SCIENCE SECTION

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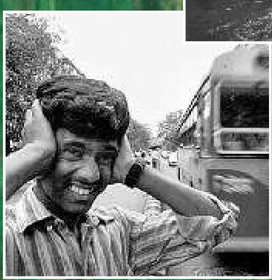
COHERENCE

SEMINAR EDITION

VOL 2, ISSUE 2, DECEMBER 2017

The Bhawanipur Education Society College
Kolkata-700020



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PREFACE

We would like to present with great pleasure 'COHERENCE' our scientific magazine. This is mainly seminar issue on 'Environmental awareness: Demand of the Day' organized by Environmental Development committee of our college in collaboration with Department of Environmental Science, University of Calcutta.

We live in environment and use the environmental resources like air, land and water to meet our needs. While meeting our needs, we put pressure on the environment .When the pressure exceeds carrying capacity of the environment it creates serious problem of environmental degradation. The environmental degradation poses a great danger to man's own survival. Therefore there is a need to create 'awareness' about environmental protection. It is the responsibility of every citizen to use our environmental resources with care and protect them from degradation.

The main objective of publishing this magazine is to originate environmental awareness and its protection amongst the undergraduate students as well as the researchers in this field. Environmental awareness serves as an educational tool, helping people around the world understand the economic, aesthetic and biological importance of preserving resources. Various research papers on air pollution, green house gases, water pollution, wastes and their management, alternative energy and sustainable development, resource utilization and biodiversity of ecologically sensitive regions have been published here. Articles are thoroughly checked and reviewed by experts working in this area. New and emerging trends in environmental science are the key highlights of the articles presented here.

We convey our grateful thanks to Teacher in –Charge and management of our college for their encouragement and financial support.

Dr. S. K. Datta
Vice Principal (Science)
The Bhawanipur Education Society College

FOCUS

Baby steps and teething troubles are not for humans alone: they play dominant role in inorganic growth process also. This was our learning in the process of publication of the second issue of Coherence, a culmination of academic efforts of the Science faculty of Bhawanipur Education Society College.

In this issue we have been more focused in our academic exercise. The first issue of coherence was multi faceted, but here we present a collection of articles discussing man made environmental disasters with extensive mal utilization of air, water, energy and biotic resources while also instilling a sense of hope for the future. The academic discourse was based on the essence that'environmental awareness is the demand for the day'. Moving beyond the rhetoric of 'reduce, reuse and recycle", the academia present research papers on ecological security, mitigation strategies using energy technology for ground water contamination, conservation and honest utilization of marine and mangrove biodiversity green audit, to name a few major themes.

The awareness on alarming situations that demand interventions have been discussed with focus on priority areas earmarked by WWF 2014. The dilemma of curbing airpollution which may unmask the aerosol cooling effect and enhance the surface warming is highlighted and the need for a common integrated framework is put forth. Suggestions on adaptation strategies to mitigate the reject management is considered to be an optimal, economic and sustainable method. Some interesting issues in terms of a strict and proactive conservation strategy being imperative for food security is the core idea in most of the papers included in this volume. Fundamentals of solar photovoltaic systems and global green initiatives are delineated.

In preparing this volume the team has received genuine support and encouragement from scholars in the field of environment science, authors and reviewers, who have contributed in making this publication possible. The editorial board acknowledges the sponsorship of the University Grant Commission in publication of this volume. The administrative body of the Bhawanipur Education Society College has no mean contribution in success of this venture. We acknowledge all.

Kolkata
December 2017

Dr. Pradip Dutta Gupta

Contents

Air pollution, greenhouse gases and climate change – An Indian perspective

Tapan Kumar Adhya
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Abstract :

Humankind is influencing the composition of the atmosphere on a planetary scale through emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). We are also contributing to air pollution through emissions of precursors of ground-level ozone and aerosols, including black carbon. Air pollution is currently the largest environmental cause of premature deaths, in addition to being a substantial driver of climate change. As such, air pollution is both a result and a driver of global change in the Anthropocene. Greenhouse gases (GHGs) warm the surface and the atmosphere with significant implications for rainfall, retreat of glaciers and sea ice, sea level, among other factors. Around three decades ago, it was recognized that the increase in tropospheric ozone from air pollution (NOx, CO and others) is an important greenhouse forcing term. What is less recognized, however, is a comparably major global problem dealing with air pollution. Until about a decade ago, air pollution was thought to be just an urban or a local problem. But new data have revealed that air pollution is transported across continents and ocean basins due to fast long-range transport, resulting in trans-oceanic and trans-continental plumes of atmospheric brown clouds (ABCs) containing sub micron size particles, i.e., aerosols. Aeerosols intercept sunlight by absorbing as well as reflecting it, both of which lead to a large surface dimming. The dimming effect is enhanced further because aerosols may nucleate more cloud droplets, which makes the clouds reflect more solar radiation. The dimming has a surface cooling effect and decreases evaporation of moisture from the surface, thus slows down the hydrological cycle. On the other hand, absorption of solar radiation by black carbon and some organics increase atmospheric heating and tend to amplify greenhouse warming of the atmosphere. Aerosols are concentrated in regional and mega-city hot spots. Long-range transport from these hot spots causes widespread plumes over the adjacent oceans. In S. Asia, the large north-south gradient in the ABC dimming has altered both the north-south gradients in sea surface temperatures and land–ocean contrast in surface temperatures, which in turn slow down the monsoon circulation and decrease rainfall over the countries of the continent including India. Globally, the surface cooling effect of aerosols may have masked as much 47% of the global warming by greenhouse gases, with an uncertainty range of 20–80%. This presents a dilemma since efforts to curb air pollution may unmask the aerosol cooling effect and enhance the surface warming. Thus efforts to reduce GHGs and air pollution should be done under one common framework. The uncertainties in our understanding of the aerosol effects are large, but we are discovering new ways in which human activities are changing the climate and the environment.

Key words: Global climate change, Greenhouse gases, Air Pollution, Positive and negative feedback, Integrated climate model

Introduction

The atmosphere is a thin shell of gases, particles and clouds surrounding the planet. It is in this thin shell that we are dumping several billion tons of pollutants each year. The major sources of this pollution include fossil fuel combustion for power generation and transportation; cooking with solid fuels, and burning of forests and savannah. The ultimate by-product of all forms of burning is the emission of the colorless gas, carbon dioxide (CO_2). But there are also products of incomplete combustion, such as CO and NOx, which can react with other gaseous species in the atmosphere. The net effect of these reactions is to produce ozone, another greenhouse gas. Energy consumption also leads to aerosol precursor gases (e.g., SO_2) and primary aerosols in the atmosphere, which have direct negative impacts on human health and ecosystems.

Humankind is influencing the composition of the atmosphere on a planetary scale through emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). We are also contributing to air pollution through emissions of precursors of ground-level ozone and aerosols, including black carbon. Air pollution is both a result and a driver of global change in the Anthropocene. Greenhouse gases (GHGs) warm the surface and the atmosphere with significant implications for rainfall, retreat of glaciers and sea ice, sea level, among other factors. Around three decades ago, it was recognized that the increase in tropospheric ozone from air pollution (NOx, CO and others) is an important greenhouse forcing term. What is less recognized, however, is a comparably major global problem dealing with air pollution. Until about a decade ago, air pollution was thought to be just an urban or a local problem. But new data have revealed that air pollution is transported across continents and ocean basins due to fast long-range transport, resulting in trans-oceanic and trans-continental plumes of atmospheric brown clouds (ABC) containing sub micron size particles, i.e., aerosols. In S. Asia, the large north-south gradient in the ABC dimming has altered both the north-south gradients in sea surface temperatures and land–ocean contrast in surface temperatures, which in turn slow down the monsoon circulation and decrease rainfall over the countries of the continent including India. Since, globally the surface cooling effect of aerosols may have masked as much 47% of the global warming by greenhouse gases, with an uncertainty range of 20–80% this presents a dilemma since efforts to curb air pollution may unmask the aerosol cooling effect and enhance the surface warming. Thus efforts to reduce GHGs and air pollution required to be studied under one common framework.

Sun is the source of all the energy for the planet earth. The incident solar radiation drives the climate system, atmospheric chemistry as well as life on the Earth. About 30% of the incoming solar energy is reflected back to space. The balance of 70% is absorbed by the surface–atmosphere system. This energy heats the planet and the atmosphere. As the surface and the atmosphere become warm, they give off the energy as infrared radiation, also referred to as 'long wave radiation'. So the process of the net incoming (downward solar energy minus the reflected) solar energy warming the system and the outgoing heat radiation from the warmer planet escaping to space goes on, until the two components of the energy are in balance. On an average sense, it is this radiation energy balance that provides a powerful constraint for the global average temperature of the planet. Greenhouse gases (GHGs) absorb and emit long wave radiation, while aerosols absorb and scatter solar radiation. Aerosols also absorb and emit long wave radiation (particularly large size aerosols such as dust), but this process is not significant for the smaller anthropogenic aerosols.

Among the different greenhouse gases, contribution to the global warming is highest by CO_2 simply by virtue of its staggering concentration which has increased substantially due to industrialization and currently stands at 407 ppm. Among the three major greenhouse gases, namely CO_2, CH_4 and N_2O, CO_2 can originate both by abiological and biological means. As stated earlier, the increase in the production of CO_2 is mostly due to fossil fuel burning. In the ecosystem, however, CO_2 originates from respiration as well as mineralization of organic matter. Biogenic CH_4 is produced through methanogens by organic matter decomposition. In the initial process of decomposition, the fermenting bacteria hydrolyse polysaccharides and further convert sugar monomers to alcohols, fatty acids and H_2. Further, secondary fermentation carried out by syntrophic microorganisms convert them into acetate, CO_2 and H_2. Syntrophy with methanogens is carried out due to consumption of formed H_2 as soon as degradation is accomplished. Other physiological group of fermenting bacteria, i.e., homoacetogenic bacteria ferments sugars directly to acetate. Some of the homoacetogens are able to convert $H_2 + CO_2$ to acetate which is finally converted to CH_4. Nitrous oxide, another important GHG is also produced biologically through the intervention of two major groups of microorganisms, namely nitrifiers and denitrifiers that initially converts NH_3 to NO_3 and ultimately reduced to N_2. In both processes, N2O is evolved. While ocean has the potential to absorb certain amount of CO_2 this would lead to other side effects like acidification of the ocean and resultant changes in the coral reef bleaching and adverse impacts to marine life. A substantial quantity of CO_2 is also fixed by the process of photosynthesis. Similarly, apart from biological formation, certain amount of methane is also released to the environment from oil exploration and coal mining. However, for N_2O production only marginal quantity is produced through chemical means.

Inter-Governmental Panel on Climate Change (IPCC) concludes that the climate system will warm by 3^0C (2^0C–4.5+0C) for a doubling of CO_2. The radiative forcing for a doubling of CO_2 is $3.8Wm^2$ (15%). Thus, it is inferrd that the climate sensitivity term (also referred to as climate feedback) is $1.25Wm^{-2\,0}C^{-1}$ (¼ $3.8Wm^{-2}/^{o}3C$), i.e., it takes $1.25Wm^{-2}$ to warm the surface and the atmosphere by 1^0C. If the planet, including the atmosphere, were to warm uniformly with no change in its composition including clouds, water vapour and snow/ice cover, it will take $3.3Wm^{-2}$ to warm the planet by 1^0C. The reduction in the feedback term from $3.3Wm^{-20}C^{-1}$ to $1.25Wm^{-2}\,{}^0C^{-1}$ is due to positive climate feedback between atmospheric temperature (T) and water vapour, snow and sea ice. Basically as the atmosphere warms, the saturation vapour pressure increases exponentially (by about 7% per ^0C increase in T); and as a result, humidity increases proportionately Since water vapour is the strongest greenhouse gas in the atmosphere, the increase in water vapour greenhouse effect amplifies the initial warming. Similarly, snow cover and sea ice shrinks with warming, which enhances solar absorption by the underlying darker surface, thus amplifying the warming.

India has been in the lower rung of the GHG emitting countries on a per capita basis. However, agriculture which produces around 17% of the greenhouse gases and its economic developments is putting the figures to an upper scale. Mercifully with India signing the Paris climate deal on October 02, 2016, it will have to announce quantum of cuts is GHG production and emission. Similarly, the air pollution from vehicle exhaust and particulate matter production has brought global attention to the country. With Delhi being identified as the most polluted megacity of the world, onus is on the policy planners and government of the country to tackle the issue.

Global marine biodiversity: loss and conservation in the Anthropocene

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Abstract :

Oceans have been an inseparable part of human society since the prehistoric time by providing enormous resources. Most importantly, the oxygen we breathe today was first evolved in the oceans. This is now undeniable that our planet is experiencing a rapid change mostly due to extensive, unplanned, unwise and selfish human activities. A significant loss in global marine biodiversity has been noticed within the past 500 years from the palaeo-ecological records. The key factors driving such rapid degradation of marine biodiversity are eutrophication, fisheries overexploitation, physical habitat destruction, ocean acidification, pollution, land use change and global warming. Human induced pollution impacts are not only restricted to its neighbourhoods, but also widely spread to the remote places like deep seas and polar oceans. Recently discussed plastic pollution (almost 8 million tons of plastic trash is dumped into the oceans annually) is the worst example of human interference. Almost 90% of the large predatory marine fishes have disappeared. Similarly, the unique and highly productive ecosystems like corals and mangroves are under severe threat. The present era, "Anthropocene" when most of the natural processes are controlled and influenced by humans, is going to face the 6th mass extinction event due to huge biodiversity loss in both marine and terrestrial ecosystems; surprisingly, the present rates and magnitude of biodiversity decline is comparable with the past mass extinction events. The question is if these changes are reversible or not. The global concern in marine biodiversity loss is not only related to system restoration but also for its direct impact on human society. It has been well documented that the observed loss in marine biodiversity is increasingly hindering the ocean's potential for providing livelihood, maintaining water quality and its recovering capacity from deterioration. Hence, for future food security and ecosystem services of oceans, a strict and active conservation strategy should be adopted immediately and every human on this planet should be committed to leave a liveable world for the next generations.

Introduction:

Our planet earth is the only habitable planet in this universe known to us till today and this has happened mostly due to some magical synergies between several physical, chemical, geological and biological events over a very long period of time. However, the first life began in the primordial ocean almost 3.9 billion years back and through the process of natural selection the first photosynthetic organism (probably the ancient cyanobacteria) evolved thereafter and started the most magnificent magical event by producing huge amount of molecular oxygen (2.5-2.7billion years) in the environment. Evolution of oxygen in the ocean leaded to the oxidation of the atmosphere, development of ozone layer and finally the life migrated to the land from the sea due to the inhibition of harmful UV ray by the ozone layer. Hence, the oxygen we breath today was evolved in the ocean and the evolution of the large placental animal including humans was well correlated with atmospheric oxygen accumulation (Falkowski and Isozaki, 2008). Moreover, oceans are the unlimited resources for human society and provide livelihood to a major population on earth. Oceans consume huge amount of pollutants emitted to the atmosphere, maintain the hydrological cycle, balance our climate and hence, the role of ocean for our existence on earth is undeniable. However, our planet experienced a periodic explosion of floral and faunal diversification followed by several mass extinction events over the multimillion years time scale (Jackson and Johnson, 2001). As a result, 99% out of 4 billion species estimated to have evolved on the earth, already disappeared (Barnosky et al., 2011). Nevertheless, these common extinction events were balanced by speciation.

The recent era "Antrhopocene" when most of the natural processes are either controlled or influenced by human activities, is going to experience the 6th mass extinction (Pievani, 2014) event due to huge loss in global marine and terrestrial biodiversity (Dirzo et al., 2014). Surprisingly, the rate and magnitude of the recent mass extinction are comparable with the past records and even could be higher than the expected rates (Barnosky et al., 2011). Most importantly, the time scale of these changes are significantly lower in the recent days relative to the past events and makes it challenging for the earth ecosystem to recover and restore. However, the changes we are already experiencing and also going to be experienced by the posterity; this is something our planet has not has not experienced before and hence we need to admit that the appearance of the modern Homo sapiens has transformed the planet. The question is if these transformation is reversible or not? whether there is a recovery time for the earth system before we damage it further or not?

The key factors responsible for global marine biodiversity loss:

The palaeontologists gathered extensive fossil records showing the past patterns in marine biodiversity (Sheehan, 2001) which also follows the periodic patterns of global speciation and mass extinction. Today marine species richness could be only 4% of the global diversity (Benton, 2001). There are almost three hundred thousand of listed marine species comprising 15% of all described species (Kudla, 1997). However, this is now evident that global marine diversity loss is well correlated with extensive and unsustainable human activities on earth (Sala and Knowlton, 2006). A relatively recent analyses attempted to map the human interference on marine ecosystems indicated that none of the marine ecosystems are left to be impacted by humans and almost 41% of them are severely impacted (Halpern et al., 2008). The major factors driving such rapid degradation of marine biodiversity are, fisheries overexploitation, physical habitat destruction, eutrophication, ocean acidification, pollution, land use change and global warming.

Coastal areas are the most productive and highly diverse systems and house one of the most biodiversity hot spots including mangroves and coral reefs. The most common way the human perturbed the marine ecosystem is by habitat destruction and over exploitation of its resources. Due to increasing population worldwide there has been an increasing demand for food and this leaded to the over fishing without any sustainable manner. 67% of global population live within 60km of the coast and the % is increasing significantly (Hammond, 1992). Additionally, the highest populated cities on earth are the coastal cities. Hence, the coastal areas are under high level of anthropogenic pressure due to habitat destruction, releasing pollutants, eutrophication and over exploiting its resources.

Eutrophication:

Due to increasing demand for food production, usage of artificial fertilizer became a common practice in the agricultural sectors since 1980's. The usage of synthetic fertilizer was, however, well correlated with the enrichment of river carried nutrients to the coastal waters, called eutrophication. The unused nitrogenous and phosphate fertilizer is usually carried to the coastal waters via rivers and can have several deleterious impacts on the coastal water health and biodiversity. The initial nutrient enrichment may cause increase in primary production, however, may largely alter the microalgal community composition (Smyda 1997). Since microalgae are the base of the aquatic food web, this alteration may be cascaded to the higher trophic level finally impacting the fisheries resources. Additionally, eutrophication may promote harmful algal bloom formation which may cause fish mortality and degradation of coastal water quality (Gilbert et al., 2005) including deoxygenation.

Fisheries overexploitation:

Although, most of the fisheries are under the jurisdiction of coastal states, most of the world's fishes are over exploited (FAO, 1991). As result of overfishing there was a significant decline in fish catch in the 1990s in some high productive coastal areas and this resulted in a huge loss of genetic diversity in marine fishes (Elliot and Ward, 1992). Another citable example of the result of over fishing is decline in the number of commercially important fishes (Herring) with a concomitant increase in the other non valuable species like sandeels (Sherman and Alexander, 1990) which further impacted the other marine mammal and sea bird species who were their active predator (Hamre, 1994).

There has been significant loss in large marine predatory fishes both in the coastal oceans as well as in the open seas which can have serious impacts on ecosystem, since the large predatory fishes keep a strong on control on the other several smaller fish population. The highly specialized industrial fishing technique caused almost 80% reduction in large predatory fish community biomass within 15 years of exploitation; the large predatory fish stock in today's ocean is only 10% of the pre-industrial time (Ransom and Worm, 2005). Not only over fishing is responsible for marine biodiversity loss, many important marine animals like Dugong, sea turtles are also over exploited all over the globe (Norse, 1994). The global shark population has been tremendously overexploited even today. It has been estimated that almost 63 -270 millions sharks are killed annually in the global oceans (Worm et al., 2013).

Habitat destruction:

Habitat destruction is another nuisance caused by humans. Marine habitat can be significantly destroyed by dredging, trawling, tourism, mining, drainage of sewage and other pollutants. Biodiversity rich ecosystems like mangrove and coral reefs are enormously destructed for human purpose and this causes a severe threat to marine biodiversity. Marine oil spill is one of the worse way of destructing habitat and killing marine life (Dicks, 1988). However, with time the number of oil spill accidents have been decreased dramatically due to several protective measures.

Deep sea is the place of rich biodiversity and houses many commercially important and endemic fishes (Rex and Etter, 2010). Nevertheless, after exploiting and destructing most of the shallow coastal ecosystems, the highly efficient bottom trawling fishing gears are used extensively to explore the fishes in the deeper oceans. This may impact not only the biodiversity of the benthic community, but also may alter sea bottom morphology, increased turbidity, nutrient cycling, organic carbon turnover and several other biogeochemical consequences (Trush and Dayton, 2002). Moreover, bottom trawling collects both target and non target organisms thus destroys a significant part of benthic communities. Likewise, higher efficient bottom trawling systems almost destructed the long-lived marine mollusc and echinoderm species in the North Sea. In the Mediterranean almost 50% loss in marine benthic biodiversity has been recorded due to deep sea trawling (Pusceddu et al., 2014).

Introduction of invasive species:

Marine invasive species are one of the major threats to the native marine biodiversity and has been observed all around to global oceans. Due to extensive enhancement in international shipping and aquaculture practices marine invasion occurred. Only 16% of marine eco-regions have not been reported to be contaminated with marine invasive species (Molnar et al., 2008). Marine invasion is a key treat to marine biodiversity and can have profound ecological and economic impacts.

Pollution with special reference to plastic:

Due to increased human settlement, industrial development, port activities and water transport along the coastal areas considerable amount of treated and untreated sewage is being released into the coastal waters. Variety of chemical pollutants including heavy metals, organic pollutants and plastic trash enter the coastal waters and impact the coastal ecosystem (Vikas and Dwarakish, 2015). Some of these pollutants can be biodegradable and some not. 80% of the marine debris has been detected as land based and in today's oceans plastics are the major land based trash being dumped into the oceans in an enormous amount.

The plastic pollution is one of the most threatening pollution aspects in the marine environment; almost 700 marine species have been reported to be impacted or died due to plastic trash ingestion. All sorts of plastic material, particularly for food and drink packaging became incredibly popular in global market since it was introduced in 1930-1940s. The global plastic production reached almost 311 million metric tons in 2014 (Plastic-Europe, 2015). Already 8 million metric tons of plastic has entered the ocean which has severe biological, ecological and chemical consequences (Jambeck et al., 2015). The rate of plastic input into the ocean has been predicted to increase by an order of magnitude by 2025. The global ocean gyres are detected to be the large plastic accumulating places induced by oceanic currents (Law et al., 2010). Not only the coastal oceans or waters columns are accumulating plastic in the marine environment, the deep sea sediments collected from the major oceanic areas have been now found to be highly contaminated with microplastic debris and is a major threat to the deep oceans biodiversity (Woodall et al, 2014). The impacts are largely unknown, yet can be deleterious.

Natural microbial community, highly efficient in breaking down organic materials that occur naturally such as plants, dead animals, rocks and minerals, are incapable of degrading plastic since they do not have the necessary enzymes and don't recognize the man made strange plastic molecular structures. Some amount of plastic can be broken down by solar UVs, wave action, sand action and oxidation and the degradation process continues down to the molecular level, nevertheless, it still remains a plastic polymer.

Plastic debris causes aesthetic problems, and it also presents a hazard to maritime activities including fishing and tourism. Discarded fishing nets result in ghost fishing that may result in losses to commercial fisheries. Over 260 species, including invertebrates, turtles, fish, seabirds and mammals, have been reported to ingest or become entangled in plastic debris, resulting in impaired movement and feeding, reduced reproductive output, lacerations, ulcers and death. **Fish** in the North Pacific ingest almost 12,000 to 24,000 tons of plastic each year, which can cause intestinal injury and death and transfers plastic up the food chain to bigger fish and marine mammals. Thus plastic pollution is already posing a high level of threat to the marine biodiversity. Moreover, the microplastic trashes may accumulate significant amount of persistent organic pollutants on its surface (Mato et al., 2001) and can be transferred to the food chain via ingestion (Tanaka et al., 2013). Particularly when the edible marine organisms are consuming plastics, this highly toxic organic pollutants are also getting accumulated in the tissues and finally can be transferred to humans via food chain.

Climate change : global warming and ocean acidification:

Global climate change and ocean acidification are two interlinking factors impacting marine ecosystems in several means and at different magnitude. Due to intense anthropogenic activities on earth the natural elemental cycles like carbon and nitrogen got highly perturbed. After the onset of the industrial era atmospheric CO_2 concentrations increased from a value of 280ppm to 400ppm in today's atmosphere (Jackson et al., 2015). In case of unabated CO_2 addition in to the atmosphere, the present CO_2 level has been predicted to be doubled (Pachauri et al., 2014) at the end of the century and can have very large climatologically and biogeochemical impacts on earth system. As an immediate consequence of increased CO_2 accumulation into the atmosphere the mean global temperature is increasing and impacting the surface oceans as well. There has been a concomitant increase in the sea surface temperature (almost 0.74C during the last 100 years) all over the globe. Another 2 - 3C increase in mean global temperature has been predicted to occur in at the end of this century. Since temperature has a large consequence on both physical and biological properties, this is going to impact the ocean ecosystem as whole.

Due to increasing sea surface temperature, the oceans are going to be more stratified and as a consequence the surface oceans are going to be nutrient poor due to reduced mixing with a shallow mixed payer depths. This may lead to reduced photosynthetic rates in marine phytoplankton. Globally 100 billion tons of organic carbon is being produced globally and among which almost 50% takes place in the surface oceans. A diverse group of microscopic free floating algae are the major driver of biological carbon pump in the oceans which removes a significant amount of atmospheric CO_2 in to the ocean interior and thus has a strong control on earth's climate. It has been already observed that with increasing sea surface temperature there is a clear declining trend in microalgal biomass (Boyce et al., 2010) and some significant major changes in microalgal community in the global oceans

(Rouseaux and Gregg, 2015). Since these microscopic algae are the unseen drivers of the oceanic carbon cycle and make the base of the aquatic food web, any change in their standing stock and productivity will impact the entire food web dynamics including fisheries production. Fish migration is one of the important events that is getting seriously impacted by the warming of the oceans. Population level shifts have been observed in most of the marine fauna and flora due to their intolerance to the emerging environments (Doney et al., 2012). Warming is also causing rapid deoxygenation of the surface ocean waters and this may have serious impacts on marine biodiversity (Kelling et al., 2010).

Today's oceans absorb almost one third of the CO_2 coming from anthropogenic sources (Sabine et al. 2004). Increasing dissolution of CO_2 in seawater releases hydrogen ions thus lowering the pH of seawater, a process known as "Ocean Acidification" (OA) (Doney et al., 2009) which can potentially affect marine ecosystems and already have been observed in the global oceans (Boyd et al., 2010). Ocean acidification actually reflects the changes in carbon species distribution in response to increasing CO_2 levels including reduced pH and carbonate iron concentrations coupled with increasing bicarbonate and hydrogen ion concentrations. Over the last 100 years there has been almost 26% enhancement in ocean water acidity indicating the impact of CO_2 dissolution (Feely et al., 2009). This has significant impact on calcium carbonate saturation level in the sea water. With increasing hydrogen ion concentrations, the concentrations on bicarbonate ions are increasing with a concomitant decrease in carbonate ion concentrations resulting in reduction in calcium carbonate saturation levels. A huge marine animal (corals, oysters, molluscs, echinoderm, and many more) and some microalgal groups (coccolithophore) are made up of calcium carbonate shells and a reduced calcium carbonate saturation state may potentially impede their calcium carbonate shell formation and has been very well documented in marine species (Hofman et al., 2010). Coral ecosystems are under high level of threat both due to warming and ocean acidification and a major part of the global coral community has been predicted to be vanished due to climate change (Hoegh-Guldberg, 1999). Increasing CO_2 levels may increase the photosynthetic rates in some algal community, however, their responses are highly diverse (Kroeker et al., 2009).

Conservations strategies:

This is likely that anthropogenic perturbations collectively is a severe threat to global marine biodiversity and a serious ecosystem crisis is on its way. Global marine biodiversity loss will continue to happen and is very much likely to get accelerated in near future. Since, the rates and direction of biodiversity loss is highly unpredictable which makes it challenging to make any kind of future prediction. This is high time to realize and react to stop any further perturbation and to allow the systestems to restore. Humans are the best users of marine resources and hence a considerable decline in marine resources will impact the human society and their food security. Moreover, most of the management strategies to protect the environment have been made many year back depending on the rates of degredation happened during that particular time. The rates of biodiversity degradation is considerably higher today and may get faster with time. Hence a remodeling is extremely needed in the strategic sectors. A sustainable way of resource utilization is highly recommended. Conservation of the coastal habitat including corals and mangroves are essential. Re-plantation of mangroves are needed along the regions where mangroves have been removed. Eutrophication can be mitigated by reducing the usage of inorganic fertilizers. Development of clean and renewable energy is the only way to reduce further CO_2 emission in to the atmosphere. Many geo-engineering techniques are coming up to sequester CO_2 from the atmosphere. Nevertheless, the most important thing needs to be changed is our extremely selfish attitude towards our planet and environment. The next generations also have equal right to live a health life on this planet and hence every human on earth should take an oath to leave a livable planet for the posterity.

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Environmental Degradation and Ecological Security

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Development and environmental degradation are inter-twined in a very subtle manner and both have been the gamut of discussion and deliberation since long. India being a developing country, the economic development agenda has always been given priority. But to reduce the burden on environment, only sustainable technological practices need to be undertaken so that we do not harm the future progenies and do not deprive them of a clean and green earth. Unfortunately pollution has become biggest problem in modern day life and threatening the very survival of mankind. This is a global problem. Rockstorm (2009) has identified nine planetary boundaries and three of them (climate change, nitrogen-phosphorus cycle and biodiversity loss) have already been transgressed. The nine critical issues are climate change, rate of biodiversity loss, interface with nitrogen and phosphorous cycle, ozone depletion, ocean acidification, global freshwater use, change in landuse, chemical pollution and atmospheric aerosol loading.

In 2013, the 5th assessment report of the Inter-Governmental Panel on Climate Change was published. The fourteen out of the first fifteen years of the 21st century were the hottest years in history. Extreme rainfall fluctuations and irregularities have caused floods and droughts in different parts of the world. About 40% of the total carbon di-oxide emitted during the period of 1750 – 2011 was concentrated in the last four decades. Reports have shown that of the emitted carbon di-oxide, 30% has been absorbed in the oceanic pool leading to the acidification of the ocean waters and 30% more is being absorbed by the soil and the forest pools. This scenario is unique during the preceding 0.8 million years. The rate of melting of ice in the north pole at the rate of 4% per decade has been recorded and consequently the glaciers are retreating. During the period 1901-2010 the global sea-level has risen by 19 cm. Probably the most affected area is our Sundarban. Land subsidence and sea-level rise have retrograded the coastline of West Bengal by more than 400 km2 . The coast line has encroached about 12 km. in Sagar Island during 1777-2010(Rudra, 2012). The analysis of the rainfall data recorded in different districts of West Bengal during the period 1901 to 2002 reveals an alarming fact. The rainfall of June has been decreasing at the rate of 1mm/year causing overall decline of 48mm rainfall during the 20th century while the average rainfall in the month of September has increased by about 33mm. during the same period. This appears to be a great threat to the agrarian economy of West Bengal.

The 21st Conference of Parties (COP21), recently held at Paris, has resolved to curb the global average rate of increasing temperature within 2oC till the end of this century compared to pre-industrial revolution days. The impacts of climate change are many and entire ecosystem is threatened. Notably terrestrial species declined by 39% between 1970 and 2010; freshwater species declined by 76% and marine species by 39%. Many species have migrated from their habitat to survive. The participating nations have voluntarily come up with the guidelines and have agreed to follow them. India has announced to reduce the emission of carbon di-oxide to 33-35% by 2030 in comparison of 2005. Moreover extensive afforestation programmes are to be adopted to absorb 250-300tons of carbon di-oxide from the atmosphere. It is to be also noted that such guidelines are not legally bound and hence cannot be forced on any country.

Four Laws of Ecology:

Barry Commoner (1992), the eminent Physicist and Ecologist, formulated four laws which we need to understand for a better and sustainable living. These are:

1st Law: Everything is connected to everything else. This means Humans and other species are connected (dependent) in such a way that their survival depends on this connectivity.

2nd Law: Everything must go somewhere which means no matter what we do, and no matter what we use, it has to go somewhere.

3rd Law: Nature knows best. All systems in the Nature are delicately balanced. The natural world is inspiring new innovations. Scientists learn from nature's best ideas to generate breakthrough products and technologies.

4th Law: There is no such thing as a free lunch. Every action has consequences. Everything we do must have a reason behind it. We have to do something in order to get something in return. All components in global ecosystem are a connected as a whole, in which nothing can be gained or lost.

Ecological Footprint:

- The impact humans have on the environment is called an ecological footprint. A country’s ecological footprint is the sum of all the cropland, grazing land, forest and fishing grounds required to produce the food, fibre and timber it consumes, to absorb the wastes emitted when it uses energy and to provide space for infrastructure.
- WWF’s Living Planet Report 2014 found that in 2010, the global ecological footprint was 18.1 billion global hectares (gha) or 2.6 gha per capita. Earth’s total bio-capacity was 12 billion gha, or 1.7 gha per capita.
- This means that the Earth’s people needed 18 billion hectares of productive land in order to provide each and every person with the resources they required to support their lifestyle and to absorb the wastes they produced.

Our Ecological Footprint shows that 1.5 Earths would be required to meet the demands humanity makes on nature each year.

Ecological or Non-traditional Security:

- Ecological Security depends on maintaining dynamic equilibrium between humans and nature.
- The problem emerges when the Nature fails to meet the demand of rapidly growing society.
- The Ecological crises may be responsible for killing or injuring large number of people (e.g. arsenic contamination in the groundwater of Bengal Basin or deteriorating air quality in Cities).

- Global Warming will destabilize the ecological security as a) both temperature and rainfall pattern will change; b) Agriculture will be impaired; c) Coastal areas are likely to be submerged; d) Pests and Pathogens will move beyond their traditional regions.

The unsustainable development and environment crisis deepened the anxiety of Rabindranath Tagore (1924) who, while delivering a lecture, in China said *"We have for over a century been dragged by the prosperous West behind its chariot, choked by the dust, deafened by the noise, humbled by our helplessness and overwhelmed by the speed. We agreed to acknowledge that this chariot drive was progress, and that progress was civilization. If we ever ventured to ask 'progress towards what and progress for whom' it was considered to be peculiarly and ridiculously oriental to entrain such doubts about the absoluteness of the progress. Of late, a voice has come to us biding us to take count of not only the scientific perfection of the chariot but of the depth of the ditches lying across the path"*.

Fredrick Engels (1934) in his Dialectics of Nature wrote-*"Let us not flatter ourselves overmuch on account of our human victories over nature. For each such victory, nature takes its revenge on us. Each victory, it is true, in the first place brings about the results we expected, but in the second and third places it has quite different, unforeseen effects which too often cancel the first."*

The environment of the Earth remained stable for about 10,000 years prior to the Industrial Revolution in the late 18th. century. Subsequently, the stability has been threatened and the crisis looming large in the horizon in this Anthropocene era. Human well-being depends on the natural resources and ecosystem services and both are diminishing fast. The global population is growing uninterrupted and the number is expected cross 9.6 billion in 2050. We need to realize that we have only one planet and its resources are limited. The alarming situation demands interventions and priority areas identified by WWF (2014) are : a) Equitable Resource Governance, b) Redirection of financial flow, c) Wise consumption of resources with low ecological footprint, d) Better production system, and e) Preservation of natural capital.

We need to act immediately before the damage is irreversible.

Suggested Readings:

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Green Audit and our Environment

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Abstract :

In India National Action Plan on Climate Change (NAPCC) gave birth to eight missions and National Mission on Enhanced Energy Efficiency (NMEEE) is one them. Indeed a national mission on energy efficiency truly indicates the seriousness of the government. Energy efficiency or energy conservation mainly includes energy audit and energy management. In the context of energy audit in educational institutions, these buildings have many common designs, maintenance and operational functions for all the levels of institution starting from kindergarten to university. Depending on the connected load, as mandated by the Energy Conservation Act, 2001, the buildings need potential energy saving measures. Educational Buildings have another psychological implication as the teachers instil knowledge to students, and one form of it is in a form of information or awareness which, after prolonged cultivation, finally becomes wisdom. Therefore it is evident that environmental awareness is imparted in educational institutions. Energy audit is needed for keeping our climate less temperate. With increased awareness it will be easy to innovate and find new technologies as solution to some major problems from these institutions at the grass root level. In line with governmental goals and priorities the National Assessment and Accreditation Council's vision is to make quality the defining element of higher education in India through a combination of self and external quality evaluation, promotion and sustenance initiatives. In this context this paper examines the important steps in energy auditing in buildings in general and educational institutes in particular and also identifies the possible ways of substituting present energy sources with renewable energy sources like solar energy. Fundamentals of Solar Photovoltaic systems are discussed in brief and global green initiatives are delineated. Integration of Renewable Energy Systems in educational buildings is recommended.

1. Background of Energy Conservation

Even before the first oil shock of 1973, the Indian government had become seriously concerned about its meagre energy reserves in the face of increasing demand, especially that of oil. It had set up a Fuel Policy Committee in 1970 under the chairmanship of the noted economist Prof. Sukhamoy Chakraborty, the then member of the Planning Commission of India. The First Part of the Committee's Report was submitted in 1972 and taking due account of the changed energy scenario caused by the oil shock, the Committee submitted a comprehensive final report in 1974 in place of the second part [1]. A long 30 years history of governmental initiatives to make energy audit mandatory so many measures failed several times primarily because of political will in conjunction with non-acceptance by Industry. Finally Energy Conservation Act was enacted in 2001 and Bureau of Energy Efficiency was formed to institutionalise Energy Efficiency Services. The Act evolves minimum energy consumption and performance standards for notified equipments.

2. Building Energy Conservation Scenario

In regard to the Building Energy Consumption Indian Government launched many energy efficient initiatives like the Green Rating for Integrated Habitat Assessment (GRIHA), Green Building Council (IGBC), Energy Conservation Building Codes (ECBC), Star Rating by Bureau of Energy Efficiency etc, for establishing green techniques in buildings.

Green Building by IGBC is a nobel initiatives to make a building self sufficient and sustainable by being energy efficient, proper site development, water efficient, choosing proper building materials, producing less wastes, and maintaining proper indoor environment, to treat grey water, installing rainwater harvesting, and other ways to save usage of water upto 40% using proper effective appliances for air conditioning, lighting and water pumps [2].

ECBC or Energy Conservation Building Codes must be followed during construction so that the building use 40-60% less energy than the other similar building built during the same time which did not follow the ECBC norms. ECBC must follow the HVAC system, pumping system, lighting system, electrical system, water heating system [3].

GRIHA- This rating is considered during building's construction to the demolition including its operation, the resources it consumes in its whole life cycle like water, energy, material etc sidewise producing wastes. GRIHA's aim is to maintain the “greenness” by consuming less resources and producing less wastes leading to pollution, and to show environment impact through enhanced assessment methods [4]

BEE Star Ratings- BEE was formed by Government of India to construct plan and policies for reduction of Indian economy's energy intensity. Energy audit is conducted to analyze energy efficiency of office building and to compare them with other building with the help BEE star rating. This helps to progress in the energy efficiency activities in building. Green building proved to have low maintenance cost, and higher quality [5]. Overall objective of the ratings are to attain energy efficiency, structure efficiency, water efficiency, material efficiency and waste reduction efficiency.

3. Methodology for Green Energy Audit

To define the methodology of the energy audits, which is able to collect and calculate the consumptions from registered electricity and fuel consumption data. It belongs to the invoicing of the marketers of each energy resource used in the building. A tool of hourly thermal simulation which allows to calculate the thermal demand and the consumption of the air conditioning systems during a year. The following simplified steps are to be taken into consideration at the end of an energy audit. i) The quantity of electricity saved in an annual base (in kWh). ii) The annual economic profit due to energy savings (or due to the energy efficiency measures taken). iii) Annual economic benefits due to the flattening of the electricity consumption. These benefits are closely related to the energy bills and the variations of the corresponding values. For this reason, all the criteria that are related to energy aspects should be expressed both in the form of energy and economic units. iv) The auto-production of energy in an annual base through exploitation of Renewable Energy Sources (RES). v) The annual reduction of the most significant gas and liquid pollutants emissions that is expressed either in an absolute value or equivalent value in terms of green house gas reduction potential.

4. Recommendation and Protection

India's energy portfolio is dominated by fossil fuels with 68% of energy generated from coal and petroleum. To overcome these challenges India adopted National Action Plan with the priority of deploying renewable energy resources for power generation in India. According to the recent Union Budget 2015-2016, India is aiming to install 100GW of solar energy and 60GW of wind energy plants by 2022 [6]. To compete with energy generated from fossil fuels in India, policy support is provided for renewable resources at both State and Central levels.

Rooftop Solar Provision

Solar power generated from any individual's household, industrial building, commercial buildings and institutional buildings or in any other types of buildings can substitute a huge amount of power demand from non-renewable power sources and can be partly used to fulfil the energy demand of the inhabitants of the building and in case of surplus can be fed into the grid. Till date, 26 states have notified their regulation to provide with Net Metering/ Gross Metering facilities to support the installations of solar rooftops. In recent times it is possible to generate solar power of about Rs. 6.50/KWh from the rooftop solar system, which is much cheaper than the electricity generation from a diesel generator sets. It is also cheaper than the cost at which most DISCOMS which would avail power to the domestic, industrial and commercial consumers. The new technologies and initiatives will help India rise as a major country using their roof space for rooftop solar energy system on a huge scale. Rooftop Solar has the following advantages. i) No requirement of additional land ii) Improvement of tail-end grid voltages and reduction in system congestion with higher self-consumption of solar electricity iii) Local employment generation iv) Reduction of power bill by supplying surplus electricity to local electricity supplier v) Battery elimination makes easy installation and reduced cost of system vi) Savings in transmission and distribution losses vii) Low gestation time.

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Application of Plant Waste Materials: A sustainable source of bio-adsorbent for the removal of dyes from waste water

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Abstract

Textile industries use massive amount of water and discharge huge volumes of waste water that contains synthetic dyes as a product of the dyeing and finishing process. Synthetic dyes released into the environment from such process can be harmful for the aquatic organisms thriving in the receiving water bodies. Many dyes were reported to be extremely toxic for the organisms and resistant to natural biodegradation. Hence the removal of dyes from waste water is an issue of concern. Many promising techniques have been discovered for waste water treatment. However the adsorption method has been accepted as a very effective method for dye removal as compared to other expensive techniques. In the present endeavor various literatures regarding the use of different adsorbents have been collated. It was focused on the application of different plant waste materials such as agricultural waste materials, waste materials from medicinal plants and spent tea leaves of beverages such as tea and coffee can be a sustainable source for the synthesis of low-cost adsorbents.

Keywords: Dyes, Textile effluents, Waste water, Adsorption, Plant waste, Tea waste

Introduction

Use of dyes are widely prevalent in the industries such as textiles, plastics, rubber, leather, printing etc, among which textile industry ranks first in the consumption of dye. It has been estimated that around 1000 tones/year of dye are being released into water worldwide as the waste product of textile industries. Discharge of the dye containing waste water into rivers and streams poses serious threat to the natural aquatic environment. Dyes alter the food web as they interfere with the photosynthesis of the aquatic plants by either absorbing or reflecting the sunlight that penetrate into water (Bharathi et al., 2013). Besides they consume dissolved oxygen from water and damage the water quality and demolish the growth of aquatic organisms. The complex structures of the aromatic dyes are difficult to degrade naturally. The aromatic amines are carcinogenic to humans and other animals, their exposure may result in liver, intestinal, skin or bladder cancer. Therefore it is a necessity for the concerned industries to treat the textile effluents for dye removal prior to their discharge into the water bodies. (Tahir et al., 2009). For many years the scientific communities are coming up with different techniques of waste water treatment. Among them adsorption has gained importance for its trouble-free methods. Mostly activated carbons are used for the removal of dyes for its structural advantages and high adsorption abilities. One disadvantage of using activated carbon is its high commercial price.So for developing some cheaper alternatives for waste removal the researchers are trying to make adsorbents by utilizing the agricultural waste materials which have very low economic values. Usually the agricultural waste such as peels of potato, orange, banana, rice husk or tea waste are treated as useless materials and discarded off. They increase the burden of waste materials and cause disposal problems. So these waste materials can be recycled and utilized for the production of cost-effective adsorbents. A number of agricultural wastes and other plant waste materials have already been put for the manufacturing of low-cost adsorbents. Our objective is to review the use of different plants and agricultural wastes and by-products which have efficiently removed dyes from waste water by the process of adsorption.

Adsorption of dye using agricultural waste products as adsorbents

A literature survey indicated that there were about 283 published papers on how the use of low-cost adsorbents was successful in the removal of dyes. Different charcoal adsorbents were produced from agricultural wastes that efficiently removed dyes from aqueous solution. (Adegoke et al., 2015) Potato stem powder and potato leaf powder were effectively used as absorbent for the elimination of methylene blue and malachite green. The absorbents were characterized with the help of scanning electron microscope and Fourier transform infrared spectroscopy. Batch adsorption experiments were carried to understand the effect of pH, concentrations of dyes and adsorbents, time etc followed by the study of kinetics and equilibrium data. (Gupta et al., 2016) Potato peel was proved to be very effective in the removal of malachite green from aqueous solution. Batch adsorption studies were performed to understand the effect of several physico-chemical factors. Sorption kinetics were studied using pseudo first order and pseudo second order and pseudo nth order equations. Pseudo nth order kinetic model matched with the conditions of the experiment. Equilibrium data was fitted with the non linear forms of Langmuir, Freundlich and Redlich–Peterson isotherms to understand the sorption isotherm. Data matched with both Langmuir and Redlich–Peterson models though it fitted better with Redlich Peterson model. Thermodynamic parameters revealed that the adsorption process was endothermic in nature. (Geuchi et al., 2016). In a recent study, cauliflower leaf powder was used which is an agricultural waste produced as a result of crop harvesting. It was used as an adsorbent to remove the dye, methylene blue from waste water. The concentration of dye absorbed changed with the change in the initial dye concentration in the solution. The experimental result showed that the adsorption process was spontaneous and exothermic in nature. (Anwar et al., 2016). In a study different cellulose obtained from agricultural waste was used to study the adsorption of violet B azo dye. Almond shell, pistachio shell, walnut shell, orange peel and tea wastes were used for the experiment. Different parameters such as contact time, pH, concentration of initial dye and the adsorbent were studied. The result revealed that the efficiency of adsorption of the waste materials followed this pattern: Almond shell > Orange peel > Pistachio shell > Tea waste> Walnut shell. (Saeedeh Hashemian., 2014). Both orange peel and spent tea leaves efficiently removed dyes from the aqueous solution. For the adsorption of methylene blue and Remazol Brilliant Blue R orange peel and spent tea leaves were used as the adsorbents. Removal of Methylene blue was easier compared to Remazol Brilliant Blue R as studied by Lazim et al., 2015. Carrot stem powder and carrot leaves powder was studied as adsorbents for the removal of methylene blue and malachite green from water. The morphology of the adsorbents were studied by scanning electron microscope and Fourier transform infrared spectroscopy. Results showed that the reaction was exothermic and spontaneous in nature and carrot plant waste materials can be a potential source for low cost adsorbents (Kushwaha et al., 2011). *Annona squmosa* seed was used as a low cost adsorbent for the removal of methylene blue and malachite green. The result indicated that it was a better adsorbent on malachite green than methylene blue as the percentage removal of malachite green and methylene blue were 75.66% and 24.33% (27 ± 2 °C). (Santhi et al., 2016) In some cases it was seen that the modification of the adsorbents or co-treatment of adsorbents by some other products improved the quality of adsorption. An agricultural waste , oil tea shell was used for the removal of methylene blue from aqueous solution. It was found that treatment of oil tea shell with the fungus *Pycnoporus* sp. and *Trametes versicolor* enhanced the adsorption capacity. (Liu et al., 2016) Dyes can be usually classified as anionic (direct, acid and reactive dyes), cationic (basic dyes) and non-ionic (dis-persive dyes). (Bharathi et al). Methylene blue and malachite green fall in the category of cationic dyes. An anionic dye, tartrazine was used to study the adsorption efficiency of sawdust. Maximun removal percentage by the adsorbent was found to be 97% at 1mg/L of the dye. Removal percentage increased with the decrease of the initial concentrations of the dye. Experiments were performed under different parameters followed by kinetic modeling of the data. The removal process was endothermic in nature (Banerjee et al., 2017). For the removal of a light green anionic dye the agricultural waste peanut husk was used. A cationic surfactant hexadecylpyridinium bromide was used to modify the adsorbents and make it suitable for anionic dye adsorption. Results showed that the modified adsorbent favored the removal of the dye from aqueous solution. The adsorbent could be regenerated and reused after the experiment. (Zhao et al., 2017) Seed husk of Bengal gram is feasibly available and is a good source of low cost adsorbent. Adsorption studies were performed to understand the removal of anionic dye, Congo red using these seed husks as adsorbents. At lower pH the maximum removal of 92% was observed. Results showed that it is an efficient adsorbent for the removal of Congo red dye from the waste water containing synthetic dye. (Reddy and Ashwini., 2017)

Activated carbons which are commercially available are usually extracted from wood or coal. These are very expensive and researchers are looking for an alternative source for the extraction of activated carbon. A low cost activated carbon was prepared from cashew nut shell which is treated as an agricultural solid waste. It was used to study the adsorption of methylene blue in aqueous solution. It showed efficiency to reach the stage of complete dye removal. (Subramaniam et al., 2015). Activated carbon was also extracted from aamla seed, jambul seed, tamarind seed, soap nut for the removal of chromotrope dye from stimulated waste water. The results followed the order of aamla seed >jambul seed > tamarind seed > soap nut of the dye adsorption experiments were compared with that of commercial activated carbon. Aamla seed had better adsorption capacity and can be used as an alternative adsorbent to commercially available activated carbon. (Hameed et al.,2017). Activated carbon was also prepared from coconut husk followed by activation of H_2SO_4. It was used for the removal of maxilon blue GRL, and direct yellow DY 12. Results showed better adsorption capacity at lower pH. The dye adsorption was found to be spontaneous and endothermic in nature. (Aljeboree et al., 2017) Areca nut pod, which is treated as an agricultural waste was used to prepare activated carbon. It was used to study the adsorption of direct blue dye from stimulated waste water solution.

Results indicated that it can be successfully used as a low cost adsorbent to commercial activated carbon for the removal of acidic dye from waste water. (Gopalswami et al., 2010)

Tea waste as a potential adsorbent

It was estimated that around 18 to 20 billion cups of tea are consumed daily on earth. Different types of tea, either instant tea or processed, generate solid residues of spent tea leaves (STL), which are of no commercial use and are usually disposed off as solid waste. STL has potential to be used as non-conventional and cost-effective adsorbent for a number of applications like dye removal, fluoride removal from water, etc. In a study by B.H Hameed., 2009 spent tea leaves were used as a new idea of low-cost adsorbent to study the adsorption of methylene blue. Result indicated its potential to be used as a low-cost adsorbent. The interaction of methylene blue with tea waste was characterized by FTIR. The mechanism of adsorption was through ion exchange and the equilibrium data fitted with Langmuir isotherm model. (Uddin et al., 2006) Another study bu Nasuha et al., 2010 also suggested that the rejected tea leaves had high potential as adsorbents for the removal of methylene blue. To enhance the process of adsorption black tea was impregnated with metals. Batch adsorption studies were performed by using both metal impregnated tea and waste tea. The result suggested that tea waste showed much better adsorption capability compared to the metal impregnated tea(Tahir et al., 2009).Tea waste was used to study the adsorption of the anionic dye, Congo Red in aqueous solution.To enhance the adsorption process it was fabricated with silica and Fe_2O_3 nanoparticles. The nanoparticles increased the adsorption of congo red on tea waste by 5% and 10% respectively. Lngmuir isotherm fitted with the result and pseudo second order model supported the experimental data. (Shojamoradi et al., 2013). Coffee waste was also evaluated by using it in the adsorption of basic dyes, toluidine blue and crystal violet in aqueous solution and it was proved to be a probable adsorbent for the removal of basic dyes (Lafi et al., 2014).

Prospects of using agricultural and food waste materials as low cost adsorbents at the National and International level

Innumerable strategies are being initiated to find low cost alternatives for treatment of Industrial effluents. Utilizing adsorption method for dye removal has become popular all over the world. Mostly the Asian countries are coming up with alternative sources of low cost adsorbents as evident from the study of Aljoboree et al, Babylon. China has focused on some cost-effective approach of extracting activated carbon from peanut shells and oil tea shells (Zhao et al., 2017, Liu et al., 2016). South East Asian countries such as Malaysia are utilizing tea and coffee wastes for the production of adsorbents (Latif et al., 2014). As India is highly agriculture based and the second largest producer of tea in the world, it is almost taking a leading role in the detection of adsorbents from agricultural and food wastes. Adsorbents were extracted from different seeds and pulses such as Bengal gram seeds, vegetables, spices and fruits such as carrot plant products, aamla, tamarind etc. (Ashwini and Reddy., 2017, Hameed et al., 2017, Kushwaha et al., 2011)

An experiment was conducted by the authors of this article where black tea waste was applied as an adsorbent against malachite green. It was observed that a percentage removal value of 81% for a particular initial concentration of malachite green dye and 100mg/ 50 ml of black tea waste. Further experiments are being conducted to enhance the adsorption capability of tea waste.

It is often reported that mixed azo dyes in the effluent reduce the adsorption capacity. A study was conducted where the adsorption of acid yellow and acid blue was experimented with graphene oxide nanoparticles fixed on chitosan matrix and in presence of ultrasound. The results showed that the adsorbents were very effective for its application in the treatment of industrial waste water that contains mixed azo dye. (Banerjee et al., 2017) The graphene oxide nanoparticles were also used for the adsorption of crystal violet. Agricultural wastes i.e rice straw biomass was used for the synthesis of these materials. Results revealed that it served as a low-cost alternative for graphite in the synthesis of grapheme oxide nanoparticles (Goswami et al., 2017). Agricultural waste has been used for the removal of other contaminants such as the fruit peels from *Trewia nudiflora* plant was applied as biosorbent for the sorption of Cr^{+6} collected from tannery waste water (Bhattacharya et al., 2013). Biosorbents obtained from the peels of the fruits of *Lagerstroemia* sp in combination with ceramic microfiltration process was proved as a potential method for the removal of huge amount of organic loads from industrial and domestic waste water. (Bhattacharya et al., 2013)

Conclusion

Waste materials produced from vegetable peeling and agriculture has less or no economic value and they are usually disposed off. They increase the total mass of waste materials and their disposal is an issue of concern. Several strategies have been proposed for the recycling of such waste materials such as energy recovery, value added products etc. Utilizing them for the production of low-cost adsorbents is one of the most suitable solutions for waste management. Spent tea leaves are produced in large amount in all parts of the world. Dumping of these products is not friendly for the environment. Hence, the proper utilization of such waste is most advantageous. Finally the plant waste materials have an immense value so far as the bio-adsorption of dyes are concerned.

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Table 1. List of agricultural wastes and byproducts utilized for the adsorption of dyes

Sl No.	Adsorbent	Dye	Reference
1	Potato stem Potato Leaf	Methylene blue Malachite green	Gupta et al., 2016
2	Potato peel	Malachite green	Geuchi et al., 2016
3	Cauliflower leaf powder	Methylene blue	Anwar et al., 2016
4	Almond shell > Orange peel > Pistachio shell > Tea waste> Walnut shell	Violet B azo dye	Saeedeh Hashemian.,2014
5	Orange peel Spent tea leaves	Methylene blue Remazol Brilliant Blue R	Lazim et al., 2015
6	Carrot plant stem and leaf powder	Methylene blue Malachite green	Kushwaha et al., 2011
7	Annona squmosa	Methylene blue	Santhi et al., 2016
8	Oil tea shell	Methylene blue	Liu et al., 2016
9	Saw dust	Tartrazine	Banerjee et al., 2017
9	Peanut husk	light green anionic dye	Zhao et al., 2017
10.	Bengal gram	Congo red	Ashwini and Reddy., 2017
11	Cashew nut shell	Methylene blue	Subramaniam et al., 2015
12	Aamla seed	Chromotrope dye	Hameed et al., 2017
14	Coconut husk	maxilon blue GRL, and direct yellow DY 12	Aljeboree et al., 2017
15	Areca nut pod	Direct blue dye	Gopalswami et al., 2010
16	Spent tea leaves	Methylene blue	B.H Hameed., 2009 Uddin et al., 2006
17	Tea waste	Malachite green	Tahir et al.,2009
18	Spent tea leaves	Congo red	Shojamoradi et al., 2013
19	Coffee waste	toluidine blue (TB) and crystal violet	Lafi et al., 2014

E-waste and its impact on the environment

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Abstract:

Electronic waste is a subset of the waste electrical and electronic equipments (WEEE). Rapid growth of the electronic industry coupled with fast obsolescence of products leads to huge accumulations of E-waste. In this paper, analysis of its effect at various levels: material selection, extraction, manufacturing of products including design and integration technology and disposal are studied. The hazards have its impact on the environment, economic growth and societal aspects. Legislative policies, environment protection acts, extended producer responsibility (EPR) are required for recycling and cleaning of e-waste. Research for eco-friendly and functional materials enhance the growth of 'green' technology.

Keywords : E-waste, environment, WEEE, EPR, toxic materials, functional materials, e-waste management

1.0 Introduction

In the present world, technology is the one of the most influential factors in man's relationship with the environment. The word environment means the combination of external physical conditions that influence the growth, development, behaviour and survival of living organisms or an ecological community. It comprises of all physical, chemical, biotic factors and even social cultural conditions. The sum total of all these determine the conditions of development and growth as well as of danger and damage in the life of an individual or community. The growing awareness on environmental issues has gained immense progress and it is very much essential due to its scientific and societal aspects. Issues of environmental protection and sustainable development are gaining increasing importance in everyday life and nowhere are these more so than in the field of materials science, electronics and communication engineering. Rapid economic growth coupled with urbanization has increased the demand, production and consumption of electrical and electronic equipments (EEE) (Ramesh Babu, Parande, Basha, 2007) making it the fastest global manufacturing activity. The infiltration of new gadgets and appliances in every aspect has resulted due to the need of providing easy information acquisition and exchange along with more comfort, health and security to the society. As a result product obsolescence rate has increased substantially giving rise to huge accumulations of e-waste in all sectors.

E-waste is a generic term for all most all types of EEE. It covers items like TVs, computers, keyboards, laptops, mice, photocopiers, scanners, calculators, telecommunication equipments, type-writers, mobile phones, refrigerators, washing machines, dryers, digital music recorders/ players, stereosystems, toys, toasters, kettles, battery cells and many more household items (Liu, Tanaka, Matsui, 2009). According to the Organization for Economic Cooperation and Development (OECD) (http://www.oecd.org), it can also be defined as any household or business item with circuitry or electrical components with power or battery supply entering the waste stream. Large scale consumption of these devices also brings end to their life and makes them obsolete. WEEE is non-biodegradable, industrial and synthetic in nature. It contains toxic and hazardous elements/materials that are sources of environmental pollution, contamination of ground water, surface water, air and soil. Hence it affects the entire ecosystem posing environmental health risks to all animals and human.

India has been a major contributor in e-waste due to its significant growth in electronic and information technology. Recent policy changes in India have led to an influx of leading multinational companies to set up electronics manufacturing facilities, research and development centres for hardware and software. Information and communication technology influences economic growth and brings about technological and societal changes (Williams, 2011).While having some of the world's most advanced high-tech software and hardware developing facilities, India's recycling sector is not that developed (List of E-waste Recyclers in India, 2007). The dumping of e-waste in India from developed countries (Harder, 2005) has further complicated the problems with waste management. Kolkata figures among the top electronic waste generating cities in India.

In this paper, we explore how the technological pathway of material selection, designing and production of electronic devices and disposal influences the environment. E-waste contains valuable materials such as copper, silver, gold and platinum which could be processed for their recovery. Furthermore, developments of novel “environment friendly or green materials” pose new challenges for materials scientists and engineers.

2.0 Materials and Method

2.1 Objective

The objective to study the lifecycle analysis essentially deals about considering the entire environmental impact, energy and resource usage of a material or product (http://www.materials.ac.uk/guides/environmental.asp). It encompasses the entire lifetime from extraction to end-of-life disposal. It can be an extremely effective way of linking many different aspects of the environmental impacts of materials usage. In order to gain insight into materials extraction, we need to know the resource level covering material abundance and the energy required for extraction along with a detailed consideration of environmental impacts of extraction processes. For example, the production of aluminium requires large amounts of energy and produces a significant contribution to overall green house gas emission. In that case, recycling of used aluminium is more favourable by comparing energy usage for extraction of new aluminium.

Several materials are used in the electronic industry for development of various end products used as large and small household appliances, appliances for information and communication technology, in the area of consumer electronics, research laboratories, etc. It comprises of materials such as : Iron

(Ferrous), Aluminium, Copper, Lead, Cadmium, Mercury, Gold, Silver, Palladium, Indium, Zinc, Gallium Arsenide to name a few. Material selection is based on factors depending on material structure, chemical and physical properties, processing and design as well as more general areas such as legislative, economic and social aspects. Table 1 provides the areas of usage of these materials in different electronic devices.

2.2 Methodology: manufacturing, designing and production

Electronics industry is a highly competitive industry where technical performance rules over environmental concerns. Health hazards in semiconductor manufacturing occupations are an issue in occupational hygiene due to the chemical hazards encountered. Health manifestations are due to low level exposure to toxins. Use of toxic materials such as arsine, phosphine potentially expose workers to health hazards which include cancer, miscarriages and birth defects. Although there is comparatively low rate of physical accidents in the semiconductor industry, protective gear issued to workers protects the products and process from contamination by workers but is not designed to protect workers from contamination by the process, products and materials. A Scientific Advisory Committee funded by the Semiconductor Industry Association (Ladou & Rohm, 1998; Semiconductor Industry Association) concluded that there was no evidence of increased cancer risk to cleanroom workers, although it could not rule out the possibility that circumstances might exist that could result in increased risk. However, in India cleanroom facilities are not easily available and setting up of one also requires large amount of investments.

Manufacturing of computers, microchips and printed circuit boards requires large energy consumption and also human exposure to many nasty chemicals. For instance, for its fabrication, a 2-gram microchip necessitates 1600 grams of petroleum, 72 grams of chemicals, 32,000 grams of water and 700 grams of elemental gases (Williams, Ayres & Heller, 2002). Fig.1 is a schematic for the production of semiconductor devices and micro-chips. After manufacturing the chips, terminals are added and all are placed inside a protective cover. Few additional components (resistors and capacitors) along with the chips are then integrated on the circuit board which includes a base, some wiring and gold plating on leads and lead-tin soldering.

The processing and designing also requires the sustainability criterion. It will therefore cover issues such as design for successful recycling, waste minimisation, waste-impact minimisation, energy efficiency and increased lifetime. Also economic, social and legislative issues have significant influence on technical issues. For example, material selection within the industry is now heavily influenced by 'end-of-life product' and 'hazardous material' regulations. It is sensible to define sustainable materials as those that have distinct differences that achieve environmental benefit compared to conventional materials. Therefore, the list would include:

i) Materials of a significantly plant based nature, including wood, natural fibre composites, natural polymers.

ii) Materials produced using a large proportion of waste material, including recycled polymers, composites made from waste mineral powders.

iii) Materials for Green Energy include functional materials, and many of which serve an environmentally beneficial purpose, particularly in the production of green energy. These include: solar cell materials, fuel cell technology, catalytic pollution control, etc.

Extended Producer Responsibility (EPR)is an emerging principle for a new generation of pollution prevention policies that focus on product systems instead of production facilities. It is a sustainable solution as it imposes accountability over the entire life cycle of products and packaging introduced in the market. It means that the responsibility of producers for their products is extended to the post-consumer stage and a company must be concerned not only with making the product and how it functions, but also with what will become of the product at the end of its useful life. Worker safety, prevention and treatment of environmental releases from production, financial and legal responsibility for the sound management of production wastes are taken care by assigning producers and distributors to include management at the post-consumer stage. EPR encourages preventing pollution and reducing resource and energy use in each stage of the product life cycle through changes in product design and process technology. It emphasizes that producers bear a degree of responsibility for all the environmental impacts of their products. This includes upstream impacts arising from the choice of materials and the manufacturing process to the downstream impacts from the use and disposal of products (EPR – Sustainable solution to Electronic waste, 2007).

EPR also encourages development of environmentally friendly product which requires fewer resources, contain fewer harmful substances and are easier to reuse/ recycle. This helps environmentally responsible product development and product recovery. The goals of EPR can be summarized as follows:

- Overall waste prevention;
- Use of non-toxic materials and processes;
- Development of closed material cycles;
- Durable products;
- Encouraging the increase of reuse, recycle and recovery;
- Polluters Pay Principle.

Some such companies which have taken an initiative in this regard include Apple, Dell, Epson, Gateway, HP, IBM, Lexmark, Sony and Toshiba (Extended Producer Responsibility).

3.0 Results

3.1 Impact on health and environment

EEE contains multiple components made of different elements or materials among which some are toxic and can have an adverse impact on human health and the environment if not handled properly. These hazards arise due to the improper recycling and disposal processes used. Serious impacts are posed in places near to e-waste dumping grounds and those in proximity to places where e-waste is recycled or burnt. For example, cathode ray tubes of computer monitors contain heavy metals such as lead, barium and cadmium, which can be very harmful to health if they enter the water system. These materials can cause damage to the human nervous and respiratory systems. Also flame-retardant plastics, used in electronics casings, release particles that can damage human endocrine functions.Further the process of e-waste management possesses both potential occupational and health hazards (Pinto, 2008). Table 2 enlists the different materials contained in e-waste along with the areas they affect.

The usages of electronic appliances have not only increased power consumption but its physical impact on human-life is noteworthy. Health effects on computer users include damage to wrists, eyes, spinal column, lack of physical exercise leading to obesity and decrease in concentration level.

E-waste hazards to biotic life or environment cannot be overlooked. The post consumptive

remains of the electronics products containing toxic elements are creeping slowly and steadily inside the environment making it poisonous. By entering the soil, it leads to soil degradationby eating all the soil nutrients. It makes the soil infertile. Suspended particles in air cause breathing problems and various other health issues. Marine life is also damaged through the process of groundwater contamination and subsequent mixing with river and sea water. Hence directly or indirectly, the biotic life comprising of natural vegetation, human population and animals are suffering the hazardous influences of e-waste.

3.2 E-waste management

In this section we refer to the end-of-life issues for electronic devices. E-waste contains both valuable as well as hazardous materials which require special handling and recycling methods. The treatment of materials at the end of their lifetime is a significant subject area and encompasses aspects such as recycling techniques and material limitations, bio-degradability and composting, chemical and energy recovery. Questions arise that where does all of these go, what happens to it at its destination and what is the impact of such processes on the environment?

The major components of e-waste management consist of two steps:

- e-waste collection, sorting and transportation
- e-waste recycling which involves dismantling, recovery of valuable resource, sale of dismantled parts and export of processed waste for precious metal recovery.

WEEE (Waste Electrical and Electronic Equipment, 2011) relates to the waste legislation directive, which specifies minimum collection and recycling rates for waste electrical and electronic equipment. In this regard, material issues arise when this legislation is taken in conjunction with that dealing with hazardous waste, e.g. the ROHS directive. Many components within WEEE contain materials that will be designated as hazardous and hence requires special treatment. Examples include Lead solders, Phosphorus coated monitor and TV screens, Mercury switches, batteries, Brominated flame retardants in plastics, refrigerants, etc. Fig. 2 shows the necessary steps at various stages of waste management procedure. Recycling of end products consists of two types of technologies- one that is hazardous and the other that is state-of-the-art recycling steps.

The former includes three methods which are-

(i) Incineration which is the process of destroying waste through burning. Because of the variety of substances found in e-waste, incineration is associated with a major risk of generating and dispersing contaminants and toxic substances such as gases and residual ash. Copper, which is present in printed circuit boards and cables, acts a catalyst for dioxin formation when flame retardants are incinerated. Also PVC in significant amounts is highly corrosive when burnt and also induces the formation of dioxins. Incineration also leads to the loss valuable of trace elements which could have been recovered had they been sorted and processed separately.

(ii) Open burning process releases many more pollutants. Inhalation of open fire emissions can trigger asthma attacks, respiratory infections, and cause other problems such as coughing, wheezing, chest pain, and eye irritation. Chronic exposure to open fire emissions may lead to diseases such as emphysema and cancer. Often open fires burn with a lack of oxygen, forming carbon monoxide, which poisons the blood when inhaled. The residual particulate matter in the form of ash is prone to fly around in the vicinity and can also be dangerous when inhaled.

(iii) Land-filling is one of the most widely used methods of waste disposal. However, since all landfills leak and the leachate often contain heavy metals and other toxic substances, it can contaminate ground and water resources. Older land-fill sites and un-controlled dumps pose a much greater danger of releasing hazardous emissions. Mercury, Cadmium and Lead are among the most toxic leachates. Mercury, for example, will leach when certain electronic devices such as circuit breakers are destroyed. Lead has been found to leach from broken lead containing glass, such as the cone glass of cathode ray tubes from TVs and monitors. Besides leaching, vaporisation is also of concern in land-fills. In addition, land-fills are also prone to uncontrolled fires which can release toxic fumes. Significant impacts from land-filling could be avoided by conditioning hazardous materials from e-waste separately and by land-filling only those fractions for which there are no further recycling possibilities. This further ensures proper land-fills that respect environmental technical standards.

The latter part also comprises of three steps-

(i) Detoxication where removal of critical components is done in order to avoid dilution of and / or contamination with toxic substances during the downstream processes.

(ii) Shredding is the mechanical process which provides concentrates of recyclable materials in a dedicated fraction thereby separating the hazardous materials. The gas emissions are filtered and effluents are treated to minimize environmental impact.

(iii) Refining of resources in e-waste is possible and the technical solutions exist to get back raw with minimal environmental impact. Most of the fractions need to be refined or conditioned in order to be sold as secondary raw materials or to be disposed of in a final disposal site, respectively. During the refining process, three flows of materials is paid attention: Metals, plastics and glass.

There are also organizations which are working on e-waste management issues. International networks include the Silicon Valley Toxics Coalition, Basel Action Network (BAN), International Solid Waste Association, Solid Waste Association of North America, Environmental Protection Agency, etc. Within India such networks include Knowledge bank for e-waste management in India, the Toxics Link, the E-waste Guide and National Solid Waste Association of India (NSWAI).Also the Ministry of Environment & Forests (MoEF) of the Government of India along with the Central Pollution Control Board (CPCB) (http://www.cpcb.nic.in/e_Waste.php) is responsible for environmental legislation and its control.

Technical interventions are necessary to initiate production process modification, volume reduction, recovery and reuse. Sustainable management involves use of bio-degradable materials, renewable of materials and energy. Also stress should be given for minimum and green packaging material. Hence by proper e-waste management, it is possible to get back various fractions of valuable materials present in electrical and electronic equipment.

The role of citizens in e-waste management also needs mandatory action. Donating electronics for reuse, opting for those that are made with fewer toxic constituents, using recycled content, checking energy efficiency and design for easy upgrading or disassembly, using minimal packaging are some of the necessary steps to facilitate e-waste management.

Building of consumer awareness through public awareness campaigns is a crucial point that can contribute to a new responsible kind of consumerism.

To ensure eco-friendly materials for applications, research works are in progress to ensure Lead-free, Cadmium-free and Halogen-free processes for fabrication. Cross-disciplinary researchers (http://bu.edu/eng/departments/mse) are exploring materials that can help produce cleaner and more efficient sources of energy. Clean energy conversion, hydrogen generation and storage, fuel cells, green manufacturing, solid state lighting and bio-fuels/metabolic are all subjects of active research. Regulatory mandates are also increasing the demand for the development of 'green' technology. Consideration of these in depth is essential to find alternatives that can be used in future and along with analysis of hazards they are posing in waste management and treatment.

4.0 Discussion

4.1 E-waste scenario in India

In India, e-waste is becoming an important waste stream in terms of both quantity and toxicity (Wath, Vaidya, Dutt, Chakrabarti, 2010). Managing the ever increasing quantum of e-waste is a major concern along with proper scientific and environment friendly disposal. Developing countries like India is facing a fast increase in load of WEEE originating both from inland and through illegal imports (Sepúlveda, Schluep, Renaud, Streicher, Kuehr, Hagelüken, Gerecke, 2010; Streicher-Porte, Widmer, Jain, Bader, Scheidegger, Kytzia, 2005).

According to the MoEF (2008), the electronics industry has emerged as the fastest growing segment of Indian industry both in terms of production and exports. The need of the hour is an urgent approach to the e-waste hazard by technical and policy level interventions, implementation and capacity building, increase in public awareness so that India can meet global credible standards concerning environmental and occupational health.

Major e-waste generating states are Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh, Punjab, Rajasthan and Kerala contributing about 70% of the total e-waste generated in India (Wath, Dutt, Chakrabarti, 2011).

Most of the activities like collection, transportation, segregation, dismantling and disposal are done by unorganized informal sectors manually. Being a rich source of reusable and precious material (Yunus, Sengupta, 2016), e-waste is also a good source of revenue generation for many people in India. Many people earn their livelihood by collecting and selling the inorganic waste-like plastics, polythene bags, glass bottles, cardboards, paper, ferrous metals, etc. Earlier due to absence of proper adequate technologies and equipment, recycling and treatments of e-waste was very raw and dangerous. Improper recycling and disposal operations found in different cities in India involve the open burning of plastic waste, exposure to toxic solders, dumping of acids, and widespread general dumping. As a result, pollutants are dumped into the land, air, ground and surface water causing serious environmental problems. Also, the labours and workers employed in the dismantling and recycling units are poor and uneducated lacking the basic knowledge about the serious occupational and health risks associated with the operations. The worst part is that young children are also employed for this purpose. The equipments used for these purposes are hammers, chisels, hand drills, cutters, electric torch, burners and electric drills. Even the operations are carried out in congested places in the centre of cities and slums without any proper lighting and ventilation. Hence due to absence of suitable techniques and infrastructure, the workers and children are prone to serious occupational health hazards.

For replacement of the informal sector by formal one for recycling, the Government of India has enacted rules. Various recycling companies have evolved in India (Yunus, Sengupta, 2016; List of E-waste Recyclers in India, 2007) which have been granted authorization by the CPCB to maintain all desired standards. Formal recycling needs the joint efforts of all the stakeholders covering producers, consumers and bulk consumers. It requires use of proper tools, equipments, machinery which does not damage the health of workers but also results in efficient WEEE management.

4.2 E-waste scenario in Kolkata, West Bengal

Kolkata has been ranked among the top e-waste producers in India (E-Waste: Flooding the City of Joy Kolkata Report, 2007). It is home to many top companies like TCS, Wipro, IBM, Cognizant, PWC, HCL, Genpact, Siemens, etc. According to a study jointly conducted by the Associated Chambers of Commerce and Industry of India (ASSOCHAM) and Frost & Sullivan, computer equipments (68 %), telecommunication equipments (12 %), electrical equipments (8 %), medical equipments (7 %) and house-hold generated electronic waste (5 %) accounts for the types of WEEE in Kolkata. The large informal recycling industry usually employs children to dismantle electronic waste posing a grave risk. Also huge labour is associated with collection, segregation and distribution of e-waste (E-Waste: Flooding the City of Joy Kolkata Report, 2007). Formal recycling units have started developing under the West Bengal Pollution Control Board (WBPCB) for example J.S. Pigments Pvt. Ltd. which recycles e-waste listed in Schedule 1 of E-Waste (Management & Handling) Rules, 2011 (http://www.moef.nic.in/downloads/rules-and-regulations/1035e_eng.pdf).

5. 0 Conclusions

The impact of the technological revolution has grown beyond the limit of applications with its hazardous impact on environment and mankind. The concern for sustainable development by using eco-friendly functional materials are essential steps to the implementation of reduce, recycle and reuse procedure. The ongoing thrust for developing eco-friendly high performance digital systems, multi-functional consumer electronic goods, and high speed systems is mainly driving the demand for such materials. The government needs to have accountability to check the enforcement of rules through annual reports .The media can also be a key contributor in making public aware about the harmful effects of e-waste on human and environment. Strong actions must be taken to prevent illegal electronic waste imports in India (Adigun, 2012). Therefore to combat the menace of e-waste and ensure sustainable growth we need to rise above any kind of socio-economic, infrastructural and legal barriers.

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Table 1: Use of materials in EEE

Halogenated compounds	
PCB (polychlorinated biphenyls)	Condensers, transformers
TBBA (tetra -bromo-bisphenol-A,PBB(polybrominated-biphenyls),PBDE(polybrominated diphenyl ethers)	Fire retardants for plastics, printed circuit boards and casings
Chlorofluorocarbon (CFC)	Cooling unit, insulation foam
Polyvinyl chloride (PVC)	Cable insulation
Elements	
Arsenic	In the form of GaAs in LEDs
Barium	Cathode ray tubes
Beryllium	Power supply boxes with Silicon Controlled Rectifiers
Cadmium	Re-chargeable Ni-Cd batteries, cathode ray tubes(CRT) screens, printer inks, toners
Chromium VI	Data tapes, floppy disks
Lead	CRT screens, batteries, printed circuit boards
Lithium	Li-batteries
Mercury	Fluorescent lamps, batteries, switches
Nickel	NiCd batteries, CRT
Selenium	Older Photocopiers
Zinc sulphide	CRT
Rare earth elements	Fluorescent layer in CRT screens
Others	
Toner dust	Toner cartridges for laser printers
Radio-active elements	Medical equipments, fire and smoke detectors

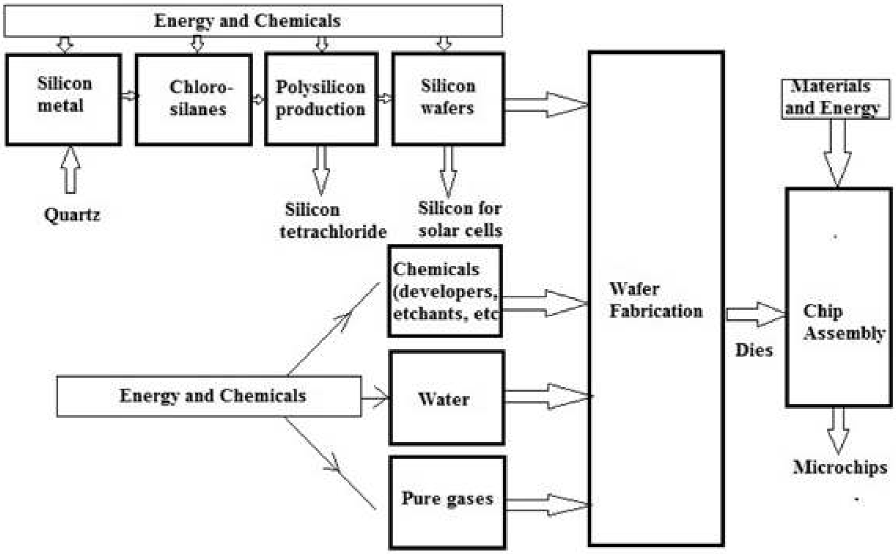
Source : Information collated from https://www.atsdr.cdc.gov/

Table 2: List of e-wastes and their constituents along with affected areas

EEE	Elements / Compounds	Affected areas
Cathode ray tubes	Lead oxide, Barium, Cadmium	Heart, liver, muscles, spleen
Printed circuit boards	Lead, Cadmium	Nervous system, kid ney, liver, reproductive system, abdomen, appetite loss, fatigue, headache
Motherboards	Beryllium	Lungs, skin
Computer batteries, printer inks and toners	Cadmium	Kidney, liver, muscles
Switches, flat screen monitors, fluorescent lamps	Mercury	Brain, skin, liver, nervous system
Cable insulation/coating	Polyvinyl chloride (PVC)	Immune system, respiratory system
Plastic housing	Bromine	Endocrine
Light emitting diodes	Arsenic	Skin, nervous system
Data tapes, floppy disks	Chromium VI	Eyes, skin
Photocopiers	Selenium	Hair loss, nail brittleness, neurological problems
Condensers, transformers, fire retardants for plastics	Halogenated compounds: - PCB(polychlorinated biphenyls),TBBA (tetra-bromo-bisphenol-A,PBB(polybrominated biphenyls),PBDE(polybro minated-diphenyl ethers)	Memory, reproductive system, lymphocyte
Cooling units, insulation foam	Chlorofluorocarbon (CFC)	Ozone layer in atmosphere

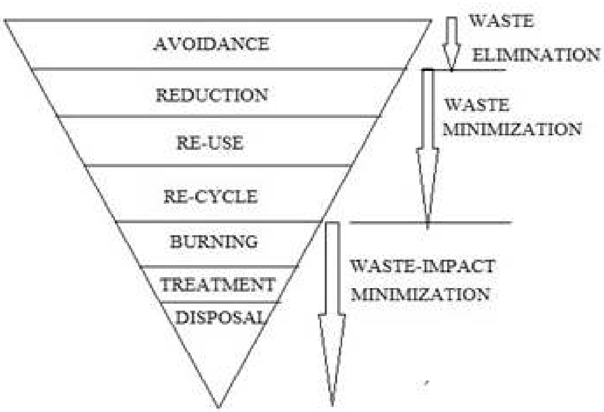
Source : Prepared by author with the help of data collected from http://ewasteguide.info/hazardous-substances ; http://ewaste.ee.washington.edu/students/impacts ; http://www.sciencedirect.com/science/article/pii/S2214109X13701013.

Fig. 1: Schematic for the production of microchips



Source: Prepared by author using information from Williams, Ayres & Heller, 2002.

Fig.2: Schematic showing E-waste management steps; the top base represents the most desired case of waste elimination, the hazards increase as the tip is approached.



Lignin Degradation by a Novel Microbe Isolated from Eucalyptus Resin Seeds Aiding in Increasing Yield of Bio Fuel Production

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Abstract:

Lignin is the most structurally complex, recalcitrant, heterogeneous aromatic polymer of the plant cell wall. The bioconversion of plant lignocellulose to glucose is a pre requisite for second generation bio fuel production, but the resistance of lignin to breakdown imposes a major obstacle in this process, hence there lies a considerable interest in the microbial degradation of lignin. This study's main objective was to isolate a novel microbe from eucalyptus resin seeds, capable of degrading the heterogeneous aromatic polymer lignin. Bacterial identification was strictly based on the standard routine biochemical as well as the morphological tests. The bacteria were then inoculated in Canada balsam glue, to check whether it degraded lignin by observing any reduction in specific gravity. After a period of 7 days a reduction in specific gravity was observed. The specific gravity was 0.9847 initially, and after a period of 7 days it reduced to 0.9717 with a % of reduction of 1.3% i.e (final specific gravity after 7 days- initial specific gravity) ×100. This was followed by an enzymatic assay for the ligninolytic enzyme lignin peroxidase. The 16SrRNA gene sequence analysis was also carried out where in the bacterial strain capable of degrading lignin was therefore identified as *Bacillus sp*.

So it could be concluded that **the isolation of the bacterial species which is capable of degrading lignin under standard laboratory conditions in a short duration of time** could be done successfully. The lignin degrading properties of *Bacillus sp*. makes it important for the second generation bio fuel producers as they are mainly dependant on the cellulose that is obtained from plants. Hence pretreatment of the plant material with this particular bacterium would increase the amount of cellulose available for bioconversion to glucose thereby giving a net increase in the yield of bio fuels like bio-ethanol etc. thus making it both an environment friendly as well as cost effective method of pretreatment

Keywords: Heterogeneous, recalcitrant, lignin degradation, Canada balsam glue, specific gravity, lignin peroxidase, *Bacillus sp.*

1.0 INTRODUCTION

Lignin is the most structurally complex, recalcitrant, heterogeneous aromatic polymer of the plant cell wall. The bioconversion of plant lignocellulose to glucose is a pre requisite for second generation bio fuel production, but the resistance of lignin to breakdown imposes a major obstacle in this process, hence there lies a considerable interest in the microbial degradation of lignin. This study's main objective was to isolate a novel microbe from eucalyptus resin seeds, capable of degrading the heterogeneous aromatic polymer lignin. Bacterial identification was strictly based on the standard routine biochemical as well as the morphological tests. The bacteria were then inoculated in Canada balsam glue, to check whether it degraded lignin by observing any reduction in specific gravity. After a period of 7 days a reduction in specific gravity was observed. The specific gravity was 0.9847 initially, and after a period of 7 days it reduced to 0.9717 with a % of reduction of 1.3% i.e (final specific gravity after 7 days- initial specific gravity) ×100. This was followed by an enzymatic assay for the ligninolytic enzyme lignin peroxidase. The 16SrRNA gene sequence analysis was also carried out where in the bacterial strain capable of degrading lignin was therefore identified as *Bacillus sp*.

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2.0 OBJECTIVES

The aim of this study was to isolate bacteria from eucalyptus resin capable of degrading lignin. Lignin is well-known for resistance to microbial degradation because of its high molecular weight and its stability due to carbon-carbon and ether linkages. Moreover the partial degradation of lignin produces some aromatic monomers like ferullic and vanillic acids which are also of importance as they act as renewable resources for the synthesis of chemicals that are ideally derived from petroleum. Microorganisms that naturally degrade plant lignin are fungi, actinomycetes and to a very rare extent bacteria. The discovery of bacteria that can degrade lignin has attracted a considerable amount of interest as they are more tolerant to temperature, pH and oxygen limitation than fungi. The isolated bacteria were identified based on the standard routine biochemical and morphological tests. Gram's test showed Gram positive rod-shaped cells. Colony identification was then conducted. From the carbon source test, it was found that the isolated bacteria acquired nutrition both from starch and citrate. IMVICs test gave a positive result for citrate utilization test only. The isolated bacteria was inoculated into Canada balsam glue and incubated for 7 days, which showed a reduction in the specific gravity which indicated it degrades lignin. To confirm this, an enzymatic assay for lignin peroxidase enzyme was conducted and its concentration was found to be 0.25 microgram per ml. The 16SrRNA identification of bacteria was carried out and the isolated organism was found to be *Bacillus sp*. Thus we can conclude that we could successfully isolate the bacterial species capable of degrading lignin under standard laboratory conditions. This particular lignin degrading property makes this strain of bacterium important for second generation bio fuel producers. Treatment of the plant material with this strain would increase the amount of cellulose available for conversion to glucose biochemically and thus increasing the yield of bio-ethanol.

3.0 MATERIALS AND METHODS:

3.1 Isolation of bacteria from eucalyptus resin seeds:

The resin seeds of eucalyptus tree were immersed in 0.1% mercuric chloride solution & distilled water taken in a watch glass. The resins were teased gently and a loopful of this suspension was streaked onto nutrient agar (peptone-0.5%, beef extract-0.3%, sodium chloride-0.5%, agar-2.0%, distilled water, pH adjusted to 6.8) plates. After a period of incubation for 24 hours at 37°C bacterial growth was observed in the inoculated nutrient agar plates.

3.2 Characterization of the isolated novel microbe:

The morphological gram staining was carried out with the bacteria obtained on the nutrient agar plate and it was found out that the bacteria were gram positive in nature. A pure culture plate was also made and the bacteria from the pure culture plate were subjected to carbon source test comprising of citrate and starch giving positive results for both. The IMVIC tests were also carried out and the bacteria responded negatively to all except for citrate.

3.3 Study of lignin degradation:

The bacteria were then inoculated in Canada balsam glue to check for its property of lignin degradation by observing the specific gravity both at the beginning and after a period of 7 days. After a period of 7 days a reduction in specific gravity was observed. The specific gravity was 0.9847 initially, and after a period of 7 days it reduced to 0.9717 with a % of reduction of 1.3% i.e.,(final specific gravity after 7 days- initial specific gravity) ×100. Thus a substantial degradation was seen after 7 days indicating that the bacteria were capable of degrading lignin under standard laboratory conditions.

3.4 Biochemical Assay for *lignin peroxidase* enzyme:

The enzymatic assay of the ligninolytic enzyme lignin peroxidase was carried out to determine its concentration. Reactions contained 25 mM sodium tartrate buffer (pH 3.0), 2 mM veratryl alcohol, culture filtrate, and 0.4 mM H_20_2; activity was followed by the increase in absorbance at 310 nm because of the H_20_2-dependent oxidation of veratryl alcohol to veratraldehyde. The concentration of the enzyme lignin peroxidase was thus found to be 0.25µgm/ml.

3.5 16SrRNA for sample identification:

Lastly The 16S rRNA gene sequence analysis was also carried out where in the complete genomic DNA of the bacterial strain was extracted from pure culture in the following manner. DNA was isolated from the culture. Quality was evaluated on 1.0% Agarose gel, a single band of high-molecular weight DNA has been observed. Fragment of *16SrDNA* was amplified by PCR using **8F** and **1492R** from the above isolated DNA. A single discrete PCR amplicon band of 1500 bp was observed. The PCR amplicon was purified and further process for the sequencing. Forward and Reverse DNA sequencing reaction of PCR amplicon was carried out with **704F** and **907R** primers using BDT v3.1 Cycle sequencing kit on ABI 3730xl Genetic Analyzer. Consensus sequence of **1401 bp** *16SrDNA* was generated from forward and reverse sequence data using aligner software. The *16SrDNA* sequence was used to carry out BLAST alignment search tool of NCBI genbank database. Based on maximum identity score first Fifteen sequences were selected and aligned using multiple alignment software program ClustalW. Distance matrix was generated using RDP database and the phylogenetic tree was constructed using MEGA5.

4.0 RESULTS AND DISCUSSION:

For the identification of the novel microbe isolated from eucalyptus resin seeds, several biochemical & morphological tests were performed . Prior to that, a suspension of the resin seeds were made in 0.1% mercuric chloride solution & sterile water, after which a loopful of the suspension was streaked out in nutrient agar plates followed by incubation at 37°C for 24 hours. Bacterial growth was observed the very next day and microbiological gram staining was performed from which it was quite evident that bacteria was a gram positive bacilli. Several standard routine biochemical tests were also performed such as the IMVIC's test & the bacteria gave negative results for all except citrate. The starch & the citrate utilization test were also carried out to check for the carbon source & the bacteria responded positively to both. The bacteria were then inoculated into Canada balsam glue to check whether it degraded lignin by observing any reduction in specific gravity for a tenure of 7 days. After a period of incubation of 7 days a noticeable reduction in the specific gravity was successfully observed under standard laboratory conditions. The specific gravity was 0.9847 in the beginning and after a period of 7 days it reduced to 0.9717 with a % of reduction of 1.3% i.e., (final specific gravity after 7 days- initial specific gravity) ×100. thus indicating that the bacteria possessed the intrinsic ability of degrading lignin. This was followed by performing an enzymatic assay for the ligninolytic enzyme lignin peroxidase , the concentration of which was found to be 0.25µg/ml. Lastly The 16S rRNA gene sequence analysis was also carried out where in the complete genomic DNA of the bacterial strain was extracted from pure culture using an extraction kit according to the manufacturer's instructions. The culture, which was labeled as **Sample V** showed similarity with *Bacillus sp. DB14344* (GenBank Accession Number: KP670226.1) based on nucleotide homology and phylogenetic analysis. Information about other close homologs for the microbe can be found from the Alignment View table. Thus the bacteria were identified to be *Bacillus sp. DB14344 and its* lignin degrading property can be utilized for large scale industrial production of bio-ethanol in order to improve its yield by facilitating the degradation of lignin and making more cellulose available for bio-conversion to bio-ethanol. Moreover the partial degradation of lignin produces some aromatic monomers like ferullic and vanillic acids which are also of importance as they act as renewable resources for the synthesis of chemicals that are ideally derived from petroleum.

5.0 CONCLUSION:

Thus it could be concluded that the successful isolation of a novel microbe from eucalyptus resin seeds possessing the intrinsic ability of degrading lignin under standard laboratory conditions by means of the ligninolytic enzyme lignin peroxidase could be done. It is important to note that this lignin degrading property of *Bacillus sp*. can be utilized for improving the bio-ethanol yield in the industrial scale by pre-treating the plant biomass with this bacterium in order to make more cellulose available for bio-conversion. Moreover the partial degradation of lignin leading to the production of aromatic polymers that are industrially important for the production of chemicals that are conventionally derived from petroleum and these compounds being renewable and environment friendly in nature also cut down on the cost of production.

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Table 1: Sequence Producing Significant Alignments

Accession	Description	Max score	Total score	Query coverage	E value	Max ident
KR029800.1	*Bacterium* YTM085707	2588	2588	100%	0.0	100%
KT355719.1	*Bacillus* sp. BAB-5492	2588	2588	100%	0.0	100%
KP788033.1	*Bacillus cereus* strain CHE	2588	2588	100%	0.0	100%
LC068777.1	*Bacillus cerus*	2588	2588	100%	0.0	100%
KT152824.1	Bacterium mrs6-1	2588	2588	100%	0.0	100%
KT254642.1	*Bacillus* sp. BAB-5306	2588	2588	100%	0.0	100%
KT221490.1	*Bacillus* sp. BAB-5280	2588	2588	100%	0.0	100%
KP670226.1	*Bacillus* sp. DB14344	2588	2588	100%	0.0	100%
KR063194.1	*Bacillus cereus* strain BS14	2588	V2588	100%	0.0	100%
KR063181.1	*Bacillus cereus* strain BS1	2588	2588	100%	0.0	100%
JQ734552.1	*Bacillus* sp. 314SI	2588	2588	100%	0.0	100%
NR_115714.1	*Bacillus cereus* strain CCM 2010	2588	2588	100%	0.0	100%
NR_112630.1	*Bacillus cereus* strain NBRC 15305	2588	2588	100%	0.0	100%
KM817220.1	*Bacillus anthracis* strain IHB B 18203	2584	2584	100%	0.0	99%
KM251578.1	*Bacillus cereus* strain sm-sr14	2584	2584	100%	0.0	99%

Table 2: Distance Matrix

		1	2	3	4	5	6	7	8	9	10	11
SAMPLE V	1		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
KR029800.1	2	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
KT355719.1	3	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
KP788033.1	4	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LC068777.1	5	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
KT152824.1	6	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000
KT254642.1	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000
KT221490.1	8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000
KP670226.1	9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000
KR063194.1	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000
KR063181.1	11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

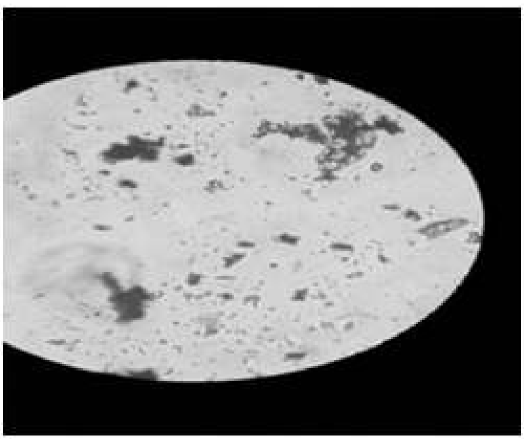

Fig1: Gram positive bacteria as seen under the microscope (45X objective)

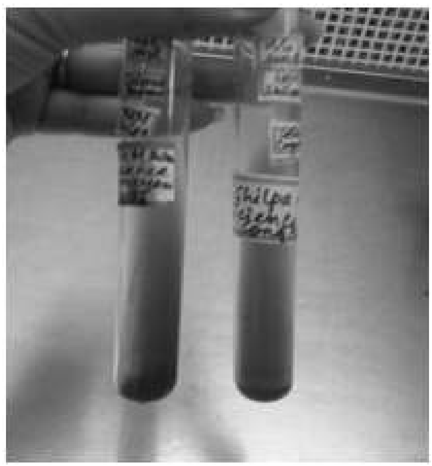

Fig2: Positive Citrate Test

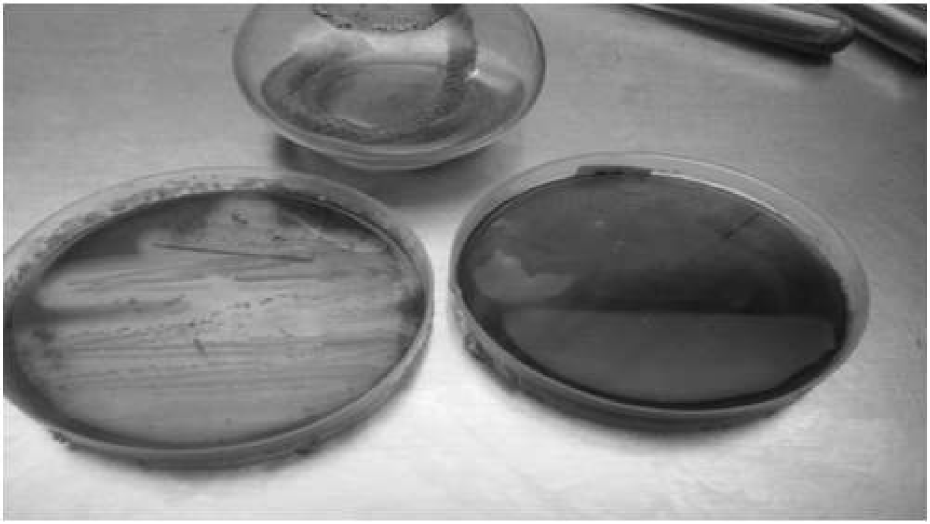

Fig3: Positive Starch Utilization Test

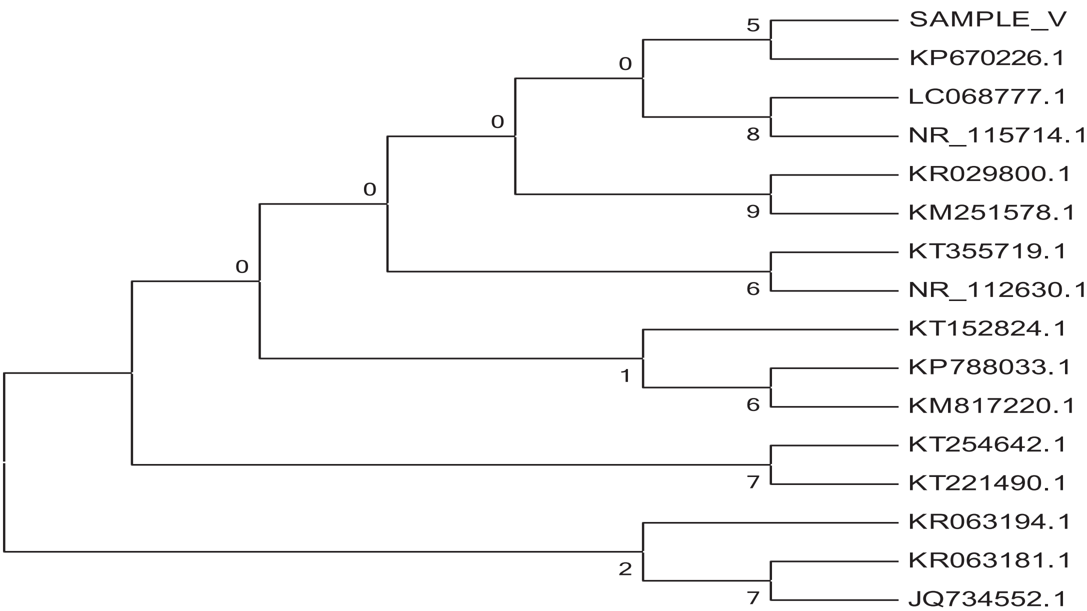

Fig4: Phylogenetic Tree

Review of common hazardous waste generated from educational institutions: Case study from plant DNA isolation protocol in undergraduate college laboratory

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Abstract:

Education and research-related institutions contribute to the generation of small quantities of waste, many of them hazardous. The amount of waste generated in academic institutions is small, less than 1% of the total generated nationally, waste in education institutions is considered heterogeneous, and may include highly toxic compounds. Academic institutions present different characteristics to those of industry, since the amounts of waste generated are smaller, diverse and distributed across various laboratories, manipulated by students in various situations that are not always supervised by trained individuals. The environmental ramifications of hazardous waste deplete natural resources and can contaminate people as well. The presence of hazardous waste in the environment is often the result of inadequate disposal. Effective control of such hazards involves both the recognition of each hazard and the development of control procedures. In a case study, common hazardous waste generated and their management methods during plant DNA isolation protocol in undergraduate college laboratory is reviewed. Work with deoxyribonucleic acid (DNA) is at the core of many of the hands-on activities in molecular biology and biotechnology that have been introduced into the undergraduate college or even in some high school biology laboratory. It appears that the key to managing hazardous wastes in secondary schools, colleges, and universities is to increase school administrators' and faculties' awareness of safety procedures and proper disposal methods for chemical wastes.

Keywords: plant DNA isolation, phenol chloroform, ethidium bromide, hazardous waste

1.0 Introduction

Academic institutions are different from most other generators of hazardous waste in several respects. The curricula and number of students at secondary schools, colleges, and universities differ, causing differences in the types and quantities of wastes generated by these institutions. Educational institutions generate waste streams that contain large varieties of chemicals, most in very small quantities (EPA, 2005). Most of what is used in university laboratories, albeit related to research or teaching at some point, can become hazardous. Educational and research institutions generate pollution because they produce harmful waste, discard hazardous materials in the sink, allow the evaporation of solvents, among other activities detrimental to the environment (Field, 1990). Examples are solvents, glassware, reagents, packaging of dangerous products, biological material, out of order, broken or obsolete equipments, broken thermometers, and outdated or obsolete computers. The amount of waste generated in academic institutions is small, less than 1% of the total generated nationally, waste in education institutions is considered heterogeneous, and may include highly toxic compounds. This puts educational institutions in a unique category, because they are required under Resource Conservation and Recovery Act (RCRA) to record and track each individual chemical once it becomes a waste. A number of academic institutions simply do not comply with the regulations, either because they are unaware of them or because they assume that the regulations do not apply to them. The level of awareness varies widely among academic institutions.

2.0 Material and Methods:

2.1 Objective: The prime objective of this paper is provide a review of common hazardous waste generated from educational institutions. In a case study, common hazardous waste generated and their management methods during plant DNA isolation protocol in undergraduate college laboratory is reviewed.

2.2. Materials: Most problems in hazardous waste management at educational institutions arise from the institutions' lack, of awareness about hazardous wastes and the applicable regulations; the transient nature of student populations; the highly variable waste streams generated, which contain multiple constituents; the insufficient resources available for hazardous waste management programs; the high cost and location of off-site treatment, storage, and disposal; and the difficulties in complying with the hazardous waste regulations.

2.3. Methods: Work with deoxyribonucleic acid (DNA) is at the core of many of the hands-on activities in molecular biology and biotechnology that have been introduced into the undergraduate college or even in some high school biology laboratory. Numerous methodologies have been developed for high-throughput and cost-effective extraction of DNA from plant tissues. These include rapid DNA extraction protocols specifically developed for plants, as well as methods applicable to both plant and animal tissues. In general, all methods involve disruption and lysis of the starting material followed by the removal of proteins and other contaminants and finally recovery of the DNA (Fig. 1). Removal of proteins is typically achieved by digestion with proteinase K, followed by salting-out, organic extraction, or binding of the DNA to a solid-phase support (either anion-exchange or silica technology). DNA is usually recovered by precipitation using ethanol or isopropanol. The choice of a method depends on many factors: the required quantity and molecular weight of the DNA, the purity required for downstream applications, and the time and expense. Gel electrophoresis is a technique used to separate DNA, RNA or proteins of different weights through a solid gel medium using electricity. The most commonly used stain for visualizing DNA is ethidium bromide. Ethidium bromide is a DNA intercalating agent commonly used as a fluorescent tag for nucleic acids, inserting itself into the spaces between the base pairs of the double helix. Ethidium bromide possesses UV absorbance maxima at 300 and 360 nm. Ethidium bromide is a sensitive, easy stain for DNA. It yields low background and a detection limit of 1-5 ng /band. The major drawback to ethidium bromide (EtBr) is that it is a potent mutagen. Solutions must be handled with extreme caution, and decontaminated prior to disposal. So the most commonly used plant DNA isolation methods use toxic and hazardous chemicals viz. phenol, chloroform, cetyltrimethylammonium bromide (CTAB), ethidium bromide.

2.3.1. CTAB method: One of the most commonly used methods to extract DNA from plants uses the ionic detergent cetyltrimethylammonium bromide (CTAB) to disrupt membranes and a chloroform-isoamyl alcohol mixture that separates contaminants into the organic phase and nucleic acid into the aqueous phase. However, many plants contain very high levels of secondary metabolites, including lipids, phenolic compounds, and viscous polysaccharides that can be difficult to remove without further processing, often with organic solvents, such as phenol or other toxic compounds.

2.3.2. Phenol: Chloroform Extraction: Phenol: Chloroform Extraction is a common laboratory technique used to separate proteins from nucleic acids. An equal volume of phenol: chloroform (50:50) is added to a nucleic acid sample. The mixture is centrifuged to separate the organic and aqueous phases. The organic phase is discarded. Ethyl ether is sometimes used to remove traces of chloroform. This is an alternative to the CTAB method that uses organic solvents to extract contaminants from cell lysates. The cells are lysed using a detergent, and then mixed with phenol, chloroform, and isoamyl alcohol. The correct salt concentration and pH must be used during extraction to ensure that contaminants are separated into the organic phase and that DNA remains in the aqueous phase.DNA is usually recovered from the aqueous phase by alcohol precipitation. The process also generates toxic waste that must be disposed of with care and in accordance with hazardous waste guidelines. The Case study for this paper is from a plant DNA isolation protocol in undergraduate college laboratory following this method.

3.0 Results: Different protocols may be followed for plant DNA isolation process. In the **case study** the most widely used Phenol: Chlroform Extraction for Plant DNA isolation has been reviewed and hazardous wastes generated are noted. There are different steps in different protocols. Each process generates different kinds of waste among which some are hazardous. Several chemicals both solid as well liquid are used in the plant DNA isolation protocols which in turn generate waste of which many are hazardous.

3.1 Hazards of using Phenol and Chloroform: Phenol and its vapors are corrosive and hazardous to the eyes, the skin, and the respiratory tract. Long-term or repeated exposure of the substance may have harmful effects on the liver and kidneys. Phenol is rapidly absorbed through the skin so toxic amounts may be absorbed through relatively small areas.Chloroform is a skin and eye irritant, and it is a suspected human carcinogen and reproductive hazard. It is harmful if swallowed. Chloroform is irritating to eyes, respiratory system and skin. It poses danger of serious damage to health by prolonged exposure through inhalation and if swallowed. Over pressurized containers of chloroform are potentially explosive. Adding chloroform to phenol enhances the ability of phenol to be absorbed by the skin. This method uses hazardous organic solvents, is relatively time-consuming, and residual phenol or chloroform may affect downstream applications such as PCR.

3.2 Hazards of using ethidium bromide (EtBr): Ethidium bromide is a potent mutagen and is an irritant to the eyes, skin and respiratory tract. Ethidium bromide can be absorbed through exposed skin and mucus membranes. While it is not regulated as dangerous waste, the mutagenic properties of this substance may present a hazard when poured down the drain or placed in the trash. Contaminated laboratory items which are used for the plant DNA isolation process that includes disposable gloves, pipettes, test tubes, etc., become contaminated with ethidium bromide. These items need proper disposal ((Lunn and Sansone, 1987).

3.3. Other common hazardous wastes: Both liquid and solid hazardous wastes generated after the plant DNA isolation process are listed in Table 1. Some highly hazardous ones are listed below.

Hydrochloric Acid is a corrosive chemical.

Phenol is a toxic and corrosive chemical and a suspected carcinogen.

Sodium Dodecyl Sulfate (SDS) is harmful if inhaled or ingested.

Sodium Hydroxide is a corrosive chemical and has mutagenic properties.

Ethidium bromide (EtBr) is a mutagenic chemical and a suspected carcinogen.

8-Quinolinol is irritating to the eyes and skin.

4.0 Discussion:

One of the basic responsibilities of any laboratory worker is to positively identify all hazardous waste being generated in the laboratory (Lunn and Sansone, 1994; Armour, 2003). Once hazardous wastes are identified, the lab must properly containerize, segregate, label, and store the waste until it is disposed. Industrial laboratories have a reputation for being more aware of safety than academic laboratories (Sanders 1986). Universal precaution procedures will be used at all times. Personal Protective Equipment (PPE) such as gloves, glasses and a laboratory coat will be worn during collection and manipulation of samples. Some other hazardous waste disposal procedure following plant DNA isolation protocol in undergraduate college laboratory is discussed below.

4.1. The immediate area of the DNA isolation procedure and all pipettes and centrifuges used in this procedure will be wiped down with a 1% sodium hypochlorite solution followed by 70% alcohol to remove the sodium hypochlorite. All pipette tips will be immediately discarded into a semi-rigid container after use. Liquid waste will be diluted with bleach to create a 1% sodium hypochlorite final solution that will stand for 10 minutes before being poured down the drain. The beaker containing the liquid waste will be washed using a 1% sodium hypochlorite solution.

4.2. Pipettes and other disposable glassware contaminated with ethidium bromide should be disposed of in the waste container designated for glass disposal. Grossly contaminated glassware may be washed in water before disposal and the rinsate treated with bleach and disposed in sewers.

4.3. Test tubes and centrifuge tubes contaminated with ethidium bromide should first be emptied, with the liquid disposed according to the appropriate procedure. Empty tubes can then be disposed in the normal trash. Grossly contaminated glassware can be soaked in water prior to disposal and the rinsate treated with bleach and disposed in sewers.

4.4. Needles, spatulas and other sharps contaminated with ethidium bromide should be disposed of directly into the sharps container.

4.5. Disposal of Electrophoresis Gels : Trace amounts of EtBr in electrophoresis gels should not pose a hazard. Higher concentrations (i.e., when the color of the gel is dark pink or red) should not be placed in laboratory trash. Ethidium bromide gels should be collected in double wrapped plastic bags.

Excess buffer should be removed before wrapping or absorbed into paper towel.

4.6. Disposal of Contaminated Gloves, Equipment and Debris: Gloves, test tubes, paper towels, etc., that are contaminated with more than trace amounts of EtBr should be placed in sealed bags and labeled for disposal similar to dangerous wastes.

4.7. Disposal of Alcohols Alcohols, such as ethanol, methanol and isopropanol, are common organic solvents used in labs. All are flammable liquids and are regulated as ignitable dangerous waste at concentrations above 24 percent in water. Additionally, methanol and isopropanol are category D toxic dangerous wastes under the Dangerous Waste Regulations at a concentration above 10 percent in water. Alcohol solutions that characterize as dangerous wastes are prohibited from discharge to the sewer. Ashbrook and Reinhardt (1985) stated that no matter what quantity of hazardous waste is generated, it is the responsibility of educational institution to train their students in proper management techniques when dealing with chemicals. Health and safety programs could publicize the hazards associated with chemicals and aid in waste reduction and disposal programs. Laboratories also tend to generate a relatively small volume of hazardous waste and many different waste-streams at each of these points of generation. In contrast, industrial generators tend to generate only a few waste-streams in large quantities at relatively few generation points. Additionally, while most individuals involved in hazardous waste generation activities at both industrial production facilities and other non-college or university laboratories are employees who are professionally trained in managing hazardous wastes, students often generate hazardous waste at college and university laboratories. Further contrast exists between the transient nature of students in a college or university laboratory settings and the relative stability of employees in a commercial production or other non-academic laboratory. Therefore, any teaching and research institution committed to its employees' and students' health must consistently uphold the laws related to workers' chemical safety, and laws on management of hazardous waste released by its laboratories (Davies *et al*, 1996). In addition to proper hazardous waste disposal or, if necessary, remediation of contaminated sites, it is important to minimize the production and impact of hazardous wastes and to recover and recycle resources where feasible. Each laboratory should develop or adopt a biosafety or operations manual that identifies the hazards that will or may be encountered, and that specifies practices and procedures designed to minimize or eliminate exposures to these hazards. Personnel should be advised of special hazards and should be required to read and follow the required practices and procedures. A scientist, trained and knowledgeable in appropriate laboratory techniques, safety procedures, and hazards associated with handling the different experimental protocols must be responsible for the conduct of work.

5.0 Conclusion:

Safe laboratory practices are an important element in the responsible conduct of research. They protect scientists, research assistants, laboratory technicians and student from hazards that can arise during experimentation. It appears that the key to managing hazardous wastes in secondary schools, colleges, and universities is to increase school administrators' and faculties' awareness of safety procedures and proper disposal methods for chemical wastes. Teachers, professors, and instructional and other personnel at all levels of education who handle hazardous waste should be instructed in the proper methods of hazardous waste handling and disposal, recordkeeping, and hazardous waste reduction. This instruction should occur both as a part of original training to qualify to teach or to perform a job and also in any continuing education courses. In conclusion, the implementation of constant training of college and university teachers along with the students with regard to safety in the use, storage and disposal of dangerous products used in laboratories of educational institutions is the key to minimize the effect of hazardous waste.

Acknowledgement

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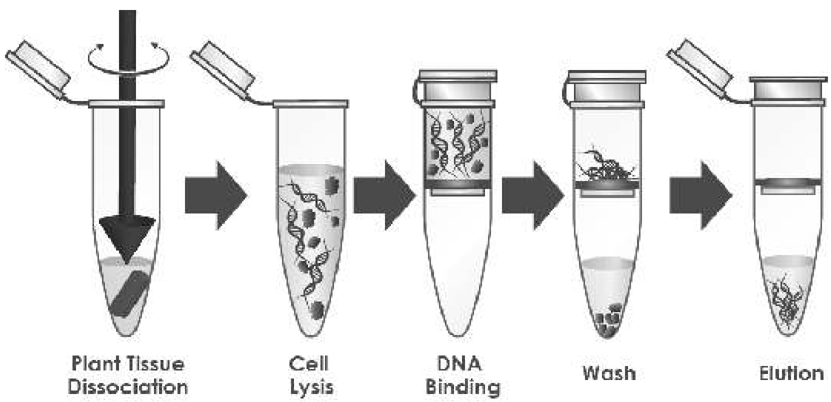

Fig. 1. Basic steps in plant DNA isolation protocol

Table 1. Types of Hazardous wastes generated in laboratories in educational institutions after plant DNA isolation protocol.

Sl. No.	Type of Hazardous Wastes	Examples
1	**Typical Liquid Hazardous Wastes**	• Organic synthesis liquid
		• Liquid solvent waste
		• Sample vials containing liquids for digestion, extraction, or preservation
		• Waste liquids associated with DNA extraction and cell lysis
		• Specimen preservatives (Formalin, formaldehyde, paraformaldehyde, alcohol, etc.)
		• Unused portions of laboratory reagents which are no longer needed
		• Laboratory reagents which have been left behind or abandoned by previous users of the lab
2	**Typical Solid Hazardous Wastes**	**4.0** Gloves used to protect workers when handling hazardous chemicals
		5.0 Absorbent or adsorbent materials used in chemical processes
		6.0 Weighing boats or papers used with chemical reagents
		7.0 Slides which have been used with or contaminated with hazardous chemicals
		8.0 Paper towels, rags, vermiculite or “kitty litter” used to clean up chemical spills
		9.0 Disposable pipette tips used to measure or transfer chemicals
		10.0 Filters and ion exchange materials used during chemical processes
		11.0 Electrophoresis gels containing Ethidium Bromide

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A Model of Oil Spilling on Sea Surface

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Abstract

Different marine oil tankers in different times get crushed in the different sea. The big hazard on the marine life is due to spill off oil on the sea surface. The aim is to concentrate our focus on this kind of catastrophes. Study of oil spilling problem to know the impact of it on marine life is very essential. In this research work a model is developed to understand its spreading effect with time and space. The effects are also represented graphically.

1.0 Introduction

Oil spill is the release of liquid petroleum hydrocarbon into the environment especially into sea. Oil spill has devastating impact on marine life. Collapse of oil tanker in 2010 in Mexico gulf [1] is a vivid example of that disaster. There are different incidents like that. Marine habitats are badly affected due to this problem. Even it mutates several marine lives. Damage of fishing industry creates indirect but big effect on the surrounding locality. Study on oil spill problem is very important in this respect. The oil spill problem can be modelled as the diffusion of oil in the water. In this piece of research work a model is developed mathematically to observe the spreading of oil on the surface of sea. Effect of degradation and evaporation has also taken into account. Spreading of oil with time is plotted graphically to illustrate the effect.

2.0 Objective:

The objective of this work is to study of oil spilling problem to know the impact of it on marine life. In this research work a model is developed to understand its spreading effect with time and space such that any agency can estimate the time for removing surface oil from a water body.

3.0 Materials and Method :

The oil spill model is built mainly considering the diffusion effect. The running water of sea exerts driving force on the system. Considering the effect that the flow in two directions i.e. along x (horizontal) and y (transverse) are not same, the diffusion coefficients are also different. It is also assumed that the rise of oil is instant making the spread along z axis irrelevant. Rate of bio degradation and evaporation are taken as constant for the time being. Source of oil is constant at a specific position. There are many more effects like sedimentation, emulsification, dissolution, dispersion which are not taken into account to simplify the problem.

Considering these facts the partial differential equations [2,3] can be written as

$$\frac{\partial \psi}{\partial t} = D_1 \frac{\partial^2 \psi}{\partial x^2} + D_2 \frac{\partial^2 \psi}{\partial y^2} + k_1 \psi + k_2 \psi$$

(1)

Where,

$k_1+k_2=k$ (2)

Ψ is oil concentration function. D_1 and D_2 are two diffusion constants along x and y respectively. Considering greater flow along x direction D_1 is greater than D_2. k_1 is the proportionality constant due to bio degradation of oil and k_2 is that for evaporation of oil.

The initial and boundary conditions are as follows,

$\Psi(x, y, z, t=0) = \delta(x)\,\delta(y)$ (3)

$\Psi(x=\infty, y, t) = 0$ (4)

$\Psi(x, y=\infty, t) = 0$ (5)

Meaning is that, initially, the oil concentration is infinity. i.e. there is no mixing with water and at infinite distance oil concentration is zero.

4.0 Results and Discussion :

The solution analytically, [4,5]

$$\psi = \left(A_1 e^{-kx/D_1} - c_1\right) + \left(A_2 e^{-ky/D_2} + B_2 e^{ky/D_1}\right)\left(e^{-k_3 t} + c_2\right) + D$$

(6)

Where, A_1, A_2, B_2, c_1,c_2 and D are different integration constants and they are to be determined by boundary conditions and feasibility of the problem. The concentration of oil can be plotted graphically using Eq. (6).

Fig. (1) shows the initial plot of concentration of oil that is just spilled out. The plot shows the effect that at t=0 the oil is totally concentrated at the point x = y = 0. The concentration height is infinity. Initially, the oil has not mixed with water.

Fig. (2) is the plot of Eq.(6). Two graphs A and B are merged in this figure to compare the concentration of oil after 2 weeks and 5 weeks. A and B represents spreading of oil after 2 and 5 weeks respectively.

This figure indicates that the spreading is greater in the x direction than that in y direction. Diffusion rate is high along x direction. It can be noticed that after 5 weeks spreading is higher than that in 2 weeks. As the oil diffuses the concentration height becomes lower.

5.0 Conclusion

A model on spilling of oil is developed. This simplified model describes the spreading of oil in different intervals. The work is based on different assumption. Many effects are not taken into account. In future there is opportunity to add other forces and reactions terms to obtain real life model.

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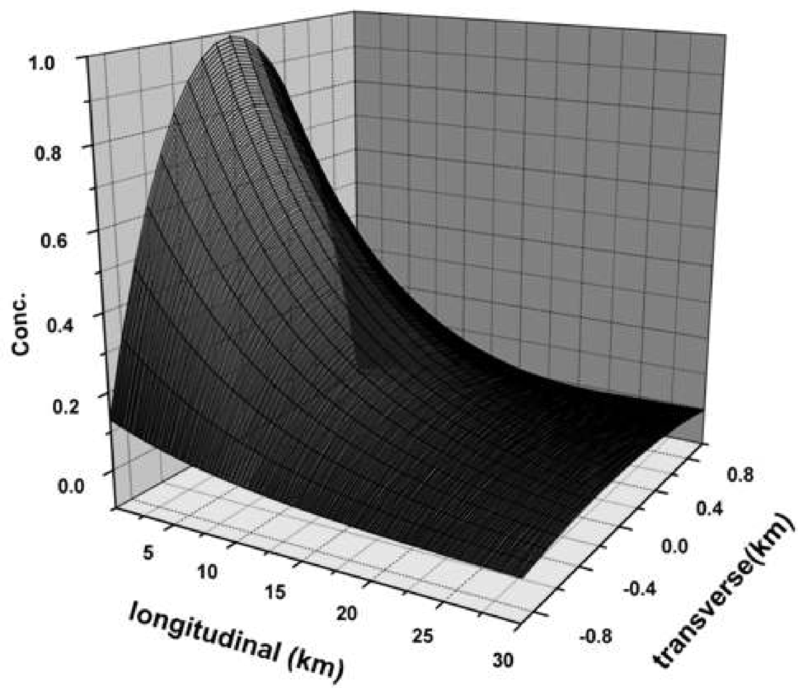

Fig1. Initial distribution of pollutant oil

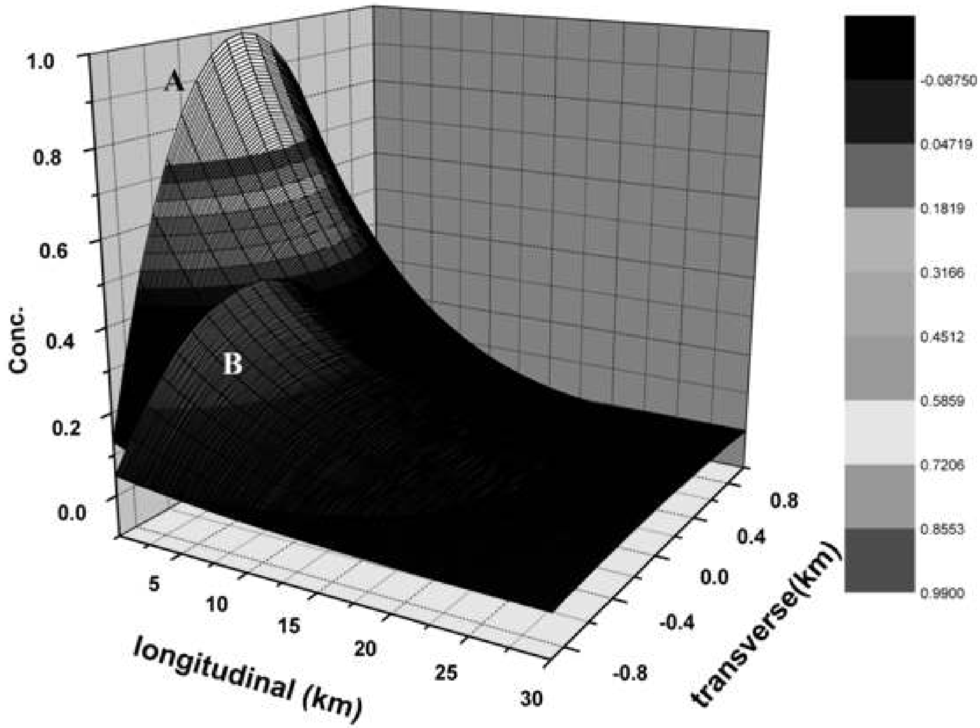

Fig.2. Concentration of oil with distance (A) after 2 weeks (B) after 5 weeks

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Pollution State of a Lake: An Analytical Model

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Abstract

A lake is a water body with sweet water and has many inlets and outlets. The pollution level of a lake depend s on concentration and nature of the pollutant of incoming water source and the rate of the outlet of the water.

In this work a mathematical model is developed on recently available data to study the variation of concentration of pollution with time. This work indicates a possibility of lake death. The study also includes the level of concentration of incoming water to prevent the lake death.

1.0 Introduction

The impact of a water body in our environment is multidimensional. The water body makes many effects on atmosphere, economy and the lifestyle of the people surrounded it. Fishing, supply of water for drinking and other works, local water ways transport, industry and in some cases irrigation system of the surrounded area depends on the sweet water lakes. In this respect a sweet water lakes are very precious to our ecosystem.

Health of a lake depends on several parameters like BOD, COD, volume of the water, area of water surface and the concentration of the pollutant. There are several types of pollutant which may flow into the lake depending on the industry and the nature of the agriculture surrounded. Some pollutants coming from agricultural are flow into the lake. Among them, DDT cannot be removed by deposition or degradation. It can be removed only by flowing by outlet streaming. Some pollutant from industrial area may be removed by deposition. Pollutant like gypsum, plaster board dust [1] may be removed by degradation. The overall concentration of pollutant is sum of concentration of all different pollutants. Here a model is introduced to study the pollution effect of a sweet water lake.

2.0 Objective:

A mathematical model is developed on recently available data to study the variation of concentration of pollution with time. This work attempts to provide a graphical view of the life of a lake .

3.0 Materials and Method :

The model

A model is the theoretical and scientific study of a real situation. In this paper a model is presented which mimics the relevant features of a polluted lake. Here, it is assumed that the lake has some inlets and outlets. Main cleanup process of the lake is the natural process. Pollutants may be replaced through running water from inlet to outlet. Natural decay process of the pollutant is also important in the model. The decay is assumed as exponential. There are many other factors like sedimentation which are omitted for the time being to simplify the model. Here it is also assumed that the rainfall and evaporation balance each other so that the average rates of inflow and outflow are equal. Another important thing is considered that the pollutants are uniformly distributed in the lake.[2]

By these assumptions net change of pollutants during the time interval ? t is

$$\Delta(VP_l) = (P_l - P_i)r\Delta t \tag{1}$$

Where, V is the volume of water, r is rate of flow, P_l is pollution concentration in the lake. P_i is the pollution concentration in the inflow to the lake. P_l has two parts. One is P_d, which is decaying part of the pollutant. Other is P_n, which represents non decaying part of the pollutant. ? t is the interval of time and ? is the decay constant.

$$P_l = P_d e^{-\lambda t} + P_n \tag{2}$$

Dividing Eq. (2) by ? t and letting ? t approaches to zero, Eq. (3) can be written as,

$$V\frac{d}{dt}\left(P_d e^{-\lambda t} + P_n\right) = \left(P_d e^{-\lambda t} + P_n - P_i\right)r \tag{3}$$

4.0 Results and Discussion :

Eq. (3) is the differential equation for the lake problem. Solving [2] Eq. (3) it can be written as,

$$P_n(t) = \frac{C_0}{r} - P_{n0}e^{\mu t} - \frac{C_1}{r+\lambda V}e^{\lambda t} \tag{4}$$

Or,

$$P_n(t) = C_2 - P_{n0}e^{-\mu t} - C_3 e^{-\lambda t} \tag{5}$$

Where,

$$C_2 = \frac{C_0}{r} \quad and \quad C_3 = \frac{C_1}{r+\lambda v} \tag{6}$$

$$\mu = r/v \tag{7}$$

P_{n0} is the initial condition of the pollutant in the lake at t = 0. μ is the characteristics time to remove pollutant from the lake. C_0 and C_1 are the integration constants.

First part of the Eq. (4) represents a constant level of the pollutant remaining in the lake. Second term is about the flow through which pollutants are removed from the lake. Third part represents the natural decay of the pollutant.

To keep the pollution of the lake under control it is necessary to increase the rate of flow of water through the inlet of the lake. It is also important to increase the volume of water of the lake. Hence the pollutants will be removed gradually with time. After a certain time lake will be more or less pollution free. However, if the rate of incoming pollutant through inlet channel is greater than the rate of pollutant removed from the lake, second term will be positive and the lake will be damaged. If this is going on after a certain time lake will be 'dead'.

Two cases are studied here using different parameters to show two types of chances that may occur in reality.

Case I

Using the parameters, $C_2 = 0.3$, $P_{n0} = 0.1$, $r = 1/10$ in Eq. (5), Fig.(1) is drawn. Fig. (1) shows the concentration of pollutant in the lake with time. With this data pollution state of the lake can be viewed. After reaching a peak of concentration of pollutant it has normally die out with time.

Case II

Using the parameters, $C_2 = 0.5$, $P_{n0} = -0.1$, $r = 1/10$ in Eq. (5), Fig.(2) is drawn. It shows that pollutants increases nonlinearly with time and remains almost constant. The removal of pollution with water flow is somehow hindered in this case. So the lake becomes 'dead'.

5.0 Conclusion

A model is built to study the pollution of a lake. It is shown that, if properly planned a lake can be saved from the pollution. Pollution can be taken under control even after reaching a high peak. High rate of flow of water, wide outlet, bio degradation, sedimentation methods are very important in this respect. It is also shown that, If proper maintenance is not taken a lake may be 'killed'. The study of water pollution is very important in the developing countries. There remains a huge chance of study of these kinds of problems incorporating much more natural effects to obtain the solution more realistic.

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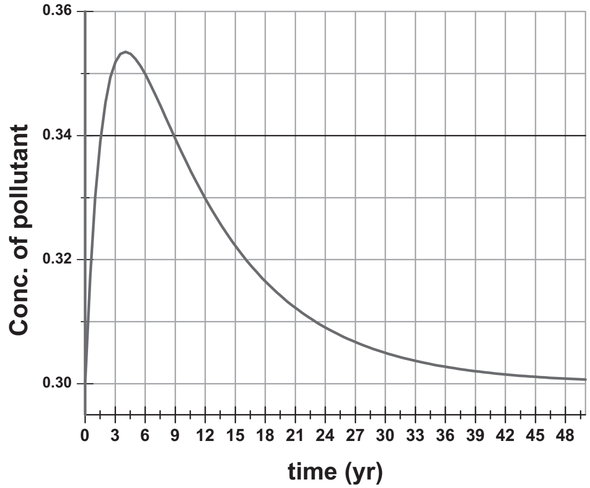

Fig. 1 Concentration of pollutant with time for the parameters C_2 = 0.3, P_{n0} = 0.1, r = 1/10.

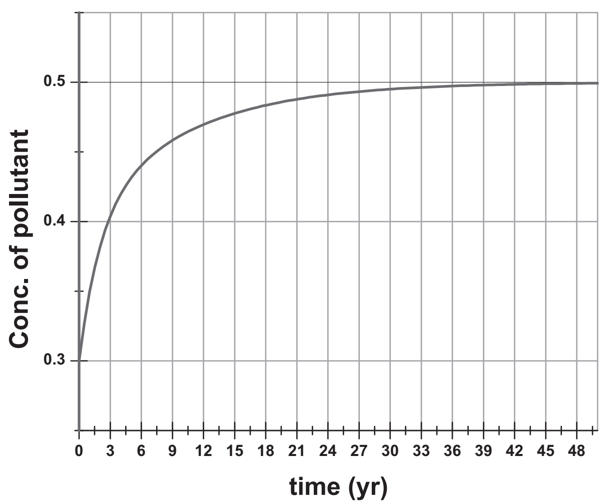

Fig. 2 Concentration of pollutant with time for the parameters C_2 = 0.5, P_{n0} =- 0.1, r = 1/10.

Waste to Wealth: Production of Industrially Important Polymer Chitosan From Tannery Waste by Microbial Fermentation of Rhizopus oryzae

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Abstract

Fleshings waste generated from the leather industry pose serious threat to the environment and are toxic to plants and animals. Hence there is an urgent need for the leather industries to develop eco friendly solutions to utilize or reuse the wastes. Collagen based protein hydrolysate can be recovered by processing these fleshing wastes. Collagen Hydrolysate, represents a good nitrogen and carbon source was prepared from fleshing waste and used as a media for growth of *Rhizopus oryzae* for the purpose of preparation of chitosan from the fungal biomass. Chitosan has been isolated from *Rhizopus oryzae* cultured in three different media namely Yeast Collagen Hydrolysate Glucose media (YCHzG) procured from HiMedia, Yeast Collagen Hydrolysate Glucose Media prepared from fleshings and Yeast Protein Hydrolysate Glucose Media prepared from fleshings and their yield is found to be 0.733g/l, 0.581g/l, 0.479g/l respectively .The respective growth curves show similar pattern of growth in all the three media. The FTIR spectrum of the prepared chitosan compared to that of Sigma chitosan used as reference gave similar patterns of band. Hence it can be concluded that the product obtained was pure chitosan.

1.0 Introduction

Collagen is the protein that predominates in fleshing wastes. Chrome and collagen based protein hydrolysate can be recovered by processing chrome shavings, fleshings, splits and trimmings. Collagen is the most predominant protein which is found in the adipose tissue of animal skin or hide. During the process of manufacturing of leather, this epidermis or adipose layer is removed. This leads to the production of large amount of solid waste called fleshings. It is from such tannery waste that collagen biopolymers can be recovered. Chitosan (β-1,4-D-glucosamine) can be derived by deacetylation of chitin. Chitin is the second most abundant polysaccharide in the world after glucose and is found largely in the exoskeleton of crustaceans, insects and also in the cell wall of certain fungi of the zygomyetes group. Chitosan being hydrophilic, biodegradable and antimicrobial finds numerous applications such as in pharmaceutical industries, in food preservation, agriculture, water purification, and also in cosmetic industries.

Commercially chitosan is prepared by deacetylation of crustaceans with strong alkali. But this has limited potential because of the limited supply and other uncertainities. However, production of chitosan is possible under controlled environment by using easily cultured fungal strains. This process of extraction of chitosan from fungal cell wall is simpler, produces less waste and is environment friendly.

In this research, Collagen Hydrolysate, representing a good nitrogen and carbon source was prepared from fleshing waste and used as a media for growth of *Rhizopus oryzae* for the purpose of preparation of chitosan from the fungal biomass. Chitosan has been isolated from *Rhizopus oryzae* cultured in three different media namely Yeast Collagen Hydrolysate Glucose media (YCHzG) procured from HiMedia, Yeast Collagen Hydrolysate Glucose Media prepared from fleshings and Yeast Protein Hydrolysate Glucose Media prepared from fleshings and their yield is found to be 0.733g/l, 0.581g/l, 0.479g/l respectively .The respective growth curves show similar pattern of growth in all the three media. The FTIR spectrum of the prepared chitosan compared to that of Sigma chitosan used as reference gave similar patterns of band. Hence it can be concluded that the product obtained was pure chitosan.

2.0 Materials And Methods

2.1: Objective: The objective of the research was to isolate Chitosan from *Rhizopus oryzae* cultured in three different media namely Yeast Collagen Hydrolysate Glucose media (YCHzG) procured from HiMedia, Yeast Collagen Hydrolysate Glucose Media prepared from fleshings and Yeast Protein Hydrolysate Glucose Media prepared from fleshings. Furthermore the Chitosan thus obtained from the respective media were compared to that of Sigma chitosan used as reference so as to conclude that the product obtained was pure chitosan.

2.2: Methodology :

2.2.0: Organism and cultivation: *Rhizopus oryzae* (MTCC 262) used in the study was donated by Dr Sujoy Das, CLRI-Chennai, India and maintained on potato dextrose agar slants at 4°C.All cultures were subcultured on PDA plates, and incubated at 27°C for 2 days whenever required.

2.2.1:Fermentation medium:

The following media were used to study the growth and production of chitosan from *R. oryzae*.

I. Yeast Collagen hydrolysate Glucose medium 1(YChG1): This medium contains yeast extract 0.2%, collagen hydrolysate 1%, glucose 1%.

II. Yeast Collagen hydrolysate Glucose medium 2(YChG2): This medium contains yeast extract 0.3%, collagen hydrolysate 1%, glucose 2%.

III. Collagen Hydrolysate Salt Medium1 (M1): This medium contains glucose 0.5%, K_2HPO_4 0.1%, $MgSO_4.H_2O$ 0.02%, $CaCl_2$ 0.01%, Collagen hydrolysate 1%.

IV. Collagen Hydrolysate Salt Medium2 (M2): This medium contains glucose 0.5%, K_2HPO_4 0.1%, $MgSO_4.H_2O$ 0.02%, $CaCl_2$ 0.01%, Collagen hydrolysate 2%.

All the above mentioned media had a constant pH of 5.

- The growth of Rhizopus oryzae in all the respective media were observed after 48 hrs.

2.2.2: Growth of *Rhizopus oryzae*:

To determine the growth curve of *Rhizopus oryzae* in different media, flasks containing the constituted media (50ml)were inoculated with 2 mycelium covered agar disc with the help of a cork borer and incubated at 27°C upto 72 hrs under submerged condition (50 rpm).The growth of *Rhizopus oryzae* were observed at 8 different time points *ie*. 6 hrs, 18hrs, 24hrs, 30hrs, 42hrs, 48 hrs, 60 hrs and 72 hrs respectively. After the stipulated time the mycelia were harvested by filtering using Whatman No. 1 Filter Paper. The filtered bio mass was washed thoroughly with distilled water and oven dried for 2-3 hours after which the individual weights of the dried biomass were taken. For the accuracy of the results average of two replicating experiments were taken to generate each data point.

2.2.3: Preparation of Collagen Hydrolysate from fleshings:

Fleshings waste collected form tannery was washed thoroughly with water(200% w/v) and cut into small pieces. Then they were washed with 3% acetic acid. The acetic acid washing was done to remove alkaline substances. After washing, the collagenous part was separated from the non collagenous part and kept separately in a conical flask (500 ml) and autoclaved at 120°C at 15psi for 30mins.The Protein Hydrolysate was obtained in liquid state which was allowed to cool. Contaminated lipid was removed by centrifugation at 5000rpm for 15 min. Lastly the lipid free solution was lyophilized using a Biobase (Model no. BK-FD10P) lyophilizer to obtain powder form of Collagen Hydrolysate and Protein Hydrolysate respectively.

2.2.4: Preparation of inoculums and production of Chitosan:

Inocula were prepared by growing the organism in potato dextrose agar (PDA) plates at 27°C for 2 days. Flasks containing the media(50ml) were inoculated with the help of a cork borer and incubated at 27°C for 2 days under submerged condition(50 rpm).After 2 days the mycelia were harvested by filtering using Whatman No. 1 Filter Paper. [Chatterjee et al.,2004].The mycelia were harvested after 48 hrs and homogenized using mortar pestle with 1N NaOH (1:40 w/v) and were further autcolaved at 121° C for 15 min. The Alkali Insoluble Mass(AIM) was filtered and the pH was made neutral by washing thoroughly with water followed by ethanol. The product was refluxed with 100 volumes of 2.5% AcOH for 24 hrs at 100°C and further centrifuged at 12,000 rpm for 15mins.Chitosan was precipitated out from the supernatant, washed several times with water and the pH was adjusted to 8.5 with 1N NaOH. Lastly the product obtained was powdered Chitosan after titurating with acetone. In this way Chitosan was prepared from the mycelia obtained using commercial Collagen Hydrolysate (Hi-Media), Collagen Hydrolysate and Protein Hydrolysate prepared from fleshing waste.

2.2.5: Charaterization of Chitosan:

For the charaterization of chitosan, FT-IR spectra of the chitosan prepared using HiMedia Collagen Hydrolysate and that of the chitosan using the two prepared media were observed taking the spectra of Sigma chitosan as reference.

3.0: RESULTS

3.1: Selection of media: The dry weights of the fungal biomass cultured in the respective media were taken. The dry weight of the fungal biomass cultured in Yeast Collagen hydrolysate Glucose medium 2 after an incubation period of 48 hrs were found to be 0.2202 g, whereas that of the fungal biomass after an incubation period of 48 hrs cultured in Yeast Collagen hydrolysate Glucose medium 1, Collagen Hydrolysate Salt Medium1, Collagen Hydrolysate Salt Medium2 were found to be 0.1984 g, 0.1669 g & 0.1928 g respectively.

For each media, 2 replicates were maintained and the average of their dry weights were calculated.

From the dry weights of the fungal biomass cultured in the respective media used for initial screening, it is evident that Yeast Collagen Hydrolysate Glucose media 2(YCHzG2) having a composition containing yeast extract 0.3%, collagen hydrolysate 1%, glucose 2% is the best suitable media yielding maximum dry mass of the fungal biomass. Hence the media YCHzG2 was selected for the present research.

3.2: Growth curve of *Rhizopus oryzae:* The suitability of Yeast Collagen Hydrolysate Glucose medium (YChG2) for growing *Rhizopus oryzae* was studied by growing the fungus in media containing commercially available collagen hydrolysate purchased from M/s Hi-Media taken as reference, and collagen hydrolysate and protein hydrolysate prepared from fleshings waste. The results indicated that the prepared collagen hydrolysate and protein hydrolysate can serve as a media and can bring about growth in microorganism in an almost similar rate as in commercially available collagen hydrolysate.

The growth curve of *Rhizopus oryzae* in collagen hydrolysate procured from HiMedia is initially slow upto 24 hrs, then it rapidly speeds up and reaches its maximum at 48 hrs. Maximum 0.25 grams of dry biomass was obtained from 50 ml of fermentation medium. However, growth is relatively slow for the other two medium prepared from fleshing waste, but maximum 0.1973 grams and 0.1593 grams were observed at their optimum growth time(48 hrs). It is relevant from their growth curves that the growth of *Rhizopus oryzae* shows similar pattern in the prepared media as compared to the commercially available media.

The Growth of *Rhizopus oryzae* as a function of time using HiMedia Collagen Hydrolysate compared with Collagen Hydrolysate prepared from tannery waste and Protein Hydrolysate prepared from tannery waste is given in Fig1.

3.3: Preparation of Collagen Hydrolysate and Protein Hydrolysate from fleshings :

Collagen Hydrolysate and Protein Hydrolysate was prepared from fleshings waste following the procedures as stated earlier. The products were weighed to derive an idea of the amount of product that can be obtained per grams of the wet weights of fleshing waste. From the findings it can be inferred that 15 g of Collagen Hydrolysate was obtained from approx. 50 g of collagenous waste separated from fleshings waste and about 8 g of Protein Hydrolysate was obtained from approx. 30 g of fleshings waste (other than colagenous waste).

The findings are attached in tabular form in **Table 2.**

3.4: Preparation of Chitosan :

Chitosan was prepared following the procedures as stated earlier. During the process, the respective weights of the alkali insoluble mass and that of the prepared chitosan were taken in order to obtain an idea about the yield of chitosan.

It was observed that 0.733 grams of chitosan has been isolated from about 1000 ml of commercial Collagen Hydrolysate media procured from HiMedia. The amount of chitosan that was obtained from about 1000 ml of prepared Collagen Hydrolysate and Protein Hydrolysate media was 0.581 grams and 0.479 grams respectively. It was observed during isolation of chitosan from the dry *Rhizopus oryzae* biomass using collagen hydrolysate from HiMedia that about 23% of the total biomass was converted into Alkali Insoluble Mass (AIM) and yield of chitosan is about 70% of the AIM indicating that the produced chitosan consists of about 16% of the dry biomass weight. However in case of Collagen Hydrolysate and Protein Hydrolysate prepared from fleshing waste, yield of biomass was 3.946 g/l and 3.186 g/l respectively.AIM obtained from those respective biomass is 21% and 22% of the total biomass respetively. Isolated chitosan yield is 14.72% and 15% of total biomass obtained from Collagen Hydrolysate and Protein Hydrolysate prepared from tannery waste respectively.

The results are attached in a tabular form in **Table 3.**

3.5: Characterization of Chitosan:

The FTIR spectrum of the prepared chitosan as compared to Sigma chitosan (as reference) is given in the **Fig 2**. From the FTIR spectra of the prepared chitosan compared to that of Sigma chitosan used as reference, it is evident that all the prepared chitosan gives similar bands as compared to the Sigma chitosan indicating that the product prepared is pure chitosan.

4.0 Discussion

One of the major solid hazardous wastes generated from the leather industry is limed fleshing waste. This fleshing waste poses serious threat to the environment. Hence there is an urgent need to develop ecofriendly solution to degrade or successfully utilize the waste. In this research, the fleshing waste is utilized to extract collagen biopolymers i.e. collagen hydrolysate, which can be further utilized as a media for zygomycetes group fungus for the extraction of chitosan. Hence an alternative source for the extraction of chitosan is developed. It can further be concluded that *Rhizopus oryzae* act as a suitable fungus to yield chitosan under controlled laboratory conditions utilizing the fleshing waste generated from the tannery industry.

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Media	Abbreviation	Incubation time	Dry weights of fungal biomass
1. Yeast Collagen hydrolysate Glucose medium 1	YChG1	48 hrs	**0.1984 g**
2. Yeast Collagen hydrolysate Glucose medium 2	YChG2	48 hrs	**0.2202 g**
3. Collagen Hydrolysate Salt Medium1	M1	48 hrs	**0.1669 g**
4. Collagen Hydrolysate Salt Medium2	M2	48 hrs	**0.1928 g**

Table 1: Table showing the dry weights of the fungal biomass in different media.

From the dry weights of the fungal biomass cultured in the respective media used for initial screening,it is evident that Yeast Collagen Hydrolysate Glucose media 2(YCHzG2) having a composition containing yeast extract 0.3%, collagen hydrolysate 1%, glucose 2% is the best suitable media yielding maximum dry mass of the fungal biomass.Hence the media YCHzG2 was selected for the present research.

Approx. wet weight of tannery waste	Name of product	Dry weight of product
Collagenous waste- 50 g	Collagen Hydrolysate	15 g
Proteineceous waste-30g	Protein Hydrolysate	8 g

Table 2: Table showing the yield of Collagen Hydrolysate and Protein Hydrolysate.

From the above table it can be inferred that 15 g of Collagen Hydrolysate was obtained from approx. 50 g of collagenous waste separated from fleshings waste and about 8 g of Protein Hydrolysate was obtained from approx. 30 g of fleshings waste(other than colagenous waste).

Media used	Quantity of media used	Wet weight of fungal biomass yielded	Dry weight of fungal biomass yielded	Weight of Alkali Insoluble Mass (AIM)	Weight of Chitosan yielded
YCHzG(HM)	50mlx20	10.786 g	4.636 g	1.043 g	**0.733 g**
YCHzG(TW)	50mlx20	10.306 g	3.946 g	0.829 g	**0.581 g**
YPHzG(TW)	50mlx20	9.484 g	3.186 g	0.685 g	**0.479 g**

Table 3: Table showing the weights of Chitosan produced from commercial Collagen Hydrolysate media compared to that of the prepared media.

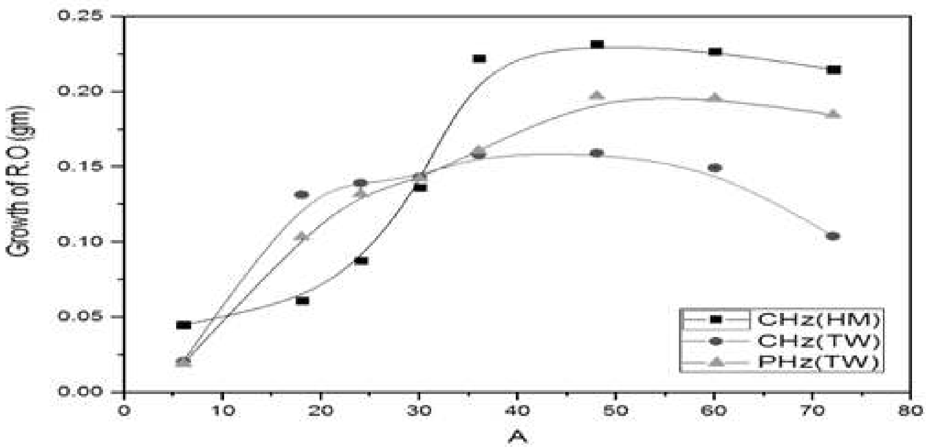

Fig 1: Growth of Rhizopus oryzae as a function of time using HiMedia Collagen Hydrolysate [CHz (HM)] compared with Collagen Hydrolysate prepared from tannery waste [CHz(TW)] and Protein Hydrolysate prepared from tannery waste [PHz(TW)].

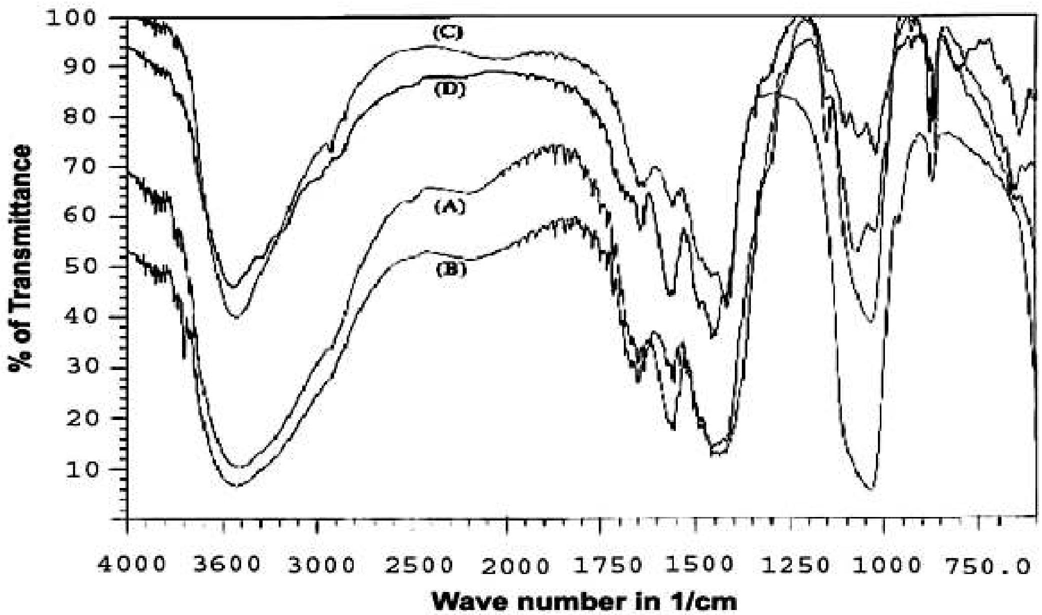

Fig 2: FTIR spectra of (A) Sigma Chitosan (reff.), Chitosan from R.oryzae(B)YCHzG (HM), (C) YCHzG (TW), (D) YPHzG (TW).

From the FTIR spectra of the prepared chitosan compared to that of Sigma chitosan used as reference, it is evident that all the prepared chitosan gives similar bands as compared to the Sigma chitosan indicating that the product prepared is pure chitosan.

Ganga Pollution in West Bengal: A Longstanding Concern

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Abstract

Ganga Basin is one of the largest river basins in Asia. The basin lies between 73°02'E and 89°05'E and 21°06'N and 31°21'N, covering an area of 1,086,000 sq km, extending over large parts of India, Nepal and Bangladesh. The largest part of the basin (79%) lies in India. It is the largest river basin in India, constituting 26% of the country's land mass (8, 61,404 Sq. km). The basin covers 11 states viz., Uttarakhand, Uttar Pradesh, Madhya Pradesh, Rajasthan, Haryana, Himachal Pradesh, Chhattisgarh, Jharkhand, Bihar, Delhi and West Bengal. The entire basin starting from its headwaters in Uttrakhand to its mouth in West Bengal is polluted by industrial and anthropogenic wastes. Several initiatives over the last century have been undertaken to clean the river and for abatement of further pollution. Starting from the Ganga Mahasabha of 1905 to Namami Ganga Programme of 2014, all initiatives taken up by the government to clean the waters of Ganga had negligible effects. The mighty river flowing through different states have different challenges in different stretches. This paper focuses on pollution of the river in the state of West Bengal and attempts to explore all such initiatives, its effect and limitations, juxtaposing the problem of Ganga Basin to other polluted rivers of the world and tries to uncover the reasons underlying failure of past initiatives and propose a way forward.

1.0 Introduction

Ganga Basin is one of the largest river basins in Asia. The basin lies between 73°02'E and 89°05'E and 21°06'N and 31°21'N, covering an area of 1,086,000 sq. km, The basin is spread over four countries, namely, India, Nepal and Bangladesh and China. The largest part of the basin (79%) lies in India. It is the largest and most important river basin in India, constituting 26% of the country's land mass (8, 61,404 Sq. km). The basin is spread over 11 states viz., Uttarakhand, Uttar Pradesh, Madhya Pradesh, Rajasthan, Haryana, Himachal Pradesh, Chhattisgarh, Jharkhand, Bihar, Delhi and West Bengal is bounded by the Himalayas in the north and the Vindhyas in the south. The ridge between the Indus system and the Ganga system, the Great desert of Rajasthan and the Aravalli hills form the boundary on the west. This vast river with its several tributaries flows through the entire north-central part of India supplying water to several cities, towns and rural areas. It has been the lifeline of a large part of northern India nourishing the ancient Indian civilization for ages. It is not only a river to millions of Indians it is revered as divine and worshipped by many as the most pious. From times immemorial, the Ganga has been India's river of faith, devotion and worship. Millions of Hindus accept its water as sacred. Even today, people carry treasured Ganga water all over India and abroad considering it "holy" (Sharma, 1997). In spite of its divine status the river across large stretches in its middle and lower course is highly polluted due to uncontrolled anthropogenic activities. The current paper looks into this problem of pollution of river Ganga trying to focus on its causes, highlighting its impact and proposes ways to revive the river to its former glory with a special emphasis on West Bengal. The paper also highlights the past initiatives in Ganga cleaning, analysing the reasons for their failure and tries to compare the Ganga story with the other major polluted rivers of the world.

2.0 Materials and Method:

2.1 Objective:

i. To learn about the issues and challenges faced by the various initiatives taken up by the Government of India
ii. To explore the effectiveness of the strategies used by such initiatives
iii. To understand the role and relationship between central, state and local self-government bodies in working towards the implementations of the various programs
iv. To develop a deeper understanding of the issues or reasons for failure of various initiatives and programs.

2.2 Methodology:

The methodology adopted for this research was qualitative one and therefore the techniques that were used are descriptive in nature. An exploratory approach was taken to collect and later analyze information from various sources. This was done as the current topic called for answering questions like 'what', 'how' and 'why'. The present research thus focused on obtaining a truthful description of the given issue.

The current research was designed under the following guidelines:

i. Collection of extensive literature from various sources like government as well as non-government organization websites, articles published in various reputed journals, newspapers, government reports etc. spanning from pre-independence (1905) era to the present time (2016).
ii. Observations and analysis from these published materials to chronologize the events and to highlight their challenges.
iii. Detailed understanding of the background, development, current conditions and environmental impact of the various initiatives based on such observations.
iv. Formulation of proposals along with several remedial measures for a cleaner Ganga.

3.0 Results

An exhaustive literature review of the various sources addressing the Ganga pollution and their subsequent analysis puts forward the following issues:

a. Understanding the Major Pollutants and The Impact of Pollution:

For a river as vast and as the Ganga, pollution comes from several sources and at several points along the long course of the river. They are varied in nature and all contribute to the pollution of the river at different rate and at different stretches .The major pollutants of Ganga are broadly classified into point and non-point sources. The point sources or fixed point entries of pollutants are the major contributors of the rivers pollution load. They include industrial effluents and waste water, untreated sewage and drains discharging waste water from urban and rural settlements. According to estimates approximately 1 billion litres of raw, untreated sewage are dumped in the river on a daily basis. The amount has more than doubled in the last 20 years and experts predict another 100% increase in the following 20 years (Jaiswal, undated). The non-point sources spread across the length of the river are also significant contributors. They are not specific to any point but are ubiquitous all along the course of the river. They include animal carcasses and half-burned and unburned human corpses thrown into the river; waste generated from mass bathing, religious events and ritualistic practises like immersion of idols; agricultural run-off containing residues of harmful pesticides and fertilisers; human defecation along the river banks and cattle wallowing.

The effects of water pollution strongly impact the balance of nature, which ultimately impacts all humans. The major impacts of Ganga pollution are as follows:

- Industrial effluent with high temperature increases water temperature, and lead to death of aquatic animals like fish.
- Toxins from industrial effluents and untreated sewage contaminate water leading to water borne diseases like cholera, hepatitis, amoebic dysentery etc.
- Pollutants lead to increase of Dissolved Oxygen which is harmful for aquatic life.
- Untreated sewage decreases light penetration and tends to loss in self-purification capability of river water.

b. Finding the causes of Ganga Pollution In West Bengal

The mighty river Ganga meets the Bay of Bengal in the state of West Bengal. The river after its long journey across the central Indian plains enters West Bengal near the Rajmahal Hills and takes a turn to the southeast. South of Farraka, it ceases to be known as the Ganga as it bifurcates itself into two. One strand known as Bhagirathi-Hugli flows southward in West Bengal and the other continues its journey in Bangladesh as river Padma. The Hooghly River or the Bhāgirathi-Hooghly, called 'Ganga' traditionally, is an approximately 260-kilometre-long (160 mi) distributary of the Ganga river in West Bengal. This stretch of the river or the lower Ganga basin comprising 8.3% of the Ganga basin in India is one of the most polluted stretches of the river (Negi, n.d.).

The pollution load of the Ganga is very high in West Bengal primarily because of the high population density of the stretch through which it drains. All major pollutants as discussed in the previous section are found to pollute the water of the river in this state. But the major load of the pollution in the state can be attributed to three major areas of concern:

i. Inadequate Sewage Treatment

West Bengal generates 1131 mld of sewage per day. However the state has only 34Sewage Treatment Plants (STPs) with installed capacity of 457 mld. Out of this actual utilization capacity is only of 214 mld. Sewage generation from Class I cities is highest(50%) in West Bengal with estimations that about 527 million liters of waste water fall into the river Ganga from the 15 class I cities located along its bank. There are several reasons for inadequate sewage treatment. Firstly, though performance of individual sewage treatment plants was satisfactory, the influent sewage strength in terms of its organic matter content (BOD value) inmost locations were found to be low in comparison to the prior assumption. Thus the STPs are mostly operated at under load condition. Secondly, it is observed that there are gaps in sewer lines and thus the sewage is not reaching to the treatment plant. Thirdly, the sewer lines are also silted and thus the sewage cannot flow smoothly towards treatment plant. Fourthly, some plants were non-functional due to due to absence of sewage (E.g. STP at Beharampore). Finally, most STPs were not provided with stand-by power arrangement (CPCB, n.d.).

ii. Pollution from Drains Discharging Waste Water

Drains discharging waste water into the river are a major concern in West Bengal. The state has 54 drains, out of which 34 drains are located on left bank contributing 1179 mld and 20 drains located on right bank of river adding 600 mld of wastewater to the Ganga. In terms of load, number and flow, drains in the left bank are more polluting than those of right bank. The drains in the left bank can be classified to 10 zones such as Kalyani, Halisahar, Naihati, Bhatpara, Barrackpur, Titagarg, Khardaha, Kamarhati, Baranagar, Kolkata with a total contribution of 74624 kg/day BOD load. Out of these, Kolkata region is the most polluting, contributing 55443 kg/day (74 %). Next to Kolkata is Kamarhati with 6310 kg/day (8%) and Khardaha with 2330 kg/day (3%). The contribution of other zones is relatively less. The more prominent drains of the left bank are TollyNallah, Dhankhati Khal, Akhra food ghar, Khardaha municipal khal, Kashipur khal, Mistry khal, adjacent Kashipur ferry ghat adjacent to Diamond club, Kashipur Khal with a load of more than 1000 kg/day .

The drains on the right bank can be classified into six zones such Hoogli, Serampur, Rishra, Bally, Howrah, Uluberia and total contribution of BOD from these add up to 22514 kg/day. The major drains (more than 1000 kg/day) are Hasting ghat road canal, Najer Ganj Khal, Chhatra canal, Bagh Khal, Telkal Ghat, Ramkrishna Mullickghat Road, Foreshore road, Martin Burn (CPCB, 2013).

iii. Pollution from Grossly Polluting Industries (GPI)

Industrial pollution through untreated waste and waste water discharge into the river is the third major contributing factor to the pollution of the river in West Bengal. In the stretch of West Bengal the river receives 87 mld wastewater from 22 grossly polluting industries (GPI). These include chemical industries, tanneries, distilleries, dairies, food and beverage industries, dyeing, textile and bleach industries and pulp and paper industries. It is observed that the chemical industries discharges 70% of total wastewater generated, followed by pulp and paper which contributes 20% of the waste load from industries. This is a deviation from the trend in upper and middle Ganga where paper and pulp industries are the most polluting ones. The average waste water generation by grossly polluting industries in the states of Uttarakhand, Uttar Pradesh, Bihar and West Bengal is approximately 45% of water consumed by these industries. However the GPIs of West Bengal are the highest polluters generating maximum wastewater of 75.5% in terms of water consumed (CPCB, 2013).

c. Highlighting the Temporal Sequence of the Major Cleaning Initiatives

Over the years various initiatives were taken up by the Government of India to solve the problem of pollution of the river Ganga and restore back to its former glory. The chronological summarization of such different measures taken up by the government is as follows:

The very first initiative taken up to clean up the river Ganga was '**Ganga Mahasabha'**, which was an Indian organisation, founded by Madan Mohan Malviya in 1905. The organization struggled against British India for uninterrupted flow of the river Ganga. This culminated into 'Aviral Ganga Samjhauta Divas' (Uninterrupted Ganga flow agreement day) on 5th November 1914. However, after that, for a long time there were no efforts to curb the ever increasing pollution in the river Ganga (Srivastava, 2014).

Though the idea of cleaning our holy river was an ever pressing concern, it was only in the year of 1979; government of India took certain initiatives. After a comprehensive survey of the river, Central Pollution Control Board (CPCB) published two reports. These reports later formed the basis of intervention activities which was known as Ganga action Plan. The **Ganga Action Plan (Phase I)** was launched in 1985 with the objective of pollution abatement to improve the water quality in the river. The studies by CPCB, on which Ganga Action Plan was based, indicated that a large proportion of pollution load in the river came from the municipal wastewater generated in twenty-five Class I towns located on the banks of the Ganga, each with a population exceeding 100,000. It constituted around 75% of the pollution from all point-sources. Remaining 25% of the pollution from point-sources was mainly due to untreated industrial effluent. Therefore, emphasis under the GAP was given on interception and diversion of wastewater and its treatment in Sewage Treatment Plants (STPs), before discharging into river. Under the GAP, the schemes corresponding to the point-sources were categorized as 'core schemes' whereas the schemes taken up to address the pollution created by non-point sources were categorized as 'non-core scheme' (IITs, 2011).

Later on, some institutional arrangements were made at the central level, and **Central Ganga Authority** came into existence under the Environment Protection Act 1986. The CGA, under the chairmanship of the Prime Minister, was constituted to finalize the policy framework and to oversee the implementation of GAP-I.

An additional agency called **Ganga Project Directorate (GPD)** was set up with adequate financial and administrative powers in order to implement projects under GAP-I. As GOI decided to expand its program to all major rivers in India, the GPD was later transformed into **National River Conservation Directorate (NRCD)**, along with transformation of the CGA into **National River Conservation Authority (NRCA)** in 1995. These changes took place after the commencement of GAP II in 1993. The NRCD designed and is still looking after the implementation of National River Conservation Plan (NRCP) in which the GAP II was merged in December 1996 (IITs, 2011).

GAP II was proposed as an extension of GAP I, where major tributaries of the River Ganga (viz. Yamuna, Gomti and Damodar, Mahananda) were included in the cleanup program. GAP II covered 59 towns located along the river in the five states of Uttarakhand, Uttar Pradesh, Jharkhand, Bihar and West Bengal.

However, both GAP I and II failed to bring any realistic change in both pollution abatement and environmental improvement in the river. Over the time, government felt the need for a more holistic approach based on river basin as the unit of planning. Accordingly, the Government of India constituted the **National Ganga River Basin Authority** (NGRBA) on 20th February 2009. The NGRBA was an empowered planning, financing, monitoring and coordinating authority for the Ganga River, set up under Section 3(3) of the Environment (Protection) Act, 1986. The mission of the organization was to safeguard the drainage basin which feeds water into the Ganga river (NRCD and MoEF, 2009).

The responsibilities of this authority were to integrate activities related to sustainable use of water, pollution abatement, maintenance of ecological flows, and river conservation. The NGRBA identified the pollution sources, built a database using scientific methods, analyzed the data and ensured its sharing. To help in its work, **National Mission for Clean Ganga (NMCG)** was set up as the implementation wing of National Ganga River Basin Authority (NGRBA). It was a registered society originally formed by Ministry of Environment, Forests and Climate Change(MoEFCC) on 12th August 2011 under the Societies Registration Act, 1860 (http://nmcg.nic.in/about_nmcg.aspx).

The most recent project taken up by the Union Government was **Namami Ganga Project** or Namami Ganga Yojana (officially known as Integrated Ganga Conservation Mission project), which integrated the efforts to clean and protect the Ganga river in a comprehensive manner. The most impressive part of this program is its budget, which is approximately Rs. 4000 crore. This program emphasized on improved coordination mechanisms between various Ministries or Agencies of Central and State governments. (GoI, 2015).

Several other programs were also initiated like **Ganga Manthan**, which was a national conference held to discuss issues and possible solutions for cleaning the river in 2014. The conference aimed to take feedback from stakeholders and prepare a road map for rejuvenating the Ganga ((http://nmcg.nic.in/about_nmcg.aspx).

4.0 Discussion

Even though the government claims that the various schemes taken up to clean river Ganga has been successful, ground realities tell a different story. A critical analysis of factors that were responsible for the failure of such initiatives are discussed below:

i. Top-down technocratic approach with lack of co-operation between Centre, State and Local Self Governments.

The organizational structure of the cleaning initiatives was hierarchical. Almost all aspects of design and program development were done by the NRCA at the central level. State governments were assigned the task of setting up sewage treatment plants and targets, identifying polluters, and enforcing sanctions against violations. The Local Self Governments (LSGs) were assigned the task of maintaining and running the projects. Local governments were not consulted to assess their readiness to undertake the responsibilities, nor were their inputs sought in the design and implementation of projects. Additionally, the initiatives did not make adequate provisions for monitoring the implementation process or for penalizing state or local governments for under-performance. There was very little accountability among state and local government institutions.

There was a gross mis-communication between the center, state and local self-governments. The State Governments had neither funds nor the required power for overhead and maintenance of assets like STPs, pumping stations, crematoria etc. Thus, the operation of nearly all the assets has practically come to a halt.

Local governments were not involved and did not receive support from the center to promote public participation. Similarly, NGOs were expected to adopt the ghats and maintain them but they did not receive financial support for their work nor were they invited to participate in decision-making (Das and Tamminga, 2012).

Such a hierarchical technocratic approach to problem solving only created fragmented, expensive systems of expertise with no real benefits.

ii. Culturally sensitive context was not given due consideration

When we attempt to understand the significance of the sacred river from the past to its present reality, the most tragic paradox encountered is that the river is worshipped and defiled simultaneously. In fact, at most times, the process of worship itself has a polluting influence since bulk of the worship materials are disposed off in the river. Even the mass bathing pollutes the river (Jaiswal, 2007).

All major initiatives were so goal-oriented that it overlooked the importance of people's everyday relationship with the river. For the programs, the local community was a homogeneous entity but in fact, different groups of people share a different relationship with the river. Issues of class, caste, and gender are interlinked and cannot be ignored. For instance, the 'dhobis' (washermen) felt marginalized when the GAP threatened their occupational livelihood by restricting the washing of clothes along some stretches of the Ganga while allowing the 'yadavs' (milkmen) to continue bathing their cattle (Das and Tamminga, 2012).

Since the different cultural and religious contexts were never considered while framing the programs, they failed to reach its desired goals due to resistance from the existent socio-cultural practices which are embedded in the social fabric of this nation.

iii. Not considering the entire drainage basin as unit of management

No holistic plan for reviving a river can be made without considering the flow pattern, contribution of tributaries, and pollution load of the entire watershed. It was essential to consider the vast expanse of the Ganga river basin and give importance to both quantity and quality of water of its large basin spread over an area of 8,61,404 sq. km. However this issue was not addressed in the initial programs.

iv. Unplanned construction of STPs

The most significant aspect of the Ganga cleaning initiatives was construction of STPs along the length of the river. However most of them were setup without prior planning. So, problems of inadequate sewage, lack of pipelines connecting to STPs, poor availability of power, etc. plagued the functioning of these STPs. In most states they worked much below their estimated capacities treating only a fraction of sewage they were installed to treat.

v. Lack of authentic data on quality and quantity of waste generation

For reducing the pollution load of the river, one must be fortified with authentic data on quality and quantity of pollution of the river. But this was hardly the case. Data were inadequate and collected through faulty sampling procedures. The water samples were collected from the upstream (before the river enters the town), downstream (after the river has left the town) and midstream (somewhere in the town) (Jaiswal, 2007). The water samples were collected from the midstream and one-fourth distance away from the river bank. But no one goes either to the midstream or to one-fourth distance from the bank to take a dip. Also the water intake points were on the bank. The river water quality should ideally be monitored at the users' points e.g., bathing ghats and intake points, which was not done.

These data thus cannot serve as reference points for planning cleaning initiatives and are therefore of little or no use.

vi. No attention given to agricultural runoff

Another important issue which lacked decision and action is agricultural runoff, containing residues of chemical fertilizers, pesticides, insecticides and weedicides, entering the river waters (Jaiswal, 2007). Agricultural run-off is the single most important non-point source of pollution which has not been addressed at all in most initiatives. In the beginning, some efforts were made to quantify the consumption of chemical fertilizers, pesticides, insecticides in the Ganga basin. But today we don't even have a vague idea about the impact of agricultural run-off on river water quality, in its ecology and its impact on the Ganga users as there is no authentic data on the amount and quality of agricultural runoff received by the river at various points along its course.

vii. Minimum discharge not given due importance

Since the scale of pollution also depends on the degree of dilution, it is necessary to maintain a minimum discharge in the river, especially at critical points, like large urban settlements and locations of major industrial units producing substantial quantities of liquid waste.

Irrigation practices and industrial water use and intake of water by power plants have always consumed large proportions of the river's water reducing its minimum discharge. This aggravates the problem of pollution as low discharge leads to less dilution of pollutants and retards the river's natural capacity of self-cleansing. This concern was never incorporated in any of the initiatives.

viii. Over-emphasis on Class I towns

This is mainly a major drawback of the GAP schemes. The association of pollution to big cities or Class I cities is largely faulty to say the least. Pollution occurs from all types of human settlements including Class II and III cities, smaller towns and even rural settlements. All of these were left uncovered in the GAP scheme, which proved to be a major hurdle in the success of GAP.

viii. Lack of people's participation

When it came to tackling non-point source pollution, the GAP professed to be a "people's program." However, critics have pointed out that participation in the GAP was symbolic rather than substantive. Participation was also limited to the more token forms such as sporadic ghat clean up campaigns and ghat-based street theater and concerts to involve Hindu pilgrims. Such events were based on volunteerism and did not create any lasting sense of ownership (Das and Tamminga, 2012).

ix. Preventive measures overlooked

GAP has always focused on curative measures, for example, in order to mitigate the problem of dead body dumping, electric crematoria or improved wood crematoria were constructed; in order to dissuade people from defecating on the river bed or on the river bank, public toilets were constructed but preventive steps like imposition of fines for polluting the river were never initiated to mitigate the non-point sources of pollution. As a result these polluting practices still continue.

5.0 Conclusion and Recommendations :

The past failures have taught us several lessons which can be incorporated in the future endeavours to clean the mightiest river of the sub-continent. The following are the suggestions for correcting the inadequacies of the past initiatives:

i. Natural environmental flow to be restored to dilute and assimilate waste

We need to accept that for cleaning the river Ganga, the availability of water for dilution is critical. It is essential to understand that rivers without water are drains bereaved of its assimilative capacity and self-cleansing property.

Ecological flow thus should be mandatory in all stretches of the river. In the upper stretches, where the requirement is for critical ecological functions as well as societal needs, it should be mandated at 50 per cent for mean season flow and 30 per cent for other seasons. In the urbanized stretches, it should be mandated based on the quantum of wastewater released in the river and calculated using a factor of 10 for dilution. All Central government funding under the National Mission for Clean Ganga should be conditional on the quantum of ecological flow made available by the state. (Narain, 2014)

ii. Stop discharge of un-treated sewage through rehabilitation and up-gradation of treatment facilities

Each day, 2.9 billion liters of waste water from sewage, domestic and industrial sources are dumped directly into the river Ganga (http://www.gangaaction.org/actions/issues/sewage-waste-management/). This indiscriminate dumping of untreated waste water needs to stop. Urban areas have to build the infrastructure for sewage networks at the scale and pace needed for pollution control.

This requires effective operation and maintenance of assets, as well as equally effective monitoring and regulation of the same.

iii. Strict law enforcement against point-source pollution

Major water consuming industries and power plants should be monitored on stringent basis to ensure treatment of effluents, stopping of waste water dumping into the river and excessive consumption of the river water. Non-compliance should be heavily penalized, and repeat offenders should be forced to close down.

iv. Imposition of fines for non-point source pollutions

Strict laws should be made and needs to be implemented stringently so that non-point sources of pollution are reduced considerably.

v. Co-ordination between Central, State and the Local agencies

One of the major reasons as to why government initiatives like GAP I and II failed was the lack of co-ordination between the different tiers of government. This needs to solved to ensure smooth functioning.

vi. Socio-religious practices to be accommodated within scientific framework for adaptive management

In a heterogeneous nation like India, no initiative can be successful without giving due consideration to the social, religious and cultural practices of its billion plus population. Efforts must be made to understand the importance of such practices and incorporate them in the plan of action. For example, religious practices like immersion of idols in the river are a highlight of several major festivals. However the paint and decorations on the idols are not environmental friendly and they pollute the river, which in turn affects the flora and fauna of the river. Though it is not possible to stop these practices overnight, so the government needs to provide with alternatives like creating immersion sites for religious ceremonies near the river and that must to be implemented through legislation.

vii. Promoting sanitation in rural areas

Nationwide, some 70% of those living in rural areas have no access to toilets which leads to rampant open defecation (http://www.gangaaction.org/actions/issues/sewage-waste-management/). Such practices on the bank of the river or on the river bed (during dry seasons) should be discouraged and facilities must be provided for construction of toilets in rural households.

viii. Reduction in the use of chemical fertilizers and pesticides to control toxic agricultural runoff

Water intensive farming and run-off from inorganic farms, includes harmful chemicals like DDT and HDH which aggravate the threats facing the Ganga River. The government should dissuade the use of such fertilizers and promote organic farming by mass education of farmers in methods and benefits of sustainable organic farming.

ix. Construction of electric crematoriums

Construction of electric crematoriums must be given due importance. Provision of uninterrupted power supply to such crematoriums should be ensured. Improved wood based crematoria should be adopted in smaller towns or villages where there is non-availability of uninterrupted power supply.

x. Awareness programs and campaigns to be conducted

Mass awareness campaigns and media-based water eco-consciousness campaigns that get people to not only stop pollution, but to also become an active part of the solution should be encouraged.

Over a billion plus citizens of India owe its life to the river Ganga, yet our National River remains one of the most polluted rivers in the world. Injudicious anthropogenic practices, lack of holistic planning and dearth of political will to clean up the river has reduced the river into a sorry state. Several initiatives of the past have taken fragmented approaches to clean the river getting partial successes. Every failure has put forward several lessons which today has built up a large repository of knowledge in managing the pollution of the river Ganga.

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Vermicomposting as a controlling measure for the rampant weed, *Eichhornia crassipes* and its subsequent use as organic manure

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Abstract:

Bioremediation has emerged as the most effective environmental tool in recent times with its benefits conquering the zenith of the most relevant and widespread problem, the anthropogenic release of adulterants into the natural system. With the damage already done, prevention and awareness has taken backseat (although very much required) and cure has become the need of the hour. In an attempt to make the most out of waste, the prime objective of the study was to simultaneously, find a purpose for the phytoremediating ability of water hyacinth (*Eichhornia crassipes*) and check the feasibility of such a purpose in our day to day life. Water hyacinths were collected from two different sites and turned into vermicompost, their absorbed metals' biomagnification ability were checked through chemical speciation by Tessier sequential extraction process and the findings were further proved with actual pot culture of four different varieties of plants, namely tomatoes, coriander, gram and chilli, grown for about 2 months with a weekly application of the prepared vermicomposts and their metal content were duly analyzed in order to ensure the non-bioavailability of the heavy metals initially present in the hyacinth bodies. The Tessier speciation showed As, Cd and Pb to be neatly packed away in the residual and organic matter–bound fractions which proves the capacity of vermicomposts to reduce the phytoavailability of such metals. This observation was supported by the final low heavy metal content of both the general and the edible parts of the plants. However, essential trace metals like iron, zinc and copper remained very much in the exchangeable and carbonate-bound fractions, therefore, accounting for their dominant presence in the plant parts. All in all, the study strongly indicates the beneficial facades of both phytoremediation by water hyacinth and its subsequent vermicomposting.

Key Words: Biomagnification, Phytoavailability, Phytoremediation, Tessier sequential extraction, Vermicomposting

1.0 Introduction:

In the awakening world of science and technology, where every alternative day witnesses the arrival of the best of man's grey matter in the form of latest machines and instruments, bioremediation stands out as a technique that has been used by humans intentionally or often unknowingly, for ages and have been re-established and re-discovered in recent times in the light of modern scientific knowledge. Although hyperaccumulation of a wide range of excessive metals by several faunal and floral species was already taking place in nature after the world entered the modern era, holding the hands of industrial revolution. But the actual idea of using certain species of plants to selectively remove a range of heavy metals from a contaminated system was introduced much later around 1983 and serious research potentials started in the 90s. The process of phytoextraction was explained by the use of *Brassica juncea* (Indian mustard) and *Thlaspi caerulescens*, which is a wild variety of the same family. Though the latter was proved to be a better accumulator of Zn, Ni and Cd, the former produces more biomass and is therefore, 20 times more effective in a single cropping than *Thlaspi sp*. It is evident that in the initial stages it was the mechanisms of metal uptake that ruled the research world and that is also when experiments involving several plant species emerged successfully among which water hyacinth was a major variety too. However, the finding for even new varieties and better uptake level is still on and, species like *Eucalyptus camaldeulensis, Medicago sativum* and *Brassica juncea* are able to grow in soil highly contaminated with heavy metals and were able to uptake the metals by a factor of 1.8, 1.4 and 1.3-fold respectively which proved that *Eucalyptus camaldeulensis* was the best from the viewpoint of metal uptake among these three species. Reports about the uptake of heavy metals by *Eichhornia crassipes* from a water body which had 3-32 times lower metal concentration in comparison to the sediment, came up. On the other hand, the bioconcentration factor exhibited an uptake increase by 3-28 folds by the weed inspite of the presence of relatively lower level of metals in the water system. Thus, water hyacinth is eligible for absorption of metals in even fairly less contaminated sites, which acts as a limiting factor in most of the species used for phytoremediation. In around 2005, descriptions about the usefulness of vermicompost in increasing the plant germination, growth, flowering, fruiting, associated plant microbial population, plant hormones such as indole-acetic acid, gibberellins, cytokinins etc surfaced. It was also stated that vermicompost could help in the suppression of plant pathogens such as *Pythium, Rhizoctonia* and *Verticillium*, quite significantly. Surprisingly, the Indian subcontinent at the moment seems to be brimming with researchers pursuing the subject of vermicomposting and its related topics. Although, it can be argued that most of the accounts lacked the support and the final proof in the form of an actual plant culture using the prepared compost and its resulting metal concentration and these are the gaps which the current study has tried to bridge upon, combining together the viability of water hyacinth as a novel accumulator, its fate post accumulation, chemical speciation of the prepared product to ensure non-availability into the food webs and its further application on plants in order prove the negative trend of biomagnification.

2.0 Materials and Methodologies:

2.1 Objective :

In an attempt to make the most out of waste, the prime objective of the study was to simultaneously, find a purpose for the phytoremediating ability of water hyacinth (*Eichhornia crassipes*) and check the feasibility of such a purpose in our day to day life.

2.2. Methodology :

2.2.1 Sampling of *Eichhornia crassipes*

Since the idea was to capture the hyperaccumulating quality of water hyacinth in a natural system, spiked solutions were avoided and choice of sampling sites was crucially restricted to highly polluted sites, where leaching of heavy metals can be fairly expected. Accordingly, two different sites were chosen for the collection of the species. The first being a pond near the Dhapa dumping area, adjacent to Captain Bheri (22°33'10"N and 88°24'42"E) and the second was a pond near a polluted residential area of Barrackpore, near Boropole bus stop (22°76'N and 88°37'E). The former was chiefly chosen for its exposure to industrial wastes, with the expectation that the water body receives a fair amount of heavy metal exposure from the nearby dumping land. On the other hand, the site at Barrackpore was identified because of the daily sewage that the pond perpetually received from all the residences around it with no sources at all from industries or factories. Therefore, the two sites are exposed to an extreme range of wastes and have thus, no similarity at all between them. From each site, the hyacinths were collected with the help of buckets and nets and immediately sealed in secure sampling bags. Soon after, they were transferred to the laboratory for further study, among which a set of each was digested and their total heavy metal concentrations were measured accordingly.

2.2.2 Vermicomposting set-up

Eisenia fetida was chosen for the experimental purpose, and the choice can be attributed to the following reasons:

- First and foremost, *Eisenia* sp. was the one which was most easily available and comes at a relatively low cost.
- Secondly, these are epigeic and are therefore, perfect for the earthen-pot compost pits used in the study.
- Moreover, the species is appropriately adapted to the humid climate and very much resistant to most diseases.
- They are also known to bioaccumulate some parts of the non-bioavailable metals from the soil system, without affecting their own physiology.
- Lastly, compared to the other species, *Eisenia* sp. are known to process organic matter more rapidly and attracts and increases the microbial population, thus reducing the time required for composting.

After the choice of the worms, the compost bed was prepared in two earthen pots of about 32cm in diameter and 28cm in height, with a bottom layer of gravel, followed by a small layer of sand and soil, upon which partly decomposed water hyacinth (to aid in their fast breakdown) was kept, covered by a layer of sawdust and manure. The earthworms were released in the pots on top of this bed with light sprinkling of loose soil. The set-up was watered as and when required so as to keep a moisture level of about 60-70% and the only problem faced was periodic infestations of ant which was taken care of with turmeric powder, a biopesticide which keeps away ant but does not affect earthworms or the preparation of compost, at all.

2.2.3 Chemical analysis

Initial parameters of the soil samples and the vermicompost samples, such as the ph, the electrical conductivity or EC (µ S^{-1}), the oxidation reduction potential or ORP (mV) and the salinity (ppm) were measured with the help of two instruments, the ORPTestr10 and the PCSTestr35. Two control soil samples were taken, one from Barrackpore and the other from the IISER-Kolkata premises. The reason behind such a step being taken was the fact that the soil used for both vermicomposting and for pot culture throughout the study, was accessed from these two areas. The other samples were taken from each of the vermicompost set-up (containing hyacinth from Dhapa and Barrackpore) on their 20^{th}, 40^{th} and 60^{th} day, respectively along with a sample of the manure which was added to each of the compost pits. Each of the samples were taken and made into a solution with distilled water in the ratio of 1:5(w/vol) and the observations were recorded in a replicate set of three per sample, whose mean value was later considered for analysis. Subsequently, each sample was tested for its organic matter content by Walkley Black method, inorganic phosphate content by the use of ammonium molybdate solution and nitrate content by Brucine method. Also the total metal concentrations of the soil and vermicompost samples were measured by prior digestion of the samples using $HClO_4$ and H_2SO_4 acids added in the ratio of 2:3(v/v) and the concentrations of As, Cd, Cu, Fe, Pb and Zn were measured using ICP-MS (ThermoScientific XSeries 2).

2.2.4. The process of Tessier sequential extraction

The whole process was an extremely tedious and time-consuming affair and was undertaken in full agreement with the original research paper as authored by Tessier et. al., 1979. But as it is stated earlier, inspite of the hankering for time, it "provides exclusively detailed information on the origin, the mode of occurrence, biological and physicochemical availability, mobilization and transport of trace metals." The procedure involved centrifugation after every step and is tabulated as follows in Table 1.

2.2.5. The process of pot-culture

The pot culture involved the plantation of four varieties of plant species, namely, tomato (*Solanum lycopersicum*), gram (*Cicer arietinum*), chilli (*Capsicum annuum*) and coriander (*Coriandrum sativum*). While tomato and chilli were grown from seedling stages, the other two were grown from seeds and were done so in three sets each, i.e., each plant variety was grown in triplicates and each vermicompost type (of Dhapa and Barrackpore hyacinth) had four such varieties in tri-sets. All the pots were regularly watered, maintained and monitored for 2 months approximately with a weekly application of compost of about 3-4gms per application. The fruits were collected after they turned ripe and were further digested for metal analysis. On the other hand, the whole plant masses were uprooted at the end of the time span and were digested accordingly too.

Both the fruits and the plants were chopped into as fine pieces as possible and oven-dried until no moisture was left at all. Followed by this, one gram of each fruit and plant mass was taken and digested with 16ml of6:2 HNO_3/H_2O_2 mixtures on the hot plate at steady temperature of 120°C for 2 hours. Then the samples were cooled and mixed with 10ml of distilled water. The resultant residue was filtered using filter paper and the filtrate was further diluted to 50ml with distilled water. Finally, all the samples were analysed for their As, Cd, Cu, Fe, Pb and Zn concentrations using the ICP-MS (ThermoScientific XSeries 2).

3.0 Results and Discussion:

It was observed that the control soil samples of the IISER and Barrackpore area were alkaline in nature and it remained same for the vermicompost samples too. Although, on close perusal, there can be observed a roughly decreasing trend from the 20^{th} day of composting to its 60^{th} day. This change in pH can be attributed to the formation of several organic acids such as humic acid, fulvic acid etc., which are essential byproducts that accompany any degradation of vegetable and plant matter. The ORP saw a decreasing trend and this can be explained by the fact that as the earthworms work through the biomass, they simultaneously stabilize it and do not create any extreme oxidizing or reducing environment. On the other hand EC was recorded to increase quite a fair deal which indicates the good ion exchange capacity of any earthworm-mediated compost, although, there is a sudden drop in the values on the 60^{th} day from a peak on the 40^{th} day. The salinity can be clearly observed to have increased a lot from the control soil samples and is quite obvious as the organic degradation produces a healthy amount of salts through the innumerable chemical reactions that take place during the whole process. But again, salinity is observed to decrease from the 40^{th} day peak to a lower amount on the 60^{th} day. Through these parameters, though, characterization is difficult to be deduced but the 60^{th} day decreasing trends point towards a more stable organic compost.

The organic matter percentage, as expected has increased several folds in comparison to the normal control soil samples. It should also be noted here, that the Dhapa compost is richer in organic carbon content than the Barrackpore one. A very similar trend is observed in the phosphate and nitrate concentrations too, with the Dhapa compost leading ahead and on a general basis the organic compost is showing much better nutrient attributes than the control soil samples. From these results, it can be vouched for that the organic compost can easily replace any commercial fertilizer, given such carbon, phosphate and nitrate contents.

From the total heavy metal concentrations in the sampled hyacinth from the two different sites, a clear trend shows the presence of all the metals in a much higher content in the Dhapa weed samples as compared to the Barrackpore hyacinth. Moreover, roots have displayed a huge accumulation capacity as compared to the other parts in all the cases except Arsenic. Thus water hyacinth's status as a superb hyperaccumulator is once again, restored. Alternatively, these values also reflect the high amount leaching of heavy metals that is taking place at the Dhapa site.

In a striking variation, the total heavy metal contents in the soil and vermicompost samples showed a sharp decrease in almost all the metals from the initial control soils to the final day of vermicomposting. Thus, the first objective of the study is near closure and can be further proved by the Tessier extraction results.

If the Tessier sequential extraction table is carefully studied, one notices the general trend of every metal becoming more and more inaccessible as the compost moves from the 20^{th} to the 60^{th} day.

Although, this fact does not disturb the availability of the essential metals like iron, zinc and copper, to the plants as they are naturally present in a huge amount in any natural system. In the case of As, F1 and F2 values have decreased to a few decimal places only, indicating its non-accessibility to the plants whereas, Cd content was too low in the bioavailable fractions to be detected at all. Thus, all the potentially harmful heavy metals were safely fixed in crystal lattice and therefore, had least chances of being biomagnified through the food chain. Most of copper was fixed in the later fractions too. Although, Dhapa compost can be seen to possess a fair amount of copper content till the end. Iron, as already stated is easily available, though a major portion of it is found to be fixed in F4 and F5. Lead was again, too low to be detected in F1and F2 on the 60th days. Finally, zinc too showed a similar trend as iron. All the metal concentrations of As, Cd and Pb are within the permissible limits of the Food Standards as set by a joint FAO/WHO committee in the year, 2011, whereas, there are no set standards for Fe, Cu and Zn as these are essential trace metals required both for the development of both plants and animals, alike. Although, it may be stated that tomato showed a slightly higher inclination towards the uptake of Arsenic than the other varieties.

4.0 Conclusion

To conclude, it may be mentioned that since this is only a short term experiment and has been applied on a small scale, the study might yield even more significant results when carried out on a larger scale. Also, the experiment has stood out to fulfill all the stated objectives and it can be safely commented that earthworms indeed hold the capacity to reduce the bioavailability of the heavy metals and that there can be no better way to control and limit the obnoxious weed of water hyacinth.

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Figure 1: A comparative graphical illustration of the Arsenic concentrations in the water hyacinth samples

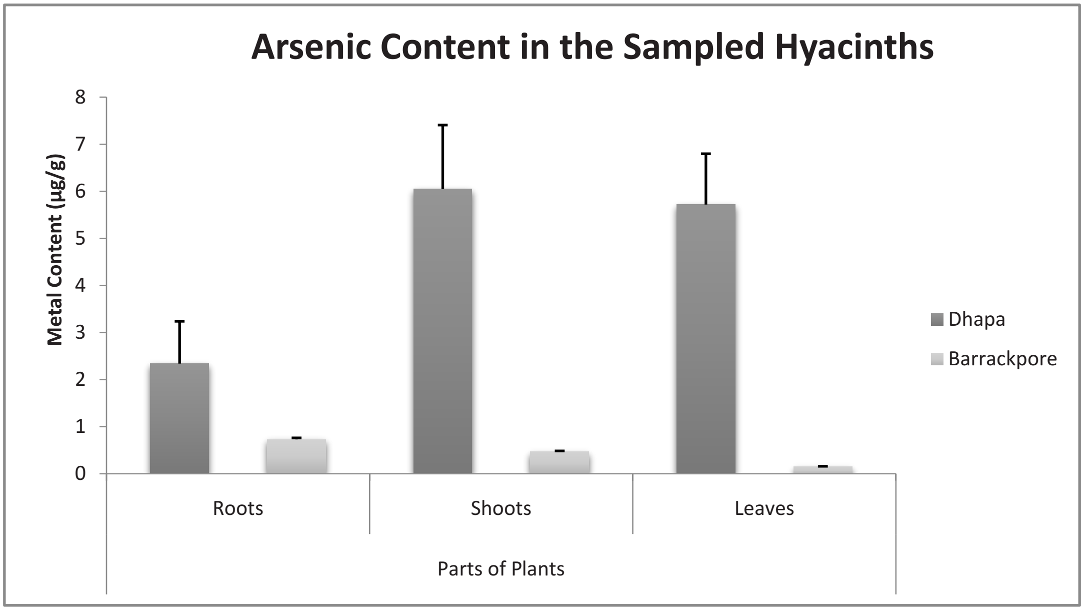

Figure 2: A comparative graphical illustration of the Iron concentrations in the water hyacinth samples

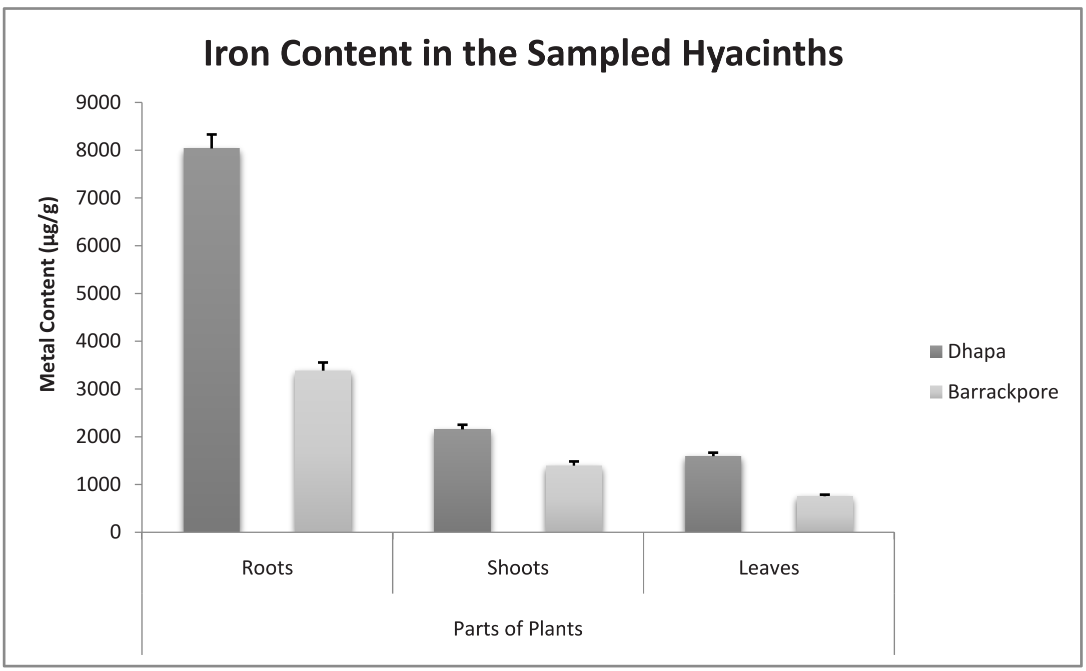

Figure 3: A comparative graphical illustration of the Copper concentrations in the water hyacinth samples

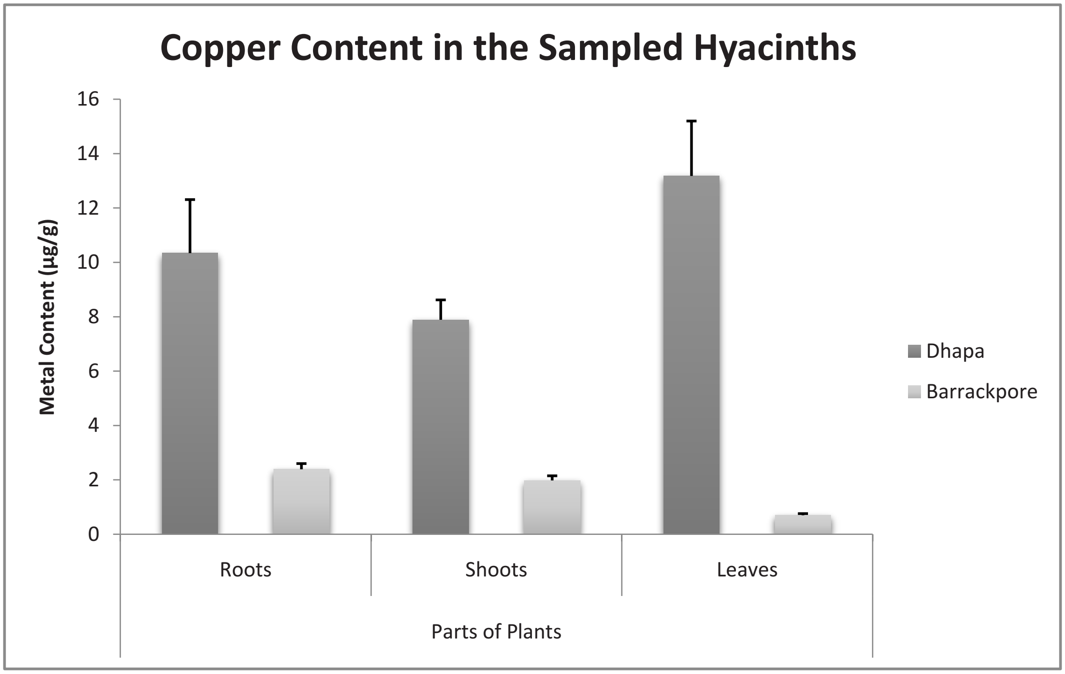

Figure 4: A comparative graphical illustration of the Zinc concentrations in the water hyacinth samples

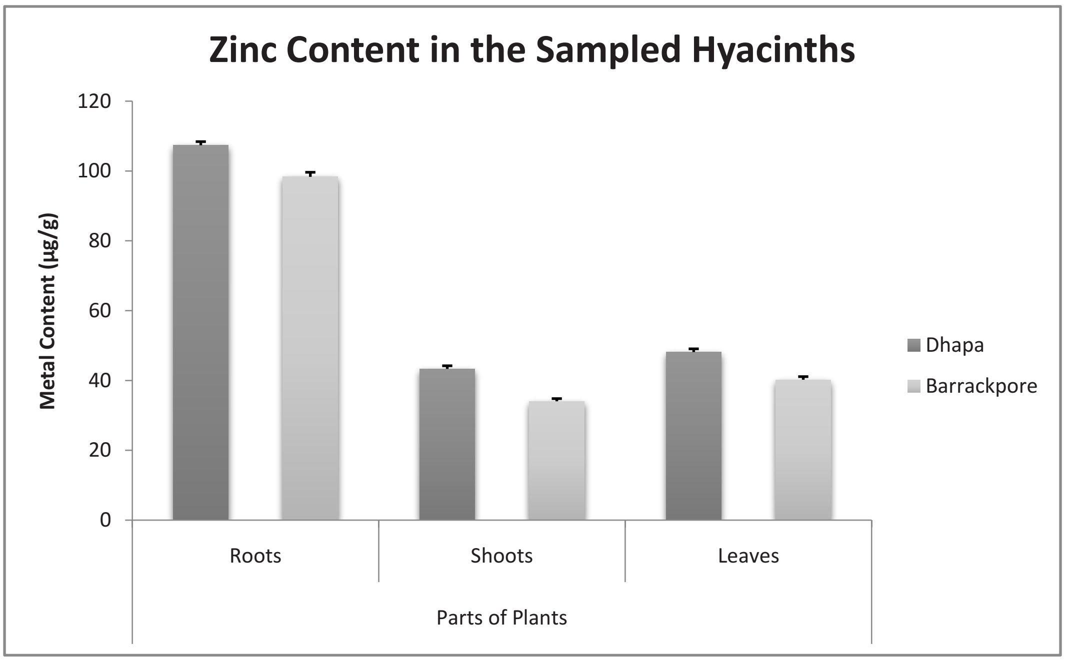

Figure 5: A comparative graphical illustration of the Cadmium concentrations in the water hyacinth samples

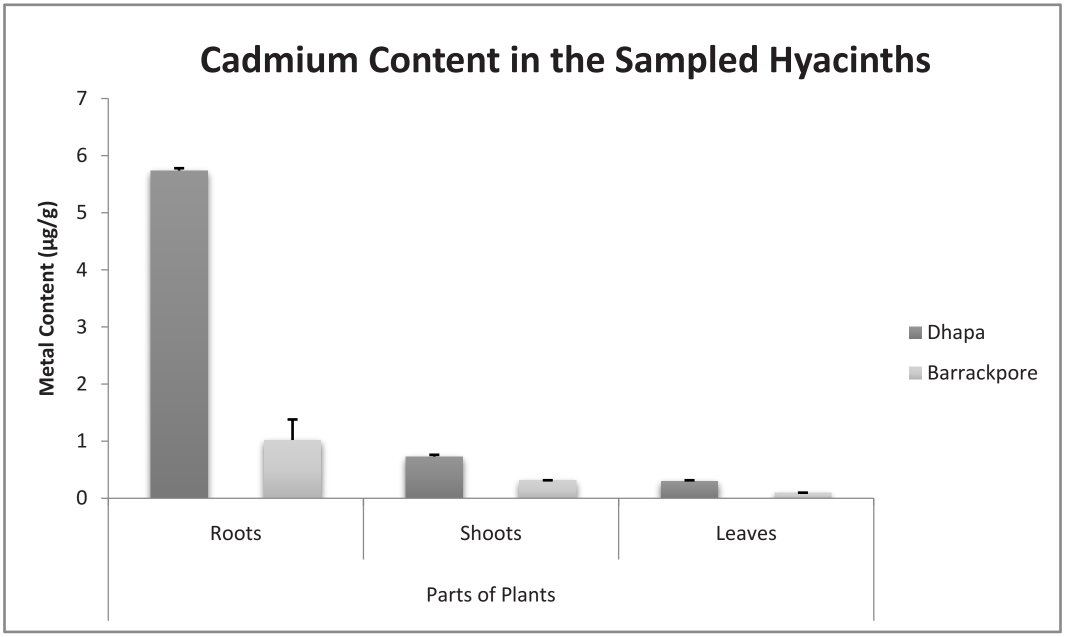

Figure 6: A comparative graphical illustration of the Lead concentrations in the water hyacinth samples

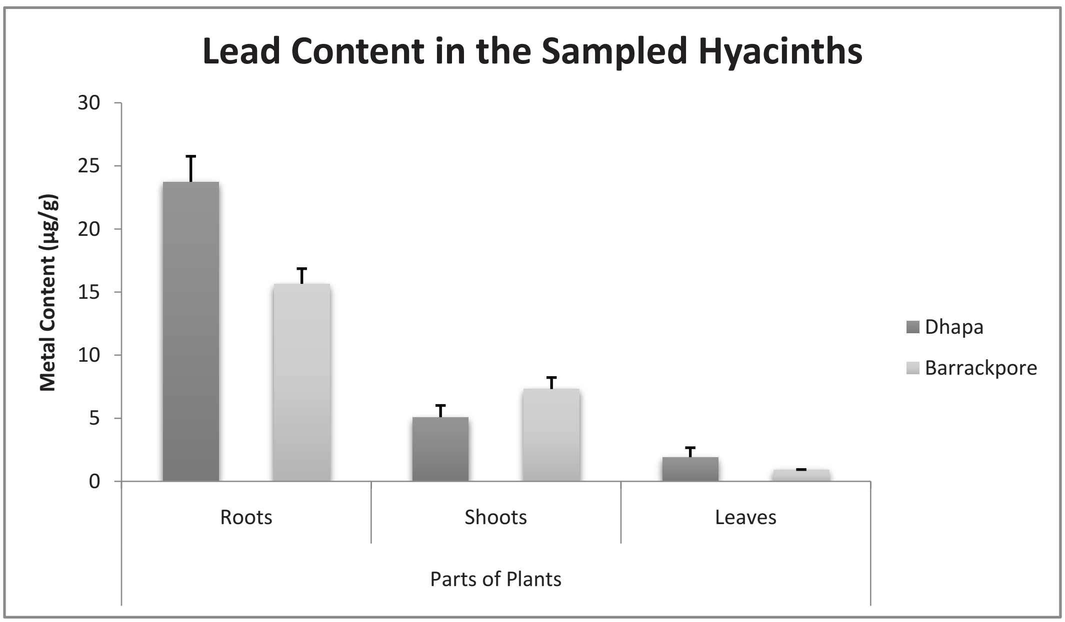

Figure 7: A comparative graphical illustration of the heavy metal concentrations of all the soil and vermicompost samples

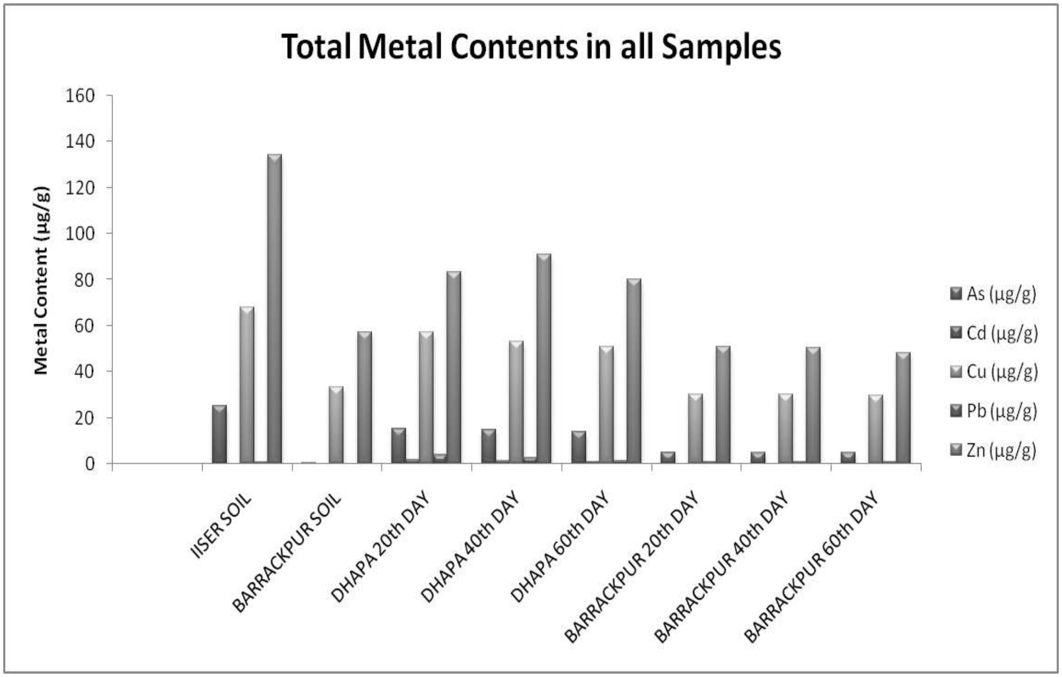

Figure 8: A comparative graphical illustration of the Iron concentrations of all the soil and vermicompost samples

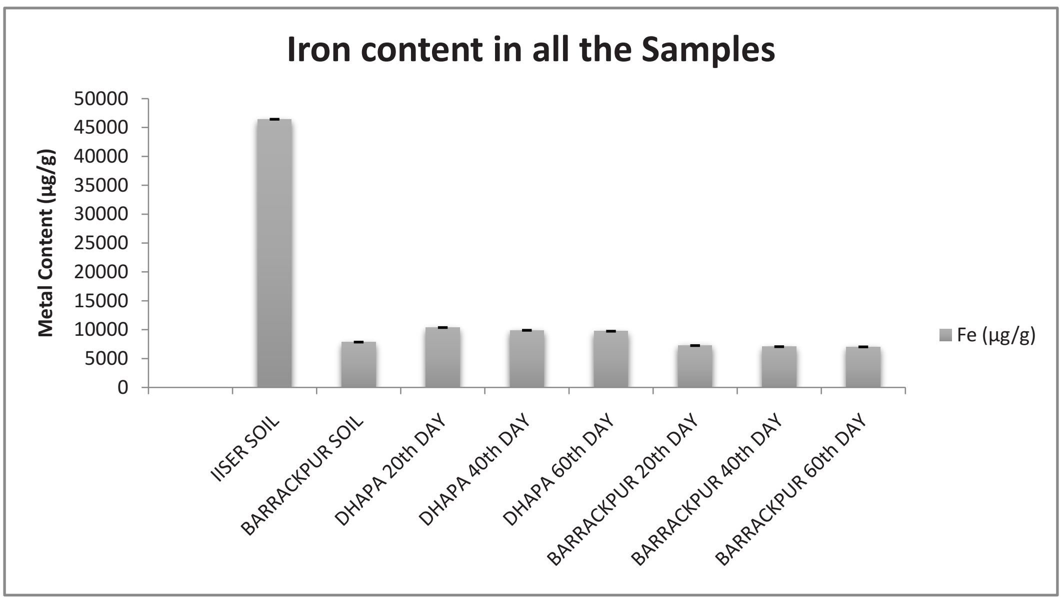

Table 1: A summary of the Tessier sequential process

SPECIATION OR FRACTION	REAGENTS USED	LABORATORY CONDITIONS
Exchangeable or F1	8ml of 1M $MgCl_2$	Agitation at 200rpm for 1hr at 25°C
Carbonate bound or F2	8ml of 1M NaOAc	Continuous agitation for 5hrs at 25°C
Fe and Mn oxides bound or F3	20ml of 0.04M $NH_2OH.HCl$ in 25% HOAc (v/v)	Continuous heating at 96°C was carried out with occasional agitation
Organic matter bound or F4	3ml of 0.02M HNO_3 and 5ml 30% H_2O_2 (pH=2, adjusted with conc. HNO_3 after 2hrs of which 3ml 30% H_2O_2 was added. After cooling, 5ml of 3.2M NH_4OAc in 20% (v/v) HNO_3 was added.	Firstly, heated at 85°C for 2hrs. After the second addition of reagent, again heated at 85°C for 3hrs with occasional agitation. After the last addition, agitation was carried out for ½ an hour
Residual or F5	10ml of HF and $HClO_4$ (5:1) was added for digestion.	First addition of the combined reagent was digested to near dryness followed by a second addition which was evaporated to dryness too. Finally $HClO_4$ alone was added and evaporated.

Table 2: Values representing the Tessier Sequential Extraction Process

Respective Metals and Their Fractions	Dhapa Compost				Barrackpore Compost		
	20th day	40th day	60th day		20th day	40th day	60th day
Arsenic (As)							
Fraction 1	0.183	0.03	0.024		0.15	0.09	0.06
Fraction 2	0.91	0.53	1.26		0.32	0.2	0.1
Fraction 3	3.67	4.03	2.52		1.32	1.88	1.35
Fraction 4	2.98	1.25	1.07		0.86	0.52	0.69
Fraction 5	8.23	8.93	9.201		2.03	1.43	2.1
Cadmium(Cd)							
Fraction 1	ND	ND	ND		ND	ND	ND
Fraction 2	ND	ND	ND		ND	ND	ND
Fraction 3	0.85	ND	0.176		ND	ND	ND
Fraction 4	0.62	0.64	0.423		0.002	ND	ND
Fraction 5	0.35	0.83	0.361		0.0935	0.0066	0.00215
Copper (Cu)							
Fraction 1	6.11	5.33	7.28		0.63	0.5	0.57
Fraction 2	8.22	9.431	10.766		0.32	0.65	0.51
Fraction 3	3.21	2.46	2.001		5.31	3.61	6.2
Fraction 4	1.33	3.015	0.93		10.05	13.21	11.11
Fraction 5	38.36	33.044	29.921		14.01	11.87	10.9
Iron (Fe)							
Fraction 1	232.21	212.03	204.66		110.07	225.63	301.92
Fraction 2	301.09	356.74	320.2		61.41	21.83	9.28
Fraction 3	2991.5	3064.7	3122.22		2362.1	1941.01	1063.7
Fraction 4	515.71	500.93	474.33		729.1	613.33	435.53
Fraction 5	6321.31	5734.66	5600.19		3941.09	4141.02	5062.07
Lead (Pb)							
Fraction 1	ND	ND	ND		0.03	ND	ND
Fraction 2	ND	0.02	ND		ND	ND	ND
Fraction 3	0.68	0.56	0.064		0.32	0.15	0.08
Fraction 4	0.71	0.53	0.4		0.09	0.1	0.07
Fraction 5	2.41	1.37	0.836		0.59	0.61	0.51
Zinc (Zn)							
Fraction 1	17.89	19.25	20.02		15.24	15.61	13.92
Fraction 2	12.44	11.26	11.03		6.31	4.21	5.01
Fraction 3	1.06	2.77	3.025		0.99	1.54	0.87
Fraction 4	1.43	3.02	2.17		5.21	6.31	1.2
Fraction 5	50.31	53.26	42.765		17.82	20.53	25.32

Table 3: Values representing the heavy metal content in the plant masses grown with Dhapa compost

Corresponding Plant Part and Variety	As (µg/g)		Cd (µg/g)		Cu (µg/g)		Fe (µg/g)		Pb (µg/g)		Zn (µg/g)	
(Dhapa Compost)	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Gram whole	0.004	0.0003	0.093	0.003	12.042	1.69	260.95	2.26	ND	ND	13.339	2.122
Gram fruit	0.0001	0.002	0.0451	0.021	7.599	1.52	203.72	1.08	ND	ND	10.626	3.25
Chilli whole	0.0032	0.0004	0.024	0.012	9.938	1.67	207.69	2.59	ND	ND	12.39	2.67
Chilli fruit	0.0003	0.0001	0.0036	0.009	6.44	1.01	122.64	3.29	ND	ND	7.065	1.93
Coriander whole	0.00015	0.003	0.077	0.0085	10.013	1.251	273.06	3.776	0.04	0	11.732	2.28
Tomato whole	0.0013	0.0005	0.082	0.006	13.33	2.42	248.65	3.44	0.04	0	15.66	3.49
Tomato fruit	0.0026	0.001	0.007	0.0002	11.459	2.66	193.22	2.97	ND	ND	14.03	2.79

Table 4: Values representing the heavy metal content in the plant masses grown with Barrackpore compost

Corresponding Plant Part and Variety	As (µg/g)		Cd (µg/g)		Cu (µg/g)		Fe (µg/g)		Pb (µg/g)		Zn (µg/g)	
(Barrackpore Compost)	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Gram whole	0.00022	0.0001	0.0073	0.0003	9.04	1.42	143.73	2.99	0.025	0.001	14.02	1.96
Gram fruit	0.00012	0.0031	0.002	0.001	1.89	0.72	106.52	2.68	ND	ND	8.34	2.01
Chilli whole	0.00025	0.0106	ND	ND	6.92	1.29	93.36	2.031	0.06	0.002	10.79	2.04
Chilli fruit	0.00039	0.0005	ND	ND	0.53	0.03	72.22	1.092	ND	ND	5.03	1.71
Coriander whole	0.00073	0.0033	0.003	0.001	7.35	2.21	156.07	3.09	0.034	0.007	8.66	1.063
Tomato whole	0.00097	0.002	0.005	0.0003	8.3	1.07	197.01	3.22	ND	ND	12.06	2.73
Tomato fruit	0.00004	0.0001	ND	ND	0.65	0.04	110.8	1.25	ND	ND	7.43	1.037

Trawl induced biotic and aquatic waste degrading marine environment in West Bengal offshore

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1.0 Introduction :

Trawl fishing is intensified in West Bengal offshore where bull trawlers are very likely to have disturbed marine biochemical composition as well as undersea habitat of baseline species of marine food chain including the world's largest mangrove food web in 'Sundarbans'. Destructive environmental impact of bottom trawling is analytically studied and statistically judged to find out the best fit method of attaining sustainable marine environment.

2.0 Materials and Method :

2.1 Area studied :

West Bengal offshore, the present study area with a number of large commercial fishing zones is demarcated by State of West Bengal on the North, Bay of Bengal on the South, Bangladesh on the East and State of Orissa on the West (Map no. 1). All modern bull trawlers usually continue fishing almost round the year, only excluding 2 – 3 months of pre-monsoon or summer.

2.2 Ecological significance of West Bengal offshore :

Estuarine & marine ecosystem with mangrove food web (Diag.1) covering West Bengal offshore enjoys huge reserve of microscopic phyto-planktons as the extensive baseline followed by other marine species at different higher trophic levels. If any of these baseline components is found lost or damaged by any sort of human intervention, entire marine food pyramid must be collapsed in long run and pose a great threat to all top consumers (Das.M, 2002). The malpractice like commercial trawling continued in West Bengal offshore through years seems to have shortened the broad base with much less supply of energy to the tertiary and top consumers (Das.M, 2010). Ultimately, sustenance of all dependant marine species is going to be at stake and the coastal humans too, as the apex species, will be endangered. Coastal fisherfolk, being absolutely dependent on marine stuffs for their major food supply and primary occupation, will be the worst sufferer out of this anthropogenic intervention into the offshore environment.

2.3 Objective :

Objective of this study is 1) to analyze the quantity and quality of trawl bio-waste 2) to determine chemical degradation of marine water, 3) to study negative trawling impact on the marine biological and chemical environment and 4) to chalk out an environmental management plan to ensure sustainable marine environment.

2.4 Methodology :

To attain the specific objective, methodological steps were followed :

a) experimental sampling of trawl discards at different offshore locations, b) analysis of collected discards and identification of species, c) analysis of physico-chemical parameters of sea water and benthic soil, d) detailed assessment of the impact of trawl bio-waste and aquatic waste on marine food chain and e) draft of Environmental Management Plan for sustainability.

3.0 Results :

To find out the sources of severe trawl induced marine pollution, the field-study experienced two major sources like biological and aquatic waste as follows.

3.1 Trawl discards collected as biological waste:

All collected samples of destroyed non-target species are identified as sting ray(*Himantura imbricata*), catfish, flatfish (flounders and soles i,e. *Solea ovata*), silver belly, clupid fish, gastropod(*Babylonia spirata)*, sepia(*Sepia scubata* and *Sepia inermis*), loligo(*Loligo sp*. and *Loliolus investigatoris*), mud octopus(*Octopus macropus*), nudibranch, sea urchin(*Temnopleurus toreumaticus*), sea anemone, squilla (mantis shrimp), portunus crab, shark, skate(*Raja.sp*), halibut*(Psettodes erumei*) a precious commercial fish in West Bengal coast, benthic crab*(Doclea ovis*) very uncommon in this coast, gobid fish or mud skipper(*Parachaeturichthys polynema*), squids*(Loligo sp*.), cattle fish, flatfish (halibut and *Silago sihama*), anchovy (*Coilla dussumieri*) and marine crabs (three species i.e, *Matuta plenipes, Matuta victor* and *Charybdis feriatus)*.

3.2 Physico-Chemical analysis to determine aquatic waste:

Data on the chemical analysis of collected samples of marine water and benthic soil is graphically plotted in Fig.2, 3, 4 and 5. It shows implicative seasonal changes in the chemical composition of benthic soil and water which highly influences the offshore marine ecosystem. Continuous trawling operation has added more effective anthropogenic chemical changes through heavy metal pollution (Fig.6) to this marine scenario.

4.0 Discussion :

A single passage of beam trawl has been reported to kill 5–65% of the resident fauna and mix the top few centimetres of sediment (Duplisea *et al)*. Increasing contribution of trawlers to the total catch of fish observed in the coastal West Bengal during the last few decades clearly indicates much more severe related destruction of bottom dweller juvenile species as biological waste because of the non-floating rather dragging device of trawl. The non-target species may have key roles in the marine food-webs that fortify ecosystem processes and functioning, which in turn determines the productivity of marine capture fisheries (Auster, P. J. and Langton, R. W). Habitat impacts and by-catches affect stocks of commercially valuable species, the natural biodiversity and ecological services provided (McAllister, D. E. and Spiller, G.) .Large number of non-target species destroyed during netting in West Bengal offshore as a result of the non-selective nature of bottom trawl obviously damages the existence of their marine predators. Continuous malpractice seems to have shortened the extensive baseline of marine food chain as well as mangrove food web in Eastern Indian offshore. It supplies much lesser than necessary food energy up to the apex species like coastal fisherfolk endangering their lives. It has already reduced stock of commercial fish along West Bengal offshore, lessened marketable quantity of fish and already created crisis of fish in the locality. The situation is gradually leading towards an irreparable loss to the fishery-dependent population all over the world as the top consumers.

4.1 Impact of Biological and aquatic trawl waste:

4.1.1 Impact analysis of trawl induced biological waste:

Bio-geographically, huge nutrients continuously washed off the land by numerous rivers of Bhagirathi-Hooghly river system to be thickly deposited onto the continental shelf of Bay of Bengal gets thinner away from the coast. So benthic biodiversity is naturally found higher near the coast thinning away from the coast proving biodiversity richness inversely related to the offshore distance. But in comparison, benthic biodiversity richness is found higher off Shankarpur though at more distance (11.9 km) from coast and much lesser off Digha though at closer (9.7 km) to coast. Actually the continuous depth of 10.7 mt off Shankarpur between 11.9 and 16.1 km has proved a shallower continental shelf with higher ecological viability of nutrient deposition for richer benthic biodiversity. In contrast, increasing trawl depth of 10.2 mt off Digha has proved steeper gradient of continental shelf (between 9.7 and 13.7 km) with natural possibility of supporting lesser benthic biodiversity. It has proved benthic nutrients deposition as well as growth of biodiversity getting thinner not only with increasing offshore distance but also with degree of gradient of continental shelf, Comparing 3rd and 4th cruises, 58.33% loss of benthic biodiversity at 6.23 mt depth between trawling distance of 4.8 and 6 km is much higher than 15% loss of benthic biodiversity at 15 mt between 10.8 and 15.24 km in the same offshore. It corroborates higher loss of benthic biodiversity at shallower continental shelf closer the coast because of maximum benthic nutrient deposition at near coast submarine zone and vice versa. In case of next marine study (2012-2014), comparing fifth and eighth marine cruises held at Shankarpur offshore, loss of biodiversity is recorded at higher rate (62.5%) in near offshore (at 2 mt from 2.5 – 3.00 km) whereas much lower (20%) in far offshore(at 9.7 mt from 12- 15 km) in more or less continuous lower gradient. Comparing sixth and seventh marine cruises held at Digha offshore, loss of biodiversity is recorded at higher rate (94.4%) in near offshore (7.6 mt at 9-14km) whereas much lower (46.66%) in far offshore(8.4 mt at 13-16.2km). It has again proved higher loss of benthic biodiversity at shallower continental shelf closer to the coast because of more benthic nutrient deposition here. Fig.1 proves trawling at higher depth far from the coast causes lesser biodiversity loss than that performed in shallow water at lower depth near the coast. Apart, four peaks of the biodiversity curve shows maximum biodiversity loss during post-monsoon and winter trawling whereas the sags indicate less biodiversity loss mainly during pre-monsoons . Unfortunately, most of the commercial trawlers in West Bengal offshore fishing grounds practice fishing invariably in the biodiversity-enriched shallower water closer to the coast to ensure highest catch with maximum profit at the cost of maximum damage to marine ecosystem. Moreover, trawling remains in its' full swing specifically during the post-monsoon and winters putting less effort in pre-monsoons and summer as the 'trawl maintenance' and the declared 'no fishing' period to protect fish-spawning. Thus marine biological waste as well as biodiversity loss in West Bengal offshore remains accelerated through years.

4.1.2 Impact analysis of trawl induced aquatic waste:

Another alarming impact of trawling found is marine chemical changes. According to the chemical analysis of benthic soil (Fig.2), increasing percentage of sand with decreasing silt & clay closer to the coastline at minimum depth and increasing silt & clay with decreasing sand away from the coast on the continental shelf area proves the presence of very nutritious wide submarine bed formed of thick deposition of fresh silt by various distributaries of the river Hooghly at its' estuarine mouth that supports very rich growth of benthic biodiversity in entire Bay of Bengal offshore developing a great fishing zone. As a support to the fact 'higher marine biodiversity richness towards the coast and vice versa' already proved before, presence of organic carbon in benthic soil is also found higher towards the coast in Fig.3. Both biodiversity as well as organic carbon decrease away from the land. Moreover, Electrical conductivity or salinity of the benthic soil (Fig 4) is found increasing landward with a decrease from the land. Whereas benthic soil salinity decreases near the coast specifically during post-monsoon because of the dilution with rain water and higher volume of river runoff through Hooghly estuary spreading along the West Bengal coastline. Salinity of sea water (Fig 5) curve interestingly shows a marked relation with daily tidal times and also with change of seasons. Though sea water salinity shows higher near the coast, it effectively remains lower during on-tides in morning with gradual increase during off-tides in late morning through noon up to afternoon. Two peaks of the curve one highest in winters & pre-monsoons and other lower in post-monsoons prove sea water salinity increasing slowly after the end of monsoonal rain during the winter with maximum up-rise during entire pre-monsoon till the on break of next monsoon. All these physico-chemical parameters of benthic soil and sea water have together supported a highly favourable biochemical offshore environment contributing to rich growth of benthic biodiversity all along the broad continental shelf. But a satellite image (Fig.8.) shows how this Eastern Indian benthic biodiversity is scooped out by regular commercial trawl route that needs to be immediately taken care of.

4.1.2.1 Trawl induced heavy metal pollution :

As a leading busy industrial zone of India 'Hooghly Industrial Belt' occupies both sides of the river Hooghly, not very far from its' estuarine mouth and hence causes entire West Bengal offshore subjected to heavy chemical pollution. Not only the huge municipal waste water from Kolkata but continuous oil spill and lethal water washed out of huge number of mechanized diesel operated trawlers are also additionally responsible for severe marine water pollution and benthic soil pollution in most of the commercial fishing grounds. None of these trawlers in West Bengal offshore have marine pollution control measures. Many of these do not even have authentic registration obtained from the Government. Fig. 6 shows a glimpse of benthic soil pollution as well as seasonal changes along the trawl survey routes in West Bengal offshore in three parameters i.e, lead, cadmium and copper from the industrial including trawl toxic effluents considered as the most lethal polluting agents in the coastal and marine ecosystem. As a whole, cadmium is present in non-considerable amount and lead and copper increase with increasing distance and depth though remains lower during post-monsoon up to early winter. Because monsoonal rain dilutes down the degree of lethality and gradually becomes higher since per-monsoon through summer till the onset of next monsoon.

4.2 Degradation of marine ecosystem :

Trawl induced biotic and aquatic degradation ultimately causes an irreparable loss to the marine ecosystem of West Bengal offshore as a whole, in the following order :

a)Loss of sea anemons and sea urchins must put their predators i.e, sea snails, sea spiders, grey sea slugs, sea stars and large demarsal fishes into crisis of survival, b) destruction of sepia and loligo creates severe food crisis for commercial fish species, cuttlefish, pelagic finfish, ocean pike, sting ray, eel, dolphin, seal, marine (diving) birds, c) skates are also destroyed putting their predators i.e, shark and sting rays in danger, d) Regular loss of shark, sepia, loligo, flat fish (flounders and soles), squilla and halibut as indispensable food is ultimately causing food crisis for coastal population as the top consumers of marine food chain, e) destruction of cuttlefish as major food for dolphins, sharks, seals causes crisis of their survival, f) flatfishes (*Sillago sihama, Cinoglosus sp.)* and anchovy (*Coila dussumieri*) destroyed largely by trawling create lack of food for bony-fishes and fin fishes, g) marine benthic crabs namely *Matuta plenipes* and *Matuta victor* are totally destroyed putting flatfishes in danger as their important food, h) Destruction of benthic crabs namely *Charybdis feriatus* and *C.variegata* create food crisis for finfish and bony-fishes, i) destruction of eel i.e, *Uroconger lepturus* creates food crisis for bass, lake trouts, fish-eating birds and marine mammals. j) random destruction of grooved rajor fish (*Centriscus scutatus*) puts seals in food crisis.

5.0 Conclusion :

To ensure conservative use of marine resources suggested Environmental Management Plan (Fig.7) highlights : **a) Preventive measures** : i) trawl netting must be strictly banned and legal penalty should be imposed in case of violation of order, ii) night trawl should specifically be banned forever as it is the resting period of fish naturally increases the percentage of damage of non-target species, iii) monsoon trawl should also be banned forever as the spawning and maturity period for larvae and their juveniles before being caught during the next fishing season, iv) trammel nets must be introduced instead of trawl. Because trawl as a dragging device destroy benthic habitats on sea-floor. But trammel as a floating gear floats just above sea-floor to catch fish without damaging the benthic species and undersea habitats. **b) Curative measures** : i) free of cost training for local fishermen on scientific 'on boat' restoration of caught non-target species alive to be instantly released into ocean, ii) strict rules on instant 'on boat' release of non-target species alive into sea iii) regular along-the-coast inspection by village administration units (Panchayets) with local NGOs, iv) stop further registration of new trawlers in West Bengal offshore.

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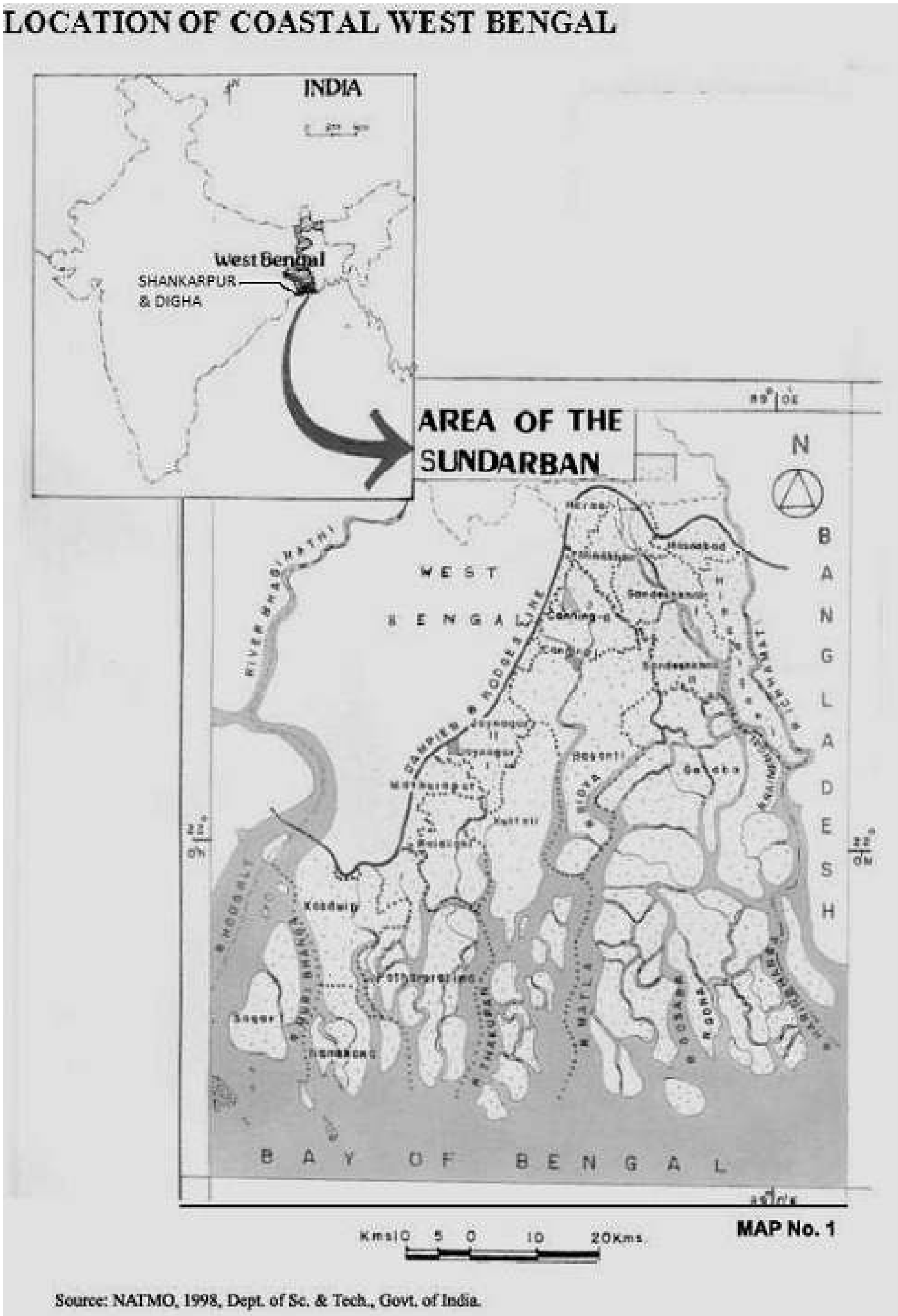
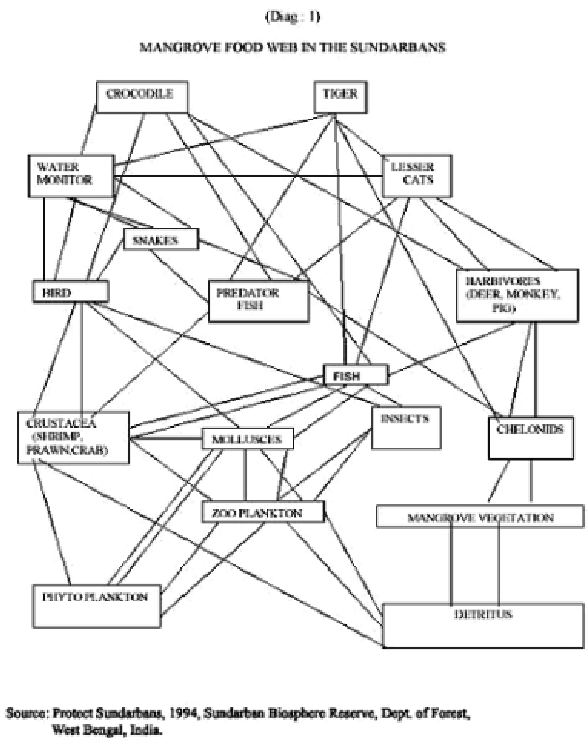
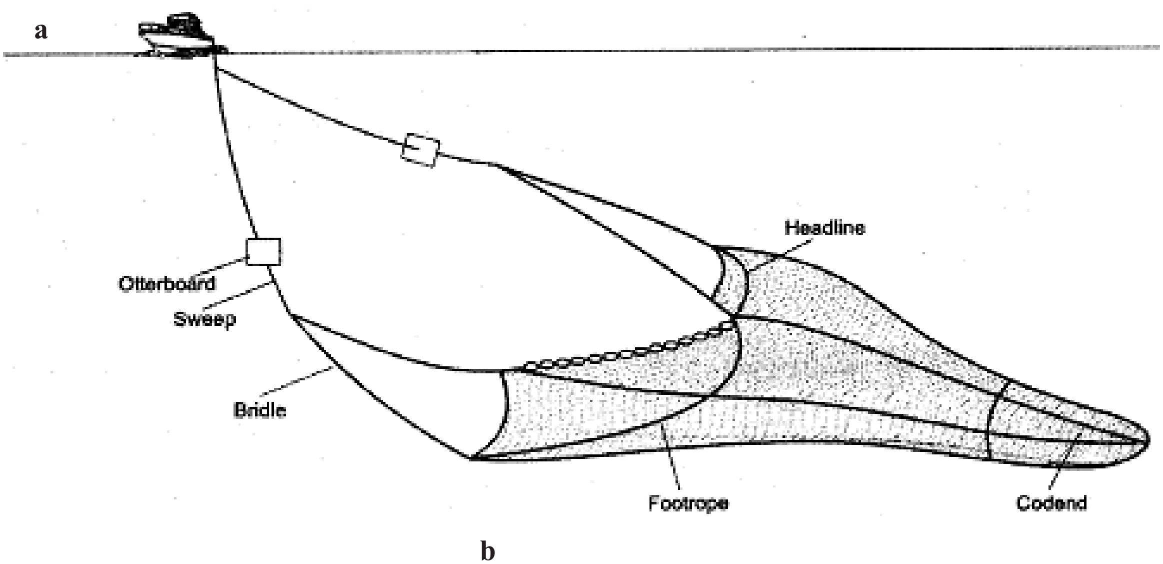


Map No.1 Location of the Coastal West Bengal.



Diag.1 – Mangrove Food Web



Diag.2a, 2b Trawl net functioning under sea (Current Science, Vol. 90, No. 7, 10 April 2006, Pg. 922) 2a A trawler in operation, 2b A bottom trawl net and its parts.

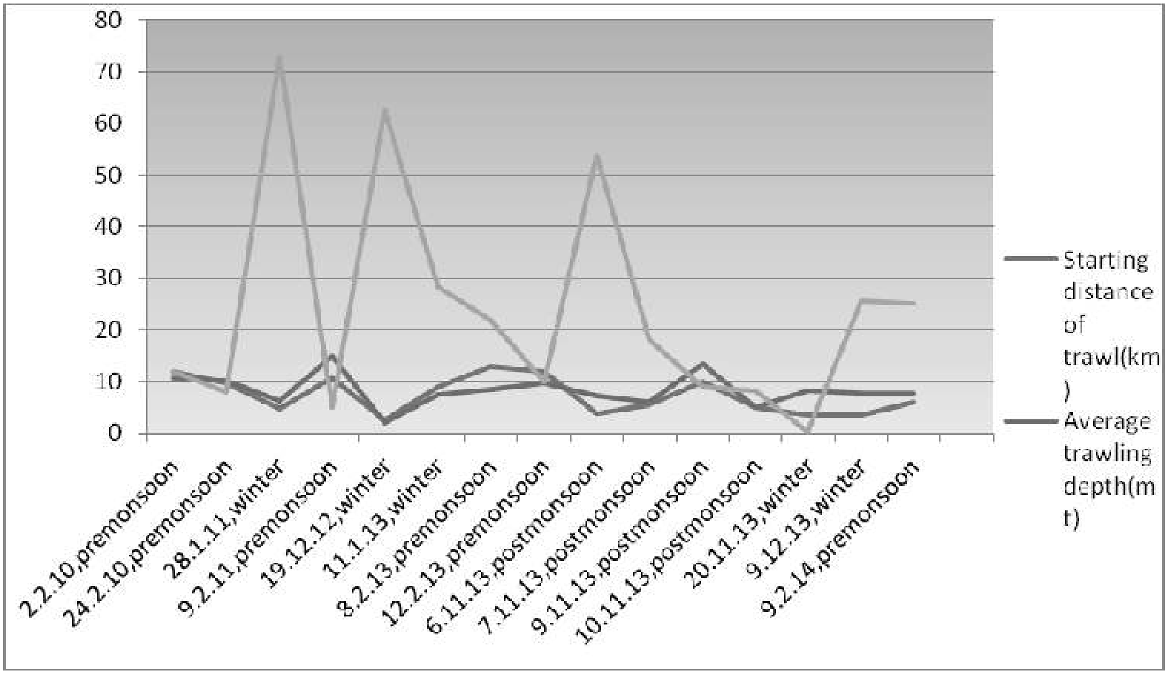


Fig.1 Seasonal marine biodiversity loss by trawling with distance and depth, 2010 – 2014

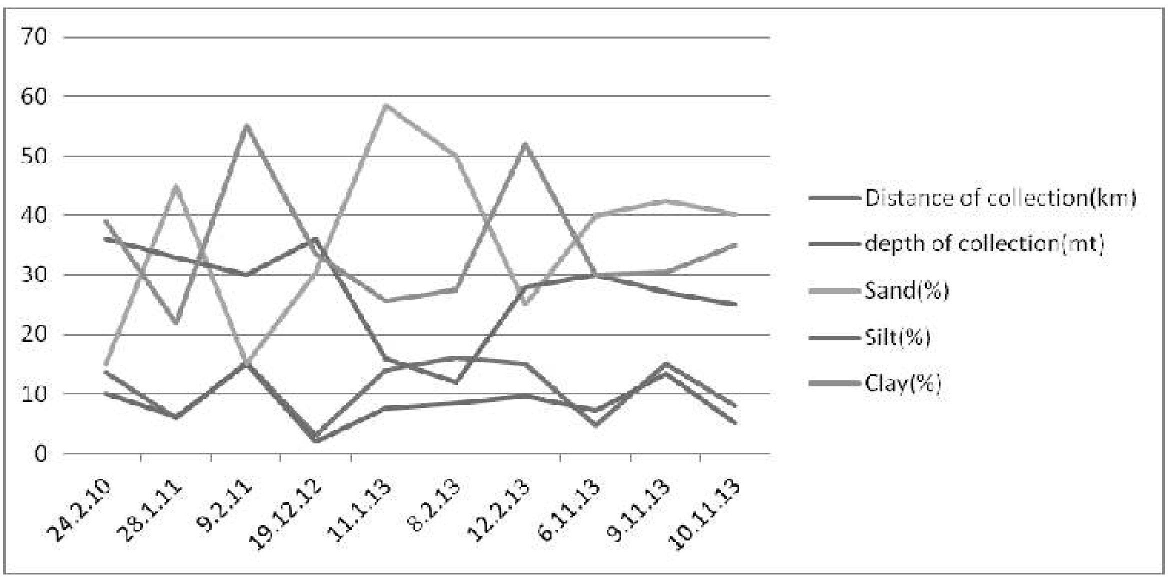


Fig.2 Changes in benthic sand, silt & clay with 'distance' & 'depth' during 2010 – 2013

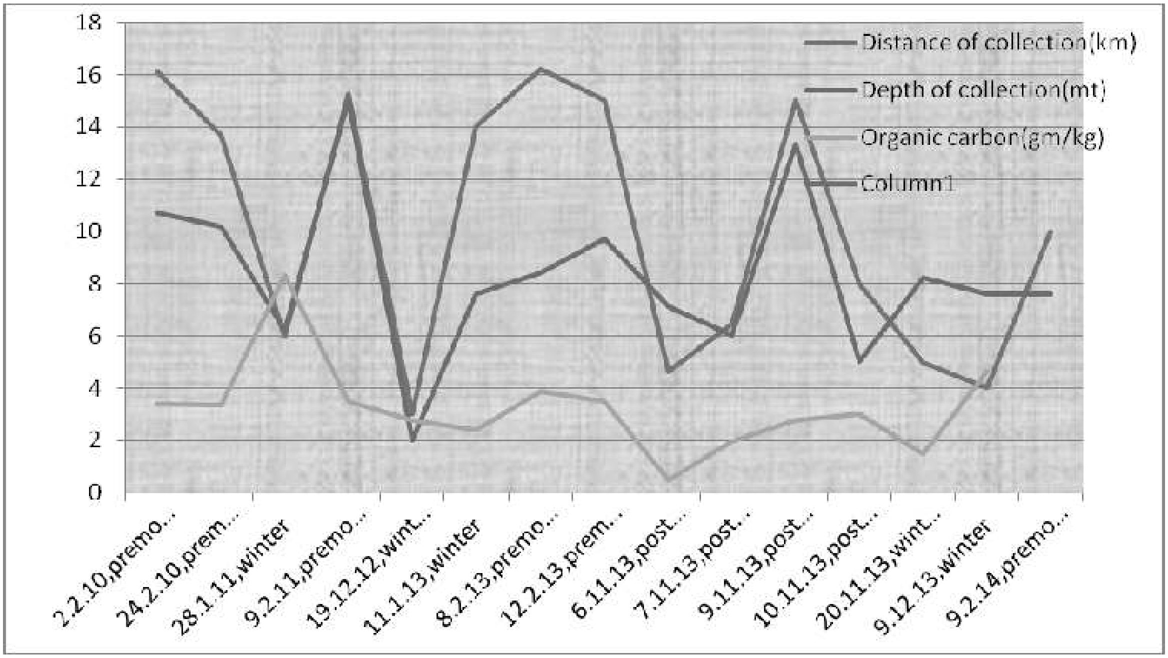


Fig.3. Changes in organic carbon in benthic soil with 'distance' & 'depth', 2010 – 2014

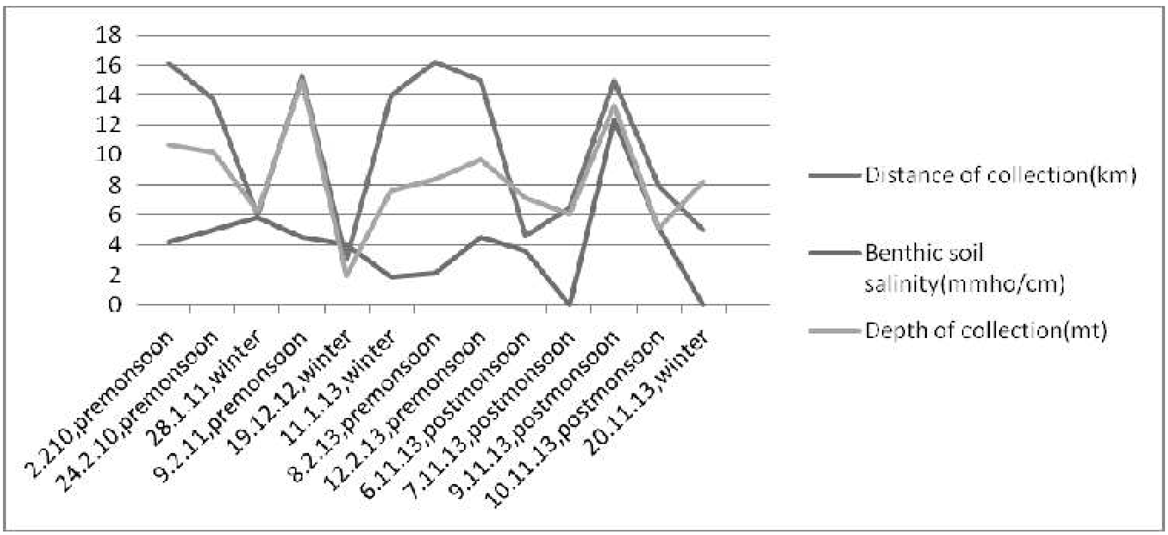


Fig.4 Seasonal changes in benthic soil salinity with 'distance' & 'depth', 2010 – 2014

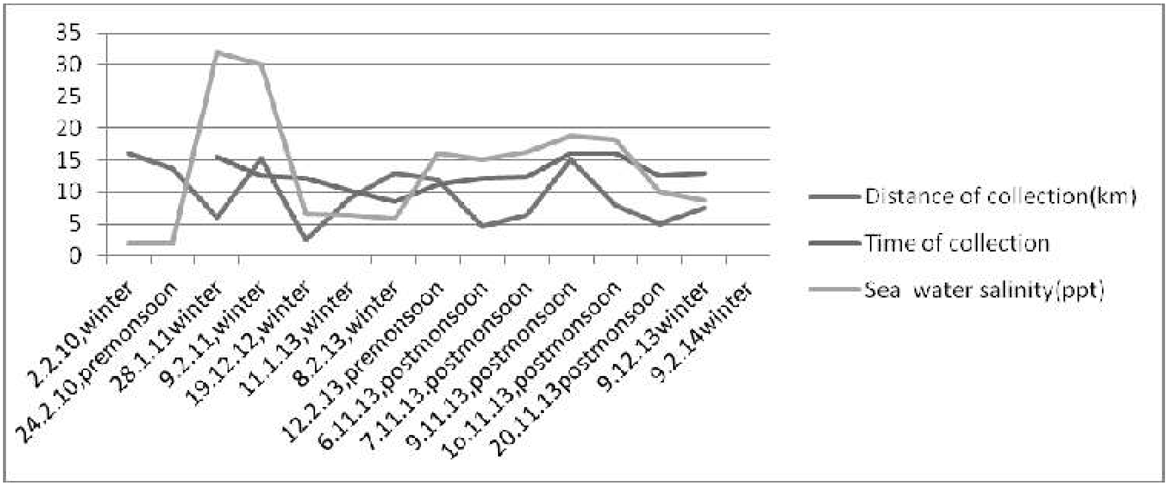


Fig.5 Seasonal changes in sea water salinity with 'distance' & 'time' during 2010 – 2014

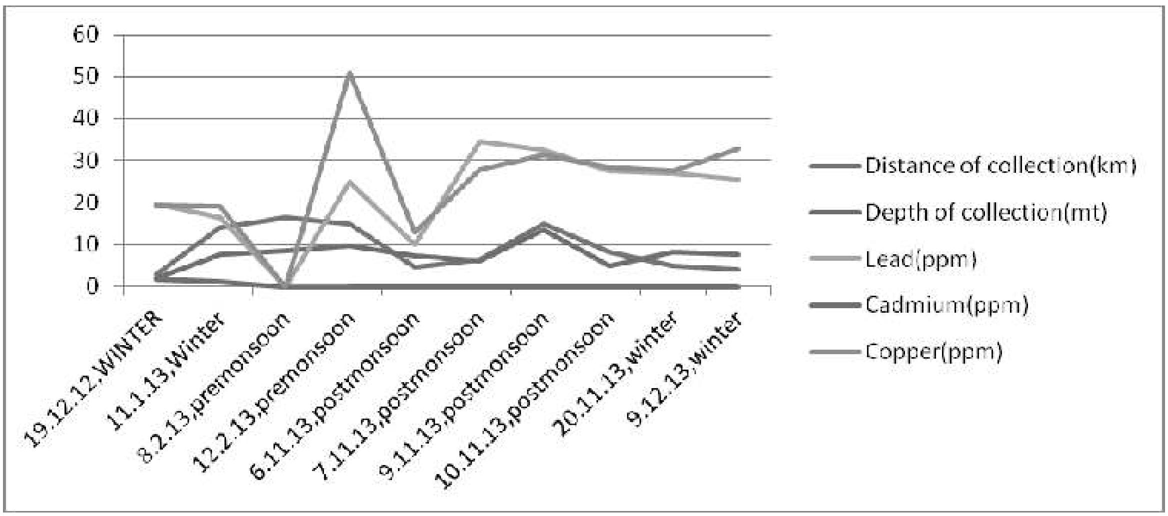


Fig.6 Changes in benthic soil pollutants with 'distance' & 'depth' during 2010 – 2013

Environmental Management Plan

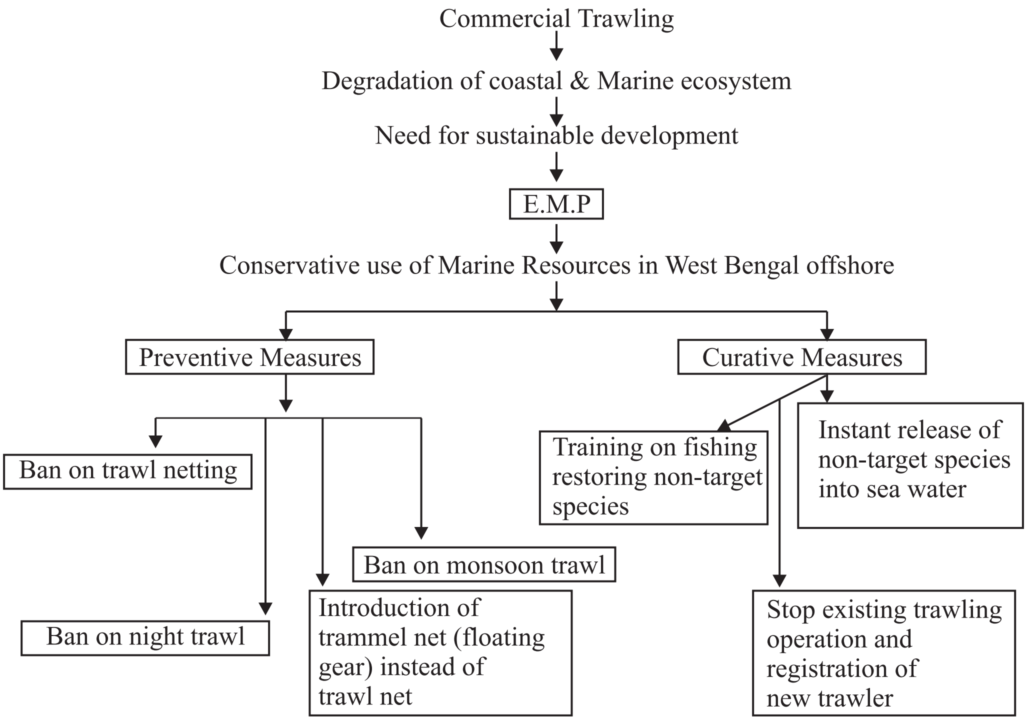


Fig.7 Environmental Management Plan

Fig.8 Landsat image of undersea Trawl fishing grounds

Environmental Awareness and Action Towards Reuse and Recycle: A Correlational Case Study on Waste Management

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Abstract

The degradation of natural environment primarily takes place due to human behaviour. So it is necessary to study the psychological factors like awareness, values opinions and beliefs of people and their role in precipitating harmful as well as pro-environmental behaviour. This study analyzes the relationship between the environmental awareness of the students with their reported environmental actions comprising Reuse and Recycle regarding solid waste, waste water, Bio-waste, E-waste and Hazardous waste. The responses were collected from Eighth grade students (N=600) studying in and secondary and higher secondary schools. The research instrument developed by the researchers consists of 12 pair of items. It measures the level of environmental awareness and the degree to which one practices the related environmental action. For analyzing the data chi-square with contingency of coefficient test was employed. The results showed that in case of reuse, the score of awareness and action significantly correlated. Whereas weak relationship exists between these two scores in terms of items related to recycle.

Key Words: Environmental awareness, environmental action, Reuse, Recycle and waste management

1.0 Introduction

The concept of environmental education has evolved during last decades. The period of metamorphosis demonstrates how the emphasis has shifted from acquiring environmental awareness, and knowledge towards environment towards civic action to minimize and arrest degradation of environment caused by unmindful human action. But environmentally significant behaviour is a complex issue and many factors are attributed to it apart from mere environmental knowledge, awareness and attitude. *Kollmus and Ageyman* (2002) had analysed the different theories of behaviour to explain the attitude behaviour gap in the context of environment. Among the various theoretical frameworks related to awareness attitude behaviour they have emphasized on *Theory of Reasoned Action* and their *Theory of Planned Behavior* (*Fishbein & Ajzen,* 1975; *Ajzen & Fishbein,* 1980). This is what has been done in this present research. *Waste can be defined as matter for which society no longer has any immediate use, something that is rejected because it is considered to be worthless or not needed. It is difficult to define rather it is readily recognized.* Researches on Reuse and Recycle in the Indian perspective especially in school education context are not adequate. Hence this work is to be accepted as in right direction especially to understand the importance of Reuse and Recycle vis-à-vis environmental awareness and action.

2.0 Objectives of the Study

This paper observes the perceptions of the students regarding their knowledge (awareness) of Reuse and Recycle. The present study investigates the relationship between students' awareness and action regarding Reuse and Recycle. This study is unique as it explores the extent of interrelationship between the two variables and their likely consequences on environment.

3.0 Methodology of The Study

3.1 Sample

The sample was drawn from the schools of eighth grade students studying in secondary and higher secondary schools, situated in the city of Kolkata and Howrah, West Bengal. In the present study random sampling was done. In random sampling the researcher selects sample units form the population following principle of random selection. The present sample comprises 600 (N) students comprising both girls and boys.

3.2 Instrument

The research instrument was based on Environmental attitude and action scale developed by *Kaspolu and Turan* (2008). The items were modified to relate to Bengali culture and practices. It consists of 12 pair of items representing Reuse and Recycle regarding solid waste, waste water, Bio-waste, E-waste and Hazardous waste to measure the level of environmental awareness and the degree to which one practices those environmental actions. Actually each item is essentially a pair of awareness and action in the context of a particular environmental issue for example saving water. This item has two parts as indicated below-

- *Awareness: Broken and dripping taps should be repaired*
- *Action: I repair or have someone to repair broken and dripping taps*

All the items are framed in the same manner. Each item has three responses options- always, sometimes and never for action related part and completely agree, neither agree nor disagree and not agree for awareness part.

4.0 Results and Discussion

The results show 12 dimensions of awareness-action item in relation to eighth grade students. For analyzing the data chi-square with contingency of coefficient (3X3 way) test was employed. It illustrates students' ideas about environmental services and their sensitivity or responsibilities towards environmentalism.

From *table -1,* it can be concluded that students' awareness-action link towards excessive packaging was low and not significant *(Chi-square=8.36, df=4, P=0.0792)*. Unnecessary packaging increases the amount of waste and therefore decorative packages mostly of plastics and non bio degradable materials must be avoided. But it seems that the students have failed to realize the importance of less packaging. Packages made of Styrofoam and plastics contaminate the food with harmful chemical and cause immense harm to environment. However, they are attractive and act as advertisement and the consumers are ready to pay higher prices for that. The school students included in the sample group may be aware of ill effects of excessive packaging but their behavior in this respect is not eco-friendly. *Table no-2* scores revealed that students' relationship between awareness and action towards uses of recycle paper was highly correlated *(Chi-square= 243.09, df=4 , P>0.01)*. Findings from *table -3* indicated that there is no significant relationship between students' awareness and action *(Chi-square=7.52, df=4, P=0.1108)*. From *table- 4*, it was observed that the students' awareness and action relation to food scraps was not significant *(Chi-square=3.94, df=4, / P=0.4142)*. This implies that students' sensitivity towards environment may not be low but practicing such behavior is not always possible due to various constraints.

Data from *table – 5*, states that students' theoretical knowledge about environment does not necessarily result in recycling behaviour patterns *(Chi-square=5.11, df=4, P= 0.2762)*. Knowledge as well as attitudes is not enough to behave responsibly (*Kasapog˘lu and Turan, 2008). Thus the relationship is weak and there is lack of sensitivity towards environment. However, it is to be admitted that the students can buy recycled materials only when they are easily available, which is not always the case in Indian market.* Results from *table -6* illustrated that there is no significant *(Chi-square=6.6, df=4,/ P=0.1586)* relationship between students' awareness and action with regard to sorting E-waste disposal. As such practices is very rarely been carried out in India, therefore students of eighth grade often lack the understanding of such concepts.

According to the results of *table no-7* regarding saving /reuse water, it was reported that the relationship between students' awareness and action towards conservation of water was significant *(Chi-square=85.87, df=4, .96 P<0.01)*. The value of 'p' signifies the relation between the two variables is positive and moderate. Thus if awareness towards saving water is high it will lead to rise in practicing environmental friendly behaviours. From *table- 8*, it was observed that the students' awareness and action relation to the usage of rechargeable batteries was not significant *(Chi-square=3.52, df-4, P=0.4748)*. This implies that students' sensitivity towards environment may not be low but practicing such behavior is not always possible due to various constraints in this case the high price of the rechargeable batteries. Observation of *table – 9* reveals that the 'p' value is 0.02 which is significant at 0.05 levels *(Chi-square=10.85, df =4, P<0.5)*. Table 9, however shows a different result pertaining to reuse of different types of materials namely glasses and bottles. The reuse of bottles is a very common practice which the students have observed and may be encouraged by their family members. *Table – 10* showed that students' awareness-action relationship towards reusable shopping bag etc. was significant at 0.05 level *(Chi-square=9.84, df=4, P<0.5)*. Results from *table -11* illustrated that there is no significant relationship between students' awareness and action with regard to broken and old household item *(Chi-square=5.78, df=4 P=0.2162)*. From the table no. 12 it is evident that the students are aware about the importance of reuse of old clothes and books but donating these materials is something which they fail to practice *(Chi-square=9.85, df=4, P<0.05)*. Hence there is a clear gap between awareness and action in respect of reuse of materials.

5.0 Conclusion

From the findings, it can be concluded that the students' relationship between awareness-action regarding Reuse and Recycle for waste management were moderately correlated. Furthermore the results revealed that the scores of awareness and action were significantly correlated in terms of reuse items. Awareness often resulted in preserving and conserving the resources. In this respect, students who were motivated to save water, energy, reusing empty bottles, etc. carry out a sustainable behaviour pattern. Results of some previous studies *(Kaiser et al, 1999*), postulated that there is a positive and significant relationship between environmental knowledge and energy consumption behavior. In contrast, the scores of awareness-action relation regarding recycling items reflected low and weak relationship. It is evident from the study that students are more concerned about environmental problems which they face quite frequently like reusing old books, bottles etc but somehow they fail to transform in to daily practice. The study implies that the current curriculum should be revised with more content from environment including recycling practices as one of the vital approaches to sustainable living. At the same times it must be admitted that traditional curricular transaction fail to motivate students to participate actively in matters pertaining to environmental issues. Environmental education should permeate the whole school life. *Conde and Sanchez* (2010) suggested that environmental education should be integrated with school life and the teachers and school authority should practice what they preach. They emphasized that every action in school must satisfy environmental criteria and there should be environmental monitoring by the eco vigilante.

Man is the worst polluter. The activities of human beings generate many by products which are apparently useless and considered as waste. Consequently the physical environment is threatened as the massive amount of waste gets deposited in to ground water, soil and air (Day, 1998). It plays havoc with the functioning of bio sphere. Modern technology helps to increase waste but it provides little effort in the context of waste management and disposal (Palmer, 1998). Besides, other factors like absence of strong government commitment, stringent rules and regulations encourage citizens to dispose the domestic waste as quickly and conveniently without bothering to find out its repercussion. The littered and unsorted wastes contaminate the streams and rivers posing great health hazards mainly for the poor and slum dwelling people. UNPFA (1999) had also underscored the need for research to acquire knowledge and information pertaining to peoples' current engagement and disenchantment in waste management.

The present study highlights the fact that teaching environmental education by traditional approach does not help to attain the objectives of the subject. The environmental awareness may increase but the students fail to translate the knowledge into environmentally significant behaviour. The school authority must introduce drastic changes within the school campus so that the students have enabling situation to practice Reuse and Recycle related to environmental action.

The present study highlights the importance of introducing Environmental Education as a separate discipline in the school curriculum. Apart from imparting theoretical knowledge some practical oriented concepts like Reuse and Recycle should be introduced. Thus teaching environmental education should be based on a coherent approach. *Garcia* (2000) stated that greening of curriculum can be ensured when environmental consideration is taken into account as an educational principle in decision making process. The contexts of green curriculum are preparation and use of appropriate teaching materials, motivating the students, improving their attitude and habits and adding more environment related contents in the curriculum (*Conde and Sanchez,* 2010). In. other words the school ethos should reflect environmentalism whereby students will acquire courage, commitment and motivation to take active part in solving environment related issues.

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Table No. 1- Showing the awareness-action item related to excessive packaging (Recycle)

Action \ Awareness	Agree	Neither Agree nor Disagree	Disagree	Total
Always	91	23	39	153
Sometimes	199	31	47	277
Never	121	16	33	170
Total	411	70	119	600
Chi-square=8.36, df=4, P=0.0792				

Table No. 2- Showing the awareness-action item related to uses of recycle paper (Recycle)

Action \ Awareness	Agree	Neither Agree nor Disagree	Disagree	Total
Always	127	19	11	157
Sometimes	229	23	27	279
Never	21	74	69	164
Total	377	116	107	600
Chi-square= 243.09, df=4 , P=0.01				

Table No. 3- Showing the awareness-action item related to Rubber and Leather (Recycle)

Awareness / Action	Agree	Neither Agree nor Disagree	Disagree	Total
Always	115	17	41	173
Sometimes	164	29	54	247
Never	139	14	27	180
Total	418	60	122	600
Chi-square=7.52, df=4, P=0.1108				

Table No. 4- Showing the awareness-action item related to Food Scraps (Recycle)

Awareness / Action	Agree	Neither Agree nor Disagree	Disagree	Total
Always	74	17	17	108
Sometimes	81	21	33	135
Never	213	65	79	357
Total	368	103	129	600
Chi-square=3.94, df=4, / P=0.4142				

Table No. 5- Showing the awareness-action item related to buying products made from recycled materials (Recycle)

Awareness / Action	Agree	Neither Agree nor Disagree	Disagree	Total
Always	65	26	12	103
Sometimes	175	47	38	260
Never	143	51	43	237
Total	383	124	93	600
Chi-square=5.11, df=4, P= 0.2762				

Table No. 6- Showing the awareness-action item related to sorting disposals (Recycle)

Awareness / Action	Agree	Neither Agree nor Disagree	Disagree	Total
Always	69	12	24	105
Sometimes	77	16	28	121
Never	209	74	91	374
Total	355	102	143	600
Chi-square=6.6, df=4,/ P=0.1586				

Table No. 7- Showing the awareness-action item related to saving water/waste water (Reuse)

Awareness / Action	Agree	Neither Agree nor Disagree	Disagree	Total
Always	232	21	44	297
Sometimes	188	22	7	217
Never	41	34	11	86
Total	461	77	62	600
Chi-square=85.87, df=4, .96 P=0.01				

Table No. 8- Showing the awareness-action item related to use rechargeable batteries (Reuse)

Action \ Awareness	Agree	Neither Agree nor Disagree	Disagree	Total
Always	47	21	26	94
Sometimes	82	29	33	144
Never	219	65	78	362
Total	348	115	137	600
Chi-square=3.52, df-4, P=0.4748				

Table No. 9 - Showing the awareness-action item related to reuse empty plastic glass and jars (Reuse)

Action \ Awareness	Agree	Neither Agree nor Disagree	Disagree	Total
Always	196	44	86	326
Sometimes	87	41	42	170
Never	57	24	23	104
Total	340	109	151	600
Chi-square=10.85, df =4, P=0.0283				

Table No. 10- Showing the awareness-action item related to reusable shopping bag etc. (Reuse)

Action \ Awareness	Agree	Neither Agree nor Disagree	Disagree	Total
Always	199	47	68	314
Sometimes	96	39	31	166
Never	61	26	33	120
Total	356	112	132	600
Chi-square=9.84, df=4, P=0.0432				

Table No. 11- Showing the awareness-action item related to reuse broken and old household Items (Reuse)

Action \ Awareness	Agree	Neither Agree nor Disagree	Disagree	Total
Always	58	18	23	99
Sometimes	76	32	37	145
Never	227	57	72	356
Total	361	107	132	600
Chi-square=5.78, df=4 P=0.2162				

Table No. 12- Showing the awareness-action item related to donate Old Clothes and Books (Reuse)

Action \ Awareness	Agree	Neither Agree nor Disagree	Disagree	Total
Always	87	43	42	172
Sometimes	78	23	17	118
Never	195	58	57	310
Total	360	124	116	600
Chi-square=9.85, df=4, P=0.043				

Sustainability and East Kolkata Wetland: The Case Study of Waste Water Management

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Abstract

The East Kolkata Wetland(EKW), a Ramsar site, presents an unique example of sustainable socio-economic development pertaining to resource recovery through traditional practice of utilizing wastewater into fish pond. The inhabitants of EKW who belong to the lower rang of socio-economic hierarchy, are using their traditional knowledge base in managing natural resource sustainably. The uniqueness of the people living in the East Calcutta Wetlands lay in their capacity to convert, through natural resource management, an ecologically disadvantageous situation into one that offered a greater number of livelihood opportunities. However, the problem of environmental change has been escalated due to increasing neglect of urban waterbodies or wetlands. Despite having immense economic significance, population growth and associated anthropogenic interferences have depleted these resources and reduced the rates of flow of the ecosystem services. EKW is not an exception in this regard. It has also been plagued with encroaching urban development, rapid siltation of water bodies, water pollution etc, which necessitates a management plan that can take proper account of the complexity of the system and safeguard the livelihoods of the people involved

Keywords: Ramsar Site, East Kolkata Wetland, West water, Fishponds, Traditional Knowledge, Sustainability.

1.0. Introduction: Development whether it is economic or technological should not be at the cost of ecological system that sustains all forms of life. It must be sustainable and its fruits must be reaped by all across generations. Sustainability comes to the scene in this respect. It is a systematic concept, relating to the continuity of economic, social, institutional and environmental aspects of human society and affects every level of organization, from the local neighbourhood to the entire planet. So the concept of sustainable development actually is an alternative growth strategy which has transformed the dichotomous relations between environmental protection and developmental needs into an 'interdependent and mutually reinforcing' one. It underscores those efforts that fullfil the needs of the present without compromising the ability of the future generations to meet their own needs. The report of the Brundtland Commission namely "Our Common Future" argued that the concept of Sustainable Development "provides a framework for the integration of environmental policies and development strategies thus breaking the perception that environmental protection can only be achieved at the expense of economic development"(Baker, 1997, p.3).

However, the term sustainable development refers to the judicious use of a nation's own natural resources too. Wetlands are among the most diverse and productive ecosystems containing rich diversity of flora and fauna. They are important for human welfare and sustainable natural resource management. But often these water bodies are targeted for urbanization and developmental works. Despite having immense economic significance, population growth and associated anthropogenic interferences have depleted these resources and reduced the rates of flow of the ecosystem services. Even the problem of environmental change has been escalated due to increasing neglect of urban water bodies or wetlands. But to save the wetlands the strategies that are required must be based on traditional knowledge and should not be dictated by the North. Specifically, indigenous community knowledge, developed through ages is essential to maintain sustainability of the wetlands. In this context the East Kolkata Wetland is a case in point. It is a unique place where the inhabitants with their traditional knowledge and expertise successfully participated in sustainable waste water management. This effort not only generates employment and alleviates poverty of the region but also contributes towards maintenance of ecological balance and promoting sustainable use of natural resources

2.0. Objectives: Against this backdrop the present study will shed light on the following issues:

- How the EKW substantiates the principle of 'waste as resource' by creating the world's largest ensemble of wastewater fishponds- a unique method of waste water purification along with recovering nutrients in the municipal waste water?
- How traditional knowledge of local inhabitants has contributed to the process and it generates income opportunity?
- What are the roadblocks?
- What are the possible ways to combat the threats?

3.0. Methodology: The study employs descriptive analysis and case study method. It uses primary data from governmental reports, Conventions, field visit. The study analytically uses secondary materials like books and journals and relevant articles in the websites.

4.0. Results:

4.1. Traditional Ways of Mastery in Resource Recovery Activities: Sustainable development of the rich countries and that of the poorer countries is not one and the same. The divided economic conditions force different environmental management activities on different nations. While the rich and the well fed are more interested in the environment because they want to secure their future, the poor and the dispossessed, caught in a daily struggle to survive, are more interested in the environment because they want to secure their present. The inhabitants of EKW who belong to the lower rang of socio-economic hierarchy, are using their traditional knowledge base in managing natural resource sustainably. The uniqueness of the people living in the East Calcutta Wetlands lay in their capacity to convert, through natural resource management, an ecologically disadvantageous situation into one that offered a greater number of livelihood opportunities. With the decay of the Bidyadhari, the brackish water fishing could no more be sustained in the wetland region. With the help of a creative fish producer, the local people were successful in growing fish in a water area using city sewage and subsequently, a second crop of paddy using pond effluent in a manner evident today. A large number of the poorer fish farmers revived their livelihood opportunities for the next few generations. A population was thus saved from migrating to more difficult pastures in search of living. The wetlands form a challenging example of productive commercial activities and perhaps hold out one of the largest number of livelihood opportunities for the poorer section of the community within a single patch (Ghosh).

4.2. Challenges and Roadblocks: The EKW is the finest example of integrated resource recovery systems utilizing traditional knowledge for the benefit of environment as well as society**.** This wetland is of immense significance for maintaining of ecological balance and environmental sustainability. But today aspirations for development precede the concern for the utility of it. This actually results in their encroachment and destruction over the years. The problems can be enumerated in the following ways:

4.2.1. Encroachment: The lopsided development policies of the government to expand Kolkata to its eastern fringes were not going well with the concept of environmental sustainability. Though such expansion has generated more living spaces and the construction of EM Bypass led to the progress in communication between north-south, it causes detriments for this waste recycling region. Decrease in the area of EKW would lead to detrimental consequences like changes in ecosystem qualities (flora and fauna), loss of livelihood as well as revenue resulting from a reduced wetland area.

4.2.2.Threats to Sewage Fed Fisheries (SFF): The SFF, for which the wetland is known globally, has been constrained due to inadequate management of water regimes, technology integration and weak marketing, post marketing and value addition opportunities.

4.2.3. Siltation of Canals: Canals are the lifeline of the East Kolkata Wetland system as they transport sewage from the city to the area, distributing it for use in the fish farms and subsequently for agriculture and horticulture. Siltation of the canal system impedes efficient distribution of sewage, and is a major concern for sustaining production within the wetland.

4.2.4. Poor Water Quality in Canals: The deterioration of water quality in canal and ponds caused irreparable loss of pond ecosystem in terms of poor fish yield, loss of biodiversity and inefficient nutrient recovery. Good quality sewage, which is a critical component for sustainable resource recovery, was practically lacking for fish pond management. The deterioration of water quality in canal and ponds caused irreparable loss of pond ecosystem in terms of poor fish yield, loss of biodiversity and inefficient nutrient recovery. Good quality sewage, which is a critical component for sustainable resource recovery, was practically lacking for fish pond management (Mukherjee,2011).

4.3. Efforts to counter Challenges: Given such problems like encroaching urban development, rapid siltation of water bodies, water pollution etc, here is an urgent need of a management plan that can take proper account of the complexity of the system and safeguard the livelihoods of the people involved. Overtly, different steps have been initiated for the conservation of EKW(Choudhuri, 2012). The state Government formulated a strategy for evicting the 25,000 odd encroachers of the wetland. According to environment officials these people were lodged in hutments spanning an area of 10000 acres. The government wanted to resettle them in the same area but in a planned manner and also train them for self employment under the East Kolkata Wetland Development Project. This was supposed to be executed with financial assistance from international organizations. In March 11, 2006, the government of West Bengal has passed the East Kolkata Wetland Management and Conservation Bill 2006. According to this Bill, anyone convicted to be guilty of altering the nature of the wetland would be fined an amount of approximately USD$ 2000 along with 3 years of imprisonment. It also allowed the State Govt. to form an Authority called East Kolkata Wetlands management Authority (EKWMA) under the chairmanship of Chief Secretary to the Govt. of West Bengal and identified certain functions pertain to the jurisdiction of this authority' viz-

- Detecting changes in ecological character and land use, and enforcing land use control; Preventing any unauthorized developmental project within the boundaries of the wetland system;
- Preventing any mining, quarrying, blasting or any operation of the like nature to protect and conserve the wetland system;
- Undertaking measures to abate pollution, and conserving the wetland biodiversity;

Promoting research and networking with other Ramsar sites;

- Raising awareness on wetlands in general and EKW in particular Promoting conservation principles – like sewage fed fisheries and ecotourism (East Kolkata Wetland Newsletter, 2010).

All these functions can be materialized only if they are connected with the goals of conserving biodiversity, improving livelihood of local people and guiding the management of wetlands in a way that complies with Ramsar Convention dictum.

5.0. Discussion:

5.1. Wetlands as Ecosystem Service Provider: The major ecosystem services that wetlands provide include fish, fiber, water supply, water purification, climate regulation, flood regulation, coastal protection, recreational opportunities, and tourism. Actually tangible and intangible diverse resources and products of wetland functions have historically provided a source of income and livelihood for human beings. As natural habitats for fish they have the potential to produce large fish stocks which are exploited commercially in some regions. But, human actions such as drainage water from wetlands for agriculture, forestry; discharge of pesticide, herbicides, nutrients from domestic sewage etc are greatly responsible for degrading wetland sustainability. The loss of wetland ecosystem services damages the health and well-being of individuals and local communities and diminishes their development prospects too. The problem is particularly severe in countries that have weak policy and management strategies, negatively affecting the conservation and sustainable management of wetland resources.

In view of such problems there exist several country level laws regulating wetland resources with respect to protection of water, fish birds and lands. International laws and conventions are also present for the same purpose. Ramsar Convention is significant in this respect. It is an intergovernmental treaty which provides the framework for international cooperation for the conservation of wetlands. The Convention uses a broad definition of wetlands. It includes all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peat lands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans. Under the “three pillars” of the Convention, the stakeholders commit to:

- act towards the wise use of all their wetlands;
- mark suitable wetlands to be included in the list of Wetlands of International significance (the “Ramsar List”) and ensure their effective management;
- cooperate globally on transboundary wetlands, shared wetland systems and shared species.(The Ramsar Convention and Its Mission)

The Ramsar list of wetlands of international importance now includes a large number of sites. The agreeing parties are bound to accept a number of obligations in order to enhance the sustainability of their respective wetlands. Designation of a wetland as a Ramsar site marks the commitment of the contracting party, to undertake measures for ensuring its wise use. Wise use of wetlands is defined in the Convention text as 'the maintenance of their ecological character, achieved through implementation of ecosystem approaches, within the context of sustainable development'. Ecological character is 'the combination of ecosystem components, processes and benefits / services that characterize the wetland at any given point of time'. The 'Wise Use' concept of the Ramsar Convention provides an overarching framework for management planning for wetlands. The planning process provides a mechanism to achieve an overall agreement between wetland managers and stakeholders on the objective of site management to achieve wise use and thereby maintenance of ecological character of the site as a whole.(Ramsar Convention Secretariat, 2010).

5.2. East Kolkata Wetland (EKW)- the case in point: EKW was declared by the Government of India as 'wetland of international importance' under 'Ramsar convention' on 19 th August, 2002 and as 'Ramsar site' in November, 2002. In 1992, a case study on the East Calcutta Wetlands was presented in the expert committee meeting of the Ramsar Convention. This was the only example of wise use from India, which was included among 17 other case studies selected from all over the world. This was the beginning of a effort that led to the declaration of the East Calcutta Wetlands as a Ramsar site. In India, there are eighteen other sites which are included in the Ramsar list of Wetlands of International Importance. The East Calcutta Wetlands are being conserved predominantly as an urban facility. This is a new dimension in wetland conservation strategy. It has been claimed sometimes that Kolkata is the only metropolitan city in the world where state government has introduced development controls to conserve the wetlands, which doubles up as waste treatment system through recycling process. Actually the wetlands to the east of Kolkata are well known over the world for their multiple uses. EKW utilizes the city sewage for four traditional resource recovery practices with scientific basis. Major components include garbage farms for cultivation of vegetables, waste water fed pisciculture, paddy cultivation utilizing fish pond effluent and sewage fed brackish water aquaculture (outside EKW region). EKW contains about 272 Bheries spread over an area of 4,000 hectares. Every day 980 million litres of raw sewage is treated which is on an average about 16% of the total treated of this country per day (Ray Chaudhuri et.al., 2012).

The wetland is largely manmade, comprising intertidel marshes including salt marshes, salt meadows with significant waste water treatment areas like sewage firms, settling ponds, oxidation basin(EKWMA, 2009). This natural wetland supports the world's largest wastewater fish culture covering an area of 4000 Ha and contributes a significant percentage of the total Indian economy. This age-old practice of the fish cultivation utilizing wastewater in this wetland has been described extensively. Nearly 10,915 tons of fish is produced annually in about 286 wastewater fed fishponds. At present only 30 percent of about 5, 50,000 m3 of wastewater per day from Kolkata Metropolitan City flowing through network of canals is utilised for aquaculture and irrigation purposes. The rest 70 percent of the wastewater is directly discharged into the Bay of Bengal. It is one of the rare examples of combination of environmental protection and development management where a complex ecological process has been adopted by the local farmers by mastering the resource recovery activities. It is the largest ensemble of sewage fed fish ponds in the world in one place (Mukherjee, 2011).

5.3. Converting Wastes to Resources : In the EKW, the local people have created the world's largest ensemble of wastewater fishponds which perform the twin functions of recovering copious amounts of nutrients available in the municipal wastewater and at the same time purifying the wastewater to desirable standards(Ghosh, 2005). They are the forerunners in establishing the new world view of ' waste as resource' touted relentlessly by the leaders and thinkers of modern environmental movement only recently. To talk about more vigorously about the capacity of EKW as a wastewater management site, its working process needs to be clarified. Actually, the responsibility of the Kolkata Municipal Corporation ends with the reaching of the wastewater to the outfall channels. Thereafter, the sewage and wastewater is drawn into the fisheries of the East Calcutta Wetlands by the owners of the fisheries, where within a few days' detention and the organic compounds of the wastewater are biologically degraded. Organic loading rate in these fish ponds appears to vary between 20-70 kg. Per hectare per day (in the form of bio-chemical oxygen demand). There is a network of channels that is used to supply untreated sewage and to drain out the spent water (effluent). The cumulative efficiency in reducing the B.O.D. (a measure of organic pollution) of the sewage wastewater is above 80 per cent and that in reducing the coliform bacteria is 99.99 per cent on an average. The solar radiation here is about 250 langleys per day, and is adequate for photosynthesis to take place. In fact, the sewage fed fishery ponds act as solar reactors. Solar energy is tapped by a dense population of plankton. Plankton are consumed by the fish. While the plankton play a highly significant role in degrading the organic matter in the wastewater, it becomes a problem of pond management to tackle the phenomenon of plankton overgrowth. It is at this critical phase of the ecological process that the fish play an important role by grazing on the plankton (Kundu et.al., 2008). The two-fold role played by the fish is indeed crucial – they maintain proper balance of the plankton population in the pond and also convert the available nutrients in the wastewater into readily consumable form (viz. fish) for the humans. Fish are raised in five major phases: pond preparation, primary fertilization, fish stocking, secondary fertilization and finally fish harvesting. About 12 different species of fish are raised which occupy different ecological niches of the pond eco system(Dey, 2009). This complex ecological process has been adopted by the fish farmers of the East Calcutta Wetlands. They have developed such a mastery of these resource recovery activities that they are easily growing fish at a yield rate and production cost unmatched in any other freshwater fish ponds of this country (Ghosh). DIAGRAM 1

6.0. Conclusion:

The EKW is a multifaceted wealth of Kolkata that needs to be preserved with great concern. This unique ecosystem impacts the daily lives of people in Kolkata and in the region in several ways. The human ingenuity involved with this site has been locally developed and replicated with the help of traditions of resource conservation and environmental rescue. It gives the inhabitants food, sanitation and livelihood. In return they provide a unique blend of ecology, economics and engineering to develop least-cost alternatives in municipal waste management that would ensure maximum recovery of nutrients available in waste. It is the world's largest organic sewage management system. Though the EKW has faced multiple barriers but they can easily be overcome by changing attitude and awareness. The immediate needs to restore the ecology of the region require proper awareness regarding the huge invisible services that this vast region provides in terms of waste water management, collection of rain water runoff, food production, conserving bio diversity and income generation. Though efforts were made time to time by desilting the canals, pollution control, capacity building through training, as well as devising governmental policies to stop encroachments for developmental needs, but these are not adequate. The place requires low cost management and respect for technology drawn from traditional practices. The balance integrated management of aquaculture, watershed and within water body management is required to counter the threats that the wetland is facing today. In the long run this only can make this wetland ecosystem intact. Finally to maintain the sustainability of EKW, development should be reassessed in tandem with the sustainable development principles. To assess the utility of the region there are certain needs like-

- Initiate collaboration with civil society groups, and to partner with both corporate and government sectors.
- More works should be done towards poverty alleviation and sustainable development programmes so that inhabitants might not engage themselves in non wetland based services. It would result in non accountability to the rule of maintaining and sustaining the balance of the ecosystem of wetlands.
- Awareness camps and field visits by researchers must be encouraged as it may lead to participatory community engagement in the conservation of the wetland and concerns for the development of the EKW must be generated among the local youth as they are the torch bearers of future.

So the 'kidney of Kolkata' – the EKW requires efforts from all sectors and stakeholders to materialize the goal of transforming waste into resource. All should act towards building a crucial nexus between wise use of resources, application of traditional ingenuity and efforts for socio economic wellbeing of the wetland dwellers then only the sustainability of the wetland can be restored.

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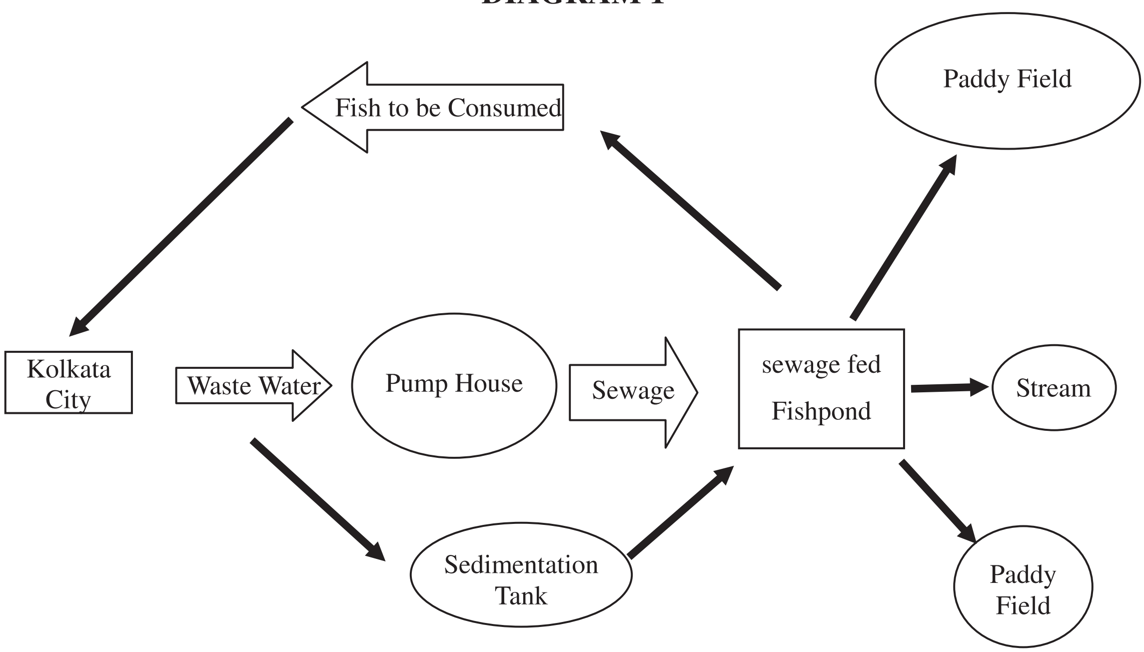
DIAGRAM 1



An Overview on Bromination : A Green Approach

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Abstract

Anample range of organo-compounds with bromo functionality in nature are formed through photochemical reactions,geothermal events, and metabolic pathways. A huge number of commercially important products are mainly used as flame-retardants, herbicides, pesticides, gasoline additives, halons, polymers, pharmaceuticals, agrochemicals*etc*. They also act a significant role as intermediates in the fields of agrochemicals and pharmaceuticals. C–C formation bond using cross-coupling reactions named as Heck, Stille–Suzuki and Sonogashira coupling can be employed with these bromides. So bromination on organic molecules is one of the most important tools in organic synthesis and mostly can be performed using molecular bromine in industry and agriculture. Elemental bromine is used to manufacture a wide variety of bromo compounds used in industry and agriculture. However, there is risk in treatmentof molecular bromine, as volatile elemental bromine is harmful and is a strong irritant. It causes painful blisters on exposed skin and mainly mucous membranes. Therefore, the use and handling of bromine needs special precautions.

Therefore, bromination under mild condition and milder brominating agents such as monobromomalononitrile (MBM), 2,4-diamino-1,3-thiazole hydrotribromide, Bu_4NBr_3,1,8-diazabicyclo[5.4.0]undec-7-ene hydrobromideperbromide, 1,8-diazabicyclo[5.4.0]undec-7-ene hydrobromideperbromide, H_2O_2–V_2O_5–Et_4NBr, $NaBrO_3$–NaBr, CAN/LiBrare used as green reagent for the bromination on organic molecules.

Keywords: Green technology, brominating, environment friendly, less hazards

1.0 Introduction: Impact of green chemistry on utilization of molecular bromine

Green Chemistry is environmentally benign chemistry which eliminates and reduces the use or generation of hazardous substances in the design, manufacture, and application of chemical products."Now a lot of different approaches are being pursued in the laboratories mainly at the postgraduate and undergraduate level to make students realization of the meaning of green and safe chemistry (Ahluwalia, 2007, p. 1856; Ahluwalia, 2006, p. 1). A huge number of commercially important products are mainly used as flame-retardants, herbicides, pesticides, gasoline additives, halons, polymers, pharmaceuticals, agrochemicals *etc* (Gribble, 1999, p. 335). They also act a significant role as intermediates in the fields of agrochemicals and pharmaceuticals.

2.0 Objectives

C–C formation bond using cross-coupling reactions can be employed with these bromides. So bromination on organic molecules is important in organic synthesis and mostly can be performed using molecular bromine. Elemental bromine is used to manufacture a wide variety of bromo compounds used in industry and agriculture. However, there is risk in treatment of molecular bromine, as volatile elemental bromine is harmful. It causes painful blisters on exposed skin and mainly mucous membranes. Moreover, corrosive and toxic nature of bromine water is a severe drawback for handling such chemical. Therefore, milder and eco-friendly brominating agents are urgently desirable for the bromination on organic molecules (Eissen and Lenoir, 2008, p. 9830).

3.0 Materials and Method:

Types of sources to avoid molecular bromine

Various solid organic ammonium tribromides like Me_4NBr_3, 2,4-diamino-1,3-thiazole hydrotribromide, Bu_4NBr_3, 1,2-dipyridiniumditribromide-ethane(DPTBE), $PyHBr_3$, phenyltrimethylammoniumtribromideand1,8-diazabicyclo[5.4.0]undec-7-ene hydrobromide-perbromide ($DBUHBr_3$) are exploited for bromination which avoid the direct use of molecularbromine (Toda and Schmeyers, 2003, p. 701). Another method involves oxidative bromination using hydrogen bromide and bromide salts like H_2O_2–V_2O_5–Et_4NBr, oxone/HBr, oxone (the active component is potassium monopersulfate,$KHSO_5$)/NaBr, H_2O_2–HBr, ^{t}-BuOOH–HBr,Selectfluor®/KBr, $NaBrO_3$–NaBr, CAN/LiBr, and cerium(IV)ammonium nitrate (CAN)/KBras a bromine sourcewhere bromine is generated in situ in the reaction mixture (Bora et al., 2000, p. 247). Also *N*-bromosuccinimide (NBS) and monobromomalononitrile (MBM) are also employed for bromination reaction (Pathak, Kundu and Pramanik, 2014, p. 10187).So some of bromomination reactions involving milder brominating agents are included in this review article.

4.0 Results and Discussion:

Some of controlled bromination reaction using green brominating agents

(i) Pathak, Kundu and Pramanik (2014) have successfully designed a mild reaction conditions for monobromomalononitrile (MBM) where it can perform as an efficient and selective mono brominating agent (Figure 1). The efficacy of the methodology lies in the bromination of enamines containing activated aromatic rings and 1,3-dicarbonyl compounds with shorter reaction time and high yields of the product formation (Pathak, Kundu and Pramanik, 2014, p. 10187).

(ii) Mallick and Parida (2017) reported an oxidative bromination on phenols using KBr where H_2O_2acts as oxidizing agent over HPA (15%) impregnated on a zirconia support at room temperature in acetic acid (Figure 2) (Mallick and Parida, 2007, p. 889). Here bromination occurs selectively in para position of phenols and good to excellent yields are obtained.

(iii) Potassium peroxymonosulfate is an inexpensive and readily accessible oxidizing agent. It is commonly used as Oxone®($2KHSO_5{\cdot}KHSO_4{\cdot}K_2SO_4$) and is a versatile oxidant for the transformation of a wide range of functional groups (Webb and Levy, 1995, p. 5117). A number of different aromatic substrates were subjected to the bromination reaction to test the generality of this method by Webb *et al* (Figure 3).

Employing user friendly brominating agents as a transport medium for brominereduces the chance of expose towards hazardous potential of molecular bromine,examples include; poly(vinylpyrrolidone) (PVP) (Lakouraj, Tajbakhsh and Mokhtary, 2005, p. 481), sol—gel-entrapped pyridiniumhydrobromideperbromide (PHPB@s.g.) (Levin, Hamza, Abu-Reziq and Blum, 2006, p. 1396), pyridine hydrobromide (Tanaka, Shiraishi and Toda, 1999, p. 3069), 1,2-dipyridiniumdibromide-ethane (Kavala, Naik and Patel, 2005, p. 4267), *N*-octylquinolinium bromide (Kaushik and Polshettiwar, 2006, p. 2542), pentylpyridinium bromide (Salazar and Dorta, 2004, p. 1318) and tetramericDABCO (TM)-bromine (DABCO=1,4-diazabicyclo[2.2.2]octane) (Heravi, Derikvand and Ghassemzadeh, 2006, p. 125).

5.0 Conclusion

The demand of environmentally benign reactions is very much significant in view of today's ecofriendly and sensitive attitude. 'Benign by Design' symbolizes the 12 principles of Green Chemistry by John Warner and Paul Anastas. These principles have proven with ample examples for the evaluation of the synthetic chemical procedures that can help scientist to develop new eco-friendly routes. These are very much useful for less waste and also these paths use and produce less toxic substances. The research to avoid toxic, highly reactive, corrosive, and hazardous molecular bromine is still current topic of interest. Still now most of the new bromination methods, which replace the use of molecular bromine, have severe disadvantages, owing to waste production as well as environmental, health and safety aspects. So bromination under mild reaction condition is still urgent requirement.

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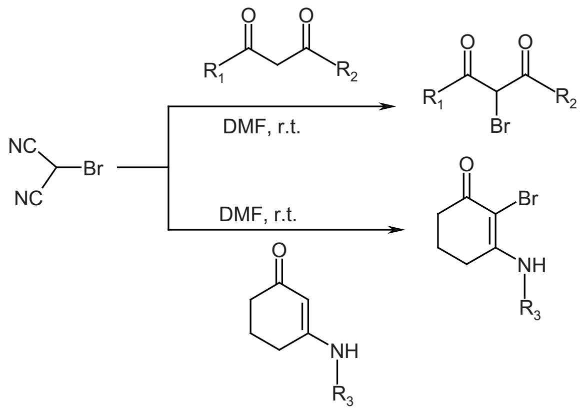

Figure 1: Monobromomalononitrile: an efficient regioselective mono brominating agent

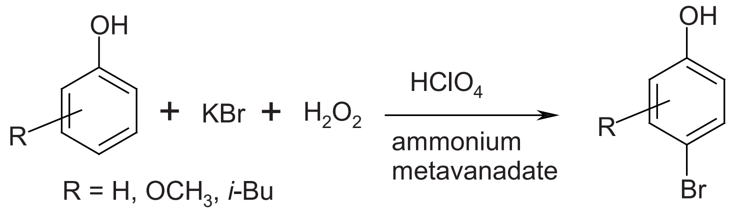

Figure 2: oxidative bromination on phenols using KBr/H_2O_2

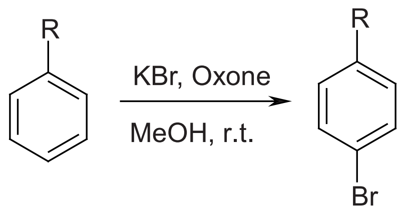

Figure 3: Bromination on aromatic compound using potassium peroxymonosulfate

Magnetite Nanoparticle production and utility in management of heavy metals from water: a Areen synthesis approach using fungi

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Abstract:

Study of magnetite nanoparticles is important due its effectiveness in removal of heavy metals from water. Magnetic nanoparticles (MNPs) like Fe_3O_4, nanoscalezerovalent ion (nZVI) which utilises the mechanism of corrosion are effective in converting the reactive metallic form to inert metallic stages. Nano size metal oxide(NMOs) which includes ferrite oxide, aluminium oxides, manganese oxide, magnesium oxide and titanium oxide provides specific affinities and large surface area to adsorbe heavy metals from aqueous phase. Several physical and chemical processes are available for the production of nanometal, the techniques like ultraviolet irradiation, laser ablation, lithography, photochemical reduction are vividly used for the production of nanometals but these techniques are expensive and involve hazardous chemical substances. The idea of green synthesis is in itself a novel approach, where the essential toxic chemicals necessary to convert the metals to its nano size can be kept aside and biological enzymes can be employed for conversion of metal salts to its respective metal nanoparticle. In this regard , fungi like *Fusarium*sp., *Aspergillus*sp., *Alterneria*sp., *Nigrospora*sp., and different others can be isolated easily from soil, effected leaf, leaf litter and root region of the plants and can be used for production of magnetite nanoparticle, which can be utilised to remove heavy metals like Cd, Zn, Pb, Cu, Ni, Cr, Mn and other metals. Present review tries to explore the current status of mycosynthesis of nano metals and its application in management of heavy metals in water in the successive sections.

1. 0 Introduction:

Heavy metals which are released from various industries possess the hazardous effect on both human health and environment. Heavy metals are non-biodegradable and cannot be metabolized or decomposed. Heavy metals has the potentiality to enter into the food chain causing toxic effect in course of the life span. Utilisation of nanotechnology for the removal of heavy metals from water is one of the effective prospects for detoxification of water. Magnetic nano particles (MNPs) which includes metal oxides like iron oxide Fe_3O_4 nanoscaleZerovalemt ion (nZVI) can adsorb heavy metals on its surface (Coston et al., 1995). Metal oxide nanoparticles (NMOs) which include ferrite oxide, aluminium oxides, manganese oxide, magnesium oxide and titanium oxide bears the same properties like MNPs (Coston et al., 1995).

Physical and chemicals methods for the development of iron nano particle possess various toxic chemicals, hence the approach for utilising fungal organism for the green synthesis is novel and cost effective. Fungal samples with correct optimization of pH, strain selection, incubation time for culture can be effective for the production of nanoparticles. The combination of above approach plays quit effective for the production of silver nanoparticle from *Fusariumoxysporum*(Hamedi et al., 2014). Fungi like *Fusarium*sp., *Aspergillus*sp., *Alterneria*sp., *Nigrospora*sp., and different other species isolated from soil, effected leaf, leaf litter and root region of the plants and can be used for production of magnetite nanoparticle, and can be utilized for the removal of heavy metals.

2.0 Objectives:

The review extensively covers the following topics:

I) Necessity of nanometal in water purification

II) Biosynthesis of magnetic nanometarial form fungi

III) Role of NMOs (Nano size metal oxides), MNPs (Magnetic nano particle)and nZVI (Nanoscale Zero ValentIon) in removal of heavy metal

3. 0 Results and discussion :

Review analysis of each area of the topic:

3.1 Necessity of nanometal in water purification

In course of history the water quality standards have been revised several times, for example WHO (World Health Organisation) has reduced the recommended value of arsenic in drinking water from 200 ppb to 10 ppb through various revisions in last 50 years. During this exert period the concentration of lead is reduced from 100 ppb to 10 ppb (Pradeep et al. 2009;Richardson, 2007). With the improvement of technology the water quality standard is tend to get revised in context to molecular level. Many available processes are prevailing which can be utilised for the purification of water but they posses various pros and cons, so it's vital that advantages of nanomaterial chemistry must be utilised. The surface-to-volume ratio of nanomaterials provides higher surface for contaminant adsorption (Zhou et al., 2005; Alonitis et al.,2003; Shannon et al., 2008).

Few advantages of nanometals for the purification can be draws in following order:

(I) Contaminant can be removed at very low concentration.

(II) Low concentration of nano metal can adsorb high amount of contaminant due to its large surface-to-volume ratio.

(III) Novel reaction can be carried out due to large surface energy , which is never possible for bulk analogues material.

3.2. Biosynthesis of nanoparticle from fungus

Fungi is one of the nnoval candidates for the production of nanoparticles. In very recent years, fungi like *Fusariumoxysporum* (Mukherjee et al., 2002; Mohanpuria et al., 2008), *Trichodermaviride* (Ahmad et al., 2008), *Aspergillusniger* (Gade et al., 2008), *Phomaglomerata* (Birla et al., 2009), *Penicilliumfellutanum* (Kathiresan et al., 2009) has shown production of nanoparticles.

Mycelia mesh of fungi can withstand agitation and flow pressure, and different condition in bioreactors in comparison to bacteria and plant materials. Fungus can be easily grown and handled. Due to higher extracellular protein secretion nanoparticles which produced outside of the cell does not bear any cellular components.

3.2.1. Intercellular and extra cellular synthesis of nanoparticles by fungi

Fungus is very much capable in production of both intercellular and extracellular nanoparticles, intercellular nanoparticles are generally smaller in size then extracellular one. The limit for the size can be related to particles neuclating inside the cell of an organism. *verticillium* sp. has shown production of gold nanoparticle of 20nm both inside and outside of the cell. With the change of pH *verticillium* sp. has shown production of different shape of gold nanoparticle, at pH 3 gold nanoparticle are of spherical shape where as at pH 5 the nanoparticles are of triangular, rods and of hexagonal shape (Mukherjee et al., 2001). Intercellular synthesis of silver nanoparticle by *verticillium* spis of rods and quasi hexagonal shape, of size ranging from 8nm to 25nm (Mukherjee et al., 2001).

Extracellular synthesis has much more utility as it is void of any unnecessary cellular components. Fungus is mostly regarded for the extracellular production of nanonoparticles due to their high secretary protein products. *Colletotrichum* sp (Shankar et al., 2003). an endophytic fungus from leaves of *Pelargonium graveolens*, has the capability to reduce gold ions to its zero-valent ion configuration. Morphology of these gold nanoparticles are quite different they can be from flat disk like to rod like. *Aspergillus fumigates*(Gade et al., 2008) can form silver nanoparticles immediately after addition of silver nitrate solution to the extracellular extract. TEM analysis has shown that the nanoparticles are of triangular and spherical shape.

Among various fungi *Fusariumoxysporum*is the sole fungus which is utilised for production of different nanoparticles starting from gold, bimetallic alloy (Au-Ag), silica, zirconia, magnetite, quantam dots etc (Sathyavathi et al., 2010).

3.2.2. Synthesis of magnetic nanoparticle by fungus

Oxide nano particle has huge importance due to its vast application in fields from biomedics to catalysis to electronics, iron oxide nanoparticles like maghaemite and magnetite are very much unique and are utilised in MRI (magnetic resonance imaging), ferro fluids etc.. Mixture of salts like $K_4[Fe(CN)_6]$ and $K_3[Fe(CN)_6]$ in presence of*Fusariumoxysporum and Verticillium sp*extracellular enzymes has shown to produce magnetite nanoparticles in time span of 24 h(Bharde et al., 2006). The shape of the particles were quasi-spherical with 20-50nm in size.*Aspergillusoryzae*TFR9 has sown to produce iron nanoparticles from $FeCl_3$. *Alternariaalternata*which can produce Fe-NPs from iron nitrate (Tarafdar et al., 2013). Appreciating this fact that organism collected from iron rich soil has the possibility to hydrolyse the iron salt solution, a mixture, of iron cyanide salt complexes under suitable condition. After hydrolysis the resultant ions which releases out are ferric ions and ferrous ions. Iron oxide nanoparticles (IONPs) has huge potential role in environment and developing technologies, it has broad spectrum utility from environmental remediation to water purification (Bhargava et al., 2013).Table 1 contains list of few fungus and nanoparticle synthesized by them

3.3 Role of NMOs (Nano size metal oxides), MNPs (Magnetic nano particle)and nZVI (Nanoscale Zero ValentIon) in removal of heavy metal

3.3.1. Nano size metal oxides

Most wildly including NMOs are iron oxides, manganese oxides, titanium oxides and aluminium oxides. In the following section utility of NMOs are presented in relation to removal of heavy metal. Table 2 contains Shape, size, surface area, and targeted metals for various NMOs

3.3.2A Nano size ferric oxide

Nano sized ferric oxides (NFeOs) are one of the most low cost absorbent, and can be pumped to the contaminant site easily with negligible amount of risk. The studied NFeOs are goethite (α-FeOOH), hematite (α-Fe_2O_3)(Grossl et al., 1994; Chen et al., 2010), amorphous hydrous Fe oxides, maghemite (γ-Fe_2O_3) (Hu et al., 2005; Hu et al., 2006), magnetite (Fe_3O_4) (Mandavian et al., 2010)and iron/iron oxide (Fe@Fe_xO_y)(Deliyanni et al., 2004).

Hematite(α-Fe_2O_3) and Goethite(α-FeOOH) poses high surface area which makes it a efficient absorbent, Cu^{2+} adsorption from goethite is much effective by pressure pump technique. CU^{2+} absorption on nano-hematite and nano-geolith in terms of, kinetics and dynamics are same. The adsorption process follows the pseudo-second-order kinetics. The equilibrium for the reaction involving the Cr (VI) removal bynano-maghemite (γ-Fe_2O_3),and nano-magnetite(Fe_3O_4) is independent of initial Cr(VI) concentration and the absorption capacity increases when pH of the reaction decreases. Nano-maghemite emerges as the high selectivity component for Cr(VI) from water(Hu et al., 2005; Hu et al., 2006). Adsorption of other heavy metal like Ni (II) on maghemite is highly dependent on pH. Nano-magnetite is commonly used as a magnetic core for, composite sorbents for the purpose of removal of heavy metals.

Composition of NFeOs with different support

Role of NMOs towards the removal of heavy metal is quite speculative. But as NMOs are present as fine and, ultrafine structure so it's come to the probability that they may get agglomerated and sometimes becomes difficult to separate hence decreasing the effectiveness of the nanoparticles. Hence coating the nanopaticles with biological or chemical component leads to a solution to the problem of agglomeration(Cumbal et al., 2005).

Surface modification of NFeOs by biological component

Polyacrylic acid (PAA) on Fe_3O_4 nanoparticles followed by the treatment of Amino-functionalized diethylenetriamine via activation by carbodimide prevents the problem of aggregation (Illes et al., 2003; Illes et al., 2006) and oxidation by air(Maity et al., 2007). The coated nano particle can absorb Cu^{2+}, Pb^{2+}, and Ni^{2+}.

Surface modification of NFeOs by chemical component

Chemicals like zeolite act as an excellent host for the encapsulation of iron nano particle. The adsorption of different heavy metals like Zn^{2+}, Cr^{3+}, and Cu^{2+} on 3:1 ratio of zeolith and iron oxide in order of $Cr^{3+} > Cu^{2+} > Zn^{2+}$(Oliveira et al., 2004)

3.3.2B. Nano size manganese oxides

NMnOs, has been exploited for the removal of phosphate and arsenant ions. Hydrous manganese oxide HMO shows sorption of heavy metal in an order $Pb^{2+}>Cd^{2+}>Zn^{2+}$. Mixed valence manganese oxide shows selective, adsorption of Cd^{2+}, Ni^{2+}, and Cu^{2+} in presence of Mg^{2+} and Ca^{2+}(Gao et al., 2008).

3.3.2C.Nano size aluminium oxides

Aluminia (Al_2O_3) is the traditional heavy metal adsorbent, and α-Al_2O_3 has less adsorptive capacity then γ-Al_2O_3(Hiraide et al., 1995; Li et al., 2008). Physical and chemical modification of γ-Al_2O_3 nanoparticles with different functional group having donor atoms for example nitrogen, phosphorus, oxygen, sulphur improves their adsorption towards heavy metals(Chang et al., 2003). Fixing of γ-marceptopropy-trimethoxysilance (γ-MPTMS) on γ-Al_2O_3(Afkhami et al., 2010) improves selectivity towards Pd, Hg, Au, and Cu ions. The mechanism behind adsorption of heavy metals by γ-MPTMS modified nano-alumina are (I) metal ions get adsorbed due to affinity of, -SH (II) metal ions hydrolyzation (III)adsorption by electrostatic interaction. The 1st mechanism plays the effective role in removal of heavy metal from acidic water and 2nd and 3rd mechanism plays the effective role for removal of heavy metal from basic water. SDS (Sodium dodecyl sulphate) and DNPH (2,4 dinitrophenylhydrazine) coated nano γ-Al_2O_3 shows effectiveness against removal of trace Cr (III), Cd (II), Ni (II), Co (II), Pb (II), and Mn (II) (Afkhami et al., 2010).

3.3.2D. Nano size titanium oxide

Nano particle from TiO_2 exhibit different surface acidity, catalytic reactivity chemical behaviour and surface plane which enhances the metal removal efficiency. The TiO_2 nanoparticles could remove metals like Zn, Cd, Pb, Ni, Cu from tap water of san Antonio (Afkhami et al., 2010).

The absorption characteristic of heavy metal followed by nano size titanium oxide is modified first order kinetics. Comparison of distribution coefficient for titanium nano particle and other nano particles is much better.

3.3.3. MNPs and its role in removal of heavy metal

SuperparamagneticFe_3O_4(iron oxide) with surface functionalization coating of DMSA(dimercaptosuccinic acid) plays an effective role in adsorption of soft metal like Ag, Hg, Cd, Pb and Ti. These metals effectively bind on the DMSA ligand and in case of As it binds with lattice of Iron Oxide. These nanoparticle posses high surface area of 114 m^2/ g and gets attracted to a magnetic field and thus can be separated easily within a minute by 1.2T magnet. The stability, capacity, chemical affinities of magnetic, nanoparticle is much more stable then resin based adsorbents, nano-porus silica(SAMMS) and activated carbon in river water, ground water, sea water and human blood. Fe_3O_4 coated with DMSA has the capacity to remove Hg, 30 times larger than resin based sorbents.

Even for the removal Pb its takes just a minute for magnetic particle in comparison to resin based absorbent (GT-73) (Liu et al., 2008).

Superparamagnetic Fe_3O_4(iron oxide) coated with humic acid (HA) is effective in removal of Hg(II), Cu(II), Cd(II) and Pb(II) from water. Fe_3O_4 coated with HA could able to remove 99% of Pb(II) and Hg(II) in comparison to 95% of Cd(II) and Cu(II) from tap and natural water at, optimized pH. Leaching back of heavy metals from Fe_3O_4(iron oxide) coated with humic acid (HA) was negligible (Liu et al., 2008).

3D flower like self-assemblednano particle of iron oxide has the potentiality of removal of As(V), Orange II and Cr (VI). Decreasing the diameter of nano-crystle of iron oxide nano particle from 300 nm to 12 nm will increase the efficiency of As(III) and As(V) by several orders(Liu et al., 2008).

3.3.4. nZVI and its role in removal of heavy metal

Zerovalent iron is quite effective in destruction of pollutents in the water due to its highly reactive structure. According to PRB (Permeable relative barrier) technology zero valent iron is regarded as best reactive material, surface reactivity of nZVI is 30 times more than that to 325 mesh iron powder (Ponder et al., 2000). Nano scale iron particles has the ability to transform wide array of materials like chlorinated organic solvents, organic dyes, various inorganic compounds and metal ions. Several field test for the material has shown promising role in heavy metal removal from water(Ponder et al., 2000).

4.0 Conclusion:

Water has always shown its existence in form of most important component in our life. The being ness of us always revolves around water. Achieving the ultimate goal of availability of economic drinking water for every country is the ultimate goal in today's scenario. Purification of water through utilisation of nanometal has always proved to be effective. Essentiality of green technology is pretty much necessary due to involvement of hazardous chemicals for the synthesis of nanometals in physical and chemical process of manufacturing. Fugus with its rich diversity are one the suitable candidate for the nanometal synthesis. Although there are several drawbacks but in future fungus mediated nanoparticle research can lead us to its application in various areas of agriculture, chemistry, medicine and electronics. To date NMOs, are widely considered for the removal of heavy metal, they poses various advantages of kinetics, preferable adsorption and high capacity for removal of heavy metal from water, although development of NMOs is in its pre stage but few issues which are needed to be solved, to obtain the best composite absorbent. Both MNPs and nZVI are also in developing stage, heavy metals from these can be recovered simply by using magnetic field thus reducing water treatment expenses. Ultimately above all production of magnetic nanoparticle and its application in removal of heavy metal is quit elusive future aspect, and utilising fungi broadens the scope of eco friendliness, thus opening up the future for purification of contaminated water by removal of toxic heavy metals.

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Table 1.List offew fungus and nanoparticle synthesized by them

Fungus name	Nanoparticle Synthesis	cellular formation	Size	Reference
Verticillium sp.	Gold, Magnetite	Intracellular	20 nm	(Bharde et al., 2006)
Trichoderma sp	Gold	Intracellular	Not determined	(Ahmad et al., 2008)
Aspergillus sp.	Gold	Intracellular	8.92 nm	(Gade et al., 2008)
*Colletotrichum*sp.	Gold	Extracellular	20-40nm	(Shankar et al., 2003)
Trichodermaviride	Silver	Extracellular	5-40nm	(Bharde et al., 2006)
Fusariumoxysporum	Silver magnetite	Extracellular	5-50nm 100-400nm	(Sathyavathi et al., 2010)
Aspergillus.fumigatus	Silver	extracellular	5-25 nm	(Tarafdar et al., 2013)

Table 2.Shape, size, surface area, and targeted metals for various NMOs

NMOs absorbent	Size and shape	Surface area(m^2/g)	Targeted metal	Reference
Goethite	Niddle like Length 200nm Breadth < 50nm	50	Cu (II)	(Grossl et al., 1994; Chen et al., 2010)
Hematite	Granular, crystals of 75nm	24.82	Cu (II)	(Grossl et al., 1994; Chen et al., 2010)
Amorphous iron oxide	Particles, 3.8nm	600	Pb (II)	(Mandavian et al., 2010)
Hydrous manganese Dioxide	Pparticles diameter 2.1nm	359	Pb (II)	(Hu et al., 2005; Hu et al., 2006)
Hydrous amorphous aluminiumOxide	Particles, diameter 1.9nm	411	Pb (II)	(Hu et al., 2005; Hu et al., 2006)
γ-Al_2O_3 MPTMS modified	---	---	Cu (II), Hg (II), Pd (II)	(Oliveira et al., 2004)
γ-Al_2O_3 DNPH modified	Particles , diameter 68-87 nm	42.62	Pb (II), Cd (II), Cr (III), Co (II), Ni (II), Mn (II)	(Afkhami et al., 2010)
TiO_2	Particles with 10-50nm size	208	Pb (II), Cd (II), Ni (II), Zn (II), Cd (II)	(Afkhami et al., 2010)

Investigating the status of E-waste generation in India in the context of consumption and production of Electrical and Electronic Equipment

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Abstract

The emergence of Global production network and expansion of global production has led to significant structural changes in the economies across the world. During Industrial Revolution in the 18th century, advancement in the field of science and technology led to a new regime. In the 20th century, the revolution associated with Information and Communication technology altered the operation and organization of economies. Due to the ICT revolution, the real time connectivity not only widened the horizons and speed of distribution channels but also generated enormous electronic wastes from electrical and electronic products. An array of hazardous and non-hazardous wastes has evolved with technological innovations which pose serious threat to sustainable development. Electrical and Electronic products contain toxic materials which are harmful for the society at large and environmentally unsustainable. The wastes originating from electrical and electronic devices have been termed as Waste Electrical and Electronic Equipment (WEEE) by the European Union. However, in an emerging economy like India, this waste is referred to as electronic-waste or simply e-waste. The expansion of global markets and increasing consumer demand for EEE contributes to the increased burden of e-waste in India. E-waste is generated in India from refrigerators, washing machines, televisions, personal computers, printers and mobile phones. The objective of the present study is to investigate the status of e-waste generated In India through consumption and production of Electrical and Electronic Equipment. This paper adopts the concept of "Consumption and Use Method" and the "Market Supply Method" and attempts to develop indicators of e-waste generation with some modifications in the Indian context.

Keywords: E-waste generation, consumption and use of EEE, production of EEE.

1.0 Introduction

The emergence of Global production network and expansion of global production has led to significant structural changes in the economies across the world. During Industrial Revolution in the 18th century, advancement in the field of science and technology led to a new regime. In the 20th century, the revolution associated with Information and Communication technology altered the operation and organization of economies. The transition from an industrial economy to knowledge based one is observed to happen through the information society where information systems are constantly being developed for greater accessibility and affordability and also to meet the demands of ICT infrastructure which includes both telecommunication and computer networks. Due to the ICT revolution, the real time connectivity not only widened the horizons and speed of distribution channels but also generated enormous electronic wastes from electrical and electronic products. An array of hazardous and non-hazardous wastes has evolved with technological innovations which pose serious threat to sustainable development. Electrical and Electronic products contain toxic materials which are harmful for the society at large and environmentally unsustainable. The wastes originating from electrical and electronic devices have been termed as Waste Electrical and Electronic Equipment (WEEE) by the European Union. However, in an emerging economy like India, this waste is referred to as electronic-waste or simply e-waste. The Information Technology industry in India on one hand has been instrumental in contributing to the digital revolution through promotion of both software and hardware, and on the other hand it generated significant amount of e-waste both internally and through imports. India is one of the major destinations of dumping of e-waste through imports for recycling and reuse of Electrical and Electronic Equipment. Consumer electronics such as televisions, refrigerators, air-conditioners mobile phones; computer hardware; industrial and automotive electronics; medical electronics are manifestations of internal generation of e-waste in India. In the era of globalization the generation and transmission of e-waste is not only rapid but also the magnitude of the threat imposed on health and environment is large. This is due to constant multifarious innovations associated to technology and hence perpetual obsolescence of electronic equipment. Specific to the Indian context several literatures related to e-wastes generation and management are available. Agarwal and Arupendra (2014) conducted a survey targeted towards companies failing to adhere to the E-Waste (Management & Handling) Rules, 2011. The report aims at providing a comprehensive view of stakeholders' perspectives on E-wastes and identifies the drivers of and barriers to waste management. Borthakur and Sinha (2013) in their study, quantify the amount of e-waste generated in India with the stakeholders and their involvement and attempt to formulate an inventory of e-waste in India both domestically and through imports. Khattar (2007) studies both formal and informal stakeholders participating in e-waste treatment in India and found that the formal recyclers dominate the informal ones.

2.0 Materials and Method

2.1 Objective of the study

The complexities involved in e-waste and the lack of reliable data related to electronics sector makes it difficult to quantify the amount of e-waste. The broad objective of this paper is to study the burden of e-waste generated in India. In this context the specific objectives are to investigate

i) The amount of e-waste generated through consumption and use of EEE

ii) The amount of e-waste generated by the production and sale of EEE.

2.2 Methodology

From the perspective of methodology, there are several significant contribution to the literature on e-waste. Saphores et al., (2009) examines the waste generated through personal computers, refrigerators and telephones in order to design strategies for recycling and reuse of the same. Based on sales data on computers, the reuse and storage parameter of obsolete machines was studied by Widmer et al., (2005). Lohse et. at., (1998) In their work, described three approaches on generation of e-waste and management of WEEE: Consumption and Use Method; Market Supply Method and the

Inventory Method. The "Consumption and Use Method" has been applied in Netherlands by using the data on the electrical and electronic appliances used in households in estimating the potential amount of WEEE. The "Market Supply Method" takes into consideration the figures of production and sales of EEE in Germany. The Inventory Method has been applied by the Swiss Environmental Agency by assuming that the markets are saturated and for every new EEE being purchased by private households an old EEE attains its end life.

To investigate the status of e-waste in India, this paper adopts the concept of "Consumption and Use Method" and the "Market Supply Method" and attempts to develop indicators of e-waste generation with some modifications in the Indian context.

E-waste is generated in India from refrigerators, washing machines, televisions, personal computers, printers and mobile phones. The expansion of global markets and increasing consumer demand for EEE contributes to the increased burden of e-waste in India. Based on the conceptual understanding, this paper attempts to study the "Consumption and Use Method" by considering data on five variables: radio/transistors, televisions, computers/laptops, landline and mobile phones. A normalized score is computed for a total of 35 states and union territories. This is done to accurately examine the status of e-waste generated through consumption of EEE across Indian States and Union Territories (UT).

Steps in the computation of the Normalized Score for the e-waste generated through consumption and use of EEE:

1. The actual values of each of the modified variables are determined.
2. Ranks are assigned to each state and union territory for the five variables individually.
3. A normalized score for the five variables are computed
4. Overall normalized score is calculated by taking the average of the five normalized scores for each state and union territory.

The normalized score on each variable for each state and union territory is computed in the following manner.

$$Normalized\ Score = \frac{No.of\ states\ \&\ UTs\ below\ the\ particular\ state\ or\ UT\ in\ rank\ based\ on\ the\ variable}{Total\ number\ of\ states\ under\ consideration}$$

A state or U/T normalized score on a particular variable between 0.9 to 1.0 implies that the state is in the top 10 percentile amongst other states and U/T on the basis of its performance on that variable. Similarly a state normalized score on a particular variable between 0.1 to 0.2 implies that the state or U/T is in the bottom 20 percentile but above the bottom 10 percentile amongst other states and U/T on the basis of its performance on that variable.

To address the second specific objective, the "Market Supply Method" is adopted. Here production figures on various verticals of the Electronics Sector are considered. The verticals are Consumer Electronics, Industrial Electronics, Automotive Electronics, Computer Hardware, Mobile Phones, Strategic Electronics, Electronic Components, and Light Emitting Diodes (LEDs).This data related to production of electronic hardware explains for the amount of e-waste generated nationally. An emerging vertical of Electronics sector is Medical Electronics which is associated with diagnosis and health care sector. However, data on this segment is unavailable due to lack of efforts related to maintenance of records on part of the agents involved in this sector.

3.0 Results

3.1 Consumption and use of EEE

Table 8 gives the normalized score on radio/transistors, televisions, computers/laptops, landline and mobile phones for the Indian states and union territories computed on the basis of 2011 census data.

Data on radio/transistors reveals that Gujarat, Manipur and Jammu & Kashmir are the highest contributors to the e-waste generated through use of this asset. Chhattisgarh and Andhra Pradesh contribute the least to e-waste generation in terms of ownership and use of radio/transistors. The normalized score of West Bengal is 0.342 that is between 0.3 to 0.4. This implies that the state is in the bottom 40 percentile but above the bottom 30 percentile amongst other states and union territories on the basis of its contribution to the e-waste generation through use of radio/transistors per 1000 households.

Number of televisions owned by households also contributes to the bulk of e-waste generated through consumption of EEE. In this context Gujarat, Delhi and Tamil Nadu are the highest contributor to such waste generation. However West Bengal in this respect projects a lower score of 0.229 which is a better performance in terms of e-waste generation compared to ownership of radio/transistors.

Normalized scores of computers/laptops imply that Gujarat, Goa and Chandigarh contribute the maximum to the generation of e-waste. Odisha and Chhattisgarh are the least significant states in terms of e-waste generated through use of desktop computers/laptops. In this respect West Bengal has a score of 0.314, that is it lie in the bottom 40 percentile among other states and union territories.

Gujarat, Goa and Kerala generate the maximum amount of e-waste through consumption and use of Telephones, whereas Chhattisgarh and Nagaland barely add to the quantum of e-waste generation in India. West Bengal along with Bihar and Assam is among the bottom 30 percentile in terms of telephone ownership and use.

Availability and use of Mobile phones add to the quantum of e-waste besides other assets owned by households. Gujarat, Daman & Diu and Andaman & Niccobar Island are among the top 10 percentile in contributing to this category of waste generation by households. Odisha and Chhattisgarh is at the bottom most position in this respect. Contribution of West Bengal, Tripura and Madhya Pradesh in e-waste generation through mobile phones is among the bottom 20 percentile.

The overall normalized score for the five assets own by households in India is presented in Table 9. The overall score is computed by taking the average of the normalized scores of the five variables for each state and union territory. Gujarat project itself as the highest contributor of e-waste due to consumption of EEE. Odisha and Chhattisgarh remain at the bottom 10 percentile in terms of ownership of EEE and consequently the least contributor to the quantum of e-waste generation.

3.2 Production and sale of EEE

Table 10 and Table 11 show the growth of various EEEs in India in the last ten years. In the era of globalization there has been convergence of information, communication, media and entertainment. This has resulted in changing consumer preferences for consumer electronics. Therefore the demand for consumer durables projects an increasing trend. Moreover, innovations in technology and designing system have been instrumental in significant growth in the electronics sector.

The Consumer Electronic industry registered a sustained increase in demand with change in preference towards LCD/LED TVs and a declining market for conventional picture tube TVs.

Industrial Electronic sector has witnessed growth over the last ten years due to its linkage effect with infrastructure and critical hardware technologies. Data on Automotive Electronics for the recent period is not available. With growth in the automobile industry and digitization, the automotive sector is found to exhibit a growth trend.

Consumer's shift in preferences towards notebooks, tablet PCs have been instrumental in registering considerable growth in Computer Hardware. Mobile phones exhibit a significant decline in production domestically. However, the market has shifted to the import route to meet the increased demand for smart phones. Strategic Electronics sector comprises of navigation aids, military communication system, satellite based communication, disaster management, and such devices. With increased role of IT in defence and surveillance, this sector projects substantial growth. LED lighting, automotive electronics, energy meter, solar energy and IT products are the drivers of growth in electronic components manufacturing.

2.0 Discussion

Among other global nations, India is one that generates quantum of e-waste through consumption and production of EEEs. The Information Technology industry in India is a significant contributor to the digital revolution across the world. Penetration of new electronic devices and appliances coupled with obsolescence of products with shorter life-span, pose an alarming threat to all countries. Millions of people are unaware of the emerging problems associated with consumption and production of EEEs. Growing demand for consumer goods, for example, mobile phones, televisions and computers, are a result of rapid urbanization. However the rates of obsolescence of such consumer electronics, and rapid turnover of electronic gadgets pose a serious challenge for appropriate infrastructure for e-waste management in Gujarat, Delhi, Chandigarh, Goa, Kerala and Pondicherry which are the highest WEEE generators.

3.0 Conclusion

According to Manufactures' Association for Information Technology(MAIT), the Government, public and private (industrial) sectors account for almost 70% of the total amount of e-waste generated within the geographical boundary of India. Although the EEEs consumed and used by households are potential creators of electronic wastes, a relatively small amount of approximately 15% is contributed by the household sector who consumes consumer durables in considerable amount. The Govt. of India has taken several initiatives towards e-waste management. First, the Central pollution Control Board (CPCB) in 2007 enacted 'Guidelines for Environmentally Sound Management of Electronic Wastes. Second, the E-Waste (Management & Handling) Rules were notified by the Ministry of Environment & Forest (MoEF). Third, the Department of Information Technology, Ministry of Communication and Information Technology framed the National Policy on Electronics in 2012. According to the E-Waste (Management & Handling) Rules (2011), producers are liable for recycling EEE and reducing the amount of e-waste generated through production of EEE. The rules became operational in 2012 and are applicable to all economic agents involved in the purchase and sale, manufacture and processing of EEEs. The concept of 'Extended Producer Responsibility' (EPR) is pertinent in designating producers as the key stakeholders in e-waste management. This is because they are not only the manufacturers but also the agents involved in spreading awareness about hazardous components and their handling and disposal instructions.

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Table 1: Number of households availing each of the specified assets (as per 2011 Census)

States and U/T	Radio/Transistor	Television	Computer/Laptop	Telephones	Mobile Phones
Andaman & Niccobar Island	24404	63965	4960	2841	67286
Andhra Pradesh	1949681	12358093	1214271	857080	11549740
Arunachal Pradesh	57571	107624	16119	7592	104094
Assam	1404752	1751229	493311	137261	2766506
Bihar	4884055	2751541	1169044	425705	9773448
Chandigarh	65936	193932	33830	14027	148411
Chhattisgarh	618474	1760851	193151	86376	1528665
Dadra & Nagar Haveli	11354	34467	4004	1706	41837
Daman & Diu	12664	36838	3914	2494	45871
Delhi	1115077	2939423	383997	171323	2279781
Goa	100507	261842	59501	39008	173533
Gujarat	2360781	6550293	695888	402969	7136827
Haryana	821525	3203191	374866	210845	3157367
Himachal Pradesh	378917	1098553	82145	109706	907586
Jammu & Kashmir	950425	1028155	110383	72820	1194854
Jharkhand	1078620	1657422	335347	122465	2725805
Karnataka	2944833	7911490	1053785	920192	7450784
Kera	2288127	5929498	731035	893306	3608956
Lakshadweep	2165	6855	1174	870	4977
Madhya Pradesh	2176998	4811219	671130	359303	6074734
Maharashtra	4639656	13525610	1794680	1495311	12799041
Manipur	276109	240325	34821	15423	265308
Meghalaya	135460	181191	32793	8231	210473
Mizoram	74113	121725	28045	3694	141254
Nagaland	99930	151670	28797	5328	194245
Odisha	1100306	2581277	355673	176200	3441856
Pondicherry	79970	246521	22872	15439	188881
Punjab	891462	4468245	397985	361086	3368428
Rajasthan	2034880	4727542	643422	312904	7861580
Sikkim	29444	70100	10550	2249	86696
Tamil Nadu	4192387	16080190	1184373	1052287	11482800
Tripura	107995	377988	53344	17491	360143
Uttar Pradesh	8137213	10935311	2054674	1097897	20149607
Uttarakhand	290860	1237708	155326	63362	1294045
West Bengal	3679944	7091740	1225115	454850	8616602
Total	**49016595**	**116493624**	**15654325**	**9919641**	**131202021**

Source: Office of the Registrar General and Census Commissioner, India

Table 2: No. of specified assets availed per 1000 household (as per 2011 Census)

States and U/T	No. of households	Radio/ Transistors	Television	Computer/ Laptop	Telephones	Mobile Phones
Andaman & Niccobar Island	93376	261.352	685.026	53.119	30.425	720.592
Andhra Pradesh	20124534	96.8808	614.081	60.338	42.589	573.913
Arunachal Pradesh	262614	219.223	409.818	61.379	28.909	396.376
Assam	6367295	220.62	275.035	77.476	21.557	434.487
Bihar	18940629	257.861	145.272	61.721	22.476	516.004
Chandigarh	235061	280.506	825.028	143.92	59.674	631.372
Chhattisgarh	5622850	109.993	313.16	34.351	15.362	271.867
Dadra & Nagar Haveli	73063	155.4	471.744	54.802	23.35	572.615
Daman & Diu	60381	209.735	610.093	64.822	41.304	759.693
Delhi	3340538	333.802	879.925	114.95	51.286	682.459
Goa	322813	311.347	811.126	184.32	120.84	537.565
Gujarat	1218718	1937.1	5374.74	571	330.65	5856.01
Haryana	4717954	174.127	678.936	79.455	44.69	669.224
Himachal Pradesh	1476581	256.618	743.984	55.632	74.297	614.654
Jammu & Kashmir	2015088	471.654	510.228	54.778	36.137	592.954
Jharkhand	6181607	174.489	268.122	54.249	19.811	440.954
Karnataka	13179911	223.433	600.269	79.954	69.818	565.314
Kerala	7716370	296.529	768.431	94.738	115.77	467.701
Lakshadweep	10703	202.28	640.475	109.69	81.286	465.01
Madhya Pradesh	14967597	145.447	321.442	44.839	24.005	405.859
Maharashtra	23830580	194.693	567.574	75.31	62.748	537.085
Manipur	507152	544.43	473.872	68.66	30.411	523.133
Meghalaya	538299	251.645	336.599	60.92	15.291	390.996
Mizoram	221077	335.236	550.6	126.86	16.709	638.936
Nagaland	399965	249.847	379.208	71.999	13.321	485.655
Odisha	9661085	113.891	267.183	36.815	18.238	356.26
Pondicherry	301276	265.438	818.256	75.917	51.245	626.937
Punjab	5409699	164.79	825.969	73.569	66.748	622.665
Rajasthan	12581303	161.738	375.759	51.141	24.871	624.862
Sikkim	128131	229.796	547.096	82.338	17.552	676.62
Tamil Nadu	18493003	226.701	869.528	64.044	56.902	620.927
Tripura	842781	128.141	448.501	63.295	20.754	427.327
Uttar Pradesh	32924266	247.149	332.135	62.406	33.346	611.999
Uttarakhand	1997068	145.644	619.763	77.777	31.728	647.972
West Bengal	20067299	183.38	353.398	61.05	22.666	429.385
Total	**246692667**	**198.695**	**472.222**	**63.457**	**40.211**	**531.844**

Table 3: Ranking of States and U/Ts based on the no. of households having Radio/Transistors per 1000 households in 2011

States and U/Ts	No. of households per 1000 households	Rank	Normalized Score
Gujarat	1937.1	1	0.971
Manipur	544.43	2	0.943
Jammu & Kashmir	471.654	3	0.914
Mizoram	335.236	4	0.886
Delhi	333.802	5	0.857
Goa	311.347	6	0.829
Kera	296.529	7	0.8
Chandigarh	280.506	8	0.771
Pondicherry	265.438	9	0.743
Andaman & Niccobar Island	261.352	10	0.714
Bihar	257.861	11	0.686
Himachal Pradesh	256.618	12	0.657
Meghalaya	251.645	13	0.629
Nagaland	249.847	14	0.6
Uttar Pradesh	247.149	15	0.571
Sikkim	229.796	16	0.543
Tamil Nadu	226.701	17	0.514
Karnataka	223.433	18	0.486
Assam	220.62	19	0.457
Arunachal Pradesh	219.223	20	0.429
Daman & Diu	209.735	21	0.4
Lakshadweep	202.28	22	0.371
Maharashtra	194.693	23	0.343
West Bengal	183.38	24	0.314
Jharkhand	174.489	25	0.286
Haryana	174.127	26	0.257
Punjab	164.79	27	0.229
Rajasthan	161.738	28	0.2
Dadra & Nagar Haveli	155.4	29	0.171
Uttarakhand	145.644	30	0.143
Madhya Pradesh	145.447	31	0.114
Tripura	128.141	32	0.086
Odisha	113.891	33	0.057
Chhattisgarh	109.993	34	0.029
Andhra Pradesh	96.8808	35	0

Table 4: Ranking of States and U/Ts based on the no. of households having Televisions per 1000 households in 2011

States and U/Ts	No. of households per 1000 households	Rank	Normalized Score
Gujarat	5374.74	1	0.971
Delhi	879.925	2	0.943
Tamil Nadu	869.528	3	0.914
Punjab	825.969	4	0.886
Chandigarh	825.028	5	0.857
Pondicherry	818.256	6	0.829
Goa	811.126	7	0.8
Kera	768.431	8	0.771
Himachal Pradesh	743.984	9	0.743
Andaman & Niccobar Island	685.026	10	0.714
Haryana	678.936	11	0.686
Lakshadweep	640.475	12	0.657
Uttarakhand	619.763	13	0.629
Andhra Pradesh	614.081	14	0.6
Daman & Diu	610.093	15	0.571
Karnataka	600.269	16	0.543
Maharashtra	567.574	17	0.514
Mizoram	550.6	18	0.486
Sikkim	547.096	19	0.457
Jammu & Kashmir	510.228	20	0.429
Manipur	473.872	21	0.4
Dadra & Nagar Haveli	471.744	22	0.371
Tripura	448.501	23	0.343
Arunachal Pradesh	409.818	24	0.314
Nagaland	379.208	25	0.286
Rajasthan	375.759	26	0.257
West Bengal	353.398	27	0.229
Meghalaya	336.599	28	0.2
Uttar Pradesh	332.135	29	0.171
Madhya Pradesh	321.442	30	0.143
Chhattisgarh	313.16	31	0.114
Assam	275.035	32	0.086
Jharkhand	268.122	33	0.057
Odisha	267.183	34	0.029
Bihar	145.272	35	0

Table 5: Ranking of States and U/Ts based on the no. of households having computers/laptops per 1000 households 2011

States and U/Ts	No. of households per 1000 households	Rank	Normalized Score
Gujarat	571	1	0.971
Goa	184.32	2	0.94
Chandigarh	143.92	3	0.914
Mizoram	126.856	4	0.88
Delhi	114.951	5	0.857
Lakshadweep	109.689	6	0.82
Kerala	94.7382	7	0.8
Sikkim	82.3376	8	0.771
Karnataka	79.9539	9	0.743
Haryana	79.4552	10	0.714
Uttarakhand	77.777	11	0.686
Assam	77.4758	12	0.657
Pondicherry	75.9171	13	0.629
Maharashtra	75.31	14	0.6
Punjab	73.5688	15	0.571
Nagaland	71.9988	16	0.543
Manipur	68.6599	17	0.514
Daman & Diu	64.8217	18	0.486
Tamil Nadu	64.0444	19	0.457
Tripura	63.2952	20	0.429
Uttar Pradesh	62.4061	21	0.4
Bihar	61.7215	22	0.371
Arunachal Pradesh	61.3791	23	0.343
West Bengal	61.0503	24	0.314
Meghalaya	60.9197	25	0.286
Andhra Pradesh	60.3378	26	0.257
Himachal Pradesh	55.6319	27	0.229
Dadra & Nagar Haveli	54.802	28	0.2
Jammu & Kashmir	54.7783	29	0.171
Jharkhand	54.2492	30	0.145
Andaman & Niccobar Island	53.1186	31	0.114
Rajasthan	51.1411	32	0.086
Madhya Pradesh	44.8389	33	0.057
Odisha	36.815	34	0.029
Chhattisgarh	34.3511	35	0

Table 6: Ranking of States and U/Ts based on the no. of households having Telephones per 1000 households in 2011

States and U/T	No. of households per1000 households	Ranks	Normalized Score
Gujarat	330.65	1	0.971
Goa	120.84	2	0.94
Kerala	115.77	3	0.914
Lakshadweep	81.286	4	0.88
Himachal Pradesh	74.297	5	0.857
Karnataka	69.818	6	0.82
Punjab	66.748	7	0.8
Maharashtra	62.748	8	0.771
Chandigarh	59.674	9	0.74
Tamil Nadu	56.902	10	0.714
Delhi	51.286	11	0.68
Pondicherry	51.245	12	0.657
Haryana	44.69	13	0.62
Andhra Pradesh	42.589	14	0.6
Daman & Diu	41.304	15	0.571
Jammu & Kashmir	36.137	16	0.543
Uttar Pradesh	33.346	17	0.514
Uttarakhand	31.728	18	0.486
Andaman & Niccobar Island	30.425	19	0.457
Manipur	30.411	20	0.429
Arunachal Pradesh	28.909	21	0.4
Rajasthan	24.871	22	0.371
Madhya Pradesh	24.005	23	0.343
Dadra & Nagar Haveli	23.35	24	0.314
West Bengal	22.666	25	0.286
Bihar	22.476	26	0.257
Assam	21.557	27	0.229
Tripura	20.754	28	0.2
Jharkhand	19.811	29	0.171
Odisha	18.238	30	0.143
Sikkim	17.552	31	0.114
Mizoram	16.709	32	0.086
Chhattisgarh	15.362	33	0.057
Meghalaya	15.291	34	0.029
Nagaland	13.321	35	0

Table 7: Ranking of States and U/Ts based on the no. of households having Mobile Phones per 1000 households in 2011

States and U/T	No. of households per 1000 households	Ranks	Normalized Score
Gujarat	5856.01	1	0.971
Daman & Diu	759.693	2	0.943
Andaman & Niccobar Island	720.592	3	0.914
Delhi	682.459	4	0.886
Sikkim	676.62	5	0.857
Haryana	669.224	6	0.829
Uttarakhand	647.972	7	0.8
Mizoram	638.936	8	0.771
Chandigarh	631.372	9	0.743
Pondicherry	626.937	10	0.714
Rajasthan	624.862	11	0.686
Punjab	622.665	12	0.657
Tamil Nadu	620.927	13	0.629
Himachal Pradesh	614.654	14	0.6
Uttar Pradesh	611.999	15	0.571
Jammu & Kashmir	592.954	16	0.543
Andhra Pradesh	573.913	17	0.514
Dadra & Nagar Haveli	572.615	18	0.486
Karnataka	565.314	19	0.457
Goa	537.565	20	0.429
Maharashtra	537.085	21	0.4
Manipur	523.133	22	0.371
Bihar	516.004	23	0.343
Nagaland	485.655	24	0.314
Kerala	467.701	25	0.286
Lakshadweep	465.01	26	0.257
Jharkhand	440.954	27	0.229
Assam	434.487	28	0.2
West Bengal	429.385	29	0.171
Tripura	427.327	30	0.143
Madhya Pradesh	405.859	31	0.114
Arunachal Pradesh	396.376	32	0.086
Meghalaya	390.996	33	0.057
Odisha	356.26	34	0.029
Chhattisgarh	271.867	35	0

Table 8: Normalized Scores of the specified assets (computed as per 2011 census)

States and U/Ts	Radio/ Transistor	Television	Computer/ Laptop	Telephones	Mobile Phones
Andaman & Niccobar Island	0.714	0.714	0.114	0.457	0.914
Andhra Pradesh	0	0.6	0.257	0.6	0.514
Arunachal Pradesh	0.429	0.314	0.343	0.4	0.086
Assam	0.457	0.086	0.657	0.229	0.2
Bihar	0.686	0	0.371	0.257	0.343
Chandigarh	0.771	0.857	0.914	0.743	0.743
Chhattisgarh	0.029	0.114	0	0.057	0
Dadra & Nagar Haveli	0.171	0.371	0.2	0.314	0.486
Daman & Diu	0.4	0.571	0.486	0.571	0.943
Delhi	0.857	0.943	0.857	0.686	0.886
Goa	0.829	0.8	0.943	0.943	0.429
Gujarat	0.971	0.971	0.971	0.971	0.971
Haryana	0.257	0.686	0.714	0.629	0.829
Himachal Pradesh	0.657	0.743	0.229	0.857	0.6
Jammu & Kashmir	0.914	0.429	0.171	0.543	0.543
Jharkhand	0.286	0.057	0.143	0.171	0.229
Karnataka	0.486	0.543	0.743	0.829	0.457
Kerala	0.8	0.771	0.8	0.914	0.286
Lakshadweep	0.371	0.657	0.829	0.886	0.257
Madhya Pradesh	0.114	0.143	0.057	0.343	0.114
Maharashtra	0.343	0.514	0.6	0.771	0.4
Manipur	0.943	0.4	0.514	0.429	0.371
Meghalaya	0.629	0.2	0.286	0.029	0.057
Mizoram	0.886	0.486	0.886	0.086	0.771
Nagaland	0.6	0.286	0.543	0	0.314
Odisha	0.057	0.029	0.029	0.143	0.029
Pondicherry	0.743	0.829	0.629	0.657	0.714
Punjab	0.229	0.886	0.571	0.8	0.657
Rajasthan	0.2	0.257	0.086	0.371	0.686
Sikkim	0.543	0.457	0.771	0.114	0.857
Tamil Nadu	0.514	0.914	0.457	0.714	0.629
Tripura	0.086	0.343	0.429	0.2	0.143
Uttar Pradesh	0.571	0.171	0.4	0.514	0.571
Uttarakhand	0.143	0.629	0.686	0.486	0.8
West Bengal	0.314	0.229	0.314	0.286	0.171

Table 9: Overall Normalized Score for the e-waste generated through consumption of EEE

States and U/Ts	Normalized Scores
Gujarat	0.971
Delhi	0.846
Chandigarh	0.806
Goa	0.789
Kerala	0.714
Pondicherry	0.714
Tamil Nadu	0.646
Punjab	0.629
Haryana	0.623
Mizoram	0.623
Himachal Pradesh	0.617
Karnataka	0.611
Lakshadweep	0.6
Daman & Diu	0.594
Andaman & Niccobar Island	0.583
Sikkim	0.549
Uttarakhand	0.549
Manipur	0.531
Maharashtra	0.526
Jammu & Kashmir	0.52
Uttar Pradesh	0.446
Andhra Pradesh	0.394
Nagaland	0.349
Bihar	0.331
Assam	0.326
Rajasthan	0.32
Arunachal Pradesh	0.314
Dadra & Nagar Haveli	0.309
West Bengal	0.263
Meghalaya	0.24
Tripura	0.24
Jharkhand	0.177
Madhya Pradesh	0.154
Odisha	0.057
Chhattisgarh	0.04

Table 10: Production on Electronic Hardware for the period 2005-2010(in Rupees Crore)

Verticals of Electronics Sector	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
Consumer Electronics	18000	20000	22600	25550	29000
Industrial Electronics	8800	10400	11910	12740	15160
Computer Hardware	10800	12800	15870	13490	14970
Mobile Phones	7000	9500	18700	26600	31000
Strategic Electronics	3200	4500	5700	6840	6980
Electronic Components	6800	8800	9630	12040	13610

Source: Ministry of Communication and Information Technology

Table 11: Production on Electronic Hardware for the period 2010 -2015 (in Rupees Crore)

Verticals of Electronics Sector	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Consumer Electronics	32000	34300	40447	47599	55806
Industrial Electronics	17000	18700	25800	33600	39374
Automotive Electronics	NA	NA	5629	7278	NA
Computer Hardware	14970	16500	9376	17484	18691
Mobile Phones	35400	40500	46000	26650	18900
Strategic Electronics	7700	8500	9000	13800	15700
Electronic Components	21800	24800	26645	32102	39723
Light Emitting Diodes (LEDs)	NA	NA	1275	1941	2172

ABOUT THE COLLEGE

Established in 1966 under the aegis of The Bhawanipur Gujarati Education Society, The Bhawanipur Education Society College aims at Learning for Leadership and Liberal Values. Affiliated to the University of Calcutta, the college offers a number of undergraduate degree courses in Science, Arts, Commerce and Management. Post-graduate programmes in Commerce and English are also offered. Recently, two new undergraduate degree programmes in Computer Science and Journalism & Mass Communications have been introduced, and there are further plans to offer new courses in the near future.

The goal of the BES College is to contribute to nation building by establishing itself as a centre of academic excellence. To this end the college has undertaken a policy of continuous upgradation of faculty and student profiles, teaching- learning processes, student support systems, extension and skill development activities, administrative processes and other supportive infrastructure.

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