management, Sustainable urban drainage system (SUDS), river restoration, urban sanitation, grey water reuse, building bye laws.

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Field of Interest:
Water Quality, Sediment Dynamics in Fluvial Systems, Environmental Impact, Risk Assessment and Management, Environmental Geo-informatics.

Assessing the effect of arbuscular mycorrhizal fungi on the phytoremediation potential of Eichhornia crassipes (Mart.) Solms on cadmium uptake

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Abstract

The heavy metals including cadmium are serious environmental pollutants especially in areas of high anthropogenic pressure. Phytoremediation of heavy metal contaminated sites can be done by using plants, which is an emerging technology. Aquatic macrophyte *Eichhornia crassipes (Mart.) Solms* (water hyacinth) has been successfully utilized for the removal of cadmium (Cd) from aqueous solutions. Arbuscular mycorrhizal fungi (AMF) can form mutual symbiotic association with plant roots and although grows in an aquatic environment *Eichhornia* is mycorrhizal. The effect of AMF on metal uptake in plants is still in controversy. Therefore, the present study was carried out with the objective of assessing the effect of AMF on the phytoremediation potential of water hyacinth on Cd uptake and also examining the growth of *Eichhornia i*n different Cd concentrations. Pot experiments, where AMF inoculated and non-inoculated to *Eichhornia crassipes* were carried out at the plant house under natural light conditions at the Faculty of Applied Sciences, Rajarata University of Sri Lanka. Four Cd concentrations were applied to water which were 5 ppm, 10 ppm, 20 ppm and 50 ppm. Cadmium concentrations of plant shoot and roots of mycorrhizae added plants were higher than non-mycorrhizae addition treatments. The Cd uptake was increased as the concentrations of the Cd increased and it was significantly higher in roots than in shoots. The bioaccumulation of Cd in roots of *Eichhornia* with added mycorrhizae was increased up to 0.25 mg/kg-^{1}, whereas uptake in shoots was found 0.22 mg/ kg-^{1} Cd at higher metal concentration (50 ppm). The relative growth rate and dry biomass increased in plants treated with low concentration of Cd, but decreased with high Cd concentrations in both mycorrhizae added and non-mycorrhizae added treatments. Overall, the highest value of relative growth rate was 0.53 g/day^{-1} for water hyacinth treated with Cd at 5 ppm with the added mycorrhizae the lowest value was 0.3 g/day^{-1}, treated with Cd at 50 ppm without mycorrhizae addition. These results proved that the influence of AMF on phytoremediation potential of *Eichhornia crassipes* in cadmium contaminated soil-water environment. It can be concluded that *Eichhornia*plants do have a higher potential as phytoremediator of aquatic systems contaminated with Cd with the added AMF.

Key words: Cadmium, Eichhornia crassipes, Phytoremediation, Arbuscular mycorrhizal fungi

1. Introduction

The increase in the environmental levels of heavy metals has been of growing concern over the past years. They are natural components of soil and rocks, usually occur at low concentrations and do not pose health risks to human and animals. However, due to anthropogenic activities, the concentration of metals, such as cadmium is becoming increasingly high. Therefore, these heavy metals need to be removed from the environment. Unlike organic compounds that can be mineralized, heavy metals must either be physically removed or converted to a biologically inert form (Anwesha and Fulekar, 2012).
Phytoremediation is an environmentally friendly, cost effective method, which is the use of plants and their associated microorganisms (Fulekar, 2016). Arbuscular mycorrhizal fungi can form mutual symbiotic association with plant roots including *Eichhornia*. Though, phytoremediation is a good method, it is a slow process. Therefore, it is important to investigate the efficacy of cadmium phytoremediation with using *Eichhornia crassipes* with the endophytic arbuscular mycorrhizae.

2. Material and methods

A pot experiment was carried out to study the growth and Cd uptake by *Eichhornia,* inoculated with and without AMF to the attached soil. The water was collected from the tank at dry zone of Sri Lanka and each pot was filled with approximately 5.5 L of water. Plants were collected from the same tank and selected for uniformity in size and shape and exposed to four different Cd levels, 5, 10, 20, 50 ppm in a water filled pot for a period of 52 days. Cadmium solutions were prepared with using $CdCl_2$. The sampling from aqueous solution containing metals has been carried at an interval of 1st, 3rd 7th, 14th and 52nd day. After uprooting plants, each sample was divided into root

and shoot and oven-dried at 60°C and dry weights of roots and shoots were determined. Finely ground plant roots and shoots were digested in a nitric-perchloric acid mixture (2:1). The extracts of *Eichhornia* shoots and roots, soil and remaining water were analyzed for Cd by atomic absorption spectrophotometry (Shimadzu AA-6701G). In addition to that, relative growth rate of tested *Eichhornia* plants and percentage mycorrhizal colonization in roots were determined.

3. Results and discussion :

Eichhornia shoots and roots in which arbuscular mycorrhizae added, were shown higher Cd concentrations irrespective of the added Cd (Figure 1). Shoot and root Cd concentration was significantly higher ($P<0.05$) with the 50 ppm Cd addition. Roots were accumulated more Cd than the shoots of both mycorrhizae added and non-added treatments.

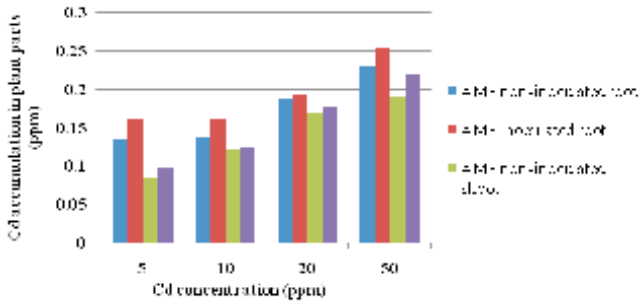

Figure 1. Concentration of Cd in the *Eichhornia* shoot and root extracts.

Soil Cd concentrations were significantly higher in the treatment which was added 50 ppm cadmium to the water (Figure 2). Non AMF added treatments soil extracts were shown higher accumulation of cadmium than AMF added treatments..

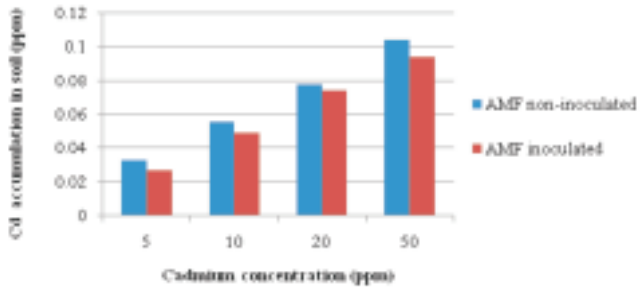

Figure 2. A comparison of cadmium concentration of with AMF added and non- AMF added treatments.

In the present experiment the total dry biomass and the relative growth rate was reduced with the increasing Cd concentrations (Figure 3 and figure 4). However, relative growth rate and dry biomass of *Eichhornia* were high in AMF added treatments.

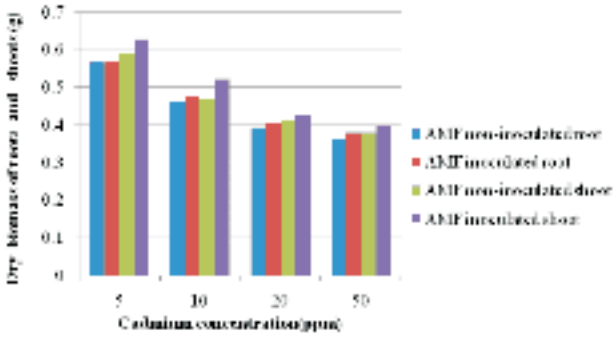

Figure 3. Dry biomass of plant parts with increasing Cd concentrations

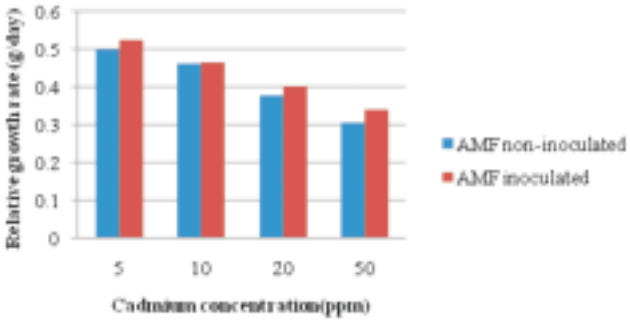

Figure 4. Relative growth rate of *Eichhornia*plants with increasing Cd concentrations.

4. Conclusions

Eichhornia crassipes has potential to tolerate the cadmium concentrations in the applied experimental conditions. Absorbing and accumulating Cd in shoots and roots exhibited the potential of *Eichhornia* to be used as an efficient phytoremediator for cadmium.

5. References

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Removal of Fluoride and Hardness from Groundwater using Carbon Electrolysis and Chicken Bone Char Filtration

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Abstract
Quality of groundwater is significant for public health, where excessive fluoride and hardness cause health complications. Therefore, their removal before consumption is essential. This study was to evaluate the possibility of removing fluoride and hardness from groundwater using carbon electrolysis technique and Chicken Bone Char (CBC) filtration. A pilot scale filter was prepared for CBC filtration using 0.08mm CBC for subsequent experiments. For all different initial fluoride concentrations, CBC filtration removed fluoride below Sri Lankan standard (1.0 mg/l) while electrolysis managed to achieve it for initial fluoride concentrations below 3 mg/l.

Keywords:*Fluoride, Hardness, Carbon electrolysis, Chicken Bone Char filtration*

1. Introduction

Water has a profound influence on human health. Excessive consumption of fluoride causes dental and skeletal fluorosis, ossification of tendons and ligaments and also neurologic damage (Reardon and Wang, 2000). Although hardness is not known as a cause for serious health issues, common effects of hard water are unpleasant taste and smell and scaling in equipment and containers used for boiling (WHO, 2011). Therefore, it is essential that the public is provided with treated water to ensure their health and safety.

There are many methods used to remove fluoride and hardness which include chemical additive methods, contact precipitation and adsorption/ion exchange methods (Lyengar, n.d) for fluoride removal and chemical precipitation and ion exchange, reverse osmosis, electrodialysis, nano-filtration, crystallization, distillation and evaporation for hardness removal. Most of these techniques are costly and require sophisticated technology and some produce increased amounts of sludge and form sediments on membranes (Malakootian, Mansoorian and Moosazadeh, 2010). Taking these issues into consideration, these are not feasible for community or domestic level treatment in a developing country like Sri Lanka.

However, electrolysis and bone char filtration can be highly suitable to Sri Lanka context due to their minimum waste production, low cost/power requirement, least man power requirement and no/less chemical addition. Finally, the aim of this study was to evaluate fluoride and hardness removal from contaminated groundwater and the effect of initial concentrations and other water quality parameters on removal efficiency, in carbon electrolysis and CBC filtration.

2. Material and methods

All pilot experiments were carried out using RO water and well water was used for subsequent experiments related to both CBC filtration and carbon electrolysis by spiking fluoride stock solution and calcium and hardness stock solutions into water samples. Fluoride Ion Selective Electrode (ISE) (Thermo Fisher Scientific) and titration method were used to measure Fluoride and total hardness concentrations respectively.

Identification of the effective size of CBC for fluoride and hardness removal

Effective sizes (D10) were identified to be 1.5, 0.45 and 0.08 mm for the three samples by sieve analysis as per British Standards and equilibrium studies were conducted to determine the strength of the adsorbent (CBC) for the removal of the fluoride in the water Freundlich isotherm was selected as appropriate by fitting experimental data.

For isotherm modelling, 0.1, 0.2, 0.3, 0.4 and 0.5 g of CBC of each particle size was added to the fifteen sample bottles which were filled with 100 ml of the prepared 10 mgF-/l solution and shaken for 30 minutes and set aside until they obtained equilibrium condition.

Removal Efficiency of Fluoride with the presence of Hardness 50ml of 10 mgF-/l solution was filled into six separate bottles having 0.01g, 0.03g, 0.05g, 0.10g, 0.15g and 0.20g of the Chicken Bone Charcoal. Samples were shaken for 24 hours. Procedure was repeated with Mg2+ and Ca2+.

Experimental procedure for CBC filtration

Samples with initial fluoride concentrations of 7, 5, 3 and 1 mg/l were selected to determine the effect of initial fluoride concentration on fluoride removal. Water samples were filtered using the prepared CBC filter and effluent was collected and measured.

Experimental procedure for carbon electrolysis

A batch type carbon electrolysis reactor was prepared with a Carbon (C) cathode and a Platinum (Pt)

anode. They were separated by an unglazed clay diaphragm and a direct current was passed for 120 minutes. Anode and cathode baths were respectively filled with 550ml and 410ml of raw water respectively. Water levels at the anode bath and the cathode bath were maintained the same. For each experiment, the fluoride concentration was measured at 60 minute intervals while total hardness was measured at the end of 120 minutes. A set of experiments were conducted to evaluate the effect of initial concentrations on fluoride and hardness.

3. Results and discussion

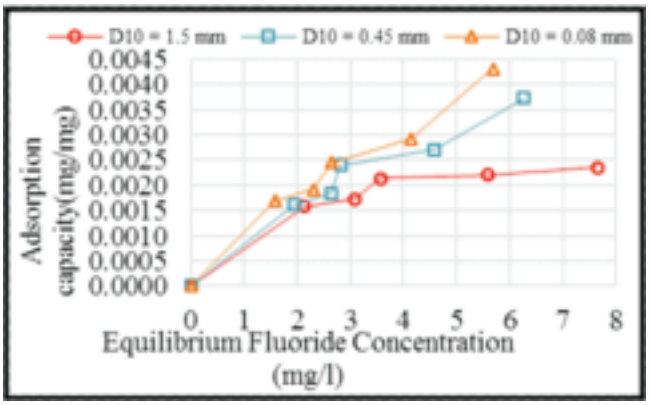

Figure 1.Adsorption capacity vs equilibrium fluoride concentration for each effective size.

0.08mm effective size (Fig.1) show the highest adsorptioncapacity compare 0.45mm and 1.5mm sizes.

When compare the adsorption capacity of fluoride while presence of hardness, it is comparatively high with the availability of Ca^{2+} than the Mg^{2+} (Fig. 2).

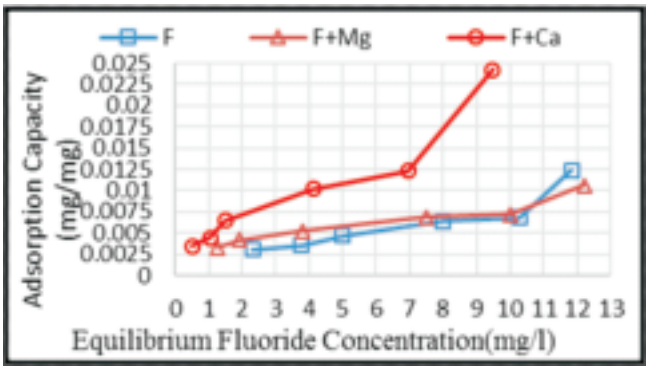

Figure 2.Adsorption capacity vs equilibrium fluoride concentration with the Hardness.

Sri Lankan standard (SLS) for fluoride in drinking water (1.0 mg/l) was achieved in all cases for CBC, irrespective of the initial fluoride concentration. By carbon electrolysis, it was only achieved for initial concentrations >3.0 mg/l.

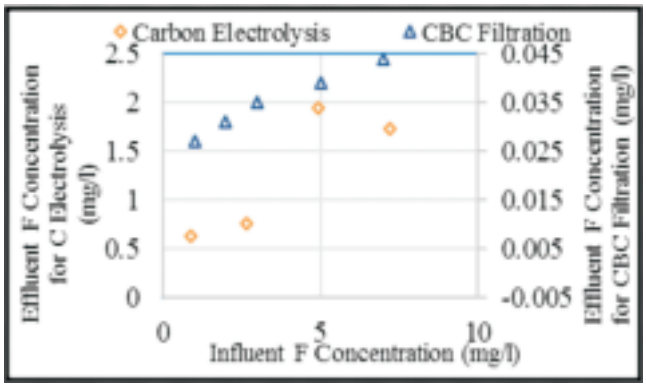

Figure 3.Initial and final F concentrations for carbon electrolysis and CBC filtration under different initial F concentrations.

4. Conclusions

0.08mm effective size of CBC have the highest adsorption capacity and it increases with the presence of hardness. CBC filtration removed fluoride even below SLS (1.0 mg/l) while electrolysis managed to achieve it only for initial fluoride concentrations below 3 mg/l.

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Sandalwood (Santalum Album) Leaf Powder as an Effective Biosorbent for removal of Dyes from water

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Abstract

In the present work, the leaves of *Santalum Album* (locally known as the Sandalwood or Chandan tree) in the form of a powder were investigated as a biosorbent of dyes Brilliant Green, Congo Red and Methylene Blue from synthetic coloured effluents. The adsorption was carried out in a batch process at different concentration, adsorbent dose, pH, temperature, etc. Different doses of SLP were found to remove more than 90% of the dyes from 10 ppm Brilliant Green solution, 20 ppm Congo red solution, and 25 ppm Methylene Blue solution. The interactions were tested with respect to both pseudo first order and second order reaction kinetics with the later being found more suitable. Considerable intra-particle diffusion was found to be active simultaneously. The sorption process was in conformity with Langmuir and Freundlich isotherms.

Key words: Sandalwood Leaf Powder; Brilliant Green; Congo Red; Methylene Blue, adsorption.

1. Introduction

The Sandalwood tree (*Santalum Album*) of family *Santalaceae* is native to the Indian sub-continent, and its seeds and leaves have been in use since ancient times to treat a number of human ailments and also as a household pesticide. A variety of medicinal and germicidal properties have been attributed to its leaves, bark, seeds and other parts (Kumar et al. 2012). Various parts of the tree are used as anti-inflammatory, anti-androgenic, anti-stress, anti-hyperglycemic, anti-viral and anti-malarial agents, and also for anxiolytic, liver-stimulant, humoral and cell-mediated immuno-stimulant activities (Kumar et al. 2012). In the present work, synthetic coloured effluents containing the dyes, Brilliant Green, Congo Red and Methylene Blue have been treated with Sandalwood Leaf Powder (SLP) as an adsorbent.

2. Materials and methods

Mature Sandalwood leaves were collected and then washed repeatedly with water to remove dust and soluble impurities. Then they were dried first at room temperature in a shade and then in an oven at 333-343K for several hours till the leaves could be crushed into fine powder. The Sandalwood Leaf Powder (SLP) is sieved and the 200- 300 mesh fraction is preserved in glass bottles for useas an adsorbent. The dyes, Brilliant Green (Qualigens, Mumbai), Congo Red (Fluka, Switzerland) and Methylene Blue (Glaxo, Mumbai) were used without further purification. The synthetic effluent solutions were made by dissolving the required amount of dye in double distilled water.

3. Results and discussion

Characterization of the adsorbent:

FTIR measurements of SLP showed the presence of peaks for a large number of functional groups, viz. OH, 3597 3600, NH2, 3399, =CH, 3297, >C=N, 1656, =CC=, =CN< and =CO, 1160, >C=O, 1633, 1656, 1672, 1688, 1714, >C=C<, 1656, and >C=S, 1105. It is also known to contain a number of fatty acids like oleic acid, steric acid, palmitic acid, linoleic acid, etc. The presence of polar groups on the surface is likely to give considerable cation exchange capacity to the SLP. XRF analysis of SLP showed the presence of Ca, Cu, Fe, K, and Mn. SEM micrographs (Figure 1) revealed that the powder consisted of fine particles of irregular shape and size with a large number of steps and kinks on the external surface.

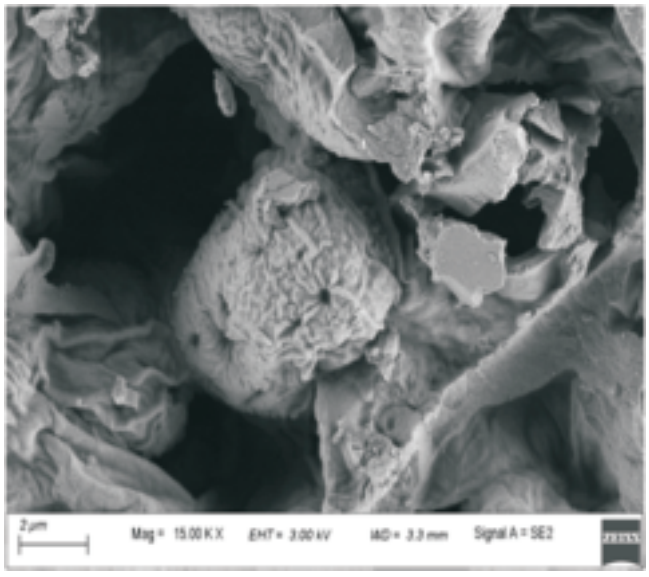

Figure 1 *Scanning electron micrographs of SLP adsorbent.*

Adsorption capacity

It was observed that SLP doses of 500 mg/L, 1000 mg/L and 2000 mg/L respectively were sufficient to remove nearly 90% of the dyes from 10 ppm Brilliant

Green solution, 20 ppm Congo red solution, and 25 ppm Methylene Blue solution respectively. The SLP is seen to be an excellent adsorbent for all the three dyes. However, the nature of variation of adsorption capacity with concentration of the synthetic effluent shows some significant differences.

Effect of pH on adsorption of the dyes

The pH of the medium had little effect on adsorption of the dyes on SLP. It is likely that the surfaces of SLP particles are neither acidic nor basic and thus, the two basic dyes, Brilliant Green and Methylene Blue as well as the neutral dye, Congo Red have no particular preference for the adsorption sites in SLP at different pH values.

Adsorption isotherms

The adsorption data yielded good fits with Freundlich and Langmuir isotherms in case of each dye. The values of Freundlich coefficient, 1/n, are in the ranges of 0.26 to 0.52 for Brilliant Green, 0.05 to 0.26 for Congo red and 0.50 to 0.68 for Methylene Blue. The other coefficient K was in the range 38.6 to 73.1, 22.61 to 84.76 and 2.51 to 9.49 respectively for Brilliant Green, Congo Red and Methylene Blue. The values indicate the adsorption of the dyes on SLP to be a favourable process (Singh & Srivastava, 1999) for actual use in treatment of coloured effluents.

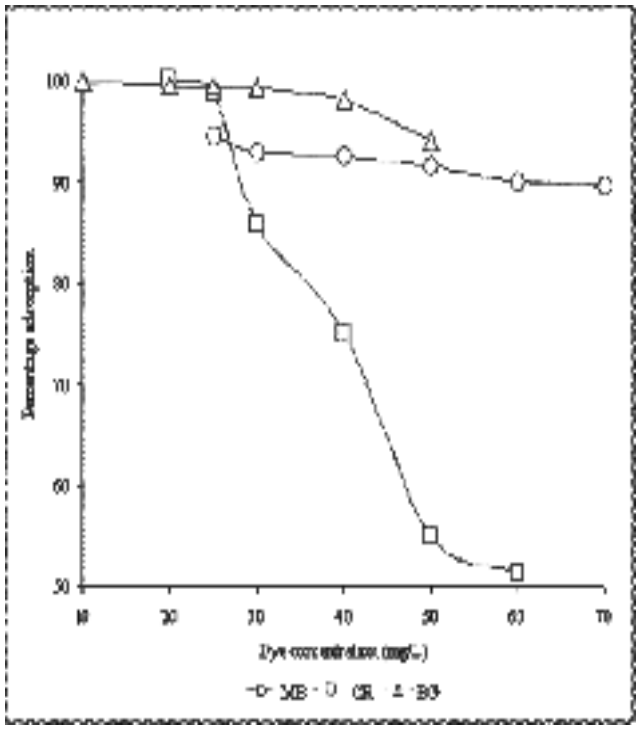

Figure 2 *- Comparative study of adsorption of the dyes methylene blue (MB), congo red (CR) and brilliant green (BG) on SLP at 300 K [Contact time 5 h, SLP 2 g/L].*

The Langmuir coefficients also showed a wide range of values. It is likely that the sites on SLP particles holding the dye molecules are energetically non-uniform and non-specific and therefore, the adsorption coefficients have wide variation.

Thermodynamic parameters

The H^0 values indicate that the adsorption of Brilliant Green and Methylene Blue on SLP takes place by an endothermic process with adsorption of about 10 kJ mol^{-1} for each of the dye. The adsorption of Congo Red is an exothermic process with the liberation of 15.3 kJ mol^{-1}. In all the cases, the G^0 values were negative, viz., 14.45 16.46, 13.03 13.04, and 12.54 14.26 kJ mol^{-1} for Brilliant Green, Congo Red and Methylene Blue respectively, indicating the spontaneous nature of the process. The values of S^0 are very similar (80.16 and 80.33 $JK^{-1}mol^{-1}$) for Brilliant Green and Methylene Blue indicating that the adsorption process leads to an increase of entropy. For Congo Red, the S^0 value (17.29 $JK^{-1}mol^{-1}$) showed a decrease, which might be due to an enhancement of ordering of the dye molecules on the SLP surface as is observed for adsorption of gases on solids. Increasing the temperature of adsorption increases the inter-particle and intra-particle diffusion rates of the dye molecules and therefore, affects the adsorption process (Al-Qodah, 2000).

Kinetics of adsorption

The adsorption declined linearly for the dyes. This was more rapid for Congo Red than for the other two dyes. The values of the first order rate constants calculated by using the Lagergren plots support this:

Brilliant Green: $k_{ad} = 4.84 \times 10^{-3}$ min^{-1}

Congo Red: $k_{ad} = 6.68 \times 10^{-3}$ min^{-1}

Methylene Blue: $k_{ad} = 3.69 \times 10^{-3}$ min^{-1}

4. Conclusion

The SLP is a very promising adsorbent for dyes from water. The adsorption sites on the surfaces of the SLP particles are heterogeneous, non-specific and non-uniform as in the case of many other adsorbents and hence can be successfully used for removal of dyes from water. The Sandalwood tree regularly sheds its leaves during January-February, which become waste. These leaves can be put to good use as an adsorbent for removal of colour from industrial and other effluents.

5. References

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Starch immobilized TiO_2 nanoparticles in As(V) remediation from aqueous solution

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Abstract

Environmental chemists have been engaged in pioneering safer and cheaper techniques to overcome the threat posed by arsenic present in drinking water. In this regard, present study developed some new materials based on starch and TiO_2, viz. CTAB (N-cetyl-N, N, N trimethyl ammonium bromide) modified TiO_2 (CMT) and starch immobilized CMT nanoparticles and attentively compared their efficacy towards As(V) removal. Although, the modified TiO_2 showed highest arsenate ion removal rate (~99% from 400µg/L), the starch immobilized CMT (SPC) was found to be the best material for regeneration. For a targeted solution of 400µg/L, a material dose of 2g/L was found to be sufficient to bring down the As(V) concentration below 10 µg/L. The sorption followed Freundlich multilayer pattern and was governed by a pseudo second order kinetic model. The maximum sorption capacity was found to be 1.024 and 1.423 mg/g SPC and CMT, respectively.

Keywords: Arsenic threat, starch immobilized TiO_2, sorption, kinetics, regeneration.

1. Introduction

Arsenic toxicity is a global health problem which is affecting millions of people every day. According to International Agency for Research on Cancer, it is grouped among the most carcinogenic substances. Although the maximum permissible limit for arsenic in drinking water is 10µg/L, as suggested by World Health Organization, a huge population in the world is exposed everyday to a very high concentration of arsenic through drinking water.

The high sorption capacity of different nanomaterial has attracted the researchers to pioneer safer and cheaper techniques to overcome this difficulty. TiO_2 and its different modified forms in nano size are considered as one of the bright out coming of those efforts. Plenty of works are reported, where TiO_2 and its different modified forms have been successfully utilized in the removal of different metals including As(III), As(V), Cr(VI) etc.

Use of surfactant like CTAB (N-cetyl-N,N,Ntrimethyl ammonium bromide) increases the stability of TiO_2 nanoparticles in water by forming micelle around them and thus can enhance the dispersibility of the particles in aqueous medium. But CTAB contains a hydrophilic end also. This might enhance the solubility of modified TiO_2 particles in aqueous medium. Thus some amount of particles may get leached in water during wastewater treatment. Present investigation focused on the immobilization of the CTAB modified highly efficient TiO_2 nanoparticles over starch biopolymer to effectively use in As(V) remediation and tremendously enhance the reusability of the material without hampering the removal efficiency .

2. Material and methods

Analytical grade nanosized TiO_2 (mixture of rutile and anatase) and Sodium arsenate dibasic heptahydrate ($HAsNa_2O_4.7H_2O$) were purchased from Sigma-Aldrich. Starch polymer was purchased from SRL, India. Gluteraldehyde solution (25%), used as cross-linking agent, was purchased from E-Merck, India. CTAB (N-cetyl-N,N,N trimethyl ammonium bromide) was purchased from LOBA Chemie, India. Ethanol was supplied by Jiangsu Huaxi International Trade Co. Ltd, China. De-ionised water was obtained from Milli-Q water purification system (Millipores.A.S.67120 MOLSHEIM, FRANCE). All other reagents and chemicals used were of analytical grade.

The equilibrium adsorption capacity was calculated using the Eq. (1)below

$$Q_e = \frac{(C_i - C_f)V}{M}$$

3. Results and discussion

3.1. EDX Study

Figure 1 (a-e) show the EDX spectra of TiO^2, CTAB, CMT, SPC, As-CMT (AMT) As-SPC (ATC) respectively. EDX spectra of TiO_2 (a) and CTAB (b) showed the presence of their corresponding elements in their structure. In (c) presence of bromine, carbon and nitrogen indicated the successful incorporation of CTAB to TiO_2

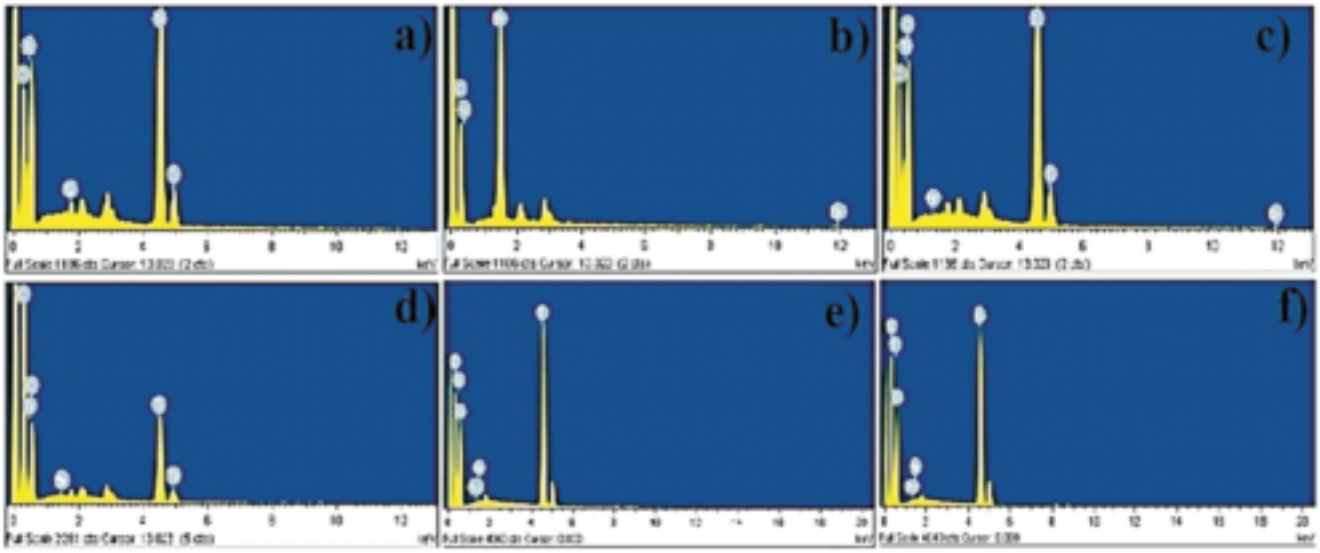

Figure 3 EDX spectra of (a) UTi, (b) CTAB, (c) CMT, (d) SPC, (e) AMT and (f) ATC

3.2. Comparison of effectiveness of UTi, CMT and SPC towards As(V) removal

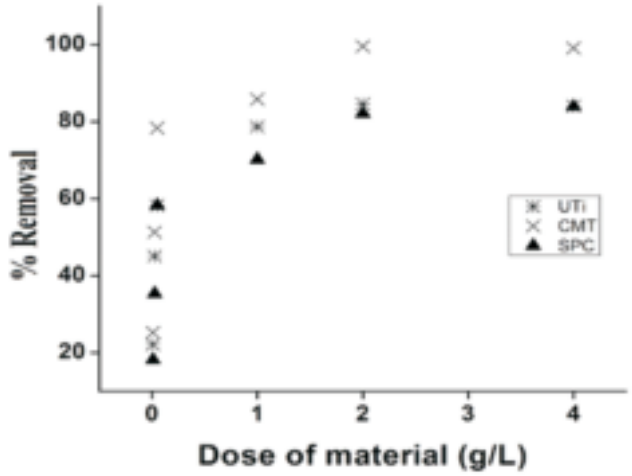

Figure 2 Efficacy of TiO_2, CMT and SPC for As(V) removal

The efficiency of TiO_2, starch, CMT and SPC materials towards As(V) removal was done. Starch alone didn't produce any significant result. TiO_2, CMT and SPC showed good results as shown in Fig. 2. CMT exhibited better removal efficiency than TiO_2 and brought down the arsenic concentration below 10 µg/L. CTAB prevented the aggregation of TiO_2 particles and thus exposing more surfaces for interaction with arsenate ions in solution. But part of the CMT entered into the aqueous phase during the experiment causing a significant loss of the materials. This could be reduced by immobilization with crosslinked starch (SPC)

Table 1 Sorption parameters of different isotherm

Model	Parametrs	SPC	CMT
Langmuir	$q_{m(mg/g)}$	1.024	1.423
	b (L/mg)	131	10.82
	R^2	0.989	0.998
	R_L	0.019	0.187
Freundlich	K_f(mg/g)	2.854	2.751
	n	2.557	1.666
	R^2	0.931	0.944
Temkin	A_T (L/g)	1.28 X 10^3	1.28 X 10^2
	B (J mg^2)	1.13 X 10^4	8.62 X 10^3
	R^2	0.987	0.974

From table 1 it was observed that the R^2 values for all the models showed good co-relations of the data. Thus the sorption could be reasonably explained by all the models under consideration. The preferential order for sorption, among these models is as follows- Langmuir >Temkin >Freundlich

4. Conclusions

(a) CTAB modified TiO2 was successfully immobilized over low cost starch
(b) CMT and SPC were capable of bringing down the As(V) below 10 µg/L.
(c) Sorption followed multilayer physisorption pattern and governed by second order kinetics
(d) SPC showed the best result

5. References

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Arsenic removal from drinking water by Carbon based material

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Abstract:
Arsenic content in drinking water which poses a threat to human health is a matter of concern amidst the scientific communities of the world. The cost-effective, user friendly technologies providing pure water are required to counter the serious health hazards due to consumption of arsenic contaminated water. A low cost non-toxic carbon based material, synthesized in laboratory is found to be active for the removal of arsenic from drinking water. Batch experiment shows that this synthesized material can remove 410 ppb of arsenic in a 500ppb arsenic solution under controlled conditions of 90 minutes exposure time at rpm 100 and pH 7.0. Therefore, this cost effective, eco-friendly synthesized material for arsenic removal from drinking water may prove beneficial not only for the regionally arsenic prone areas of North East India but also globally.
Key words: arsenic, removal, drinking water, cost effective technology

1. Introduction

Arsenic in drinking water and its health related problems is a serious concern nowadays in all over the world (Bhattacharya et al. 2007). In recent years arsenic in groundwater North Eastern Region states of India namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura creates an apprehension to the scientific community (Acharyya *et al.*, 1999; Chakraborti *et al.*, 2003; Singh, 2004, Chetia et al., 2011). The concentration of As in groundwater samples is higher than the permissible level (10 ppb) as prescribed by WHO (WHO 1993). Groundwater in 21 of 27 districts of Assam, 3 of 4 districts of Tripura, 6 of 13 districts of Arunachal Pradesh, 2 of 8 districts of Nagaland and 1 of 9 districts of Manipur had been contaminated by As (Singh, et al., 2004). In Assam, the maximum level of As was found in Jorhat, Lakhimpur, Nalbari, and Nagaon districts. During flood As was found in the range of 100-200 ppb in the plain area of Assam, i.e Barpeta, Dhemaji, Dhubari, Darrang, and Golaghat,. In Jorhat district, the contamination of As was highest in the range of 194-657 ppb. The concentration of As in Lakhimpur district was in between 50-550 ppb. In Nalbari district, the range was 106 ppb to 422 ppb. Remaining 11 districts of Assam where As was detected contained As in between 50-100 ppb. Chronic As exposure is harmful to human health and can cause cancer of the skin, lung, liver, urinary bladder and kidney (Tchounwou et al. 2003; Bunnell et al. 2007; Jie and Waalkes 2008) and other diseases, including, cardio-vascular and peripheral vascular diseases, diabetes, peripheral neuropathies, portal fibrosis and adverse birth outcomes (Xia et al. 2009) etc. To address the problem of drinking water, this cost effective, eco-friendly synthesized material for arsenic removal from drinking water may prove beneficial not only for the regionally arsenic prone areas of North East India but also globally.

2. Material and methods

Adsorbent: The material used for the removal of arsenic from water is prepared synthetically in the laboratory. Basically the material is composed of metals dispersed on carbon support. The importance of the material is very cheap carbon source and the metals are non toxic in nature which makes this material viable to be used in water purification.

Arsenic stock solution: Arsenic Standard solution of 500 ppb has been prepared in the laboratory of from arsenic stock solution of concentration 1000 ppb by the method of dilution.

Treatments of arsenic samples and their analysis

In a typical experiment; 10 mg, 50 mg and 100 mg of the adsorbent was mixed with 20 ml of standard arsenic solutions and stirred for 30, 60, 90, 120 minutes with fixed rotation of 100 rpm and pH at 5.0, 6.5, 7.0 and 8.5 respectively. The treated water samples were analyzed by Arsenic test kit for arsenic concentration and then by AAS (Hydride Generation-Atomic Absorption Spectrometry (HG-AAS; Perkin Elmer 200, USA, detection limit 0.02 ìg/L)) using freshly prepared analytical grade reagents purchased from Merck, India. Standards were procured from Perkin Elmer, USA.

3. Results and discussion

The pH of surface water lies between 6.5 to 8.5 whereas ground water lies between 6.0 to 8.5. Considering this fact we have chosen pH range from 5.0 to 8.5 to test the adsorbent and see its arsenic (As) removal capacity. The arsenic adsorption results are summarized in **Table 1**. It has been observed that material is active for the removal of Arsenic from aqueous solution. Capacity of As adsorption increases with increasing time and amount of materials used. Moreover, pH has significant effect on the As

adsorption. 100 mg of the adsorbent at pH 7.0 is capable to remove 410 ppb (82%) of arsenic in 90 minutes which is significantly a considerable amount. However, adsorption increases with the increase of pH from 5.0 to 7.0 but further increase to pH = 8.5 has lowered the As adsorption.

Table 1 Arsenic adsorption at different time and pH ranges

Entry	pH	As solution (ml)	Adsorbent (mg)	Adsorption of As (ppb)			
				30 min	60 min	90 min	120 min
1	5.0	20	10	145	186	212	190
2		20	50	223	276	245	234
3		20	100	256	298	267	232
1	6.5	20	10	168	214	268	154
2		20	50	196	245	288	267
3		20	100	276	322	372	363
1	7.0	20	10	188	243	288	175
2		20	50	212	276	312	278
3		20	100	289	354	410	324
1	8.5	20	10	145	201	258	142
2		20	50	166	233	262	256
3		20	100	266	308	357	346

4. Conclusions

Low cost non-toxic carbon based material synthesized in our laboratory is found to be active for the removal of 410 ppb of arsenic in 90 minutes at pH 7.0. There is no medicine to cure chronic As toxicity except healthy diet and safe water. A plan of arsenic removal from potable water by using the synthesized material has been considered in the present study so that the technology should be cost effective, eco-friendly and efficient to meet the requirement of the people residing in the arsenic prone areas of not only in the North Eastern Region of India but also other part of the globe.

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Comparative LCA Study of Biological Nutrient Removal Plants

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Abstract

Life cycle assessment (LCA) can be used as an effective tool even in the case of biological nutrient removal (BNR) processes for sustainability assessment in wastewater treatment.Two different wastewater treatment technologies (Anaerobic/anoxic/oxic process and Bio-Denitro process) has been performed using assessment method CML-IA baseline 2000. Maximum environmental benefits are associated with nutrient removal from wastewater. LCA results indicate that of the technology investigated, A^2O process performed best in most of the impact assessment categories as compare to bio-denitro process. The operational phase has a larger contribution (mainly due to electricity consumption) to environmental impacts as compared to constructional phase.

Keywords:*Wastewater; LCA; SimaPro; BNR.*

1. Introduction

Urban wastewater has emerged as one of the major roots of environment pollution. Initially the treatment of wastewater was concerned with removal of organic matter. Nowadays, the policy is also to remove nutrients and heavy metals to low level. Results show that the maximum environmental benefits are associated with nutrient removal from wastewater [1]. The treatment of wastewater enhanced the quality of surface water but at the same time other environmental problems arose e.g. emission of CO_2, CH_4 and N_2O. A greater efficiency of wastewater treatment needs higher consumption of electricity and chemicals.In this context, the aim of this study was to identify, quantify and compare the environmental impacts associated with two different sewage treatment plants (STPs) based on BNR processes, namely biodenitro process and Anaerobic/anoxic/oxic (A^2O) process, using LCA methodology.

2. Material and methods

In this study, the methodology used involves the environmental impact evaluation with process analysis from the perspective of the standardized LCA (ISO 14040 14044: 2006). Two BNR wastewater treatment plant (WWTP) were selected in the scope of present study, based on A2O and biodenitro processes. Boththe STPswere designed for 20 MGD(90MLD).Nilothi-II

STP is located at Nilothi near Delhi. The STP is designed on biodenitro process equipped with phosphate and Nitrogen removal from Anoxic Zone.Pappankalan II STP is located near Pappankalan, Delhi. The STP is based on anaerobic / anoxic / aerobic (A^2O) process equipped with phosphate and Nitrogen removal.

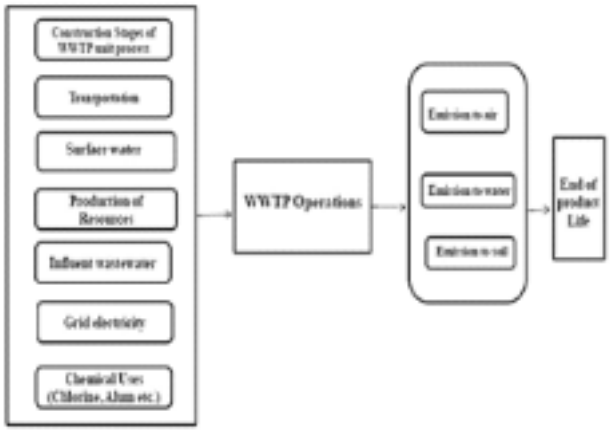

Figure 1.System boundaries applied in LCA

Figure 1 shows the system boundaries of current LCA study from construction to its demolition.The functional unit adopted in the present study was 1 m3 of treated wastewater by the systems**.** All materials, fuel and processes considered in the life cycle of two advance BNR wastewater treatment systems studied were collected on site except some gas flow like CO2, CH4, and N2O emissions during the operation, which could not be measured and had to be estimated from literature. Chemicals and electricity production inventories were taken from SimaPro 8.0 which was used in this study.

Table 1. Environmental impacts with their

Impact category	Code	Unit
Abiotic depletion (fossil fuels)	ADF	MJ
Global warming (GWP100a)	GWP	kg CO_2eq
Marine aquatic ecotoxicity	MAE	kg 1,4-DB eq
Terrestrial ecotoxicity	TE	kg 1,4-DB eq
Acidification	AC	kg SO_2eq
Eutrophication	EU	kg $PO4^{--}$eq

The data prepared during inventory analysis was processed through SimaPro and output examined using assessment method CML-IA baseline (version 3.02). Six impact indicators were analysed for construction and operational phases of STPs as shown in Table 1.

3. Results and discussion

With respect to treatment performance both the evaluated plants were observed to be performing well within the limits of aerobic and/or anaerobic processes. The effluent values of major performance parameters of A^2O and biodenitro processes were recorded as 5, 29, 6, 17.6, 1.9 mg/l and 5, 30, 7, 20, 2.8 mg/l for BOD, COD, TSS, TN and TP, respectively.

Table 2. Impact assessment for 1 functional

Impact (Code)	Construction		Operation	
	A^2O Process	Biodenitro Process	A^2O Process	Biodenitro Process
ADF	0.17	0.16	76.97	89.21
GWP	0.03	0.02	7.61	8.82
MAE	13.99	14.28	12505.85	15230.16
TE	7.76E-05	7.11E-05	0.07	0.06
AC	8.35E-05	7.93E-05	0.05	0.06
EU	2.73E-05	2.76E-05	0.03	0.04

Table 2 shows that environmental impacts due to constructional phase were almost same for both the systems whereas impacts due to operational phase of both the systems were observed to be quietly comparable. However, the impact of construction phase was found to be negligible as compared to operational phase for both the system. Previous studies also reported the same trend therefore only operational phases may be compare for impact assessment [2,3].

Figure 2 shows the relative impact contribution for selected impact indicators on percentage basis for both the systems. It clearly indicates that load on environment by A^2O process is 15-27 % less as compared to biodenitro process in all impact indicators except terrestrial ecotoxicity. For impact indicator TE, biodenitro process is ~ 10 % less as compare to A^2O process. Impact indicator TE is dominated in both the system due to sludge application to land.The role to GWP from both plants is dominated by production of electricity energy that used in operational phases. Specific power consumption was found to be 0.23 and 0.26 kWh for A^2O and biodenitro process respectively. The environmental impact associated with eutrophication caused by the final effluent characteristics.Phosphorus contribution to eutrophication is 140times that of COD [4].The overall difference between the EU impact is ~27%.

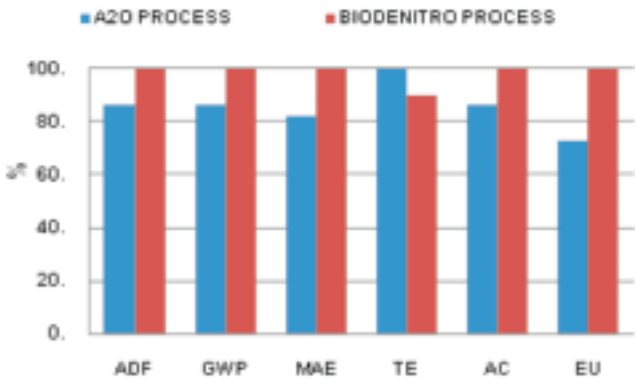

Figure 2. Comparison of life cycle impact assessment (LCIA)

4. Conclusions :

LCA can be used as an effective tool even in the case of BNR processes for sustainability assessment in wastewater treatment. Considerable amount of resources can be saved if LCA based methodology is adopted in up-gradation of existing wastewater treatment.

Environmental impacts due to constructional phase were observed almost same whereas due to operational phase there is the differences between both the technologies. LCIA results indicate that of the technology investigated, A^2O process performed best in most of the impact assessment categories as compare to bio-denitro process. The operational phase has a larger contribution (mainly due to electricity consumption) to environmental impacts as compared to constructional phase.

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Decentralized and low cost system for nutrient removal from primary treated sewage by aquatic weeds

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Abstract

An attempt was made to investigate the aquatic weeds to remove the nitrogen and phosphorous using four aquatic plants i.e. two emergent plants (*Typha latifolia and Phragmites australis*) and two floating plants(*Eichhornia crassipes and Lamina gibba*) from primary treated sewage. This study focuses on the nutrient removal efficiency based on the coverage area and biomass based calculation from the aquatic weeds reactor. Results indicate the highest removal of the nutrients i.e. nitrogen and phosphorous was observed from the plants area based calculation since weight of the emergent plants are higher as compared to floating plants. The study indicates that the physiological characteristics of the aquatic plants greatly affect the performance of the system.

Keywords: ***Nutrients, Aquatic Plants, Sewage,***

1. Introduction

UrbanIn the field of wastewater treatment there are several types of wetlands for nutrient removal depending on vegetation and hydraulic flow *(Loodsdrecht et al. 2004)*. Besides constructed wetlands, other type of wetland such as natural wetlands and mangroves are also used for removal and immobilize the nutrient *(Clough et al. 1983)*. Being recognizing as a low cost and effective treatment systems, worldwide this wetland ecosystems are used for the treatment and disposal of wastewater *(Brix 1994)*. Constructed wetland (CW) is considered for wastewater treatment in small communities and rural area or decentralized villages due to simple operation and friendly. This type of system is effective to reduce the large amounts of non-point source pollutants occurred by the rainfall and rain washing the village grounds and fields. *(Liu et al. 2004)*.

Researcher also reported that Constructed and natural wetlands are often used being a low cost treatment system for domestic wastewater effluent, single-residence septic tank effluent and large municipal wastewater *(Cooke 1992)*.

Previous studies focuses on the performance of constructed wetlands (CWs) based on design, dimension, and substrate used.

The role of plants is equally important but a limited studied available yet. Current study investigate the four various types of plants viz. (*Typha latifolia and Phragmites australis* - emergent) and (*Eichhornia crassipes and Lamina gibba* - floating plants) for nutrient removal based on the plant mass and the area occupied by plants in reactor calculation.

The primary objective of this study was to explore the nutrient removal-capacity of four aquatic plants, two emergent plants and two floating plants from primary treated sewage.

2. Material and methods

Following table summarizes the batch reactor configuration

Table 1: Reactor configuration

Depth of Reactor	0.60 m
Bed depth	0.45 m
Pebbles depth	0.25 m
Fine Gravels depth	0.10 m
Sand depth	0.10 m

The cylindrical shape batch reactors were made of plastic containers with dimensions explained in Table 1, accommodating capacity 5560 L of volume. The reactors were replaced in three different layer having depth 0.25 m ,0.10 m, and 0.10 m with 50-80 mm pebbles size, 10-20 mm fine gravels and 0.62.4 mm of sand respectively. Plants *(Typha latifolia, Phragmites australis,Eichhornia crassipes, Lamina gibba)* were collected from a freshwater body and bank of Yamuna River) located vicinity of campus of the Jamia Millia Islamia, New Delhi, India. The specimen was brought to the laboratory and inoculated in sewage for the further use.

3. Results and discussion

Results revealed that the aquatic weeds *Typha latifolia* and *Lamina gibba* could reduce the N and P up to 75 and 55% respectively. Fig. 1 shows the average per cent removal of N and P from different aquatic plants. The removal of N and P was calculated based on two physical

parameters viz. area occupied by aquatic weeds and gain in weight of the aquatic weeds in vertical free surface flow (VFS). Results referred that the removal rates of N and P were having a significant variation calculated based on area and weight parameters. Results suggest that the average removal of N varies 48 to 76% in a reactor observed based on surface area of plant occupied. The mean removal of P was ranged 30 to 55% for the same reactor.

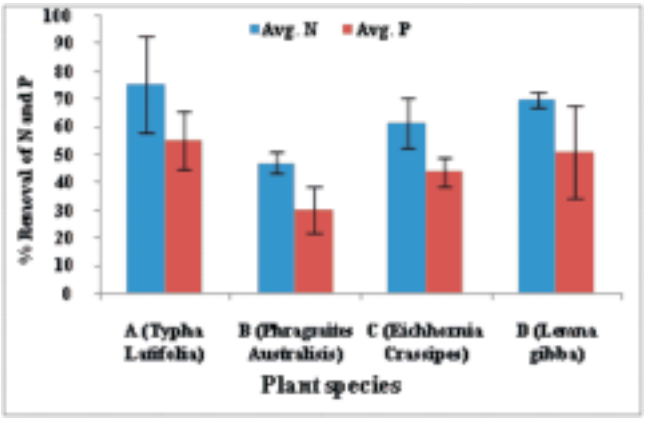

Figure 1. Nitrogen and Phosphorous removal rates (area and biomass based calculation Mean+ SD values)

When removal of N and P compared with the reactor analysed based on weight of plants gain calculations, the removal efficiency differed significantly.

The variation in pH and alkalinity was insignificant throughout the test period. The dissolved oxygen was varied significantly from 2 - 6 mg/L in both type of reactor under investigation.

4. Conclusions

Following conclusions were drawn from the present study:

- Aquatic weeds based natural treatment system resulted in the significant amount of dissolved oxygen and insignificant change in pH, compared with unplanted natural system. Species of the weeds were observed an influence on dissolved oxygen and pH in planted system.
- Different types of aquatic weeds have shown significant effect on nutrient removal rates in the VFS-natural system. Highest removal of nutrients was observed in VFS-natural system planted with aquatic weeds as compared to the non-planted VFS natural system.
- The N and P removal rates by weeds treatment was observed in ranges of 15 45 mg NP m^{-2} d^{-1} in area based treatment system as compared to 2 12 mg N-P kg^{-1} d^{-1} in weight based calculations.
- Results have demonstrated that T. latifolia is represented as the most efficient plant for removing nutrients in the VFS- natural systemcompared to the nutrient removals in terms of plant weight calculations.

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Urban Solid Waste Management
[SESSION B1]

PROCEEDING

Evaluationof biogas generation from different wastes by using single inoculum: A batch study

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Abstract

The potential of mono digestion of fruit-vegetable waste (FVW),kitchen waste (KW)and garden waste(GW) using cow dung (CD) as inoculum was investigated in batch reactors under mesophilic conditions. The biogas generation was measured using water displacement method. Results revealed that the FVW yields the highest biogas of 3200 mL from the 110 g COD m-3 d-1. No significant difference was found in TS/VS reduction among all studied substrates.

Keywords: Anaerobic digestion; biogas; Organic wastes; Inoculum

1. Introduction

Waste production is an integral part of the society and it is being produced from every process directly or indirectly. Waste can be categorised in various ways depending on the physical state, composition, and source of generation of the waste. Anaerobic digestion (AD) seems to be a viable and sustainable technique among all the techniques available that can be used for waste management in rural areas [2,5]. AD is a biochemical process in which biodegradable material is broken down by microorganisms [4,5]. The main advantage of this process is the production of biogas, that can be used as an alternative for energy, digestate that can be used as soil conditioner in agricultural fields, high organic loading rates (OLR) and low sludge production [2,5]. This process reduces the methane content that is being sent to the atmosphere due to degradation of waste in the open[1,4,5]. Kitchen waste and fruit vegetable waste are highly putrescible and produces nuisance in the environment [1]. The present study explores the kitchen waste, fruit-vegetable waste, and garden waste as substrate for anaerobic digestion.

2. Material and methods

The substrates used in the present study were kitchen waste (KW), fruit-vegetable waste (FVW) and garden waste (GW). The kitchen waste was collected from the canteen left over food, fruit vegetable waste from the nearby juice shops, and garden waste was collected from Jamia MilliaIslamia, New Delhi. The waste collected was segregated and grinded to fine size in a grinder prior to feeding in the reactor. Fresh cow dung was used as an inoculum. The experiments were performed in a specially designed glass vessel of 5L capacity as shown in Figure 1. The waste brought fed into the reactor and closed airtight to ensure anaerobic conditions in the reactor. The physical parameters for the study included total Solids, volatile solids and chemical parameters were included COD and alkalinity were analyzed as per APHA standard methods. The pH was measured using pH meter CL 54+ (ToshconIndustries Pvt Ltd).

Figure1. Pictorial view of batch setup

3. Results and discussion

The pH values of all substrates were found to be between 6.0 -7.7 which are in the optimum range of pH needed for the AD [2]. Reduction in pH value before and after digestion indicates rapid acidification of the waste and production of larger amount of volatile fatty acids [1]. The volatile solids (VS) and total solids (TS) reduction was highest for the fruit-vegetable waste indicating it to be the easily biodegradable material.The higher COD values were

maximum for FVW as shown in Figure 2. Alkalinity was found maximum for KW as in Figure 3.

Figure 2. Initial and Final COD (mg/l) for KW, FVW and GW

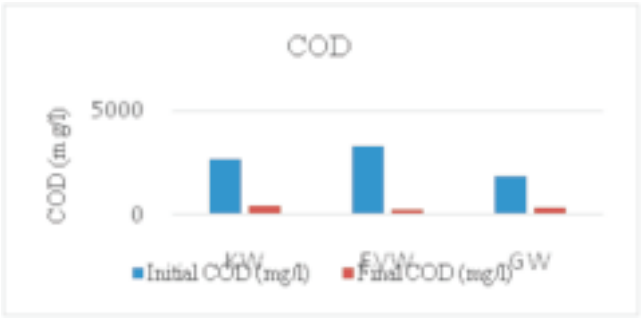

Figure 3.Initial and Final Alkalinity for KW, FVW and GW.

The reduction in TS/VS values indicates production of biogas in the reactor. The initial TS/VS values of KW, FVW and GW were 0.124, 0.178, 0.154 and after digestion, these values

Figure 4. TS/VS Reduction based on initial and final characterisation

The biogas generated was recorded on daily basis. Comparative results of biogas production for KW, FVW and GW are represented in Figure 5. The minimum biogas yield was zero and maximum biogas yield was noted as 3500ml in FVW.

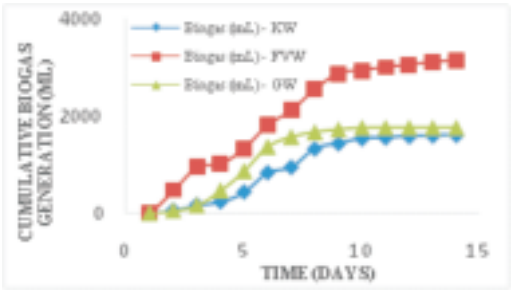

Figure 5. Comparative results for KW, FVW and GW for cumulative biogas production

4. Conclusions :

The experimental study indicates that the highest amount of biogas was produced from anaerobic digestion of KVW. No significant difference was observed in TS/VS reduction in all substrates. All waste produced in rural areas can be used effectively to achieve the targeted goals of reducing the waste.

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Urbanization and municipal solid waste: Evaluation of metal solubility and eco-toxicity potential

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Abstract :

Improper management of solid waste often leads to contamination of water resources through uncontrolled leachates. This research evaluated the solubility dynamics and eco-toxicity potential of Municipal Solid Waste (MSW) of two cities of the region namely, Guwahati (GMSW) and Tezpur (TMSW)**.**Occurrence of heavy metals in soluble forms was considerably high in GMSW, which is of serious environmental concern**.**Furthermore, metal fractionation study indicated higher eco-toxicity potential of MSW generated in Guwahati as compared to the waste in Tezpur**.**

Keywords : Municipal solid waste; eco-toxicity; solubility; metal fractionation

1. Introduction

Waste generation, intrinsic to urbanization leads to health hazard and environmental degradation. Several studies demonstrated that leaching of pollutants from MSWs considerably contaminates the surface water, groundwater, and soil through continuous discharge of metals and other potential toxic elements. However, the predominance and concentration of contaminants in MSW leachates are largely dependent on the solubility dynamics of the elements.Eco-toxicity and bioavailability of heavy metals mainly depend on their different forms or fractions. Therefore, a study on various fractions of heavy metals is essential to understand eco-compatibility of solid wastes [1].

2. Material and methods

Water-soluble concentration of different elements in the MSW samples of both the cities was determined following Bhattacharyya et al. (2011) and Goswami et al. (2014). Solubility dynamics of the MSWs was studied using Visual MINTEQ geochemical model.Chemical fractionation of metal (Fe, Cr, Cu, Ni, Pb, and Zn) forms in the MSW sampleswere carried out by following sequential extraction methodstandardized by Tessier et al. (1979) [1].

3. Results and discussion

The results of the solubility experiment are presented in (Fig 1 & 2). Fig.1, illustrates changes in pH, alkalinity and major anions and in Fig 2.demonstrates variations in heavy metals. Alkalinity of TMSW samples was considerably higher as compared to GMSW (Fig. 1). This is probably due to high occurrence of Ca, Mg and Na in soluble form in the waste material (Fig. 2).The concentration of heavy metals in MSW samples varied considerably depending on the nature of waste components. Pb did not solubilize from TMSW, probably due to very low

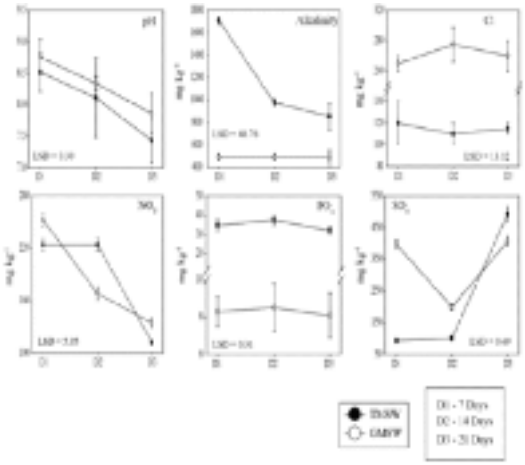

Figure 1.Temporal variation of pH, alkalinity, major anions in water-soluble part of TMSW and GMSW.

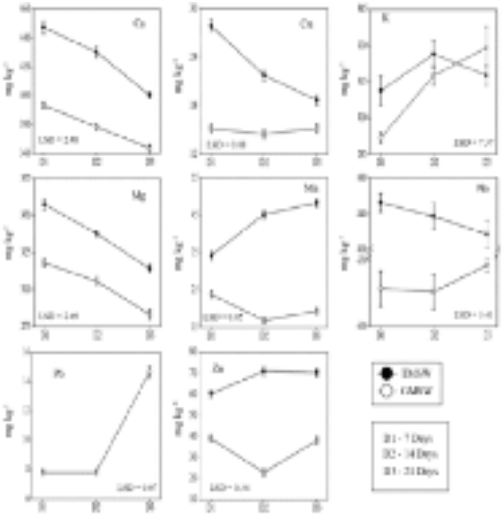

Figure 2.Temporal changes in bioavailability of micronutrients and heavy metals in water-soluble part of TMSW and GMSW.

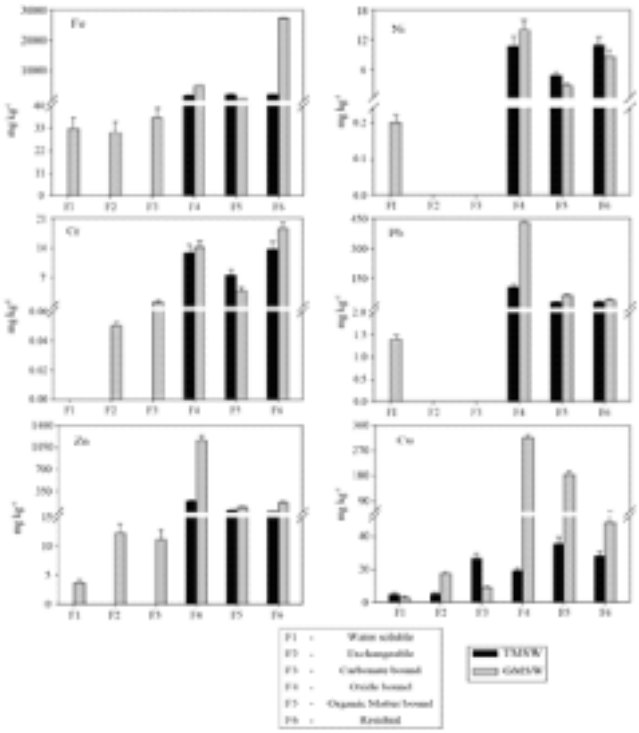

Figure 3.Different fractions of Fe, Ni, Cr, Pb, Zn and Cu in TMSW and GMSW.

Fig. 3 represents the various forms of Fe, Cu, Zn, Ni, Cr and Pb in the investigated MSW samples. All the heavy metals in various forms were prominently higher in GMSW with respect to TMSW.Water soluble or exchangeable fractions of most of the metals, except Cu, were not observed in TMSW samples.On the contrary, GMSW samples recorded considerable amounts of water soluble and/or exchangeable fractions of Fe, Zn, Ni, Cr and Pb. These two fractions are highly bioavailable because changes in the ionic composition of water greatly affect the adsorption-desorption and mobility processes of metals [1].

4. Conclusions

Solubility study illustrated diverse dissolution/precipitation dynamics of Ca, Cu, Zn and Pb in the solid wastes.Furthermore, metal fractionation study indicated higher occurrence of recalcitrant fractions of metals compared to exchangeable fractions in both TMSW and GMSW.

5. References

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C-H bond activation in methane over Pd_nPt_{4-n}(n=0-4) subnanoclusters: A comprehensive density functional study

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Abstract
Methane is the second most abundant anthropogenic greenhouse gas, so its presence in the atmosphere affects the earth's temperature and climate system.Understanding C-H cleavage of methane is significant in designing suitable catalysts and achieving substantial reductions.We report a comprehensive DFT exploration on the C-H bond activation of methane, an important step for conversion reaction of methane to liquid fuels, over pristine and heteronucleic Pt and Pd tetramers. Subnanoclusters exhibit great promise for catalytic activities, implicitly much greater than monolith. Doping is known to be an excellent and simple way of catalyst design and bimetallic nanoparticles are more promising due to synergistic effect. Heterometallic clusters with active Pt-site are found to have the ability to enhance C-H bond activation in methane.

Keywords:*C-H bond cleavage, metal hydrogen bond formation, pristineand hetero-metallic subnanoclusters.*

1. Introduction

Combustion engines have a dominant role in the contemporary industrial economy. Combustion of fossil fuels is, however, a major source of air pollution. Increasingly demanding emission standards have led to extensive research in order to achieve superior catalytic performance for the decomposition of environmental pollutants.

Functionalisation of alkane through C-H bond activation by transition metals has attracted enormous attention to secure the supply of chemicals and energy as well as to combat environmental pollution. Binding of methane to metal centres has resulted in altered and/or improved reactivity in a variety of molecules, through associated changes in the relative energies of their orbitals or their polarity. However, there are very few practical methods for direct conversion of alkanes to more valuable products due to chemical inertness. Noble metals exhibit very good performance for a number of these processes, but usage can be sometimes too expensive. Highly selective, efficient and robust catalysts are therefore important to meet this challenge. One method for reducing the amount of noble metals required for a reaction is substitutional doping.

To date, only a few studies have been carried out onheterometallic clusters on how methane will interact. Henceforth, in the current study we carried out a detailed density functional (DFT) calculation with the objective to prepare robust catalyst with higher activity and shed light on the fundamental step of methane conversion.

2. Material and methods

All DFT calculations have been performed using DMol3 program. Gradient corrected density functional formalism (GGA) using BeckeLeeYangParr (BLYP) exchangecorrelation functional has been employed. Pd being a heavy atom, relativistic all electron density functional theory (VPSR) based DNP basis set is used.All the geometries have been fully relaxed and harmonic frequency calculations were performed to confirm that each optimized structure corresponds to a minimum.Potential energy profile for activation of CH4 from molecular form (MA), passing over transition state (TS) to dissociative form is studied. The most plausible pathway for the activation of CH4 investigated as follows:

$$Pd_nPt_{4-n}+CH_4 \rightarrow Pd_nPt_{4-n}CH_4(MA) \rightarrow TS \rightarrow Pd_nPt_{4-n}HCH_3(DA)$$

3. Results and discussion

Considering spin polarisation, every structure is optimized at two spin states (M=1 and 3), and the structure with the lowest energy for each case is considered. A schematic potential energy surface of the reaction is constructed to search the most dominant cluster to carry out the reaction efficiently. For a heterometallic system, the reaction starts with the adsorption of CH_4 on cluster forming the molecularly adsorbed species. However, there is the possibility of adsorbing CH_4 on Pd- or Pt-site. Therefore, we have considered both the pathways.

The relative energies for this reaction are reported in Table 1, the optimized geometries (including bond lengths, bond angle and the Hirshfeld charge of reactant, intermediates, transition states and products) for the reaction have been illustrated in Figure 1. Energy profile diagram (including energies of reactant, intermediates, transition states and products) of this reaction steps has

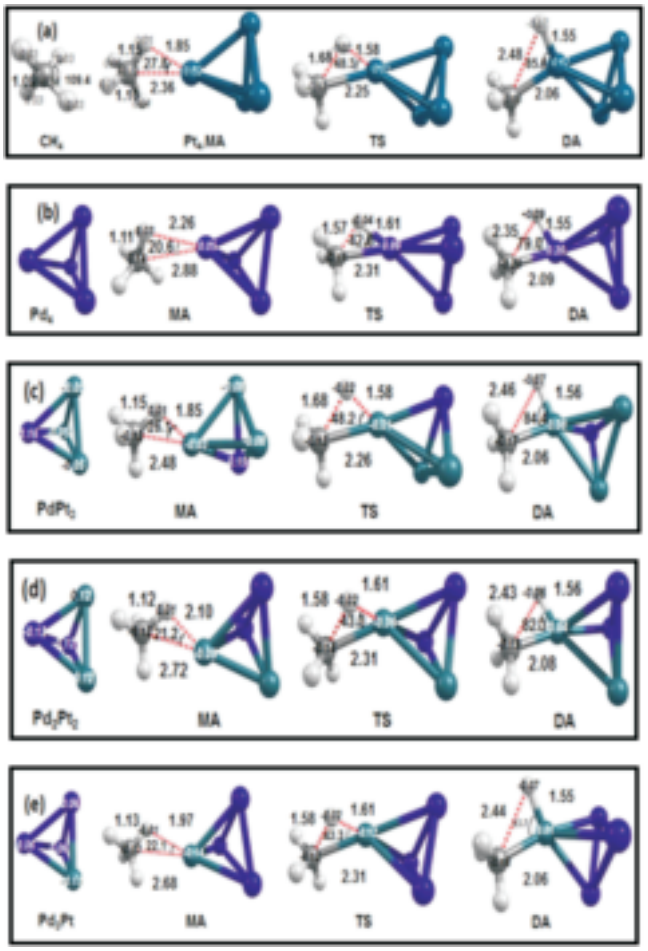

Figure 1.Optimised structures of transition state and intermediates for methane activated over(a) Pt_4, (b) Pd_4 and (c) $PdPt_3$, (d) Pd_2Pt_2 and (e) Pd_3Pt for selected structural parameters (distances in Å, bond angle in degrees) and Hirshfeld charges |e| (shown in *italic*).

Table 1.Barrier height (kcal.mol-1 and eV)

System	Kcal.mol^{-1}	eV
Pt_4	4.30	0.18
Pd_4	25.29	1.01
$PdPt_3$ (Pt-active site)	3.01	0.13
Pt_3Pd (Pd-active site)	21.13	0.91
Pd_2Pt_2 (Pt-active site)	6.20	0.26
Pt_2Pd_2(Pd-active site)	24.00	1.03
Pd_3Pt (Pt-active site)	10.59	0.46
$PtPd_3$ (Pd-active site)	43.8	1.89

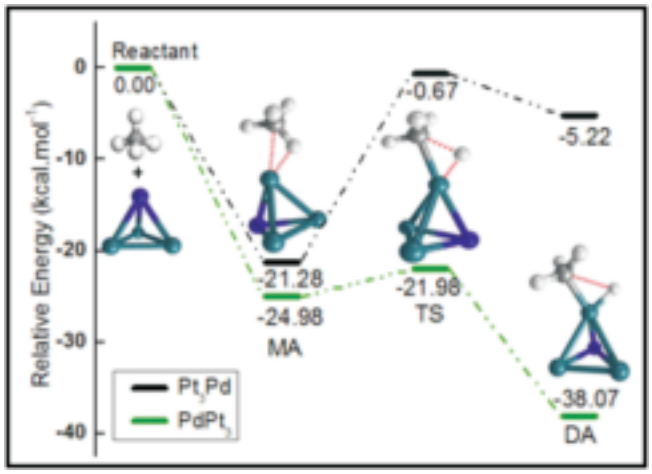

Figure 2.Potential energy profile for the activation of methane over $PdPt_3$ at the two active sites. The total energy of the reactants is taken as zero. (Green lines- Pt, black lines- Pd as the active site).Only dominant catalytic system among the considered systems is shown here.

4. Conclusion :

(a) When CH_4 binds with a higher affinity to a cluster, less energy is required to cross barrier.

(b) Higher energy barrier is associated with pristine as well as substituted Pd clusters (reaction carried on the Pd-site).

(c) Reactions for CH_4 dissociation on pure Pt and heterometallic clusters, with Pt acting as active site, are exothermic in nature.

(d) Catalytic activity order for the fissible systems: $PdPt_3 > Pt_4 > Pd_2Pt_2 > Pd_3Pt > Pt_3Pd$.

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Assessment of plant growth promoting rhizobacteria (PGPR) on potential biodegradation of glyphosate in contaminated soil and aquifers

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ABSTRACT

Glyphosate is a broad spectrum non selective herbicide which is commonly used to control perennial weeds in the agriculture.Glyphosate may be retained and transported in soils and leached to aquifers.Borggaard O.K, Gimsing A.L (2008).There may be cascading effects on non-targetorganisms. It is important to develop methods for enhancing glyphosate degradation and eliminating in soil. Finding glyphosate degrading microorganisms in the soil and water will be a better solution. Four treatments of containing microorganisms capable of utilizing glyphosate were isolated from the long term glyphosate exposed ricefield and tested for their abilities to utilize glyphosate at different concentrations.The utilization of glyphosate by the isolates was studied by monitoring their biomass production in basal medium containing glyphosate as at 660nmwavelength by spectrophotometry. The degrading rates of glyphosate in the medium by theseisolates were also studied by assessing the concentration in the medium at 265nm wavelength.The results showed that *Pseudomonas* sp., *Bacillus* sp., and mixture of both organisms showed significant growth at low concentration and degrade glyphosate effectively. This study emphasize that testbacterial isolates in glyphosate utilization, hence their potential as candidates for bioremediation of glyphosatecontaminated sites.

Key words: Glyphosate,Herbicide, Bio remediation, *Pseudomonas* sp., *Bacillus* sp.

1. Introduction :

Glyphosate is the active component in a broad range of herbicide formulations used in world agriculture for the control of various weeds. MonekeA.N,Okpala G.N, Anyanwu C.U(2010) The proposed insignificance of the impacts of glyphosate on the environment, agriculture and even for human health has been recently challenged. And repeated application of glyphosate to the environment will cause numerous harmful impacts. It is better to find necessary ways of decontaminating the polluted environment by quickly removing or degrading the herbicide to reduce its effect on non-target organisms. PGPR plays a major role in biodegradation. Bioremediation is the most environmental friendly, cost effective way to remove that hazardous residue from soil and water. Mainly PGPR degrade glyphosate by using two chemical pathways. These are aminomethylphosphonic acidpathway and Sarcosine pathway. The main aim of this study is to test the activity of glyphosate degrading PGPR and degrading rates of different glyphosate concentrations using different microbial treatments and to select the most suitable treatment of all.Also this allowed assess the potential of PGPR on biodegradation of glyphosate containing soil.

2. Material and method

Glyphosate contaminated soil was collected from rice growing field. Six soil samples were collected from depths of 0 - 15 cm from 3 different sites. Isolation was done using a constituted basal medium containing glyphosate. The cultures were incubated in an orbital shaker at 28-30^{0}C and 120 rpm for 7 days. Then 0.1 ml aliquot was spread on the plates of basal agar medium containing glyphosate. After several subcultures, morphologically distinct colonies were identified using different biochemical tests. Isolates were sub culturing in nutrient broth.The cultures were standardized by comparing the absorbance in spectrophotometer at wavelength of 600nm with that of MacFarad 0.5nephrometer standard. Four treatment groups were used as follows *Pseudomonas*sp.,*Bacillus* sp.,mixtures of

organisms from contaminated site (*Pseudomonas* sp.+ *Bacillus* sp.),forest soil microorganisms with 50mg/ml,100mg/ml,150mg/ml concentrations of glyphosate. Each treatment was contained approximately 1.5 x 10^8 (CFU/ml). Inoculated cultures were incubated for 192 h on a rotary shaker at 120rpm and room temperature of 28^0C-30^0C. Bacterial growth (optical density) was monitored by removing one set of cultures at each concentration using spectrophotometer at the wavelength of 660nm.**(Figure1)** The degradation of glyphosate in the soil by treatments was assayed under artificially controlled conditions. Soil samples were collected from natural forest and samples were sterilized.Then 50g of soil were placed. Aliquots (1.0 ml) of the standardized culture of the same organismsas the same treatments were inoculated with 50 ml of basal medium supplemented with various concentrations of glyphosate,50,100, and 150mg/ml. Glyphosate in the treated samples were quantified by UV-vis spectrophotometry using 265nm wavelength.The supernatants were derivatization with FMOC-Cl in alkaline media.

Degraded amount of glyphosate in each treatments were calculated depends on the difference between the initial glyphosate concentration of the treatment and the remaining in the supernatant. Degradation rate (%) = (M2 - M1) / M2 x 100% (Figure2**).**

3. Results and discussion

It was shown that growth and activity of most of the tested microorganisms used for glyphosate biodegradation was higher in 50 mg/ml glyphosate concentration.

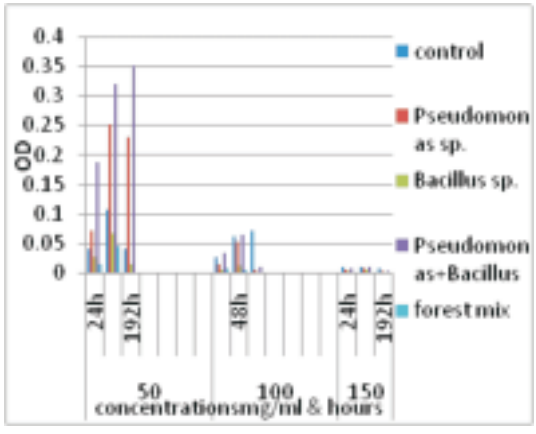

Figure1. Effect of different concentrations of glyphosate on the utilization patterns by the test isolates.In 50mg/ml and 100 mg/ml organisms were highly grew. *Bacillus* sp. showed a reduction in growth with corresponding increase in glyphosate concentration. Mixture of glyphosate utilizing bacteria effectively grows in most concentrations. Forest microorganisms decrease the growth at each concentration.

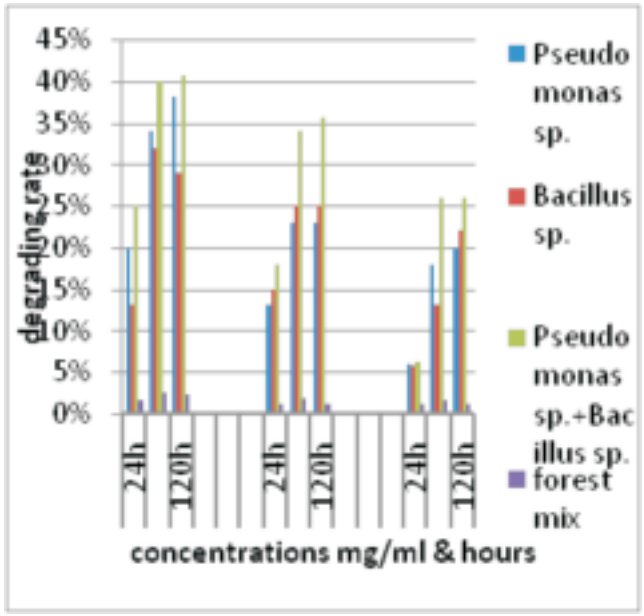

Figure2.Comparison of different concentration for rate of glyphosate biodegradation

At low concentrations of glyphosate the degrading rate was increase with the time. Mixture of *Pseudomonas* sp. + *Bacillus* sp. was highly degraded glyphosate in sterile soil. Lowest degrading rates were observed in forest soil microorganism mixture. Treatments containing organism's growth were started increasing at 24 h of incubation but peaked at 48h and continued with a steady or constant rate till the end of monitoring.

4. Conclusion :

The present study reveals that PGPR are able todegrade glyphosate even at higher concentrations, 100mg/ml. Forest soil micro biota was able to utilize glyphosate at lower rates.Higher glyphosate concentrations can betoxic to microbes.Therefore we can conclude that *Pseudomonas*sp.and *Bacillus* sp.approximately 1.5 x 10^8 (CFU/ml)together are effective in degrading glyphosate in contaminated water and soil. Andalso the ability of *Pseudomonas sp. to*withstand high concentrationsof the herbicide makes them potential candidates for this purpose.

5. References

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pH dependent leaching behaviours of Cd, Cu, Ni, Pb, and Zn from lead smelting slag

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Abstract

The leaching behaviours of Cd, Cu, Ni, Pb, and Zn from a lead smelting slag is assessed under varying pH conditions to understand the toxicities of heavy metals in geo-environmental conditions as well as the ground water pollution potential of slag. The leaching behaviours of some major cationic and anionic species are also evaluated to correlate the leaching behaviours under applied conditions. The results are analyzed by considering the behaviours of various solubility controlling phases in the studied pH range.

Key-words:*Ground water pollution*, *Lead smelting slag, Heavy metals, pH dependent leaching, waste management.*

1. Introduction

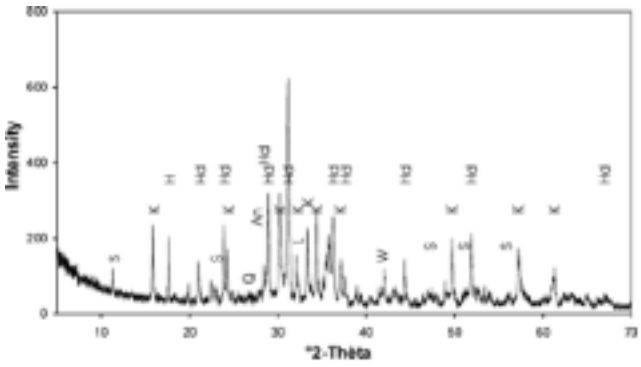
Management and treatment of solid wastes generated from different industries as well as municipalities have taken more and more importance because of the presence of elevated levels of toxic constituents and associated ground water pollution potential. For effective managements and treatments, understandings of chemical and environmental behaviours of these wastes have enough importance.Leaching tests are normally performed to assess the toxicities of wastes.In this investigation, the heavy metal leaching behaviours of lead smelting slag is conducted by using some standard leaching tests. The pH dependent leaching behaviours of some related anions and cations are eventually determined for understanding the behaviours of investigated toxic constituents in geo-environmental conditions.Moreover special attention has been paid to interpret the pH dependent leaching results of toxic elements with the help of existing geo-chemical modeling results for similar types of wastes. Such interpretation will be helpful for environmental impact assessment and risk analysis of concerned wastes.

2. Materials

The metallurgical slag (SLG) is a residue from a lead blast furnace. The prEN 14429 test was used to identify the leaching behaviour of SLG under certain pH conditions. The test consists of a set of parallel batch extractions of the material at L/S = 10 (L kg^{-1}) in closed flasks, where samples were in contact with aqueous solutions with increasing quantities of HNO_3 and NaOH for 48 h under agitation, prior to the measurement of pH. The elemental compositions of leachates were analyzed by ICP-MS. The XRD pattern of SLG was also recorded for identifying the minerals.

3. Results

The XRD pattern of slag (SLG) and the identified crystalline minerals are presented in Fig. 1. The Ca and Fe-bearing silicates and oxides are the major minerals present in SLG and therefore, for understanding of trace elements behaviours, leaching behaviours of Ca and Fe containing species should be considered seriously.



Mineral name	Chemical formula	Abundance
Anorthite	$CaAl_2Si_2O_8$	(X)
Hardystonite-Akermanite	$Ca_2(Mg,Zn)Si_2O_7$	XXX
Kirschsteinite, syn	$CaFeSiO_4$	XXX
Larnite	Beta-C_2S	(X)
Quartz	SiO_2	(X)
Sjogrenite	$Mg_6Fe_2CO_3(OH)_{16}.4H_2O$	(X)
Sphalerite	$(Zn_x,Cd_{1-x})S$	XX
Wuestite	FeO	X

XXX: Abundant, XX: meanly abundant, X: lowly abundant, (X): possibly present.

Fig.1. XRD pattern of slag and minerals present in slag with abundance.

The pH dependent leaching of various heavy metals exhibit a V-shaped curves, characteristics for amphoteric nature (Fig. 2). The leaching amount of each element at extreme acidic condition is more than that observed in extreme basic condition. The emission of some elements

like Pb, Zn, Cd are solubility controlled since their concentrations in the liquid phases are limited by the major solubility controlling phases, exists at various pH.

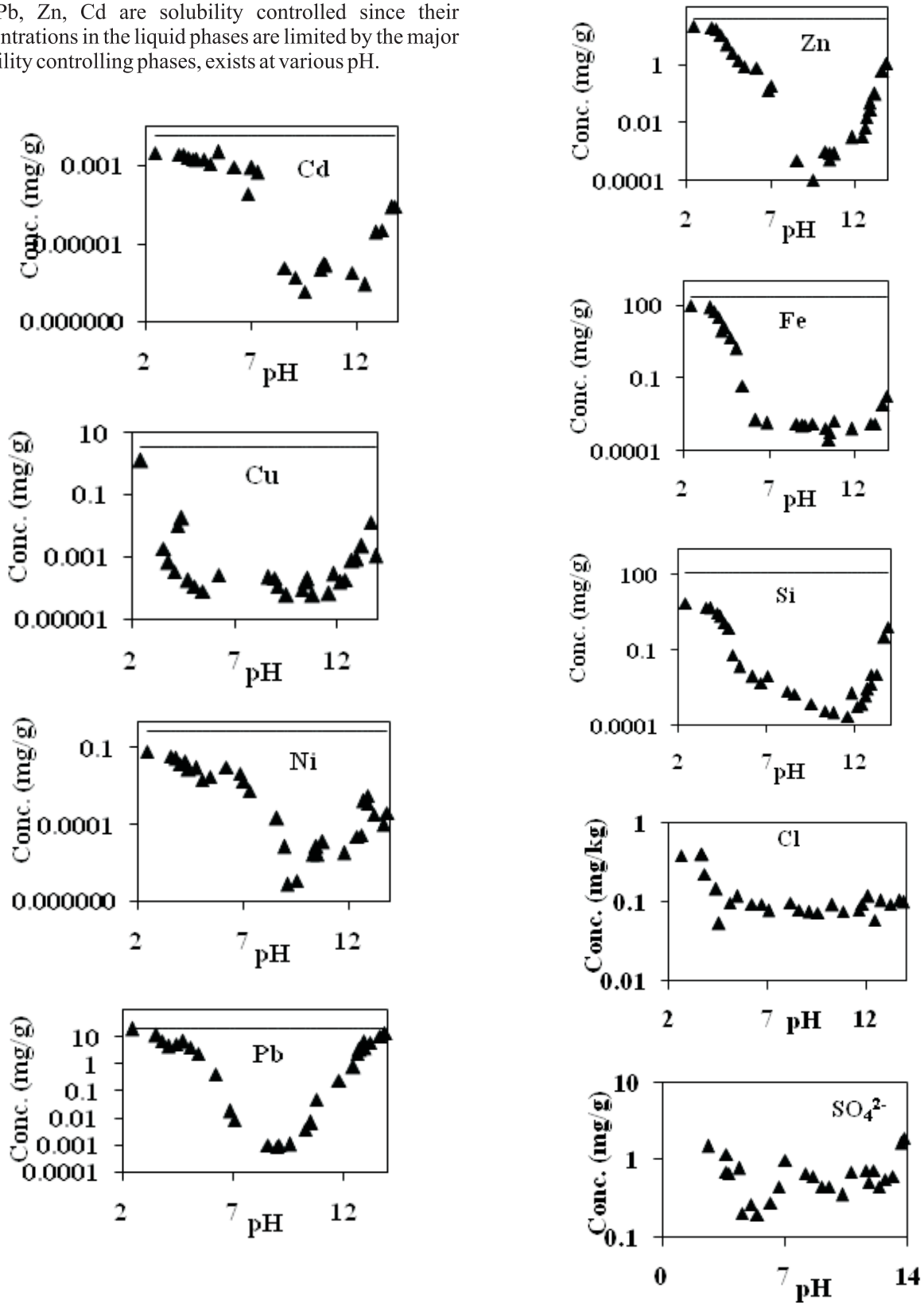


Fig.2. Leaching of selected elemental/molecular species (solid line: total amounts in SLG).

Considering the similarities of leaching properties of alkaline wastes such as MSWI bottom ash and APC residue, FFC fly ash and metallurgical slags, in this investigation therefore, an attempt has been made to explain the leaching behaviours of trace elements using the existing geo-chemical modeling informationfor related wastes [1]. For example, the major solubility controlling phases for Pb present in fly ash generated in secondary Pb smelting are: anglesite ($PbSO_4$) and $PbSO_3$ under acidic condition and laurionite (Pb(OH)Cl) under alkaline condition [2]. Quina et al (2009) observed $Pb_2(CO)_3Cl_2$, PbClOH and $Pb(OH)_2SO_4$ as the solubility controlling phases for APC residue at pH 4-6, 6-12 and pH > 12 respectively [3]. From the striking similarities of the pH dependent leaching curve of Pb obtained in this study with the similar curves of other two studies, it can be concluded that the same types of mineral phases are the solubility controlling phases for Pb leaching from slag too. The presence of substantial amounts of SO_4^{2-} and Cl^-i the leachants of SLG also supports such conclusion. Similarly, Cd mobility at pH < 9 can be related with the high Cl concentrations in the leachates of SLG ($CdCl^+$); on the other hand, $CdOH^+$ and $Cd(OH)_2$are major phases at pH above 10 (3). Moreover, precipitation of Fe at high pH can also control the mobilities of various elements by sorption/desorption mechanisms.

4. Conclusions

The emissions of trace elements are solubility controlled and therefore their concentrations in the liquid phases are limited by the major solubility controlling phases exist at various pH.The pH dependent leaching behaviours of most of the elements can be explained with the help of geo-chemical modeling results of similar types of wastes. Moreover behaviour of some major elements such as Fe must be considered during interpretation of leaching results.

5. References

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Evaluation of Water Quality in Downstream of Kelani River, Sri Lanka

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Abstract :

Kelani River is one of the most important surface water body in Sri Lanka in terms of social, economic as well as political aspects. However community behavior has not resulted in a favorable condition for Kelani River. Water quality modelling data and flood mapping results have indicated DO levels at several locations which does not satisfy the drinking and bathing standards and higher tendency for inundations, respectively. Thus to prevent the pollution getting worse it is a must for making the community aware of the potential threats as well as to implement new controlling policies with the interference of authorities.

Keywords: Kelani River; water quality modelling; DO;BOD/COD ratio; inundation

1. Introduction

Even though the Sri Lankans who lived back then maintained a favourable relationship with the environment recent human interactions with environmenthave resulted in water related issues including, abnormal increases of pollution in rivers and other water bodies, significant frequency of flooding, lack of drinking water with sufficient quality etc.

Kelani River can be identified as one of the major water body that was associated with the development of ancient civilizations. It falls from Sri Padha mountain range to Colombo with a length of 144km [1]. The catchment area has been identified as 2292 km^2 and can be divided into two segments, mountainous upper basin and lower basin below Hanwella with plain features [2]. Due to its location Kelani river has been rewarded with higher importance in social, economic as well as in political aspects. 80% of water supply of Colombo is satisfied from Kelani River. Apart of being the boundary of Colombo and Gampaha districts Kelani River has significant number of industries located along its flow path including Biyagama Free Trade Zoneand Seethawaka Industrial Zone.

However Kelani River has been identified as the mostly polluted river in Sri Lanka mainly due to the industrial wastes discharged to the river in both treated and untreated manner acting as point sources of the pollution [1]. Kelani River flows through the areas with highest population density which incorporate higher discharge of sewage and wastewater. Furthermore, severe inundation has been reported specially in the downstream low lying region [2]. This study focuses on evaluating the current water quality situation in Kelani River downstream with regards to water quality modelling and flood mapping.

2. Material and methods

In order to come up with proper mitigations or precautions it is necessary to identify the potential threats as well as the current situation associated with Kelani River downstream. Thus, several past studies have been used to evaluate the water quality and current situation of Kelani River downstream which involve water quality modelling as well as flood inundation mapping

3. Results and discussion

Water quality modelling has been conducted in 45km stretch of Kelani River downstream [1]. According to the resultsas indicated in Figure 1 [1] DO level near Maha Ela, a tributary of Kelani River was not up to the standards for drinking and bathing conditions (5mg/L and 6mg /L).

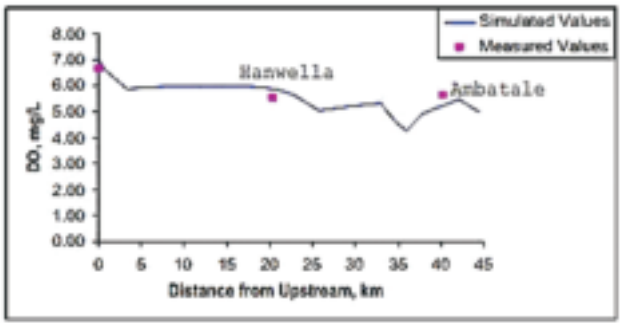

Figure 1. DO level along the reach

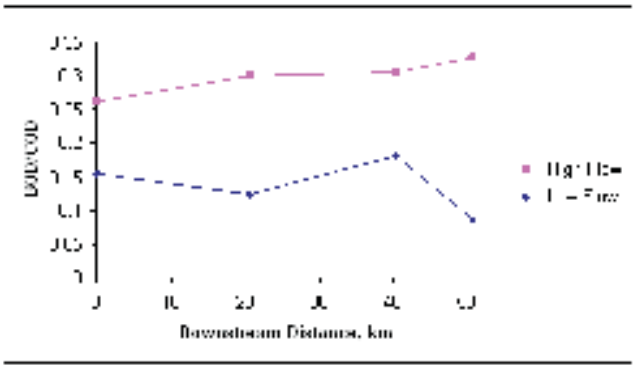

Figure 2. Average BOD/COD ratio along downstream

With the progressive urbanisation and emerging industrial establishments there is no possibility for this condition to become favourable. In a separatestudy [3], it was suggested that the importance of considering the storm water runoff as a major source of pollution to receiving water bodies when design the pollution mitigation strategies for Kelani River. Furthermore, the lower reach of the river has been subject to saline water intrusion from the ocean making the water non-potable due to excessive sand mining and lowering of river beds at the lower reaches in the Kelani River, where sand mining is particularly severe with the salt wedge has extended inwards to Ambatale (about 14 km from its point of discharge) on several occasions. This is a serious concern as much of the potable water supply for Colombo is extracted from the Kelani River at Ambatale [4].

Kaleni River basin is identified as the most vulnerable as well as the costliest flood damaged area. With the anticipated climate change the probability of experiencing more frequent heavy rainfalls has been increased. With the drastically changed land use patterns followed by an increase of imperviousness of land the inundation areas have also been expanded to a considerable extent. To identify the expanded inundation areas an inundation flood mapping has been conducted for 50 years and 100 years rainfalls. Hence vulnerable areas for redundancy for the rainfalls of 50 years periods includingHanwella, Kaduwela, Kolonnawa, Biyagama, Kelaniya and Colombo DS divisions have been identified. Also for 100 years rainfall the inundation was expected to expand towards Thimbirigasyaya, Kelaniya and Sri Jayawardanapura Kotte GN divisions.

4. Conclusion and recommentdation

At present Kelani River has undergone a considerable pollution due to the industrial as well as nonpoint sources. However if this situation continues satisfying the water demand of the Colombo will not be possible at the required quality. This situation could have changed if the public and community awareness on the current water condition of Kelani River was better. Since the water obtained at Ambatale intake is utilized by the community itself it will be the directly affected party from the Kelani River pollution hence the reaction will be very favourable.

It is necessary to control the runoff to prevent any occurrence of flooding. If the community is encouraged to have the practices such as rainwater harvesting so that water consumption as well as the chances for inundations will also be reduced.Policy makers can come up with regulations so that prevention of the propagation of Kelani River pollution as well as the risks of flooding will be reduced.

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Assessment of the impact of population density and land use pattern on the replenishment of the stream nutrient of the Brahmaputra

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Abstract

A rapid population growth and continuous migration to urban centers are posing serious challenges to urban water supplies and demands. Urban demands for continuous and secure water supplies relays on available water resources in quantity and quality. The same supplies of water in urban areas are associated with the uncontrolled releases of organic and inorganic chemical species, including nutrients. The lack of technologies or access to them reduces the ability of water systems to restore its original water quality. Result shows that downstream parts are more densely populated as well consumption of fertilizer, which is ultimately released into stream during wet periods. Total annual transport of DIN was 8.26×10^4 t $year^{-1}$. The NH_4 flux of 1.71×10^4 $tyear^{-1}$ constituted about 20.6 % of the DIN load, with the primary source being domestic sewage.

Keywords: Brahmaputra River; nitrate; phosphate; population density.

1. Introduction

Global particulate N transport by rivers is 33 million tonnes per year, more than 80% of which occurs in those with high suspended matter concentrations such as the Ganges, Brahmaputra, Mekong and Huanghe [1]. Galloway [2] predicted that by the year 2020 two-thirds of the increase in anthropogenic N-fixation will take place in Asia, accounting for over half of the global anthropogenic N-fixation during that time. Thus, considering the rapidly changing land use pattern in the tropics and unequal population distribution, substantial transport of nitrogen by the rivers to the sea can be anticipated.

Fig.1 Map of the study area illustrating the Brahmaputra River with sampling locations, Guijan to Jogighopa (Upstream to downstream)

2. Material and methods

The Brahmaputra river water and samples from its tributary were collected monthly from July 2014 to July 2015. A total of 221 samples were collected and analysed for nutrients and major ions. Samples were kept at freezing condition from the time of collection till analysis. Analysis protocols were followed from APHA, 2005. The study area map is shown in the Fig.1.

3. Results and discussion

The combination of both naturally occurring conditions and human actions creates pressure on our water resources. Pressures on water resources are increasing mainly as a result of human activity namely urbanization, population growth, increased living standards, growing competition for water, and pollution.

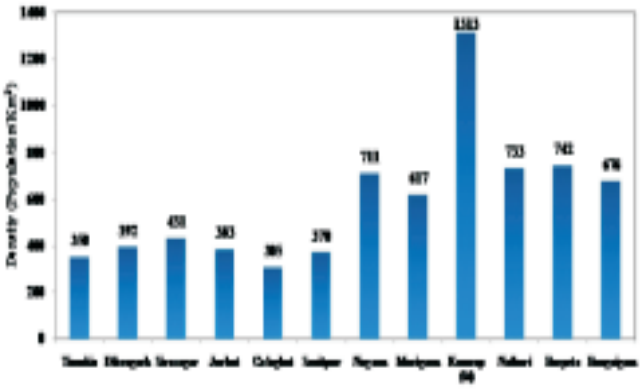

Fig.2 Population density distribution of districts through which the Brahmaputra River is travelling from upstream to downstream (2011 census)

Among these population growth stands alone a one of the major factor which directly or indirectly influence the other factors. Fig.2 is showing the population density pattern in the Brahmaputra basin in Assam. It clearly shows that downstream sites are more densely populated. Thus the anthropogenic influence can be seen more on these parts. Since *Statistical Handbook of Assam, 2013-14* shows per hectare fertilizer consumption were maximum in the midstream and downstream sites viz. Nagaon (111Kg), Kamrup (113Kg), Nalbari (140Kg) and Barpeta (100 Kg).

Table 1 Annual Yield and flux of nutrients in Brahmaputra River

Parameters	NH_3-N	NO_3-N	NO_2-N	DIN-N	PO_4-P	SiO_2-Si
Annual yield (t $km^{-2}year^{-1}$)	0.03	0.11	0.003	0.143	0.01	0.41
Annual flux (10^4 t $year^{-1}$)	1.71	6.37	0.18	8.26	0.49	23.9

We can be observe in the Fig. 3 that the Brahmaputra River travels from the region of dense agricultural land and thus agricultural runoff can play significant role in enhancement of stream nutrient concentration. Thus investigation of the relationship between land cover and water quality is particularly useful when considering diffuse source pollution. The annual flux and specific yield of N, P and Si for the Brahmaputra River system were calculated from nutrient concentrations, annual discharge and drainage area data (Table 1). Total annual transport of DIN was 8.26×10^4 t $year^{-1}$. The NH_4 flux of 1.71×10^4 $tyear^{-1}$ constituted about 20.6 % of the DIN load, with the primary source being domestic sewage. The estimated annual flux of PO_4-P and SiO_2-Si was 0.49×10^4 and 23.9×10^4t $year^{-1}$, respectively. The annual specific yield of NO_3-N and PO_4-P was 0.11t $km^{-2}year^{-1}$ and 0.01t$km^{-2}year^{-1}$, respectively.

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Assessment of the river water quality parameters and pollution: An insight from Dhaka city

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Abstract

River pollution is an alarming environmental issue of the Dhaka city but very study focused on the overall situation of the river pollution of Dhaka. Based on a thorough review of literature and direct analysis this study focused on the status of different water quality parameters and concentration of the heavy metals in and around the Dhaka city named as the Buriganga, Dhaleshwari, Turag, Shitalakhya and Balu rivers. By considering the status of the p^H, DO, TSS, TDS, conductivity and NH_3 the study indicated that the rivers are not in favor of sustaining the aquatic life. The study identified the presence of five heavy metals (Pb, Ni, Cu, Cr and Fe) in the rivers. Based on the findings of the study, the Buriganga could be considered as the most polluted river around Dhaka city. Effluents from tanneries, textiles, pharmaceuticals, dying industries and municipal wastage could be attributed for such degradation. Deteriorating trend of water quality could adversely affect the aquatic biodiversity and dependent livelihood, food security and human health. The findings of the present study will provide a clear idea about the overall status of pollution and help to develop a guideline for proper planning and better management of the river system in and around Dhaka city.

Keywords:*River pollution; heavy metal; Dhaka city; aquatic biodiversity*

1. Introduction

Dhaka stands on the Bank of the River Buriganga which is one of the most polluted rivers of the world[1]. There are another four riversnamely the Dhaleshwari, Turag, Shitalakhya and Balu flow in and around the Dhaka city. The rivers are being polluted day by day mainly due to discharge of untreated industrial and municipal wastes.[2,3]The sources of pollution are effluents from tanneries, textiles, pharmaceuticals, fertilizer factories, cement, dyeing and plastic industries[4,5,6].Metal pollution from these sources could affect the growth, reproduction and abundance of aquatic biodiversity and increase incidence of diseases[4]. Anthropogenic disturbance to environmental composition may endanger the life of aquatic biodiversity and human due to its disastrous consequences. So, this study has taken an initiative to provide a clear idea about the overall status of pollution to help develop a guideline for proper management of the river systems in and around Dhaka city.

2. Material and methods

The study was conducted based on literature review and direct analysis of water. The water samples were collected from the three different locations of the Buriganga, Dhaleshwari, Turag, Shitalakhya and Balu river. The sites were chosen based on a preliminary survey. Water quality parameters like DO, pH, TSS, TDS, Conductivity were measured in the field by HACH multi-parameter and NH3, Pb, Ni, Cu, Cr and Fe were measured by DR 6000 HACH UV-Vis Spectrophotometer in the laboratory.The secondary data and information were collected from different scientific articles and reports on river pollution

3. Results and discussion

Surface water quality data from five rivers located in and around Dhaka city were collected to assess the water quality parameters and status of pollution. Minimum DO (0.19 mg/L), p^H (4.9) and maximum TDS (840 mg/L) and NH_3(6.8mg/L) were found in the Buriganga. Minimum NH_3(0.21 mg/L) was found in Dhaleshwariand maximum TSS (896 mg/L) in Turag where maximum DO (8.1 mg/L) was in the Balu river. Minimum concentration was found during January-February and maximum concentration in August-September. The degradation and seasonal fluctuation of important water quality parameters are presented below (Table: 1)

Table 1.Water quality data of the rivers around Dhaka city (Adapted from 1,2,3,4,5,6 and WorldFish Lab analysis 2017)

Parameters	Buriganga	Turag	Shitalakhya	Balu
p^H	4.9-7.2	5.9-7.5	7.05-7.4	7.07-8.1
DO (mg/L)	0.19-7.9	2.5-9.8	1.2-6.8	0.25-7.4
TSS (mg/L)	503	896	240	340
TDS (mg/L)	420-840	342-812	192	280
Conductivity (µs/cm)	982	514.3	--	--
NH_3 (mg/L)	3.5-6.8	3.5-5	5-7.2	2.1-4.8

The study identified the presence of five heavy metals (Pb, Ni, Cu, Cr and Fe) in the rivers. Pb and Cr were detected in all the rivers. Ni was detected only in Buriganga while Cu and Fe were detected in the Buriganga, Dhaleshwari and Turag (Figure: 1)

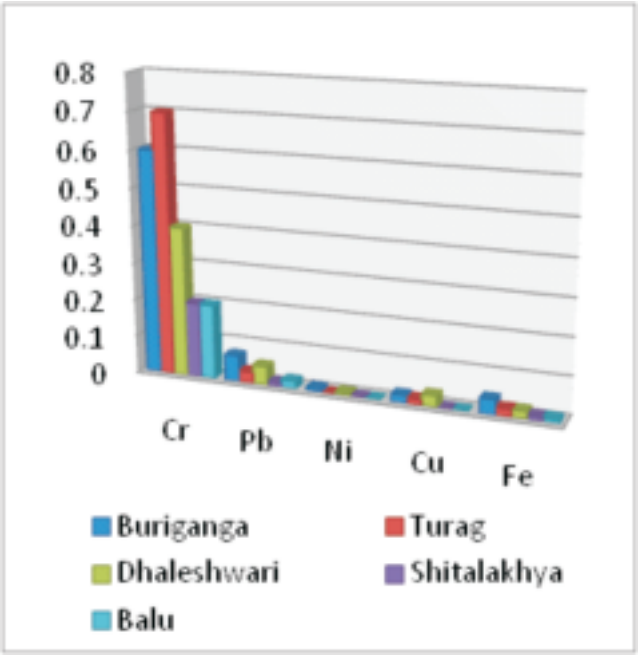

Figure 1.Concentration of heavy metals (mg/L) in the rivers of Dhaka city

River pollution affects the growth, survival and abundance of the aquatic biodiversity. Aquatic organisms like fish, mollusk and crustaceans could migrate to less polluted areas that enhance food biodiversity degradation and food insecurity. Metal pollution causes health diseases like nauseas, vomiting, bronchitis, diarrhea and asthma4.

4. Conclusion :

Buriganga is found as the most polluted river of Dhaka city due to high metal concentration and deteriorated water quality**,**whilethe status of other rivers are also in alarming state.Sources of pollutants should be immediately stopped. All the industries should have ETF to allow proper improvement of discharged effluents.

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