Volume 1, 2016

Annual Technical Volume

Environmental Engineering Division Board

The Institution of Engineers (India)

About The Institution of Engineers (India)

The Institution of Engineers (India) [IEI] is the largest multidisciplinary professional body of engineers that encompasses 15 engineering disciplines and provides engineers a global platform to share their professional interest. It also has the distinction of producing the maximum number of engineers in the core engineering disciplines, thus augmenting the nation building efforts. To promote the general advancement of engineering and engineering science and their application in India and to facilitate the exchange of information and ideas on those subjects amongst the members of and the persons attached to the Institution. Established in 1920 with its headquarters in Kolkata (erstwhile Calcutta), IEI was awarded the Royal Charter in 1935. The grant of Royal Charter to IEI constituted IEI as a BODY CORPORATE endowing its corporate members the status of Chartered Engineers. Since inception, this unique professional body has come a long way in rendering yeoman service to the nation in the field of Technology, Research and Development, Non Formal Engineering Education, Rural Development and critical issues such as Global Warming and Environmental Protection amongst many such other issues. Today, its request for professional excellence has given it a place of pride in almost every prestigious and relevant organization across the globe. The Institution is working in close collaboration with Indian National Academy of Engineering, The Institution of Electronics and Telecommunication Engineers, The Indian Institute of Chemical Engineers, The Indian Institute of Metals, The Institute of Marine Engineers (India), Computer Society of India, The Aeronautical Society of India & many others promoting and advancing the science, practice and business of engineering in all its branches in the country. The Institution has grown up with the presence of more than 100 State and Local Centres throughout the country. It also boasts of having membership strength of more than nearly Six million Members. The Institution has further extended its services to the international community with five overseas chapters at Abu Dhabi, Bahrain, Dubai, Kuwait and Qatar. In the international arena, IEI has bilateral relations with 26 engineering organizations worldwide such as, World Federation of Engineer ing Organizations (WFEO), Federation of Engineering Institutions of South and Central Asia (FEISCA), Federation of Engineering Institutions of Asia and the Pacific (FEIAP), Commonwealth Engineers Council (CEC), Federation of International du Beton (fib), World Mining Congress (WMC), Engineers Mobility Forum (EMF) and many more. Out of 15 Engineering Divisions, Civil Engineering has found one of the strongest Divisions where Corporate Membership is high.

About Environmental Engineering Division Board

The Institution of Engineers (India) has established Public Health Engineering Division in the year 1962 and thereafter, it was renamed as Environmental Engineering Division. This Division consists of quite a large number of corporate members from Government, Public, Private sectors, Academia and R&D Organizations. Various types of technical activities organized by the Environmental Engineering Division include All India Seminars, All India Workshops, Lectures, Panel Discussions etc., which are held at various State/Local Centres of the Institution. Apart from these, National Convention of Environmental Engineers, an Apex activity of this Division is also organized each year on a particular theme approved by the Council of the Institution. In the National Convention, several technical sessions are arranged on the basis of different sub-themes along with a Memorial Lecture in the memory of “N V Modak”, the eminent Environmental Engineer of the country, which is delivered by the experts in this field. In order to promote the research and developmental work taking place in the field of environmental engineering, the Institution also publishes Environmental Engineering Division Journal twice in a year, where mainly the researches and its findings are focused. Due to multi-level activities related to this engineering discipline, this division covers different sub-areas such as:

- Abetment and Mitigation of Water, Air & Noise Pollution
- Cost Effective and Emerging Effluent Treatment Technologies
- Waste to Energy Technology
- Recycle and Reuse of Wastewater
- Clean Development Mechanism Complaint Technology
- Environment Impact Assessment and Environment Management Plan for Different Engineering Sectors
- Challenges and Issues in Urban Water Conservation
- Urban Sewerage System through Trenchless and Micro-tunelling Technology
- Green House Gases and their Adverse Effect on Environment
- Hazardous Waste Management
- Green Technology

In order to promote the research and developmental work in the field of Environmental Engineering, the Institution also publishes Journal of The Institution of Engineers (India): Series A in collaboration with Springer, which is an internationally peer reviewed journal. The journal is published twice in a year and serves the national and International engineering community through dissemination of scientific knowledge on practical engineering and design methodologies pertains to Civil, Environment, Agriculture, and Architectural engineering.

Annual Technical Volume

Environmental Engineering Division Board

(Session 2015-2016)

Theme:

Environmentally Sustainable Waste Management

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Mr H C S Berry, FIE
President

Message from ....

I am glad to know that the Environmental Engineering Division Board (ENDB) of the Institution is publishing the Annual Technical Volume on the theme, "Environmentally Sustainable Waste Management". It comprises the articles, which suggest measures aimed at environment control.

It is commendable that the contributors from various states have shared their valuable practical experiences in this field, which would be useful for practicing engineers in the field of waste management. Especially, the articles cover wastewater treatment techniques, environmental impact assessment, zero liquid discharge strategies etc.

It is indeed a great pleasure that our learned Corporate Members of the Institution and eminent persons belong to environmental engineering have shared their experiences in this Volume. I must congratulate all Members of ENDB and other contributors for their whole hearted supports in bringing in this endeavour. I am also thankful to Mr B N Thyagaraja, Chairman, ENDB and Technical Department of the Institution for their efforts to publish this volume on time.

H C S Berry

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Mr B N Thyagaraja, FIE
Chairman
Environmental Engineering Division Board

Editorial

It is of great pleasure that Environmental Engineering Division Board (ENDB) of the Institution is publishing Annual Technical Volume on the theme, "Environmentally Sustainable Waste Management". It comprises various articles from different corners of the country such as, Maharashtra, Gujarat, Karnataka etc., where the learned Corporate Members of the Institution have shared their experiences on this area.

It is worthy to mention that the articles containing rainwater harvesting systems design & its evaluation strategies, agricultural wastes from fruit processing industries & its monitoring techniques, electronic waste management, emerging treatments to zero liquid discharge, wastewater management, Leadership in Energy and Environmental Design (LEED) system design, domestic wastewater treatment systems, waste management in Karnataka and many allied areas. I hope these valuable articles will be helpful for practicing environmentalists and other engineers.

I am confident that the Publication will be useful to a large section of engineers and scientists in the field for reference & quote and also help in knowledge sharing & experience for better implementation of its concepts.

I am really grateful to our esteemed Corporate Members and eminent persons belonging to environmental engineering who have contributed their valuable experiences in this Volume. I must congratulate them and all Members of ENDB for their whole hearted supports in bringing out this Volume, which will be with ISBN No. I am also thankful to the Technical Department of the Institution for their efforts to publish this volume on time.

B N Thyagaraja

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Prof (Dr) N R Bandyopadhyay, FIE, FAScT, PhD (Engg.)
Chief Editor &
Chairman,
Committee for Advancement of Technology and Engineering

Message from the Editor-in-Chief

It is heartening to learn that Environmental Engineering Division Board of The Institution of Engineers (India) has been successfully bringing out its Annual Technical Volume on the theme, "Environmentally Sustainable Waste Management". This volume is the compilation of the articles contributed by the Corporate Members of the Institution who are experts in the field of environmental protection system.

I congratulate the Chairman and Members of the Environmental Engineering Division Board and the Technical Department of the Institution for their sincere efforts to bring out this Volume. I believe that it will be of immense value to the academicians, researchers and professionals working in this emerging field of technology.

Prof (Dr) N R Bandyopadhyay

Annual Technical Volume of
Environmental Engineering Division Board
(Session 2015-2016)

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Contents

A Probabilistic Approach to Rainwater Harvesting Systems Design and Evaluation

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Abstract

Rainwater harvesting is an alternative water supply method that has become popular in recent years in india.The dependency on water for future development has become a critical constraint for development. This paper presents the best way of utilizing the stored water. Rainfall harvesting from rooftops can increase the water supply for various uses such as constructing new infrastructure building, gardening and artificial recharge of ground water. Performance of the rooftop rainwater harvesting system was evaluated on the basis of three indicators reliability, resilience and vulnerability. On the basis of these determinants the future of rain water harvesting schemes will be assessed. The study concludes with policy recommendations related to applicability of rain water harvesting scheme for meeting water crisis at Annasaheb Dange Engineering College, Campus of Maharashtra. Rainwater harvesting is considered as a best alternative to bridge the gap between the demand and supply.

Keywords: *Water scarcity, Rooftop rainwater harvesting , Modeling , Sustainability.*

Introduction

Water is one of the most precious resources on earth. The world's single biggest problem is water scarcity. The increase in demand of water due to increase in population, Urbanization, Industrial & Agricultural development. But nowdays the problem of availability of water is much more acute and serious. The roof-top rainwater harvesting system seems to cost effective and easier technical method of conserving water. This paper deals with the roof-top rainwater harvesting in campus of Annasaheb Dange College of Engineering and Technology of Ashta, city in Maharashtra state. Water shortage has become a serious problem whole over the world and is assumed to be related to the increase in population, rapid urbanization and climatic changes. India, the second most populated country of the World is witnessing rapid urbanization. As per the world urbanization prospects 2011estimates India's urban population share would grow from about 31% to nearly 52% by 2050. Roof top rainwater collection is one of the solutions for solving or reducing the problem of water availability, where there is inadequate groundwater supply and surface sources are either lacking or insignificant quality.

Need for Study

Rainwater harvesting provides the long-term answers to the problem of water scarcity and fulfill water demand. The ADCET, ASHTA has population around 3200 including students, teaching & non-teaching staff and daily visitors too. Also it is still under the expansion project so there is fluctuation in demand of water. To meet the water demand of college campus the water is collected from bore well and also by river. Analysis revealed that water required 600m3 /day. water requirement is being met through the four bore wells in the campus. So for water scarcity, the

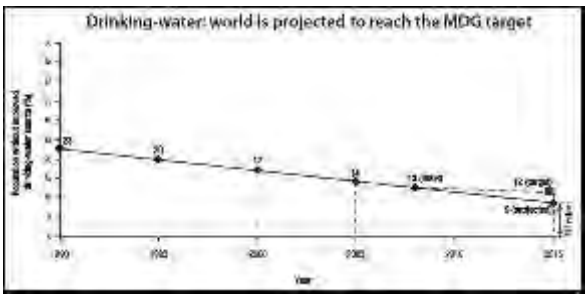

Figure 1: Drinking water shortage by 2015 (WHO and UNICEF, 2010)

rooftop rainwater system is seems to be best alternative. However, during the summer period, the bore wells yield and supply reduce considerably and this deficit is met by purchasing water through tanker supply. Rainwater harvesting also helps in increasing the soil moisture Condition and fertility factor of soil for plantation. To increase the greenery surrounding the campus. Rainwater harvesting is seems to be a perfect replacement for surface & groundwater as later is concerned with the rising cost as well as with ecological problems. Therefore, rainwater harvesting is highly recommended for campus of ADCET, campus.

Study Area

The campus of the Annasaheb Dange College of Engineering and Technology is located in Ashta city in Sangli district of Maharashtra state. The state experiences the four seasons in year. The sangli is located around latitude 16 51' 6" N and 74 33" 36" E longitude. This region falls in semiarid tract of deccan plateau. The average monsoon rainfall 359 mm and number of rainy days are 32 with maximum rainfall in 24 hrs. is 300 mm. The net annual ground water availability of sangli district is 92300 ha-m. The ADCET campus occupies the area around 28 acres in Ashta city. It includes office building, several departments, library building and hostel for both boys and girls. In the present study of Rooftop rain water harvesting for the buildings A, B and C are considered.

Background of the Study

The great challenge for the coming decades will be the task of scarcity of water .The dependency on water for future development has become a critical constraint for development. The annual precipitation in India is estimated at about 4,000 billion cubic meters. Heavy monsoon rainfalls and the annually recurring floods may have led to the common perception that water is an inexhaustible resource or there is plenty of it available[3,6]. But, as the National Water Policy document prepared by the Planning Commission says, it is a grossly misplaced conception that India is a water rich country and water is a free commodity. About 90% of the annual runoff in peninsular rivers and over 80% in Himalayan rivers occur during monsoon months and much of it in just a few monsoon storms. The projected total water demand by year 2025 is around 1050 billion cubic meter[4]. The country's annual utilizable water resources are assessed around 1140 billion m^3. Thus, almost the entire utilizable water resources would be required to be put to use by the year 2025.On the basis of the 1991 census, India's per capita water availability per year was estimated at 2214 m^3 against the global average of 9321 m^3 and this is likely to come down to 1496 m^3 by 2025. We have moved from a position of marginally vulnerable' in 1990 to that of water stresses' by 2007 and water scarcity' by 2025 [8]. Therefore, while every potential Source of water would need to be exploited, its conservation, proper utilization and efficient use has become of paramount importance.

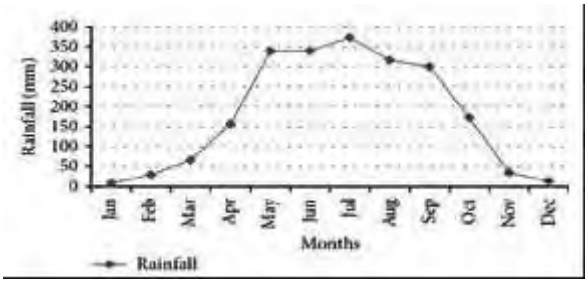

Figure 2: Monthly average rainfall in mm in sangli City

Concept of Roof-top Rain Water Harvesting.

Selection of Roof

Roof becomes the catchment which is the crucial factor in the rain water harvesting system and collected water from roof of the buildings can either be utilized for day to day domestic purposes or for artificial recharge of ground water [5]. This method is less expensive and very effective and if implemented properly helps in augmenting the ground water level of the area. The ideal roof rain water harvesting and conservation system encompasses following basic components. Catchment Area/Roof: Surface upon which rain falls, Gutters and Downspouts: System of transport channel from catchment surface to storage, Leaf screens and Roof Washers Systems that remove contamination and debris. Cistern or Storage Tanks: Where collected rain water is stored, Conveying: The delivery system for treated Rain Water, either by gravity or pump, Water Treatment: Filters and equipment and additives to settle, filter and disinfect the water.

Potential of Roof Rainwater Harvesting

The potential of rainwater harvesting from a roof is the annual yield from a given roof area. The potential of roof water harvesting in a study area has evaluated by using following formula:

Gould and Nissen Formula (1999): $S = R*A*C_r$ (1)

where,

S = Potential of roof rainwater harvesting, m^3

R = Avg. annual rainfall, mm.

A = Roof area, m^2

C_r = coefficient of runoff

Components of RWH

Roof-top rain water harvesting in our campus is collected in storage tank. The system consists of:

Catchment – The roof of various buildings, Course mesh- To prevent the entry of debris, Gutter- To convey the water from catchment to storage. Pipeline – carries the collected water, generally PVC pipes were used. First flushing- consist the valve arrangement for drain off the first spill of rain as it is contaminated. Storage tank- It is required to provide the sufficient capacity.

Rooftop Rain Water Harvesting Modelling Steps

It includes Collection of Daily Rainfall Data, Computation of Runoff coming from the roof surface Runoff,

1. Formulation
2. Calibration/verification
3. Application

Q_t = Roof area x Runoff Coefficient x Rainfall depth (2)

Model constitutes: 1. Input function; 2. Output function; 3. Transform function

Simulation Model

Simulation of operation of RWH system using standard Operating Policy (SOP) Yield from the Rainwater collection tank,

$$Y_t = \begin{cases} S_{t-1} + Qt & if\ Dt > S_{t-1} + Qt \\ Dt, & otherwise \end{cases} \quad (3)$$

a) Reliability: measure of efficiency of the system

b) Resilience: measure of ability of system to recover from failure

c) Vulnerability: measure of severity of failure.

Reliability

Period Based Reliability,

$$R_p = \frac{N^T - N^{failure}}{N^T} \times 100 \quad (4)$$

where, N^T - Total number. of simulations

$N^{failure}$ - Total number. of simulations

Resilience

As mean value of time system spends in unsatisfactory state

$$Res_1 = \left\{ \frac{1}{M} \left(\sum_{j=1}^{M} d(j) \right) \right\}^{-1} \quad (5)$$

where,

M— total number of failure events

d(j)-deficit in the j^{th} failure event

Vulnerability

As mean value of deficit volume

$$Vul_1 = \frac{1}{M} \left(\sum_{j=1}^{M} v(j) \right) \quad (6)$$

where,

M— total number of failure events

v(j)-deficit in the j^{th} failure event

These models describe mathematically the relation between rainfall and surface runoff without describing the physical process by which they are related.

Lumped Models

These models occupy an intermediate position between the distributed models and Black Box Models. e.g. Stanford Watershed Model.

Distributed Models

These models are based on complex physical theory, i.e. based on the solution of unsteady flow equations.

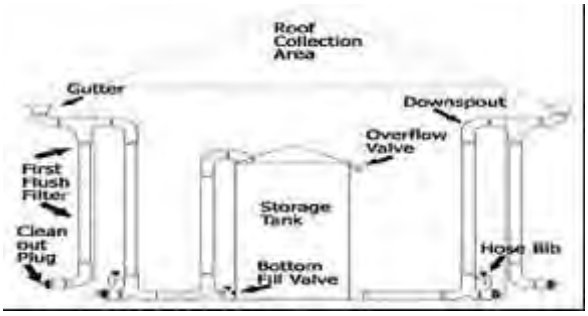

Figure: 3 Rainwater harvesting system

Conclusion

With a view to optimize water usage we are looking at alternatives, which are sustainable, reliable and cost effective . Rainwater harvesting appeared as a potential source of supply. Rainwater harvesting provides the long-term answers to the problem of water scarcity. Rain water harvesting is a unique practice because it provides both water supply and cost benefits. In ADCET, ASHTA, the water deficiency situation in hot season can be changed in to water adequate situation by adopting the Roof-top rain water harvesting techniques. The sangli reaches much of its rainfall in just 32 days in a year. So if this water is not conserved then rest of the year leads to water scarcity. This paper dealt with all aspects of RRWH to fulfilling the water requirements in college campus.

Acknowledgment

The authors would like to thank Dr.C.B.Shivayogimath, of Basaveshwar Engineering College, Bagalkot, Karnataka , for his advice and helpful discussions. The authors also thank to the ADCET, Management/authorities for providing research facilities and encouragement.

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Conversion of Fruit Waste from Fruit Processing Industry into Value Added Products

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Abstract

After independence Fruit Processing has gone through the phenomenal change from Home Made -> Cottage -> Small scale -> Large scale industry. Spectrum of Fruit Products of national & international brands is available in Market. Change in life style & quality of life along with increase purchasing power has increased the demand. Rise in Purchasing power & Change in Quality of life are increasing demand of packed food products. The fruit product is either wholesome or part of the fruit processed to make the finished product. Reject or left over of the fruit like peel, seed, fibers etc are the solid waste. It has a cost as it is a part of Raw material purchased from the market. It is nature made biomass and highly biodegradable. It comes out of the factory as a solid waste because alternatives are not known to consider as raw material for another process. Author has discussed the manufacturing of fruit based products and generation of solid waste with alternative method to make the value added products from solid waste.

Introduction

India has been bestowed with wide range of climate, geographical & geological conditions which ensure availability of most kind of fruits and vegetables. The country is the second largest producer of the Fruits and vegetables in the world, contributing 12.6% and 14.0% of the total world production of fruits and vegetables respectively. *(Source: Source. Banana, mango, citrus, papaya, guava and grape account for major share in total fruit production across India)*. The major fruit producing states are Andhra Pradesh, Maharashtra, Karnataka, Bihar, Uttar Pradesh, Tamil Nadu, Kerala and Gujarat. These eight states account for 70 % of the area under fruit cultivation. The production of fruits will further increases due to efforts made by the Government for fruit production. Potato, tomato, onion, brinjal, cabbage, cauliflower and tapioca account vv for maximum share in vegetable production in the country. India is a front runner in many fruits and vegetables with share in world production [1]. Out of the total production of fruits and vegetables, nearly 76% is consumed in fresh form, while wastage and losses account for 20 to 22% Only 2% of vegetable production and 4% of fruit production are being processed. This is in sharp contrast to the extent of processing of fruits in several other developing countries such as Brazil 70%, Malaysia 83%, Philippines 78% and Thailand 30%. [2]

Pickles, jam, jelly, sharbat are traditionally home made products of India. In early 70's, there were only few brand names for the limited fruit products. Till 70's fruits processing industry had a slow growth because of preference to home made products, liking for the fresh food rather than the preserved food, low income level, cannot afford costly processed food & considered as luxury. From late 70's onwards it has grown almost to medium-scale industry with many manufacturers and spectrum of products. The demand of the fruit products in Indian market is increasing at the fastest rate because of increase in buying capacity, change in quality of the life; lesser time is available for ladies to make home preparation, adoption of ready to serve food culture & aggressive marketing by the product manufacturer. Thus food-processing industry has gone through the phenomenal change from Home made product Cottage industry Small Scale Industry Large scale Automatic plants corporate sector with National & International Brand name. It was started with processing of Milk in Dairy of large scale & now taken the control of almost all the products served on the dining table. India is exporting the fruit products in a small way. The popular items for export are pickles, mango pulp,

frozen and canned fruits etc. With the liberal policy of Government to promote the export the future of the fruit processing industry looks bright. Many corporate sectors and the multinationals are entering in the fruit processing.

Resource Availability and Waste Generation

In a small scale Fruit processing plant resources are drawn from and waste is assimilated in, surrounding environment. However due to increase in processing capacity the resources are to be drawn from the outside of region and disposal of large amount of waste became a serious problem.

Waste Utilization

In nature nothing is waste because it has a system having processor & consumer to assimilate the biomass. This principal can be made a reality in food processing industry. All the raw materials are drawn from the nature and it is definite that all parts of fruits must have the alternative to use. The payment is made for entire quantity of fruit despite of whatever part is extracted and rejected. Therefore the rejected part also has the value. Therefore there is need to reassess the fruit waste to make value added products out of it.

Table 1: Products manufactures from fruits

Fruit	Product
Mango (Green)	Pickle, Chutney, Sherbet, Syrup
Mango (Ripe)	Juice, Sauces, Jam, Syrup
Carrot	Pickle, Sauce
Apple	Juice, jam
Banana	Powder, Candy, Jam, Sweet chutney, chips
Strawberry	Squash, candy, powder
Grapes	Juice
Pineapple	Jam, Slices
Beetroot	Chutney, Sauce
Tomato	Sauces, Puree, Ketchup

Fruit Products & Processing

There are varieties of Products manufactured from Fruits as given in Table 1.

The basic operations in the manufacturing of fruit products e.g. pickle, jams etc are similar to the home preparations. The manufacturing at large

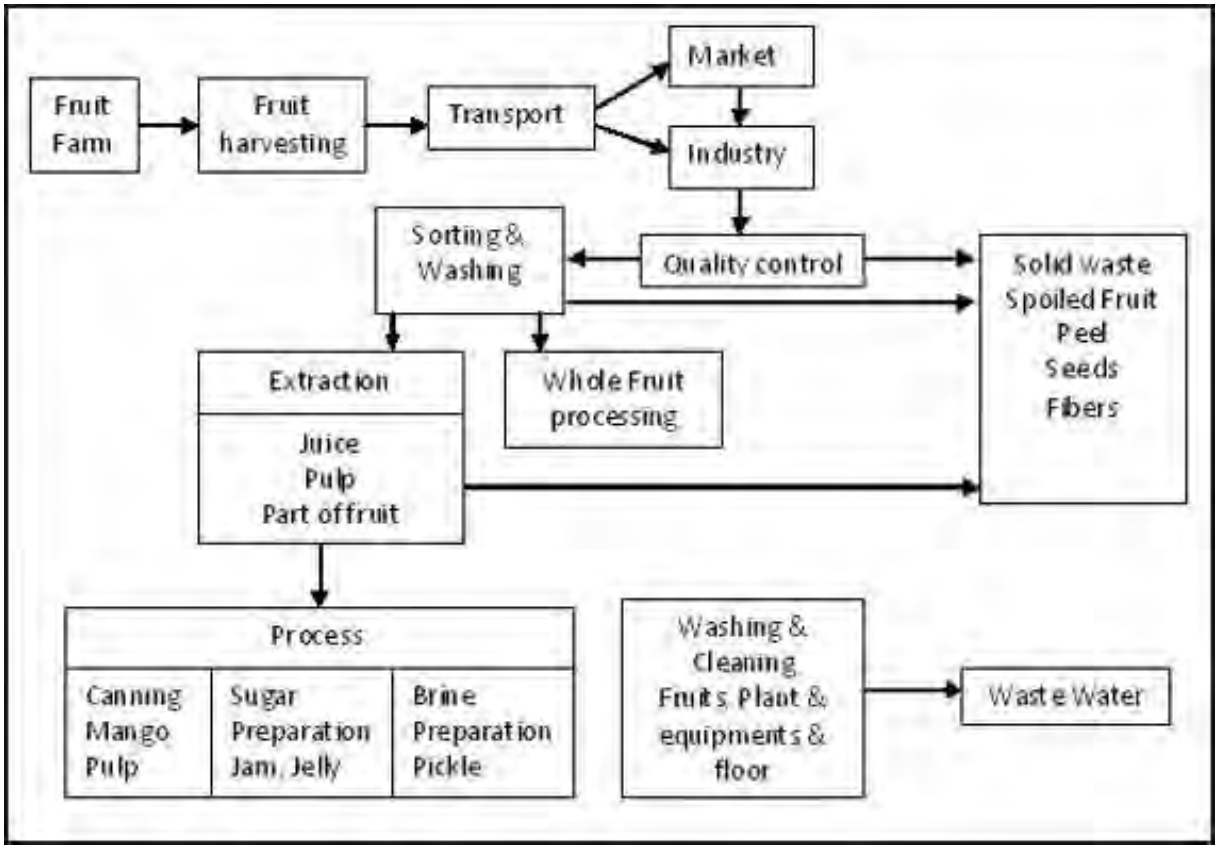

Figure 1: General process for fruit processing

scale only adds the plant and machinery for bulk handling. The extraction and the process are depending on the type of the fruit and the product to be manufactured. Water is required for washing, cleaning, and brine & sugar syrup preparation. Waste water is generated mainly from washing & cleaning operation. It contains the extract from the fruits and ingredients used in the manufacturing process beside dirt & dust contributed during harvesting & hauling. Typical flow chart applicable for majority of Fruit Processing Industries along with solid and liquid waste generation is given in Figure 1.

Solid Waste from Fruit Processing Industry

Quantity & quality of Solid waste generated depend on type of Finish Product from raw material e.g. seeds & peel from Mango Pulp & Kernel from Pickle. Solid waste is generally 25 to 60% of fruit by weight Solid waste is natural biomass & highly fermentable and perishable (by enzymatic and microbial degradation) because of high moisture (80- 90 %), total soluble sugars (6- 64 %) and crude protein (10- 24 %). Seeds/Kernel are consists of Amino acids, Protein, Oil / Fat, Carbohydrate, Vitamins & minerals. Peel or Skin is having Pectin, Oil, Chlorophyll, Color; Protein & Minerals. Stack is made of Cellulose, Lignin, Carbohydrate, and Protein. Fibers in fruit waste are of cellulose. Solid Wastes generated from various fruits are given in Table 2.

Table 2: Solid waste generation from fruits

Fruit	Waste Product
Mango (Green	Stack, Stone, Kernel
Mango (Ripe)	Peels, Stone fiber
Lemon	Seeds, Peel Fiber
Apple	Seeds, Peel
Banana	Peel, stack
Papaya	Peel, Seeds, Stack
Grapes	Seeds & Peel
Pineapple	Peel, Stack
Chilly	Stack, Seeds
Tomato	Seeds, Peels

Present Disposal Methods & Problems

Fruits are available at economical price only during the season. Obviously large quantity of finish products and solid waste are generated is short span of time. Solid waste is highly biodegradable and has to be consumed immediately. There is need to develop & adopt suitable methods to preserve fruit waste to use as resources. Currently fruit waste is disposed off as a landfill in own / other premises or handed over to local governing authority'. Disposal on land causes off smell, unaesthetic condition, favors breeding of insects & flies & attract the cattle. Leachate from fruit waste dump can impart color (due to tannin etc) to ground water and surface water. Rules and regulation permit the disposal on the land rather than utilization of fruit waste. Besides Manufacturers are not yet realizing the value of the fruit waste and not given serious thought for scientific approach to process the fruit waste.

Fruit Waste as Resource

Commercial value is assigned to fruit waste as it is a part of whole fruit. Therefore it is necessary to search alternative technology to use or convert fruit waste into value added product. This will also help to mitigate environment pollution.

Nutrient Value of Solid Waste

As biomass the solid waste consists of all the natural ingredients like, carbon, nitrogen, phosphorus and the minerals as carbohydrates, proteins, oil/fats, vitamins etc. Due to its nutrient value fruit waste can be used as it is or after processing or drying as food & cattle feed. However the possibility of organic chemicals that may hamper the digestion of the food has to be checked.

Use of Fresh Fruit Waste as Live Stock Feed

Fruit waste is wet biomass (Citrus pulp, tomato molace) can be fed to the livestock throughout the year or specifically during the lean period of green fodder production. Table 3 gives the usage of freshfruit waste as cattle feed.

Preservation of Fruit Waste

Fruit waste is to be preserved to increase its shelf life & transport to other locations. The most commonly used methods are drying or ensiling.

Conservation of Fruit Wastes by Drying

Fruit containing high moisture (fresh apple promace, tomato promace, and pineapple bran and carrot pulp) are kept in a heap on a slant till the excess water is drained out. Water is further

Table 3: Usage of fresh fruit waste as fattle feed

Sl No	Fruit waste	% of Waste	Usage as cattle feed
1	Banana peels	30	It can be fed to livestock as fresh green, ripe or dried
2	Citrus pulp Lemon & orange	50- 70	60- 65%, 30- 35% internal tissues and up to 10 percent seeds Adult crossbred cattle can consume 50- 60 kg fresh citrus pulp daily.
3	Mango Seed Kernels	9–40	Mango seed kernels can be incorporated in the 3 concentrate mixture up to 50% without any adverse effects
4	Pine Apple	30–50	Pineapple wastes are highly palatable and digestible. It can replace the roughage portion in the diet partly or completely and partly the cereals in the diet of meat animals

squeezed out mechanically by using filter press. It is dried by blowing hot air or by using a solar drier. In case a mechanical press or thermal drying facilities are not available, then the waste is spread in a 5–7 cm thick layer on a concrete floor under direct sunlight for sun drying. Wastes such as chaffed banana foliage, pea pods, tomato promace and peas can be easily sun dried. It is dried till the dry matter reaches around 90%. Dried matter is pulverized in a Willey mill using 1- 2 mm screen. It is stored in polythene bags and use as and when required.

Conservation of Fruit and Vegetable Wastes by Ensiling in Bunker or Pit Silo

Silage is fermented, high-moisture stored fodder which can be fed to cattle, sheep and other such ruminants or used as a bio-fuel feedstock for anaerobic digesters. It is fermented and stored in a process called ensilage. It is usually made from grass crops, including maize, sorghum or other cereals, using the entire green plant. Fruit waste can be ensilage with low moisture containing biomass like grass, pods, husk etc. High moisture containing is mixed with low moisture containing material & chaffed to 3 to 5 cm. It is piled in pit, silo or plastic tubes by layer by layer. It is compressed so as to leave as little oxygen as possible. Silo pit/trench is properly sealed with polyethylene sheet and a layer of mud. As the mud sealing dries up cracks may appear which need to be sealed. Environment temperature should be between 10 and 38ºC, the optimum being 32º C. Open the trench/pit after 42 days fermentation period, remove silage as per the daily requirement and cover the pit again with a polyethylene sheet. It can be packed & hauled.

Vegetable Wastes as a Source of Nutrients in Urea Molasses Multinutrient Blocks (UMMBs)

Agro-industrial wastes such as spent sugar syrup, waste bread and tomato promace can be incorporated into UMMBs without any adverse effect on palatability, nutrient utilization or health of animals. The use of these unconventional feed resources in the preparation of UMMB will replace conventional ingredients which are generally expensive, resulting in decreased cost of feeding.

Unique Value-added Products from Fruit and Vegetable Wastes

Fruit waste contains the valuable organic chemicals, which can be used in cosmetics, fruit processing and medicine. Some of the important ingredients are discussed below.

Extraction of oil from Seeds or Peels

Oil is extracted from seeds by any of the conventional method, mechanical extraction (grinding and pressing), Pressure or steam distillation & Solvent extraction. Valuable extracted oil from seeds & peels are given in Table 4.

Pigments, Food Additive & Dietary Fibers

Pigments extracted from fruit waste are extensively used as natural colorants in the modern food industry. It may be beneficial in curing cancer, coronary heart disease and other chronic conditions. The antioxidant compounds from waste products of the food industry can be used for protecting the oxidative damage in living systems by scavenging oxygen free radicals, and also for increasing the stability of foods by preventing lipid

Table 4: Valuable extracted oil from seeds & peel

Waste	Composition
Mango Seed Kernel Fat	Promising source of edible oil and its fatty acid and triglyceride profiles are similar to those of cocoa butter which can be used in chocolate manufacturing
Guava seeds oil	Guava seed contain 5–13% oil rich in essential fatty acids.
Passion fruit seed oil	Rich in unsaturated fatty acids (87.6%), mainly linoleic (73.1 %) and oleic (13.8 %) acids
Orange seeds & Peels Essential oil	It has free radical scavenging activity. Used in domestic, industrial and medicines. Adds orange flavor to beverages, desserts and sweetmeats, biscuits, chocolates, confectionery and bakery items, Soft drink concentrate, used in soaps, body lotions, creams, anti-aging and wrinkle-lifting applications, room fresheners, sprays, deodorants etc.

Table 5: Pigments, food additives & dietary fibers

Fruit waste	Pigment	Food additive	Dietary fiber
Tomato peel	Carotenoids such as lycopene		
Tomato promace			Excellent
Carrot promace	Carotenoids	Used in bread, cake, dressing and pickles	
Beet root peel	Betalains & Anthocyanin		
Onion promace		In Snacks	
Mango Peels			Excellent

Table 6: Enzymes & single cell protein from fruit waste

Fruit waste	Enzymes extracted / produce	Single cell protein
Pine apple waste	α-amylase, hemicellulase, cellulase	
Onion solid	Crude peroxidase	
Apple promace	Lignin and manganese peroxidase	Trichoderma viride and Aspergillus niger.
Citrus peels	Pectinase	Fusarium
Mango Peels	Cellulase	

peroxidation. Fibers from waste are good sources of dietary fiber supplements. These can be extracted from Tomato, Carrot & Beat as given in Table 5.

Enzymes & Single Cell Protein

Plant food residues including trimmings and peels might contain a range of enzymes capable of having a wide range of applications. Being a fermentable biomass it can also be used to produce single l cell Protein. Fruit waste & enzymes extracted or manufactured & single cell protein are given in Table 7.

Fermentation to Get Bio-ethanol, Fermented Fdible products & Citric acid

Highly biodegradable Fruit waste with or without treatment can be fermented by using specific microorganism to produce Ethanol and number of beverages such as cider, beer, wine, brandy, and vinegar. Fruit and vegetable promace and cassava bagasse etc. have been used as a substrate for citric acid production

Bio-degradable Plastic

Potato or cornstarch waste is hydrolyzed to glucose by high-temperature α amylase to solubilize the starch, and by gluco-amylase to break it down into glucose. The glucose is fermented to lactic acid by Lactobacillus. Lactic acid with equal amounts of hydroxyl and carboxyl groups can self-condense to form linear thermoplastic polyester poly-lactic acid (PLA), a biodegradable plastic. It can be used as timed release coatings for fertilizers, pesticides, and agricultural mulch films, which degrade in the soil [3].

Table 7: Value added products from fruit waste

Fruit	Waste	Product Value
Orange	Peel	Fodder - Calcium oxide is added to the peels and then crushed into small parts, which range from 2 cm to 6 cm. The wet peels have humidity of approximately 82%, which is reduced to 72% after the pressing takes place.
Orange	Seed	Vitamins, nutrients and oil extracted from orange seeds are used in food flavorings, health supplements and beauty products [2]
Papaya	Peel	The crushed papaya peel slurry generated during de-peeling of papaya is dewatered to 70% moisture and then the nutrient rich cake can be directly fed to the cattle stock. The cattle give high yield of milk.
Mango	Seed	The major components starch, fat and protein & the most of the essential amino acids. Due to its high quality of fat and protein as well as high levels of natural antioxidants Mango seed kernel can be used as a potential source for functional food ingredients, starch, and butter like oil, antimicrobial compounds and cosmetic. [3, 4]
Mango	Stone	Utilized as adsorbent. [3, 4]
Pine apple	Peel, Stem	Pineapple waste and bran are difficult to ensile due to their acidity and high moisture content. Products for food industry are Enzyme Bromelain [5], Vinegar [6]. Low-cost raw material for the production of ethanol, phenolic anti-oxidants, organic acids, biogas and fiber production
Tomato	Promace, Seed & Peel	Tomato promace and skins are high-moisture products (80%). Can be used as Fodder after drying & ensiling. The natural lacquer from tomato skin. It can be applied to the internal and external surfaces of cans used for foodstuffs. Tomato seed meal with unique protein quality could be regarded as a potential source of protein-rich adjunct in various food formulations. [5]

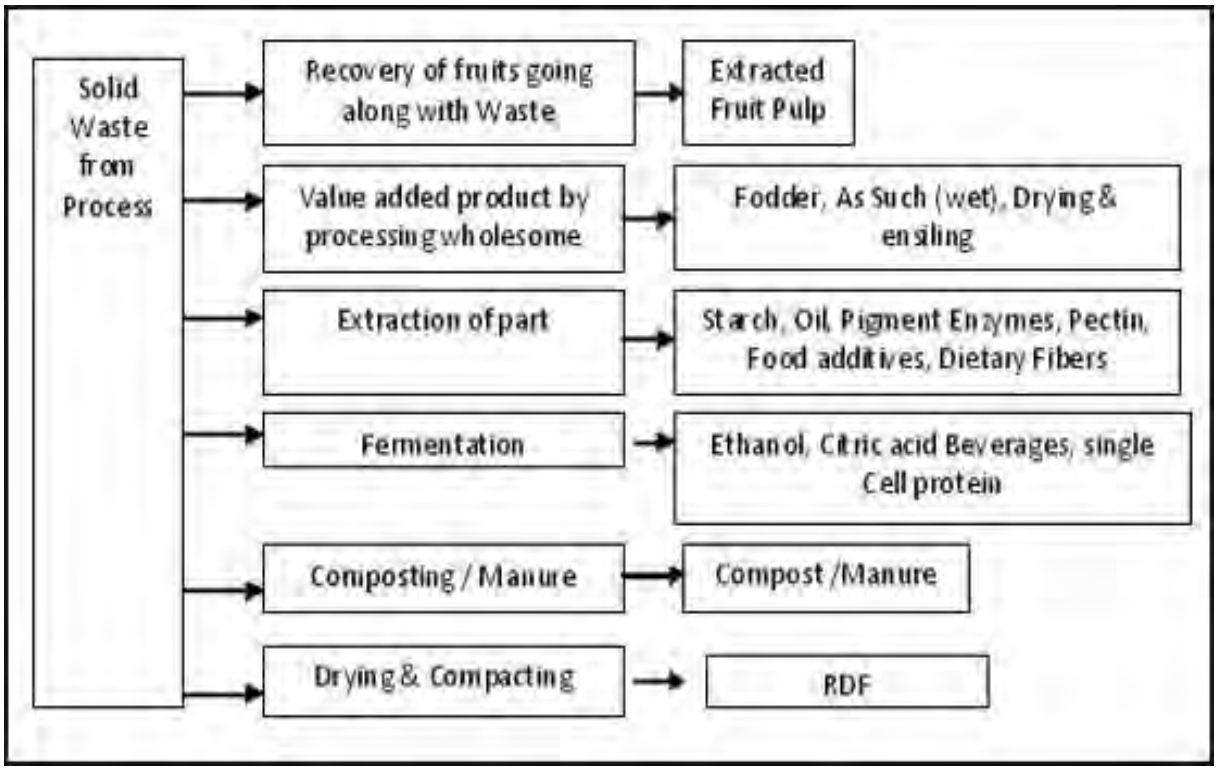

Figure 2: Methodology for selection of process for the fruit waste utilization

Starch

Mango stone contains 40 to 70% of starch. Extracted starch can be used as both food and non food purpose [4].

Fuel Value of Solid Waste

Fruit waste is a biomass, rich in carbon & has certain calorific value and can be used as a fuel. However the fresh solid waste has moisture that prohibits direct use as fuel. It has to be first dried to acceptable moisture content of 5 to 10% and then used as a fuel in agriculture residue fire boilers. It can also be briquetted to use as Refused Derived Fuel (RDF)

Returned to Farm as Value Added Product

The fruits are grown on the cost of nutrients extracted from the soil. Therefore the fruit waste can be used as a source to return the nutrients to the farm. It can be composted by conventional or vermi composting process. It can also be mulched into the soil for natural conversion into manure

Summary

Thus the solid waste from the Fruit processing industry is not a waste but a resource to have Value Added Product. Some of the Value added products from common fruit waste are in Table - 7

Conclusion

Certain value is to be assigned to fruit waste as it is a part of whole fruit. It is biomass, highly fermentable and has valuable ingredients like carbohydrate, fat, protein, vitamins & minerals. There is need to switch over from conventional process of dumping of solid waste on land to consider as resource to make value added products. The waste can be processed further in the industry or handed over to other processor to make a value added product. This is most important to ensure water and food security by reprocessing the waste biomass. Figure 2 gives methodology for converting waste into resource.The methodology ensures the sustainable Solid Waste Management solution for Fruit Processing Industry.

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Electronic Waste Management in India: Issues and Recommendations

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Introduction

Electronic waste or e-waste is a term used to refer to all items of Electrical and Electronic Equipment (EEE) and their parts that have been discarded (United Nations University, 2014). Electronic waste may also be referred to as Waste Electrical and Electronic Equipment (WEEE). Such waste may consist of temperature exchange equipment such as refrigerators and air conditioners, screens and monitors, lamps, large equipment such as washing machines and electric stoves, small equipment such as kettles and microwaves, and small IT equipment such as mobile phones and laptops. E-waste management is faced with problems in both developed and developing countries. In the US, e-waste accounts for 1-3% of the total municipal solid waste generation (Rajya Sabha Secretariat, 2011). Globally, approximately 50 million tonnes is expected to be generated by 2018 (UNU, 2015). Such rapid unsustained growth of e-waste production and use poses a major threat to environment and human health due to the presence of both precious as well as hazardous materials in EEE products. A graph representing domestic e-waste generated per capita (in kg) and the corresponding GDP (per capita) shows a fairly linear correlation between them (Figure 1), implying that countries with higher GDP are likely to have higher e-waste generation rates (Balde et al., 2015a; The World Bank, 2015). Assuming a similar trend in the future, projections of India's GDP in 2020, 2030 and 2050 predict a huge increase in the domestic e-waste generated (Table 1), from the current WEEE generation rate of around 1.3 kg/inhabitant to about 4.8kg/inhabitant in 2020 and higher. It is important to be cognisant of the fact that domestic e-waste is merely a fraction of the total WEEE produced in a country.

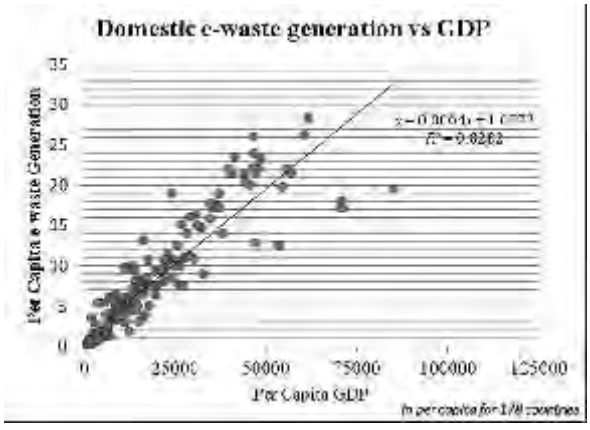

Figure 1: e-waste generated, kg per inhabitant in 2014 vs. GDP (per capita) (between 2011 and 2015)

Table 1: Projections of domestic e-waste generated in India

Year	Projected GDP per capita for India	Projected e-waste generated in India kg/inhabitant	Source
2020	9306	4.7996	(IMF, 2015)
2030	11514.6671	5.683067	(Fensom, 2015a; UNCTADSTAT,
2050	25925.1122	11.44724	(Fensom, 2015b; UNCTADSTAT, 2014b)

According to a 2009 survey by the Indian Market Research Bureau (IMRB), e-waste contains 68% television sets, 27% personal computers, 2% imports and 1% mobile phones. E-waste is made up of both hazardous and non-hazardous substances, including about 50% of iron and steel, followed by 21% of plastics, 13% of non-ferrous metals (aluminium, copper, gold, silver, palladium, platinum, etc.) and 16% of other materials (plywood, glass, concrete, rubber, circuit boards, ferrous, etc.) (Leung et al., 2008).

In India, E-Waste (Management and Handling) Rules, 2011, prevents open e-waste dumping and restricts the usage of hazardous material as per global best practices. The Ministry of Environment, Forest and Climate Change has notified the E-Waste (Management) Rules, 2016, in replacement of the E-Waste (Management & Handling) Rules, 2011. According to E-Waste

(Management) Rules, 2016, e-waste will now include Compact Fluorescent Lamps (CFLs) and other mercury-containing lamps, as well as other such equipment, and ensure collection of e-waste as well as its disposal in an environmentally sound manner. Further, the responsibilities of EEE producers have been extended to cover the post-use fate of their products, failing which they may lose the right to put any products on the market (Press Information Bureau, 20160.

Need for Sustainable e-waste Management Systems

It is estimated that the global volume of e-waste generation may increase from 41.8 Megatonnes (Mt) in 2014 to 50 Mt by 2018 – an increase of 21% (United Nations University, 2014). While the amount of e-waste generated in India is lower than the global average (less than 2 kg/inhabitant against a world average of 5.9), the increasing penetration of EEE combined with the large population size foretells a burgeoning production of e-waste in the country. It is estimated that India's e-waste generation is likely to increase three-fold, from 1.8 Mt to approximately 5 Mt per annum by 2020 (Paindit, 2016).

The problem of e-waste, however, extends beyond its quantity. To understand the issues that arise, it is important to first analyse its composition and the management systems that currently exist. E-waste is mainly a combination of materials that could be toxic or fairly innocuous in nature. Some constituents such as Lead (Pb), Mercury (Hg), Cadmium (Cd), Arsenic (As), Brominated Flame Retardants (BFRs), Dioxins and Furans, Polychlorinated Biphenyls (PCBs), etc., found in various EEE products are considered potential environment and human health hazards. Many of these chemicals are carcinogenic; they are known to cause toxicity in humans (and animals), and pose immense health risks to those who are constantly exposed, with infants and children being at high risk due to their low body weight and increased likelihood of ingestion. Many of these constituents may also bioaccumulate and biomagnify, increasing in concentration going up the food chain. e-waste also contains a significant share of precious metals such as gold, silver, palladium and platinum, as well as non-precious materials, which may be found commingled with the hazardous constituents, making e-waste both a problem for health and environment, and a burden on natural resources. The 230 million computers and the 1 billion cell phones sold in 2006 contained an estimated 70 tonnes and 535 tonnes of gold and silver, respectively, equivalent to roughly 3% of their respective global mine extractions (Boni et al., 2008a). In the case of palladium, the share of the mine production in e-waste is even higher (about 12% or 8 tonnes (Boni et al., 2008b).

Existing e-waste Management Systems

The UNU-IAS describes three main e-waste management processes that are used around the world (Boni et al., 2015b). These depend on various factors such as country, existing policies, etc. The e-waste produced may be managed through official take-back systems, as mandated by a national legislature where e-waste is collected by designated organisations, producers and/or by the government. WEEE may be reused, which refers to the provision of functioning WEEE to another consumer for its intended purpose, without hardware repair or modification, or refurbished, where the e-waste is disassembled for the purpose of internal testing or troubleshooting or replacement /repair of non-functioning parts. The final destination of the e-waste is state-of-the-art treatment facilities, which aim to recover the valuable materials as well as minimise the quantity of hazardous material that is released into the environment. Such facilities may comprise pre-processing such as manual dismantling and mechanical separation, and removal of toxic components and materials, and end-processing such as recovery of precious and base metals, plastics and batteries recycling, and disposal of non-recyclable residues. The materials extracted from the process of recycling are then used by both EEE and non-EEE industries. The United Nations Environment Programme (UNEP) introduced the green National Electronic Action Plan (NEAP) in 2005 to address the entire lifecycle of electronics, reuse, recycling and disposal of equipment, but it focuses mainly on computers, televisions and cell phones. In addition, several states in the US such as California, Massachusetts, Maine and Minnesota have taken initiatives to impose strict and effective regulations on the design, manufacture, reuse, recovery and disposal of e-waste. California has

promulgated the Electronic Waste Recycling Act of 2003, which is considered landmark legislation for e-waste regulation and management. E-waste in California can neither be disposed of in a landfill nor be exported overseas.

Another common scenario is where e-waste is disposed of similarly to household waste, through waste collection that may lead to incineration or landfills. A third scenario might appear due to the presence of existing informal systems. In developed countries, e-waste may be collected by individual waste dealers or companies and be traded. In developing countries, the e-waste may be collected by micro-enterprises that collect WEEE from households and sell it to refurbishers and recyclers. The informal sector in e-waste management may be a large, well-connected network that provides employment to unskilled workers from impoverished backgrounds.

Issues in e-waste Management Systems

While e-waste management processes that consist of sustainable collection, segregation and treatment facilities ensure safety of public health and environment, dominant Indian practices of mixed-waste management and/or informal

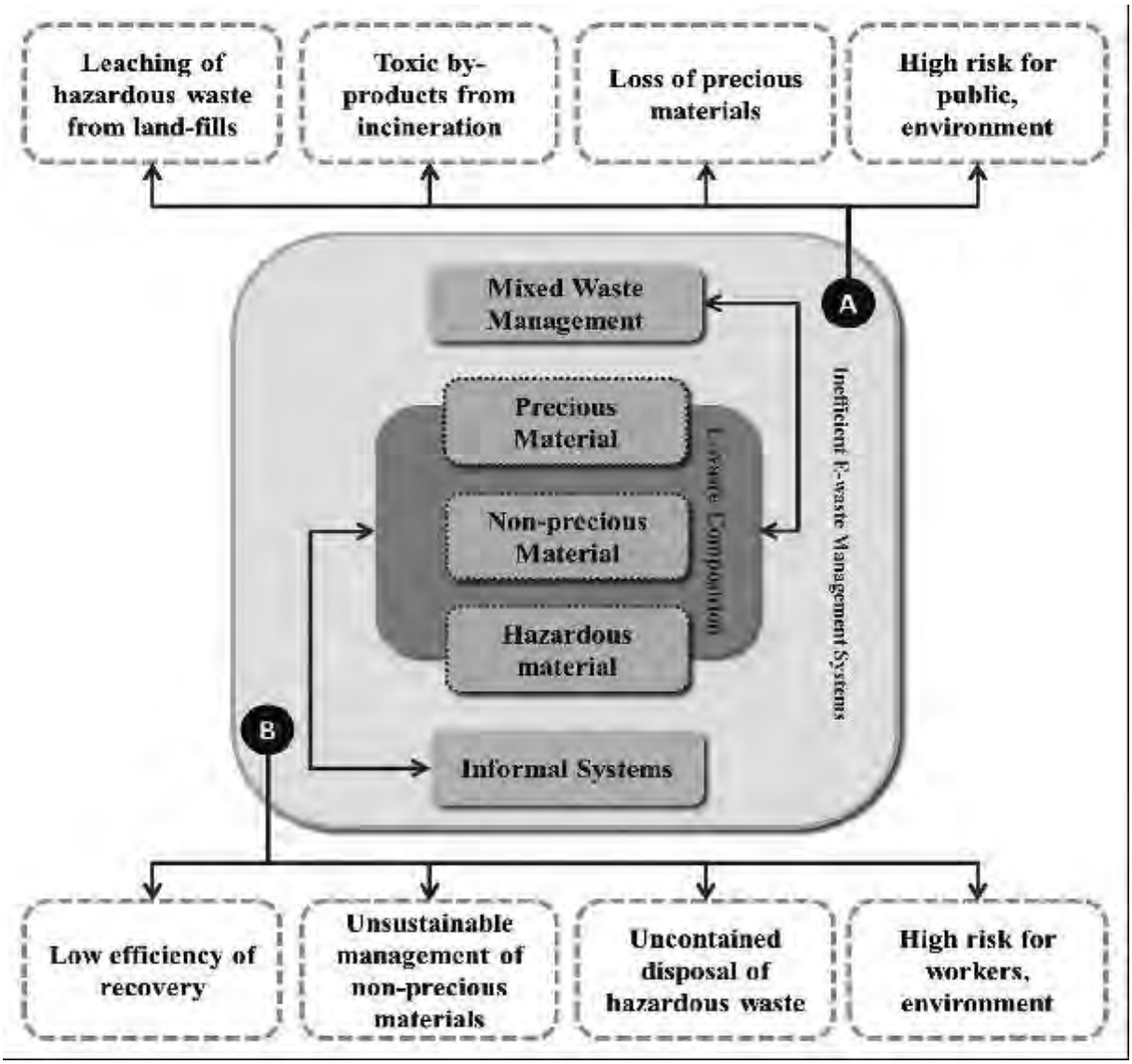

Figure 2: e-waste, its composition and its relation to inefficient management systems

systems pose undesirable impacts, which have been summarised in Figure 2.

Mixed-waste Management

Treating WEEE akin to municipal solid waste overlooks the composition of e-waste. In such a scenario, the likelihood of separation of the constituent materials is quite low. The mixed waste is either landfilled or incinerated, depending on the local waste management practices. Neither option is, however, desirable. E-waste accounts for about 40% of Pb and 70% of heavy metals in landfills. Landfilling of e-waste increases the possibility of leaching of toxic materials such as PCBs, Hg, Pb, BFRs and Cd into the soil, eventually contaminating the groundwater (Paindit, 2016). A human risk assessment done in an e-waste area in South China showed high carcinogenic risk for the exposed population due to the high concentration of Pb in the groundwater they used (Zheng et al., 2013). Incineration of WEEE may generate dioxins, furans, polycyclic aromatic hydrocarbons (PAHs), polyhalogenated aromatic hydrocarbons (PHAHs) and hydrogen chloride (Robinson, 2009). Even fairly inoffensive materials used in e-waste such as plastics (like Poly Vinyl Chloride) can produce dangerous by-products (toxic fumes like dioxins, chlorine gas, etc.) on burning. Well-designed incinerators need to be equipped with an efficient flue gas cleaning processes in order to destroy or recover the contaminants released through burning. Incineration in open air (open-air burning) can have serious, widespread consequences for both human health and the environment. Incineration can also cause certain heavy metals to become airborne and eventually fallout and deposit near the incineration facilities.

In the case of both landfills and incineration, large quantities of precious metals such as gold and silver are lost. UNEP in 2009 estimated that 1 tonne of cell phones contains about 340 g of gold, 3.5 kg of silver, 140 g of palladium and 130 kg of copper. India produces 65,000 tonnes of e-waste from mobile phones in a year , which corresponds to about 22 tonnes of gold, 227.5 tonnes of silver and 9100 tonnes of copper (Basu, 2013) – massive losses that increase the environmental burden by stressing the depleting natural resources. An estimated 70% of recoverable precious metals are lost every year in India (Basu, 2013).

Informal Sector for e-waste Management

In India, about 2.5% of the e-waste generated gets recycled through formal channels, whereas over 95% is managed by the informal sector (ASSOCHAM,2016). This sector consists of unauthorised collectors who obtain WEEE from households and institutions, segregators who then dismantle the collected scrap and recyclers who use the dismantled scrap to recover precious metals. These operators form an extensive network that is far more familiar to the public than many of the existing formal recyclers. WEEE may often be repaired (or refurbished) and sold, thus extending the products' lifetime and decreasing a small fraction of the e-waste dumped every year There are, however, many issues that exist in the informal sector. First, most of the workers in this sector are illiterate migrants who are forced to work long hours in appalling conditions for the minimum wage, many of them beginning work as minors (about 4-5 lakh children work in this sector in India) (Chaturvedi et al., 2010; Paindit, 2016). Secondly, due to their lack of knowledge, such workers are unaware of the impact their profession may have on their health and the environment. They often dismantle the WEEE manually, getting exposed to the hazardous constituents, often without any safety gear. The methods for metal recovery and WEEE recycling are primitive and hazardous, including open-air burning, acid leaching, unprotected melting of plastics and dumping of undesirable parts on land and in water. About two-thirds of the e-waste handlers in India have been observed to suffer from respiratory ailments (Paindit, 2016). Exposure to WEEE may also cause headache, irritability, nausea, vomiting and eye pain, and the workers may suffer from liver, kidney and neurological disorders due to their proximity and long-term exposure to such toxic materials (ASSOCHAM,2016). The problems in the sector are intrinsically connected to the complex nature of e-waste itself. Often, the techniques applied to handle such waste are primitive in nature and cannot successfully contain the problems that WEEE poses. Such ineffectual and dangerous methods however are practiced recklessly in India and other developing countries. In order to properly combat this issue, there needs to be a multi-tiered approach to the problem, which not only stresses on the need for appropriate

technology and service delivery methods, but also on strategic and behavioural changes and adoption of best practices by different stakeholders such as manufacturers, users, the formal and informal sector workers, etc.

E-Waste (Management) Rules, 2016

The E-Waste Handling Rules introduced in 2016 are an upgrade on the E-waste (Management & Handling) Rules, 2011 and Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008. And covers entities not authorised under the previous rules. The 2016 rules lay down the responsibilities for all the stakeholders involved such as manufacturers or producers, dealers, consumers and bulk consumers, government organisation (State Government), recyclers, dismantlers, refurbishers, etc. All the stakeholders involved in handling e-waste need to be authorised by the Central Pollution Control Board (CPCB), who have introduced guidelines for various activities such as setting up storage space, collection points, refurbishing areas, recycling units etc. which must be abided by to gain authorisation. Every step in the e-waste management process, such as collection, recycling and refurbishing needs to be documented by the corresponding stakeholder and

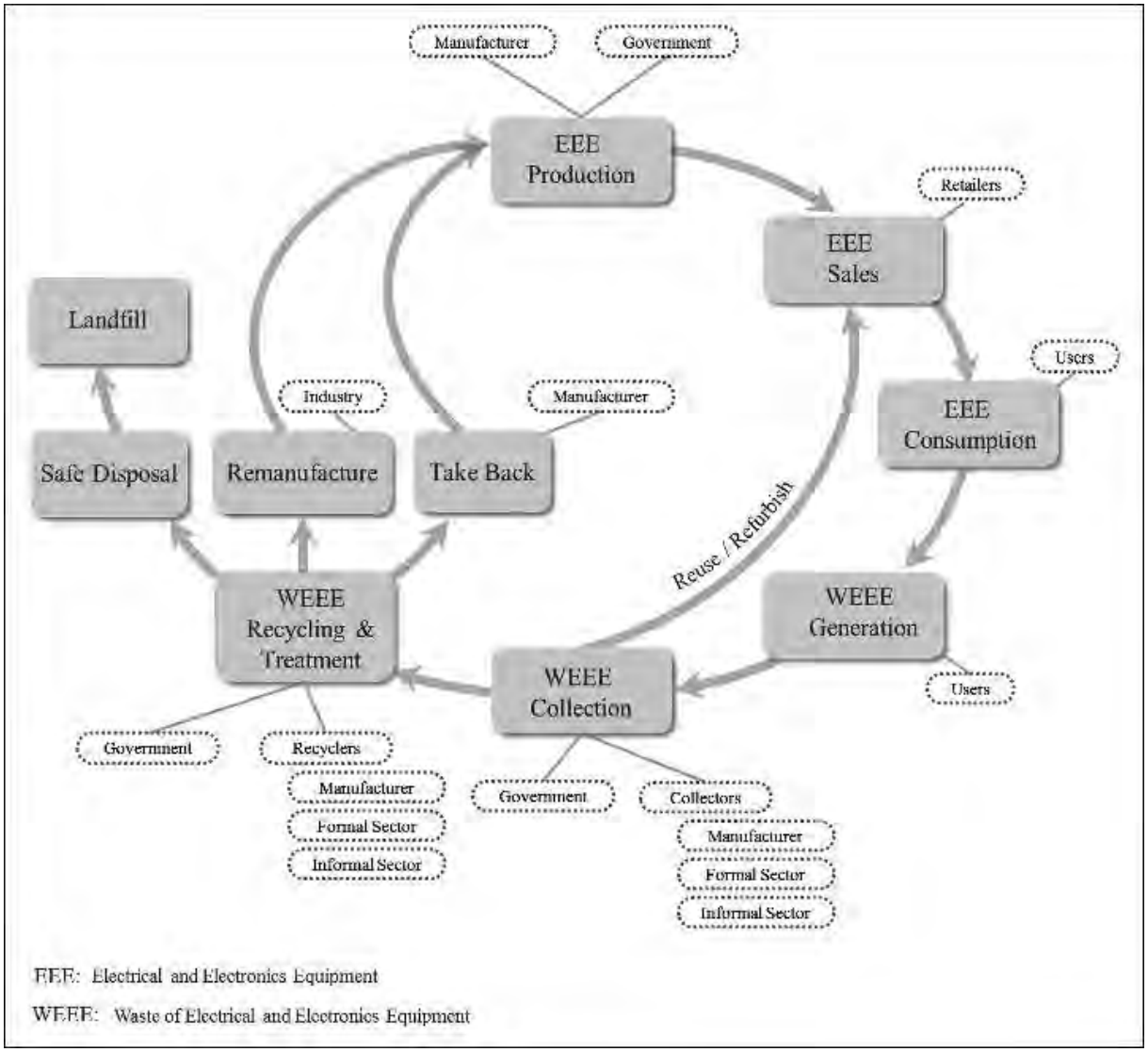

Figure 3: Recommended EEE-WEEE cycle

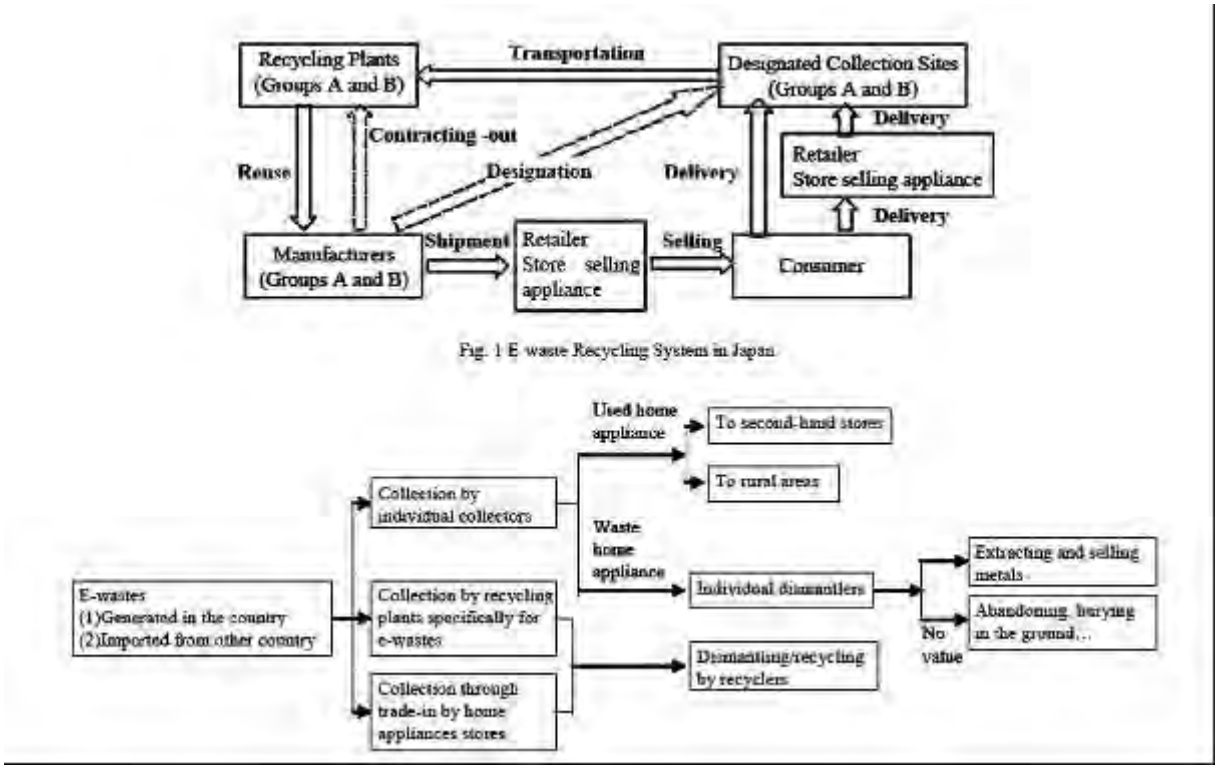

Figure 4: (Top) e-waste management process in Japan. (Bottom) e-waste management process in China

this information should be sent to the respective state pollution control board. The E-Waste Handling Rules also emphasise on the deposit return scheme, which refers to producers charging an additional amount at the time of sale to consumers, which is refunded at the return of the product at its end-of-life. The rules also define a permissible limit for hazardous substances such as Pb, Hg, Cd, Cr (VI), polybrominated biphenyls and polybrominated diphenyl ethers used in EEE manufacture (Ministry of Environment, Forest and Climate Change, 2016).

Recommendations

Identification of the process that would take into account the multi-pronged approach to e-waste management is paramount to establishing mechanisms for collection, sorting, reuse, refurbishing, repairing, remanufacturing, etc. Building on various e-waste studies, the paper recommends a process flow for EEE products that includes mapping of stakeholders at each stage of the process flow.

EEE and WEEE are the two major forms of the same product along a process, with the major difference being the change in usability or interest. It is thus important to address the process in order to have a sustainable roadmap towards e-waste management. To ensure high efficiency in resource utilisation and waste management, it is important to close the loop in a way that WEEE gets utilised in the development of electronics or other products. The process given in defines such a loop, which has been mapped with the various stakeholders involved at every stage of the process.

Government

For an efficient e-waste management process, it is important that an enabling ecosystem is created by the government, which champions a closed loop e-waste management process so that most of the WEEE generated is absorbed within the product/material cycle.

One of the primary steps taken by the government is defining the binding regulatory and policy framework that address the complete value chain (Section 4). E-waste travels through different

stakeholders via multiple channels to reach its final destination. There is often a part-to-whole approach to WEEE management, which may result in overlooking the bigger picture. It is therefore important to formally define all the channels that WEEE moves through and make regulations for each of these channels. The E-Waste (Management) Rules, 2016 overlooks the informal sector which is heavily involved in e-waste management. The rules mandate an authorisation process but there is no mandate or clause to define how the informal sector can be regularised. It should be recalled that most informal enterprises are unlikely to meet the guidelines prescribed and thus automatically get excluded from the legal system of e-waste handling process. The informal sector is also unlikely to have the knowledge of the authorisation process. Omission of this sector from the e-waste management system is not the solution; rather, the implementing agency should develop a mechanism for formalising or regularising the informal sector as well as encourage them to get authorised. Countries such as China and Japan have developed specific e-waste management processes designed to cater to the local situation, as shown in Figure 4.

All stakeholders at every stage of the management process need to be actively committed to ensuring that e-waste is minimised and managed safely and productively. While the E-Waste (Management) Rules, 2016 sets clear responsibilities and processes at the end-of-life stage, policies and mandates should be introduced at earlier stages such as encouraging segregation at household/institutional/establishment level and interventions that support businesses and manufacturers to reduce wastes through saving materials used in products, extending product lifetime, collection and reuse of products as well as reusing components of products collected etc. The government also needs to focus on mechanisms to encourage more investment on research and development on affordable technologies for extraction of resources that will be vital for the resource recovery process Lastly, consumer awareness, capacity building for stakeholders at the different stages of the process is key to implementation of the process.

Manufacturers

The manufacturers or producers of EEE are one of main stakeholders, as they are not only the original source of WEEE but can also be crucial to closing the e-waste management loop. The E-Waste (Management) Rules in 2016 emphasise on the 'Extended Producers Responsibility' (EPR), which essentially extends the manufacturers responsibility from the production stage to the whole life cycle of the product, including the post-use or recycle and disposal stage . To fulfil their responsibilities, the manufacturers can adopt solutions that will influence the production stage. For example, to enhance the life span and efficiency of the EEE products, thereby reducing the number of products rendered obsolete each year, more research and development in the production side can be encouraged. Research can also be encouraged to increase the time period between the releases of different variant of the EEE products. This would lead to reducing the number of products that are discarded or consumers shift to a better version before their useful life because of reduced performance associated with lack of software maintenance and upgrades . Further, the manufactures should abide by mandates suggested by the E-Waste (Management) Rules, 2016 for limiting the use of hazardous materials to the permissible limit in the production . Other solutions that can be employed at production stage will include the use of label materials that will assist in recycling (for example a ladled plastic used in the EEE product will give information to the recycler about the type of plastic, hence where it can be used) . Sharing of knowledge about clean technologies can also be encouraged among the manufactures to improve the e-waste management process.

As part of the EPR, the manufacturers collect the e-waste of their own EEE products for recycling or reusing in the manufacturing process. This process is called the take-back system. At this stage, the manufactures could be the part of workshops or capacity building programs regarding e-waste to disseminate knowledge or information about the different take-back systems employed by them. To increase the efficiency of different take-back systems, the manufactures could work in integration with other collectors and recyclers in

the e-waste management process. The manufactures can tie-up with other recyclers (formal or informal) or employ as third parties to undertake the e-waste recycling. This would lead to enhanced coverage in the recycling industry. In some countries like South Korea, the "polluters pay" or "deposit" concept is used. In some cases there is a lack of economic incentive for the manufactures to recycle the product and the deposit rate is far lower than the actual cost of recycling, thus they choose to pay the deposit . Thus it is important to look at different incentive mechanisms that will encourage the manufactures to recycle as well look at ways to reduce recycling cost. For example the manufactures can handhold with existing recycling plants to reduce the cost of recycling.

Retailers

The main stakeholders who influence the EEE sales are the retailers. A 'retailer' means a person who sells EEE through any means, including, but not limited to, retail sales outlets, telephone or the internet, mail, catalogues or any electronic means . The retailers play an arbitrary and infrequent role in e-waste collection, which makes it very important to clearly understand their responsibilities in managing e-waste. The role of the retailers (or "dealers") as per the E-Waste (Management) Rules, 2016 is defined by the responsibilities given to retailers by producers. The can act as collection point on behalf of producers. Another major step that can be taken is to define responsibilities for retailers on capacity or awareness building or knowledge dissemination about the e-waste and e-waste management systems. The workshops of sessions can be organised and moderated by the retail regulating agency or retail associations. Retailers should be encouraged to feature certified products that use recycled material and contain less toxic material.

Users or Consumers of EEE products

The main stakeholders who influence the consumption of EEE and generation of WEEE are the users or consumers. Some of the major users of EEE include individual households, businesses and corporate offices, public and private sector establishments, educational institutions and IT industry. The major problem that is faced here is that many of the institutions and households are unaware of appropriate e-waste disposal methods and dispose their e-waste with other solid waste . Thus engaging users in the e-waste process cycle could possibly promote awareness and help to prevent the generation of large quantities of e-waste, in line with the E-Waste Handling Rules. At the same time, awareness programmes will be important to induce behavioural changes for both users and manufactures that will positively influence the e-waste management process. The users can be conscious while buying the EEE products to opt for those that: contain fewer toxic constituents; use recycled content and are energy efficient; are designed for easy upgrading or disassembly: offer leasing or take back options and have been certified by appropriate regulatory authorities. The users can prefer to repair or upgrade the product than buying a new product. The user may also opt for refurbished equipment if the purpose is served. Further the users can also take up socials causes by donating used electronic equipment to social programmes. For example, users can donate used laptops/desktops to bridge schools or schools for underprivileged students. Some of the users such as large businesses corporate companies, public or private establishments can act as major collections points (provision of e-bins) and facilitate the take-back systems by the manufactures and other recyclers. Thus it is important the users have a pragmatic approach to towards EEE products at all levels (from individuals to the household/company level).

Conclusion

With growing urbanisation, GDP per capita and the silicon revolution, it is anticipated that the increase in the amount of WEEE generation will continue. WEEE contains valuable resources that can be recovered and reused within the same industry or has a demand for in other industries. As demand for raw materials increases, and supply especially metals, precious metals and rare earth metals are limited, it becomes imperative for countries like India, to adopt an e-waste resource recovery system, apart from the environmental concerns of dumping e-waste. The current e-waste recycling system is a far cry from a closed loop system. The paper defines the multi-pronged

approach that includes the total value chain, addressing all stakeholders. It recommends an enabling framework (policy, regulatory, legal, enforcement and monitoring), along with investment in research and development in technologies for efficient extraction of resources, and producer, retailer and consumer responsibilities that need to work in tandem to achieve the desirable closed-loop system.

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Few Emerging Treatment Technologies to Complement Zero Liquid Discharge

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Abstract

Wastewater stream with specific pollutants resistant to the conventional methods of wastewater treatment not only disturbs the biological operation of the conventional ETP but also significantly hampers the reuse utility of treated wastewater and indirectly poses challenge to achieve ZLD Zero Liquid Discharge (ZLD). Recently regulatory regime of India moved towards standard with a goal to reduce pollutant volume and its spread in aquatic and land ecosystem. Many industrial sectors are not able to achieve this discharge norm. To improve the reusability of treated wastewater and achieve ZLD, a range of advanced wastewater treatment system either in isolation or in hybrid mode are required to be incorporated in the ETP to increase the recovery of usable water and nutrients which is one of the compelling force to achieve ZLD. The present article highlights some of the emerging wastewater technologies which can tackle specific wastewater streams having critical contaminants and in turn relieve challenges against recycle and reuse potential to achieve ZLD in cost-effective manner.

Key words: *Zero liquid discharge, Effluent, Wastewater treatment, Wastewater reuse*

Introduction

Pollution of water resources emerged as big threat throughout the world. India is already heading towards water scarce situation. Sustaining India's Water Resources report 2013 by the Carbon Disclosure Project has reiterated the fact that 16 percent of world population lives in India with 4 percent of world's water. Thus in absence of regulatory water benchmarking, the nation need to protect the water availability with equal consideration for quality aspect. India's reported water footprint as 980m^3 per capita in several literatures is much lower than the global average of 1,243m^3 cubic meters per capita. India's 1.2 billion people collectively contribute to a significant 12 per cent of the world's total water footprint. The main reason behind this lower rate of water footprint is unevenness of economy and resources.

Technological advancement in the field of environmental protection and control of pollution is principally driven by economics, regulation and availability of specific resource(s). In some cases combination of these factors also play important role. Advancement in the field of wastewater treatment is one such example where scarcity of water is a major driving force besides regulatory enforcement to address the increasing concern of quality of natural resources.

Industries with high water pollution potential

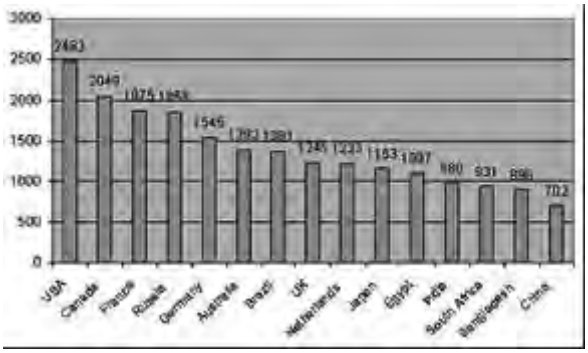

Figure 1: Per capita water footprint of different countries

discharge effluent containing high organics measured in-terms of Bio-chemical Oxygen Demand (BOD) and other toxic constituents like metals and inorganics. Standard permissible limits for compliance with respect to various parameters have been notified in India under the Environment (Protection) Act, 1986 and also amended in due course of time. These notified standards allow

industries to discharge effluents only after achieving the stated norms. Considering the fact that many industrial sectors are not able to achieve standards consistently all the time, need felt by regulatory regime to work towards Zero Liquid / effluent discharge standard. Regulatory bodies in India like Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs)/ Pollution Control Committees (PCCs) are now insisting industries to reduce water consumption and also to take measures to not-to-discharge effluents termed as ZLD condition. In the recent development during the year 2015, CPCB has prepared 'Guidelines on Techno-Economic Feasibility of Implementation of Zero Liquid Discharge (ZLD) for Water Polluting Industries' and requested stakeholders for consolidated suggestions/modifications for the same. Nine industrial sectors are covered in this guideline. The industrial sectors covered are Distillery, Tannery, Pulp & Paper, Sugar, Pharmaceuticals, Textiles, Refineries (Petroleum Oil), Fertilizers and Dye & Dye Intermediates. In five out of nine listed sectors, ZLD is considered as achievable and for rest of the four sectors, water conservation, reuse and partial ZLD is suggested. The initiative is going to reinforce the concept & application of ZLD to a great extent. The new industrial units in textile, dyes, distillery, tannery, fertilizer, pharmaceuticals and chemicals are now insisted to maintain ZLD from commissioning stage itself. The existing units in these sectors are asked to achieve ZLD in phased manner. These exercises with similar guidelines may cover all the 17 category of identified highly polluting industries in long run. Thus initiative and practical approaches towards wastewater reuse, recycle & reduction to achieve ZLD will be of prime importance in near future.

The Concept of Zero Liquid Discharge (ZLD)

ZLD is simply a situation when there is no effluent/liquid discharge from a process house or industrial installation. The intrinsic concept refers utilization of technology for installation of facilities/system to enable industrial effluent for absolute recycling of permeate and converting solute (dissolved organic and in-organic compounds/salts) into residue in the solid form by adopting method of concentration like thermal evaporation. ZLD is generally recognized based on two broad parameters i.e. water consumption versus wastewater re-used or recycled (permeate) and corresponding solids recovered (percent total dissolved /suspended solids in effluents). The fundamental of ZLD does not allow forceful injection into groundwater table or spreading of effluent on open land to achieve zero liquid discharge from the premises. Implementation of ZLD is possible and can be achieved in many industrial sectors by various means and methods. In many cases, Hon'ble Courts/Tribunals are also seeking opinion from regulators about the feasibility and possibilities of its total implementation. ZLD has been technically practiced/demonstrated successfully in many parts of the country and in many sectors, though the economic aspects are still in question. CPCB in its above referred guideline quoted that a CETP treating 1.0 MLD of waste water with conventional physico-chemical and biological treatment would require about Rs. 3.0 to 4.0 Crore as capital cost with operation and maintenance cost of Rs. 300-350 per cubic meter m^3, whereas, cost of combination of conventional ETP with ZLD facilities costs around Rs. 12.0 to 15.0 Crores per MLD. Besides economics, India need to rejuvenate the aquatic ecosystems which includes more than 300 polluted river stretches in the country. Growing pollution of water sources, especially through industrial effluents, is affecting the availability of safe water besides causing environmental and health hazards. In many parts of the country, large stretches of rivers are both heavily polluted and devoid of flows to support aquatic ecology, cultural needs and aesthetics. This situation signifies that ZLD is necessity and not a mere imposition.

Specific Wastewater Treatability Issue in Typical Effluent

The concept of Effluent Treatment Plant (ETP) in industrial units started with one common treatment facility in the premises with conventional method of treatment for all wastewater stream generated in the industry from various plant processes having different characteristics. Sometimes, predominant quantity of wastewater generated has potential to be reused after adequate treatment in the conventional treatment plant with primary,

secondary (biological treatment for organic load) and if required, tertiary treatment. But, a small wastewater stream with specific pollutant parameter, which cannot be treated by the conventional methods of treatment, not only disturbs the biological operation of the ETP, but also significantly hampers the potential of reuse of entire volume of treated wastewater and indirectly poses big challenge to improve reusability proportion and in turn ZLD status. Wastewater streams having high Ammonical Nitrogen, high phosphorous, high solids, high refractory Chemical Oxygen Demand etc. are required to be identified and subjected to advance treatment so that significant quantity of other streams can be reused and in turn efforts & resources required to be deployed for ZLD may be reduced to great extent. This may also prevent ZLD achievement from becoming an economic constraints or energy guzzler. The Multi Effect Evaporator (MEE) is one of the energy intensive technique which destruct the high COD wastewater, however the permeate reusability remains an issue. Summarily, advance methods of treatment for specific parameters also play important role in ZLD as it cannot be solely limited to usage of Reverse Osmosis, Multiple Effect Evaporator, Dryers & Thermal Destruction Systems. To achieve ZLD, a range of advanced wastewater treatment system either in isolation or in hybrid mode need to be incorporated to increase the recovery of usable water and nutrients for the further reintroduction. A set of options is suggested in the guideline of CPCB and is available in public domain. The present article aim to highlight some of the options which can supplement to tackle specific wastewater streams and in turn relieve challenges against recycle and reuse potential to achieve ZLD.

Advanced Water Treatment Options

The complexity of wastewater matrix is result of technological advancements for waste minimization and optimization of water use. The general driving force for wastewater recycling is resultant combination of National Water Policy, National Water Mission, non-availability of suitable quantity & quality of water for specific application, cost reduction & resource conservation, environmental considerations, statutory requirements and process operational requirements also. With the aim to satisfy the above driving factors and recent regulatory initiatives for ZLD, advance wastewater management systems is required to be adopted to address the treatment of specific wastewater streams having potential hindrance to achieve ZLD. Conceptual approach could involve either targeted degradation of the complex constituents in wastewater to make the wastewater treatable with conventional primary and/or secondary system for further reuse or the primary & secondary treated water should be further purified to make the water usable. Standalone technologies may not give consistently good result at times. Therefore, cavitation, photo-catalytic oxidation, Fenton's chemistry (belonging to the class of advanced oxidation processes), ozonation, use of hydrogen peroxide (belonging to the class of chemical oxidation technologies) are suggested to be used in combination. Ultrasound in combination with ozone/hydrogen peroxide, Photo-catalytic oxidation in combination with ozone/hydrogen peroxide, Sono-photo-catalytic oxidation or Photo-Fenton oxidation are some of the known hybrid technologies. An overview of emerging technologies could be a guiding tool in scoping to increase re-usability of treated wastewater by addressing specific contaminants posing challenges to achieve ZLD.

Organic Load Removal Techniques

Cavitation and its hybrid

Cavitation is defined as the phenomena of the formation, growth and subsequent collapse of micro bubbles or cavities occurring in extremely small interval of time (milliseconds), releasing large magnitudes of energy. Cavitation is classified into four types based on the mode of generation viz. Acoustic, Hydrodynamic, Optic and Particle. But only acoustic and hydrodynamic cavitation has been reported as efficient in bringing about the desired chemical changes. While going through several articles of case studies, it can be said that the cavitation offers a potential alternative for the degradation of chemicals in the wastewater treatment scheme where majority of the conventional techniques fails. However, majority of the studies available in this area are on a small scale and therefore, success at different scale may have uncertainty. It may

always be useful to use cavitation in combination with other oxidation processes like photo-oxidation or by using catalysts and/or additives. With this intensification, cavitation can be a suitable technology for degradation of wastewater streams and lowering the toxicity levels of the effluent stream for further conventional biological oxidation.

Photo-catalytic oxidation and its hybrid

The photo-activated chemical reactions are characterized by a free radical mechanism initiated by the interaction of photons of a proper energy level with the molecules of chemical species present in the solution, with or without the presence of the catalyst. The radicals can be easily produced using UV radiation by the homogenous photochemical degradation of oxidizing compounds like hydrogen peroxide and ozone. An alternative way to obtain free radicals is the photocatalytic mechanism occurring at the surface of semiconductors (like titanium dioxide) and this indeed substantially enhances the rate of generation of free radicals and hence accelerates rate of degradation. A major advantage of the photocatalytic oxidation based processes is the possibility to effectively use sunlight or near UV light. Still, for the treatment of complex mixture of effluents with the presence of potential radical scavengers, it appears that large-scale operation with high degree of energy efficiency is not strongly feasible in terms of economy due to associated issues. A major problem in the successful application of photocatalytic oxidation is the non-uniform irradiation of the catalyst and this result in a substantial loss of the incident energy and hence the overall economics may not be favorable in certain cases.

Fenton chemistry and its hybrid

The oxidation system based on the Fenton's reagent (hydrogen peroxide in the presence of a ferrous salt) has been used for the treatment of both organic and inorganic substances in effluents from different sectors like chemical, pharmaceuticals, refineries, fuel terminals, engine & metal cleaning etc. The process is based on the formation of reactive oxidizing species, able to efficiently degrade the pollutants of the wastewater. Literature reports three main reactive radical species. Two of them involve the presence of hydroxyl radicals (classical Fenton's chemistry) in either 'free' or 'caged'form whereas third oxidant has been postulated to be aquo or organo complexes of the high valence ferryl ion. The rate of this reaction is also strongly dependent on the presence of radical scavengers such as t-butanol or Clyions, but in some cases substantial decrease has not been observed even at high concentrations of these species and hence additional strong oxidants are used. Both hydroxyl as well as ferryl complexes coexist in Fenton's mechanism and depending on the operating conditions (substrate nature, metal–peroxide ratio, scavenger's addition etc.), one of them will act as predominant. Nevertheless, the system can be suitably used to decolouration and/ or removal of odour ingredients in energy efficient manner. Simultaneously the oxidation system can be effectively used for the destruction of toxic wastes and non-biodegradable portion to make them amenable to secondary biological treatment.

The applicability of hybrids like photo–Fenton methods needs to be checked for different class of chemicals existing in wastewater matrix before adopting this hybrid mode of treatment. Another advantage of using photo–Fenton oxidation is the presence of additional oxidation species i.e. aquo or organo-complexes of the high valence iron which are relatively unaffected by the presence of scavengers.

Oxidation systems with direct attack of oxidants

Ozonation and addition of hydrogen peroxide belong to separate class of oxidation systems but their combination viz. ozone/hydrogen peroxide or presence of additional energy dissipation in terms of UV/near-UV/Sunlight or ultrasonic irradiation results in the generation of free hydroxyl radicals and these combination methods again belong to the class of advanced oxidation processes. The overall efficiency of the degradation process is significantly enhanced when a combination of UV radiation, ultrasound and hydrogen peroxide is used. Apparently, use of hydrogen peroxide alone is less feasible for the treatment of complex compounds as compared to the combination with other advanced alternative oxidation techniques.

Phosphorous Removal Techniques

Reactive media filtration

Continuous backwash filters and multistage adsorption clarifier filter system are known phosphate removal techniques. An advanced filtration system type modular reactive filtration system is one of the techniques to remove phosphorus from wastewater. It is basically combination of co-precipitation and adsorption to a reactive filter media in an upflow sand filter. In this technique, a reactive hydrous ferric oxide-coated sand media is created by using an iron coagulant on the filter media and it accomplishes phosphorus removal by adsorption and filtration. This process does not require the media to be changed because it includes a continuous regeneration process. After adsorption, the iron and phosphorus are abraded from the sand grains. The iron and phosphorus passes out in a waste stream while the sand is retained in the system. The technique is suitable for small to medium plants (less than 4.5 MLD), because of relatively smaller area of filter units. For larger plant, it may not fit due sheer large number of filters required for treatment. The waste stream can be recycled to the head of the plant to accomplish chemically enhanced primary treatment. Concerns regarding this process include the fact that large recycle streams have to be sent to the biological process.

Precipitation with crystallization

Effective phosphorus recovery is implemented in the high phosphorus return stream of sludge liquor from dewatering or decanting rather than in the mainstream where the phosphorus concentration is much lower. Although phosphorus recovery could be used with sludge liquor from treatment plants using metal phosphate precipitation, the process is most practical when coupled with biological phosphorus removal, which transfers much of the mainstream phosphorus to the sludge but allows a larger portion of it to be released particularly during anaerobic digestion. The sludge liquor is returned to an upflow fluidized bed reactor along with a chemical added to generate a precipitate. A common additive is magnesium to generate a magnesium ammonium phosphate precipitate ($MgNH_4PO_4$) known as MAP or struvite. This precipitate occurs frequently in sludge handling systems even without supplemental magnesium. Controlled addition of magnesium and manipulation of upflow rate causes the precipitate to be efficiently formed and suspended in the flow until it grows to the desired size, at this point, it settles to the bottom of the reactor cone and is removed. The product may be marketed as a fertilizer. Up to 85% P recovery has been reported. This phosphorus recovery processes can be combined with phosphorus release upstream of thickening equipment and anaerobic digesters to decrease uncontrolled struvite formation. The approach involves combining primary sludge with waste activated sludge from a biological phosphorus removal process under anaerobic conditions to induce phosphorus release.

If this technique is compared with other practicing method like precipitation/adsorption with waste activated sludge i.e. biological method, both processes transfer phosphorus from the wastewater to the sludge. For an industrial effluent where sludge is generally disposed in secured landfill, the phosphorus could be inadvertently lost. Phosphorus recovery methods separate a large portion of the phosphorus from the sludge. One important benefit of phosphorus recovery technologies is that any metal ions in the sludge remain with the sludge and not co-precipitated with the phosphorus.

Ammonia Removal Technique

Biological De-ammonification

The technique involves removing ammonia in a two step process that requires initial partial nitritation to convert approximately 50 percent of the ammonia to nitrite. Anaerobic ammonia oxidation (Anammox) bacteria convert the nitrite and the remaining ammonia to nitrogen gas under anoxic conditions. The process requires only partial nitritation reduces the energy demand up to 63 percent compared to conventional nitrification and denitrification. The de-ammonification process is a completely autotrophic process and does not require any supplemental carbon. Mainstream de-ammonification and mainstream nitrite shunt are two emerging/research technologies to offer much promise.

Techniques for Removal of Solids

Compressed media filtration

This technique comprises of a synthetic fibre media bed that is passively compressed from the sides by the head of the incoming water. The lateral compression forms a cone-shaped porosity gradient that allows the stratification and removal of large and small particles from the top to the bottom of the media bed. This system may handle heavy solids loading. This filter can be used as tertiary filter to increase quality of treated water by increasing organic removal capacity.

Magnetite ballasting flocculation system

This technique uses conventional chemical coagulation and flocculation along with the addition of finely ground magnetite as a ballasting agent. The dense magnetite increases the weight and settling ability of chemical flocks, resulting in high-rate sedimentation. Approximately 85 percent of the settled sludge is recycled (similar to the solids contact process) to provide nucleation sites for flock development. Excess sludge is passed through a shear mill followed by a magnetic recovery drum to recover the magnetite before the nearly magnetite-free sludge is further processed. The recovered magnetite is returned to the process.

In comparison with other techniques it may be said that magnetite is denser than suspended solids and sand, and it generates heavy, dense flock that settles rapidly. This allows ordinary clarifiers to be loaded at higher than typical rates while maintaining high-quality effluent. The magnetite seed is recovered from sludge using a magnet instead of gravity, so recovery efficiency is high and magnetite make-up requirements are low. Even this process is useful in precipitating phosphorus as other processes employed to chemically precipitate phosphorus, precipitation performance is limited by kinetic and stoichiometric factors. However, the nucleation, solids contact and ballast provided by the technique resultantly allow phosphorus precipitates to be removed very effectively once they are formed.

Multistage filtration

Biomass solids generally comprise 8 to 10 percent nitrogen and 1 to 2% phosphorus by mass. Literature suggests that if enhanced biological phosphorus removal is performed, the phosphorus content of the biomass can be increased to 6 to 8 %. If chemical phosphorus removal is done, the metal phosphate precipitate (some of it colloidal) will have a substantial total phosphorus component. Therefore, although the discharge norm allow higher total suspended solids (100 mg/l), significantly lower total suspended solids could be achieved by multistage filtration. Implementing filtration in series with a first stage filter or first-stage clarifier and chemical addition between stages allows the finer colloidal particles that escape the first solids separation stage to be targeted. One of such technique uses a tube clarifier first stage followed by an adsorption clarifier and mixed media or up flow moving-bed filter at final stage. Multistage filtration provides effluent solids quality better than single-stage sedimentation or filtration and quite close to that provided by microfiltration membrane systems.

Nanofiltration (NF) and Reverse Osmosis (RO)

Tertiary membrane filtration for advanced treatment of secondary effluent can be accomplished using NF or RO. RO operates by high-pressure diffusion of solutes through the membrane. NF uses both diffusion and sieving action. NF removes many of the same organic compounds that would be targeted with RO but allows more of the inorganic material to remain. Both processes are used for removing organic pollutants, recalcitrant organics, bacteria, and viruses. Recently, NF and RO have been considered as technology to achieve low levels of total nitrogen but experience suggests that even RO does not consistently achieve total nitrogen levels less than 1.0 mg/L. Both are useful for removing pesticides, pharmaceuticals, hormones, and other micro-constituents and hence improve recovered water usability. Typically, microfiltration be treated through NF or RO. NF is operated at lower pressures, so it uses less energy than RO. Both require membrane replacements.

MF and UF are used for membrane bioreactors where the membrane is in direct contact with the high solids mixed liquor. These membranes provide excellent removal of particulate and colloidal material but cannot remove dissolved

constituents as can NF and RO. NF and RO remove total suspended solids, total dissolved solids, and other pathogens better than the UF. The main disadvantages of NF and RO techniques are fouling of membrane, high energy consumption and treatment of concentrated brine generated from the treatment units.

The ActifloTechnique

This is a high-rate chemical and physical clarification technique that involves formation of suspended solids onto a ballast particle (micro sand) followed by lamella settling. The process starts with the addition of a coagulant to destabilize suspended solids. The flow enters the coagulation tank for flash mixing to allow the coagulant to take effect then overflows into the injection tank where micro sand is added. The micro sand serves as a "seed" for flock formation, providing a large surface area for suspended solids to bond with. It allows solids to settle out more quickly, thereby requiring a smaller footprint than conventional clarification. Polymers may either be added in the injection tank or at the next step of maturation tank. Mixing is slower in the maturation tank, allowing the polymer to help bond the micro sand to the destabilized suspended solids. Finally, the settling tank effectively removes the flock with help from plate settlers. Clarified water exits the process by overflowing weirs above the plate settlers. The sand and sludge mixture is collected at the bottom of the settling tank with a conventional scraper system and pumped to a hydro cyclone, located above the injection tank. The hydro cyclone converts the pumping energy into centrifugal forces to separate the higher density sand from the lower density sludge. The sludge is discharged out of the top of the hydro cyclone while the sand is recycled back into the process for further use.

Another such technique uses a rapid mix tank for flash mixing to allow the coagulant to take effect then overflows into the reactor tank where sludge and polymer are added. A draft tube and mixer in the reactor allow for thorough mixing of the wastewater with the recirculated sludge and added chemicals. Here sludge instead of micro sand serves as a "seed" for floc formation providing a large surface area for suspended solids to bond with. Wastewater is allowed to flow over a weir from the reactor tank through a transition zone before entering the clarifier. Sludge is collected at the bottom of the clarifier with a conventional scraper system and recirculated back to the reactor tank.

This is similar to conventional treatment technology as both processes use coagulant for the destabilization and flocculent aid (polymer) for the aggregation of suspended materials. These materials are then subsequently removed by settling for disposal. The primary technical advancement made is the addition of micro sand as a seed and ballast for the formation of high-density flocs that have a relatively high-density micro sand nucleus and are easily removed by settling.

Techniques of Disinfection

Microwave Ultraviolet (UV) Disinfection

UV disinfection is established technique where UV transfers electromagnetic energy in the ranges of 100 to 400 nm from a mercury arc lamp to wastewater which works as a bactericide. Typical mercury vapour UV lamps contain electrodes that facilitate the generation of UV radiation by striking an electric arc. The deterioration of this electrode is main reason of failure in UV disinfection systems. Microwave UV disinfection technique eliminates the need for electrodes by using microwave-powered, electrodeless, mercury UV lamps. In this technique, microwave energy is generated by magnetrons and directed through wave guides into quartz lamp sleeves containing argon gas. The directed microwave energy excites the argon atoms, which in turn excite the mercury atoms to produce radiation, as is the case with other mercury UV lamps. Electrodeless lamps operate at low pressure, which reduces safety risks and increases lamp life. Microwave UV lamps allow greater flexibility for variations in parameters such as lamp diameter, operating pressures, and fill materials because of the absence of electrodes. This allows for greater optimization of radiation at specific wavelength regions.

In comparison with other disinfection systems, microwave UV disinfection systems use low-pressure, high-output electrodeless lamps and warm up quickly having the capability of disinfection within about 12 seconds compared to start-up times of 20 seconds to 3 minutes for

electrode lamps. The lamp has a very low residual radiation of energy, thus almost instant shutoff capability, which prevents overheating of heat-sensitive materials near the lamps.

Use of alternate chemical disinfectant

Pera-acetic Acid (PAA) is a stronger oxidant than hypochlorite or chlorine dioxide but not as strong as ozone. PAA does not affect effluent toxicity, so need not be removed as in the case of chlorine. Proxitane WW-12 is one such similar chemical. However, this is an explosive at high concentrations, but the disinfection system requires only 15% or less concentration. Compared to disinfection with chlorine compounds, PAA does not form harmful by-products after reacting with wastewater when using dosages typical for secondary effluent.

Gamma Radiation

The technique is tried and tested on disinfection of sludge generated from sewage. The method is based on utilization of Gamma rays emitted from the radioactive pencil(Co60) for the purpose of disinfection. The method need high capital cost with low operational cost and controlled operation with skill, if at all to be used for disinfection of treated wastewater. This technique can also be applied for sludge slurry having bacterial/ viral contamination.

Conclusion

The ZLD condition is emerging as a need in India due to non-compliance with regulatory standard and regulatory enforcements. The non-compliances are also attributed due to lack of thorough understanding of effluent characteristics and conventional mind set. Selection of suitable standalone wastewater treatment technology or its hybrid to deal with well characterized targeted wastewater stream is of prime importance to achieve ZLD, particularly when the critical contaminants present are not amenable to conventional biological treatment. The place of reuse is equally important and accordingly disinfection technique should be selected. The economics and targeted complex mixture to be treated are needed to be fully understood before selecting desired technique so that ZLD solution should not become costly energy guzzler.

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Innovative Technologies for Water and Wastewater Management

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Introduction

One challenge that is coming up when integrating or improving waste water treatment in the fast growing urban areas around the world, is that the land available, either is lacking, comes with a high price tag or has bad soil conditions. It can also be that there will be touristic, residential or office area's in the direct vicinity of the treatment plant that will demand a no nuisance solution (No hear,No See, No smell) so that the plant has to be partly or completely covered.Facing this challenge the Technology Portfolio of the WABAG groups offers a wide range of possibilities enabling us to offer the optimum solution in function of the given space and the effluent quality needed.

Figure 1: 16.000.000 people, city of Istanbul, as an example needs to more than triple the capacity of their biological waste water treatment and were to put them?

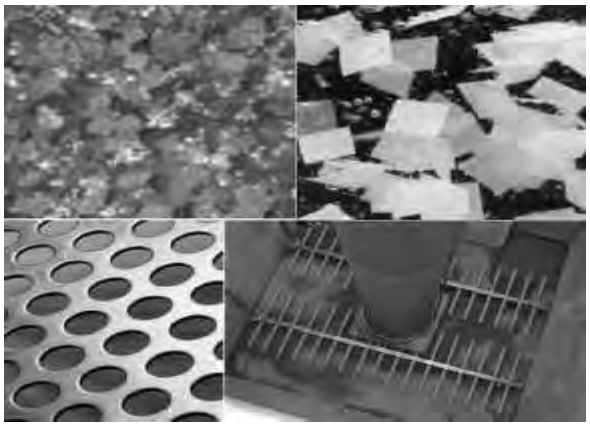

Figure 2: Fluopur Carriers with and without Biomass. Size of the carrier 1x 1x0.2 cm, The Carriers are retained in the reactor by a sieve.

Figure 3: Nitrification basin with sieves installed ready to receive the FLUOPUR carriers.

Floupur

The FLOUPUR is WABAG's MBBR Technology. MBBR stands for Moving Bed Bio-Reactor. In this type of reactor the Biomass used for removal of the pollution in the wastewater is fixed onto the surface of millions of small carriers moving around in the water to be cleaned.

This allows a much higher concentration of biomass in the reactor compared to conventional activated sludge technology were the biomass is "suspended" in the wastewater to be cleaned and the system hence get limited by the capacity of the secondary settler used to separate the biomass from the cleaned water. At Dona Imelda Sewage

Treatment Plant (6000 m3/d, DBO project at Manila, Philippines) the most compact version of the FLUOPUR using pure MBBR Technology combined with Lamella Settlers has started up this year. As the photo shows the FLUOPUR plant has been fitted in on the smallest possible available area having housing on three sides of the plant and a public road on the fourth. In Ilanz Swizerland the existing WWTP from 1978 had to be extended to achieve complete Nitrification (8000 m3/d, DB project). To optimise running cost and maximise the utilisation of the existing plant the Hybrid version of FLUOPUR with Nitrification by Biomass Fixed on Fluopur carriers combined with Denitrification in conventional activated sludge has been chosen.

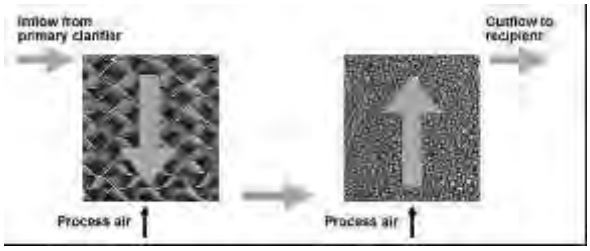

Figure 4: BIOPUR configuration with Pre-Denitrification on structured packing's followed by nitrification on granular media

Figure 5: BIOPUR installation at Llanes in Spain is being finalized (8500 m^3/d DB project). Since the plant is situated direct in the vicinity of very touristic beach area a compact

Biopur

One of WABAG's most successful Technologies over time is the BIOPUR with more than 60 installations Worlwide (CH, D, UK, I, E, S, F, MO, CN) treating the waste water of almost 5 000 000 PE. This is the Groups Biological Aerated Filter (BAF) Technology. BAF is the most compact Biological treatment available. As in the MBBR, BAF also relies on biomass fixation on a media, allowing very Biomass concentration. Further this

Figure 6: Swiss ski Resort Zermatt off-course no one wants to hear or see the WWTP so this plant finished by WABAG this year had to be placed under ground in a cave as well (12000 m^3/d DB project.

media is also used as filtration media which eliminates the need for secondary settlers. A key reason for the success of the BIOSTYR, also compared to other BAF competitors, is then utilisation of different Biomass support types in function of the effluent quality to be achieved an thenhydraulic conditions given.

Marapur

In the Membrane Bio-Reactor (MBR) the secondary settling tank of the conventional activated sludge is replaced by a Membrane. This allows to more than double the biomass concentration and at the same time the membrane installation is more compact than the secondary clarifier. As such MBR is a very compact solution and thanks to the utilisation of a membrane as final treatment stage a very high effluent quality can be achieved. WABAG's MBR solution is called MARAPUR and is based on the group's very long experience with this Technology. In fact our first Reference dates back to 1999 and since then we have been continuously improving the implementation of this technology like reducing

energy demand and maintenance cost by integrating pre filtration of the influent using our new pretreatment technology called MICROPUR (See here AFTER)

Micropur

The MICROPUR is WABAG's new Fine sieve Technology. By slowing down the rotation speed in a Rotation drum Filter utilizing a relative open

Figure 7: Ujams, Wastewater treatment, Water Reuse, Windhoek, Namibia (applying both MARAPUR and MICROPUR was started up during end of 2014 (5175 m^3/d, DBOO contract)

Mesh size, a Filtration cake layer is formed. This combination of cake layer (good filtration) and Open Mesh (high hydraulic throughput) results in a high removal rate combined with high hydraulic

Figure 8: The NEREDA® Technology is at the moment being tested at the Kloten-Opfikon WWTP (16000 m^3/d).

Capacity. The combined air water cleaning ensures a minimum production of back-wash water and full recovery of the filtration capacity. The MICROPUR will perform as good as a conventional primary settler, but It will only use 1/5 of the space! In addition the sludge will be thickened in the integrated mechanical thickener allowing taking the sludge direct to anaerobic digestion for energy recovery.

Nereda® (aerobic Granular Sludge Technology)

NEREDA® is the new comer in WABAG's Technology Portfolio of compact biological waste water solutions. This Technology is based on aerobic Granules were the bacteria normally found ins suspended form in conventional Activated sludge plants are forced to grow in dense granules instead of the lighter and more fluffy flock structure they normally have. These granules settle much faster and will again allow operating at much high biomass concentrations than in conventional activated sludge. The dense structure will allow stratification of Oxygen and Nutrients within the granule allowing achieving simultaneously complete biological Phosphorous and Nitrogen removal. NEREDA® has been Developed and patented by Royal HaskoningDHV (in cooperation with TU Delft) and in November this year WABAG signed a License agreement for applying this Technology in India and Switzerland.

BIOZONE® Process - Combined chemical-oxidative and biological effluent treatment

The BIOZONE® process has been developed by WABAG for the treatment of effluent containing a high percentage of organic compounds, which are resistant to biodegradation. The process generally consists of a two-stage activated sludge plant with an intermediate oxidation step.

Figure 9: Landfill leachate(350 m^3/d).

The areas of application include:

- Pulp and paper industry.
- Pharmaceutical industry.
- Textile industry.
- Chemical industry.
- Foodstuffs industry.
- Landfill leachate.

WABAG has successfully tested the process in various applications. In 2001 the first full-scale facility went into operation for the landfill leachate treatment plant at Würenlingen in Switzerland. In the first activated sludge stage, which is designed for high or medium sludge load, the biodegradable compounds are largely eliminated. The remaining organic substances are primarily "cracked" in the subsequent oxidation step. A comparatively small fraction is degraded completely. The chemical-oxidative "cracking" transforms a relatively large amount of the refractory constituents into biodegradable substances, which are removed in the second activated sludge stage. Depending on

Figure 10: BIOZONE-AD pilot plant

the wastewater to be treated, ozone or ozone/hydrogen peroxide are used as oxidants. In addition to the degradable organic oxidation products, the chemical reaction primarily produces water, oxygen and carbon dioxide.

The innovative BIOZONE-AD Process

WABAG has developed the innovative BIOZONE-AD process, in order to further enhance the efficiency of sewage sludge stabilisation. This method allows the extraction of 40% more methane from the sewage sludge than is possible with classic treatment processes and also results in a marked improvement in climate-friendly sewage sludge stabilisation. BIOZONE-AD supplements classic sludge stabilisation by an additional process step. Ozone is fed into the

Figure 11: 5760 m^3/d wastewater treatment plant

already stabilised sewage sludge, which leads to its oxidative digestion, i.e. the sludge can be reused biologically. The sludge treated in this manner is then returned to the digester tower, thus allowing the attainment of higher levels of degradation than those provided by conventional processes. The process allows for an increase in biogas yield by up to 40% as well as for further sludge hygienisation and a decrease in the sludge volume in order to save landfill space. The first BIOZONE-AD® pilot plant was installed and operated in Shanghai/China in a project financed by the World Bank in

Figure 12: 4320 m^3/d wastewater treatment plant

recognition of the growing global significance of sludge treatment.

ADOX® - Advanced Oxidation

Oxidative removal of pesticides and VOC

Ground and surface water are frequently subject to organic pollutants such as pesticides and chlorinated hydrocarbons. In order to prevent health risks strict legislation has been passed. "ADOX" stands for "ADvanced Oxidation" and represents a process which leads to the mineralization of organic pollutants in water by OH-radical oxidation. The main principle of the ADOX®- process is the combined use of ozone and hydrogen peroxide. Ozone is produced in an ozone generator from air or oxygen and is added to a partial stream by an injector or diffusers in the reactor. Hydrogen peroxide is dosed into the main treatment line. Subsequently, a high percentage of the pollutants is mineralized in the reaction tank. In the ADOX®-process post-treatment is accomplished by biological activated carbon filtration.

The process applications include:

- Ground water treatment for the removal of pesticides and chlorinated hydrocarbons.
- Surface water treatment with conventional ozonation being supplemented by the efficient removal of pesticides or other organic pollutants.
- Ground water remediation: involving the removal of pollutants such as chlorinated hydrocarbons, BTX and PAH.

Figure 13: 12000 m^3/d wastewater treatment plant

Figure 14: 3450 m^3/d wastewater treatment plant

Biological Denitrification – The BIODEN® Process

BIODEN® is one of the WABAG-developed biological process for ground water denitrification. The process functions according to the principles of heterotrophic, biological denitrification with ethanol or acetic acid as a carbon source. Basically, it consists of nutrient dosage, a biological filter, subsequent aeration for oxygen enrichment, downstream flocculation filtration and final safety disinfection.

The most important advantages of the process are:

- Degradation of pollutant.
- Virtually complete denitrification.
- Excellent partial load capability.
- The generation of relatively small amounts of wastewater.
- Plant stability and reliability.
- Easy adherence to all guide levels and maximum admissible concentrations.

The first full-scale BIODEN®-plant, with a capacity of 4,300 m3/d, has been in operation at Obersiebenbrunn in Austria since 1997. Nitrate levels have been reduced from 65 mg/l to < 5 mg/l. A plant in Czestochowa, Poland was commissioned at the beginning of 2006 and has a capacity of 12,000 m^3/d. It enables a reduction in nitrate levels from 80 mg/l to 5 mg/l. Furthermore, the plant ensures 100% water recovery and the treated water can be blended with raw water.

The ENR® Process - Electrodialytical Nitrate Removal

The electrodialysis process enables specific, partial desalination and has been employed for many years for the desalination of sea- and brackish water. On this basis, in co-operation with the Vienna University of Agricultural Sciences, WABAG has developed the ENR®-process for the denitrification of groundwater.

The most important advantages of the process are:

- Nitrate selectivity
- A low general level of desalination
- Reduction of hardness
- Limited space requirement
- Simple operation and quick start-up.

A large-scale ENR® plant with a capacity of 3,450 m^3/d was started-up in Austria during 1997. The nitrate concentration in this case has been reduced from 150 mg/l to <50 mg/l. During electrodialysis, salts are separated via ion exchanger membranes by means of an electrical field. Raw water passes through a stack of alternately placed anionic and cationic permeable membranes. The membrane stack is fixed between electrodes, which generate a direct current field. Due to the alternating selectivity of the membranes, cells are formed, some containing diluted water with a low level of salinity, and others filled with concentrated water, which is rich in inorganic salts. Thus, low-nitrate drinking water is produced together with a small amount of concentrate with a correspondingly high nitrate content.

Figure 15: Drainages systems installed at various places in the world

Filtration Technology

Water is the most important source of nutrition on the planet. Therefore, drinking water must meet stringent requirements with regard to quality, purity and hygiene. Accordingly, the further development of filtration technology has always been a major WABAG goal and the object of ongoing optimisation and improvement. Proven filter design provides ideal solutions for both single- and multilayer filters.

Optimised Filtration technology - the WABAG Drainage System

The drainage system, originally developed by Sulzer Chemtech (Sulzer Drainage System), is utilised in many modern filtration plants and as a rule, is installed in open or closed type concrete filters. The filter floor is the system's core component. A simple and cost effective design is vital, along with an even distribution of the backwash media and maximum operating safety. The drainage system consists of pipes arranged at right angles to the filter's longitudinal axis and fixmounted parallel to the filter bottom. The appropriate orifices in the individual drainage pipes enable the passage of the filtrate, the scouring air and backwash water into the filter material. During backwashing, air and water are introduced into the culvert below the filter bottom and into the drainage pipes via a distribution battery. This longitudinal and lateral pipe system ensures excellent backwash media distribution across the whole filter area. WABAG has installed the drainage system in a number of plants in various countries. Great operational reliability, minimised clogging danger and high backwashing efficiency, together with easy and rapid assembly, have ensured long-term customer satisfaction.

Hybrid Process - The two-stage activated sludge process for nitrogen removal

The incorporation of existing facilities during plant enlargement and modification, often makes excellent economic sense with regard to cost minimisation, but can be technically difficult. The Hybrid process, jointly developed by WABAG and the Vienna University of Technology, is ideal

Figure 16: Wastwater treatment plant in Austria

for this purpose. It meets the new requirements and due to its two-stage structure possesses specific advantages:

Process stability

The first process stage provides optimum load compensation, which even in the case of low wastewater temperatures secures the denitrification capacity of the second stage. This is an especially important advantage when dealing with industrial effluents or seasonal peak loads. Economies over conventional single-stage plants: The Hybrid process facilitates a considerable reduction in the tank volume required. Design comparisons for various plants have shown that in terms of total volume, approximately 30% can be saved. The Hybrid process has already been used on a large-scale for the enlargement of the main wastewater treatment plant in Vienna from 2,100,000 p.e. to 4,000,000 p.e. The client, Entsorgungsbetriebe Simmering, decided to employ the Hybrid process as an alternative to the bypass process due to its ability to provide operational advantages and improved wastewater quality.

The Technology

The Hybrid process is based on the conventional two-stage activated sludge process. However the biozenoses of both stages are not separated, but advantageously mixed through two innovative hybrid sludge cycles. The volume of theses cycles is relatively low (approx. 3% of raw water inlet). Cycle 1 transfers sludge from the first to the second stage, providing active denitrifying biomass and carbon sources. The denitrification capacity of the second stage can therefore be controlled via the amount of sludge transferred and is not limited by the degree of carbon removal in the first stage. On the other hand, activated sludge from the second stage is transferred by cycle 2 into the first stage. Continuous seeding of the nitrifying biomass results, which provides nitrification despite the low sludge age (high sludge load) in this stage. The nitrate produced is denitrified at a rapid rate due to high biomass activity. Improved phosphorous removal can be achieved biologically by means of an aerobic tank upstream of the first aeration tank, or by simultaneous precipitation.

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Sustainability Criteria for Green Buildings based on LEED-EB Rating System and its Key Ideologies of Credit Categories

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Abstract

Buildings have major environmental impacts over their entire life cycle. Thus, buildings are one of the major pollutants that affect urban air quality and contribute to climate change. Hence, the need to design a green building is the essence of which would be to address all these issues in an integrated and scientific manner. Many official green building programs, communities and organizations launched several rating systems to help the sustainable process assessment; all of these rating systems are built in a way to adapt the idea of Sustainability in architecture which seeks to minimize the negative environmental impact of buildings by enhancing efficiency in the use of materials, energy, and space. Hence, this paper aims at clarifying and Analyzing the application of green practices in existing buildings describes the most widely used benchmark for assessing green practices, the U.S. Green Building Council's LEED Rating System, and provides a "road map" for pursuing LEED certification. LEED or Leadership in Energy and Environmental Design, is a green building certification program that recognizes best-in-class building strategies and practices. To receive LEED certification, building projects satisfy prerequisites and earn points to achieve different levels of certification. The result of the assessment is presented in a building checklist way that allows organization to benchmark their maturity and to monitor their development. With this checklist, organizations can translate the abstract and interpretive concepts of sustainable development into practical actions. In applying green features for existing building we need to understand the basic awareness of LEED rating system credit categories, its features, methodology and importance of this organization. LEED therefore, have significant role in the process of assessing the sustainability criteria in existing buildings.

Keywords: *LEED, Green Building, Sustainable criteria*

Introduction

LEED, or Leadership in Energy and Environmental Design, is a green building certification program that recognizes best-in-class building strategies and practices. To receive LEED certification, building projects satisfy prerequisites and earn points to achieve different levels of certification. Prerequisites and credits differ for each rating system, and teams choose the best fit for their project. LEED certification provides independent verification of a building or neighbourhood's green features, allowing for the design, construction, operations and maintenance of resource-efficient, high-performing, healthy, cost-effective buildings. LEED is the triple bottom line in action, benefiting people, planet and profit.

Application of LEED certification for converting existing buildings into green building in India and optimizing operations and maintenance will not only address the country's growing energy, air quality and water crisis, it will also enhance companies' bottom line through reduced power & water bills and increasing occupant health, comfort and wellbeing. LEED certification is recognized across the globe as the premier mark of achievement in green building. Hence biggest opportunity for improvement is to retrofit our existing buildings into a green building taking into account the aspects of energy, water and materials along with cost considerations such that the

occupant well-being, environmental performance and economic returns are improved [16, 17, 18, 19].

Versions of LEED are - v4 - LEED v4, v3 - LEED 2009, v3 - LEED 2008, v3 - LEED India 2011, v2 - Schools 2007, v2 - LEED 2.2, v2 - LEED 2.1, v2 - LEED 2.0, v1 - LEED 1.0 pilot, 2009 Energy Update, v1 - PEER v1.1

Purpose of the study

Have you ever seen or heard of application of green practices in existing buildings? Converting existing building into Green Buildings aim to improve the environment by using LEED rating system credit categories for the existing building , but few people really understand them. In order to obtain clear explanation for these questions, we intend to learn thoroughly about converting existing building into Green Buildings. We would also like to know why Green Buildings having important role for the sustainable development. For those reasons, we conduct this study to search for the answers.

Methodology

The Dissertation deals with the features of the green building. The idea behind is to see whether an existing building can be converted to a green building with the application of LEED O+M: Existing Buildings | v4 rating system. The LEED O+M: Existing Buildings | v4 follows a standard format of procedure in a form of tables for features like sustainability, water efficiency, indoor air quality, etc which forms the base of our case study. The Dissertation contains seven steps of methodology which starts right from the introduction goes through the green building rating systems and ends with the recommendations for the case study and conclusion for the same. The brief description of methodology stepwise is being tabulated as below,

Identification of problem found

Building sector is the largest source of greenhouse gas emissions around the globe. Being green, or sustainable, is one pressing issue coming from both internal and external drivers for construction and engineering companies. Green building has experienced rapid growth in the past several years. A green building is one that is environmentally responsible, profitable and a healthy place to live and work. Green buildings ensure that waste is minimized at every stage during construction and operations of the building, resulting in low cost. The proposed work deals with understanding the necessity of green building, its features, and concepts behind the same and to assess how green, or sustainable, the building is, several green rating systems can be develop. It deals with study of various rating systems available along with their characteristics, suitability, development performance and applicability. It also can elaborate about what are the various requirements of building to be green? How much weightage for what aspect etc. Various rating systems can be compares for the particular project to obtain an understanding of current practices, and more importantly, to address the significance of achieving green or sustainable construction. Features of Green Building, Rating Systems available, Reliability of LEED Rating System, Green Building potential in India, can be possible to convert the existing building into the green building and its benefits and will follow by the case study.With the help of good landscaping, water harvesting, innovative water technologies, use of world class energy efficiency practices existing building can be converted into a green building.

Data collection

The data collection would include all relevant data required in designing a Green administrative building. The data to be collected would be decided from the program requirements and the inferences from case studies. This data would further be used as references during the design process. The data collected is various green measures and their applications according to LEED rating system for existing building and other rating system. Hierarchy of administrative N.I.C.M.A.R class room block, Office spaces and other space requirements Apart from this data collection analysis will be done on Efficient landscaping Glass in green architecture Utilization of fly ash in building structures, Rain water harvesting, Waste water management. The data collection will also include guidelines given by LEED for designing a building with green features in sync.

Selection of case study

The main aim of this chapter would be to put forward the kind of functions presenting parallel case studies of green buildings, realizing their positive and negative points. The chapter will end in an analysis and conclusion which will finally help in the program requirements, site selection and limits of the site. The case studies selected are – NICMAR Institutional Campus, Balewadi, Pune. And web case study of Johnson Diversey's global headquarters, located in Sturtevant, Wisconsin, is a three-story mixed-use facility constructed in 1997.

Promotion of green architecture

Study of overview categories of rating project check list and its essential ideologies and techniques for the implementation of converting non green building into green building by referring the LEED rating guide. Also doing the study of the different types of rating systems used all over the world like BREEAM, CASBEE, Green Star, Green Globes™ U.S and LEED and explains why the LEED rating system is superior to the other rating systems which distinguishes hoe its promoted for green architecture.

Selection of site

This would include the reason for selecting the site and the site details and will explain the initial design concept for development of green building form. It deals with case study of the classroom block located in the NICMAR campus and the process in which the building was rated and the credit points earned by it.

Identification of green aspects

Site inventory and design impacts are like Reduce hard paving on site/and or provide shaded hard paved surfaces, Enhance outdoor lighting system efficiency, Reduce landscape water requirement, Reduce the water use by the building, Optimise building design to reduce conventional energy demand, Optimize energy performance of building within specified comfort limits, Utilization of flyash in building structure, Use low energy material in interiors, Renewable energy utilization, Renewable energy based hot water system, Water recycle and reuse (including rainwater), Use low -VOC paints/ adhesives/ sealants, Minimize ozone depleting substances would improve for to get the certification.

Optimization of cost

By doing the some changes in the existing building for green perspective, we will get long term benefits and by doing the initial investment even more.

Formulation of clauses and certification

The concept aims at developing plan form of a building to integrate the three basic elements of climate i.e. light, air and water into the built environment. These three elements of nature, upon their integration into the built form, have their functional as well as aesthetical impact. Their functional role is much crucial in present situation as a modern building is not only amongst the worst polluter of climate but also the largest consumer of energy. So by doing the study of credit categories and its techniques from LEED which gives the essential ideologies of green building and sustainable site design and it's overview of applicability of credit categories techniques to be green building.

Recommendation and conclusion

It deals with the recommendations for implementing the green features to convert the building as a green building to achieve the certification.

Understanding of LEED Certifying an Existing Building [19]

The driving force behind implementing green practices in existing buildings is knowledgeable and diligent property management companies. Unlike fulfilling green building requirements for new construction, converting existing buildings into green buildings requires an ongoing commitment to monitor building systems, train staff, and keep up to date with certification requirements. While this may seem like added work with added costs, the financial benefits of pursuing green practices are pronounced and long lasting. As is the case in many instances, the only way to learn how to green an existing building is by actually working through the process. LEED certification begins with registration of a building and proceeds with bringing the building up to

LEED-EB standards. This process usually takes 9 to 24 months, depending on the current state of the building. After successfully meeting the LEED rating system requirements, an organization then submits all relevant information to the USGBC for certification through the LEED website.

Flow Chart of Methodology

When to use leed for existing building [20]

LEED for Existing Buildings: Operations & Maintenance was designed to certify the sustainability of the ongoing operations of existing commercial and institutional buildings [14, 16].

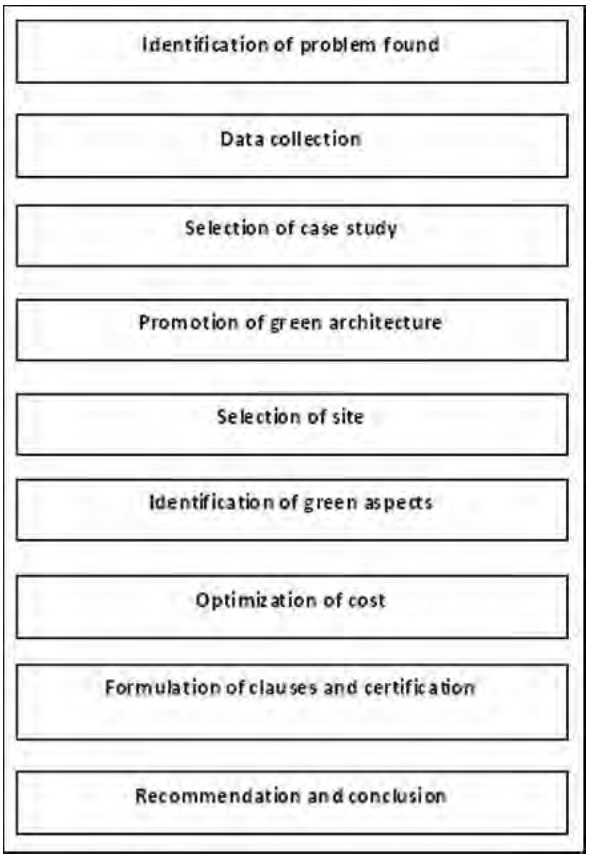


Figure 1: Flow Chart of Methodology

? All commercial and institutional buildings, including offices, retail and service establishments, libraries, schools, museums, churches, and hotels, as well as residential buildings of four or more habitable stories are eligible.

? The rating system encourages owners and operators of existing buildings to implement sustainable practices and reduce the environmental impacts of their buildings over their functional life cycles.

? The rating system addresses exterior building site maintenance programs, water and energy use, environmentally preferred products and practices for cleaning and alterations, sustainable purchasing policies, waste-stream management, and ongoing indoor environmental quality.

? The rating system is targeted to single buildings, whether owner-occupied, multitenant or multiple-building campus projects. If there are multiple buildings on the same campus, each must certify individually. Also, It is a whole-building rating system; individual tenant spaces are ineligible.

Rating system selection guidance [17]

A . LEED for building operations and maintenance

Buildings that is fully operational and occupied for at least one year. The project may be undergoing improvement work or little to no construction and must include the entire building's gross floor area in the project [12].

LEED O+M: Existing Buildings - Existing buildings that do not primarily serve K-12 educational, retail, data centers, warehouses and distribution centers, or hospitality uses.

LEED O+M: Retail. Existing buildings used to conduct the retail sale of consumer product goods. Includes both direct customer service areas (showroom) and preparation or storage areas that support customer service.

LEED O+M: Schools. Existing buildings made up of core and ancillary learning spaces on K-12 school grounds and may also be used for higher education and non-academic buildings on school campuses.

LEED O+M: Hospitality. Existing buildings dedicated to hotels, motels, inns, or other businesses within the service industry that provide transitional or short-term lodging with or without food.

LEED O+M: Data Centers. Existing buildings specifically designed and equipped to meet the needs of high density computing equipment such as server racks, used for data storage and processing.

LEED O+M: Data Centers only addresses whole building data centers.

LEED O+M: Warehouses & Distribution Centers. Existing buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings (such as self-storage).

Areas need to be focus while converting existing building into green building and for new construction:

The following table summarizes key principles, strategies and technologies which are associated with the Six major elements of green building design which are: Sustainable Sites; Water efficiency Conservation and Quality; Energy and

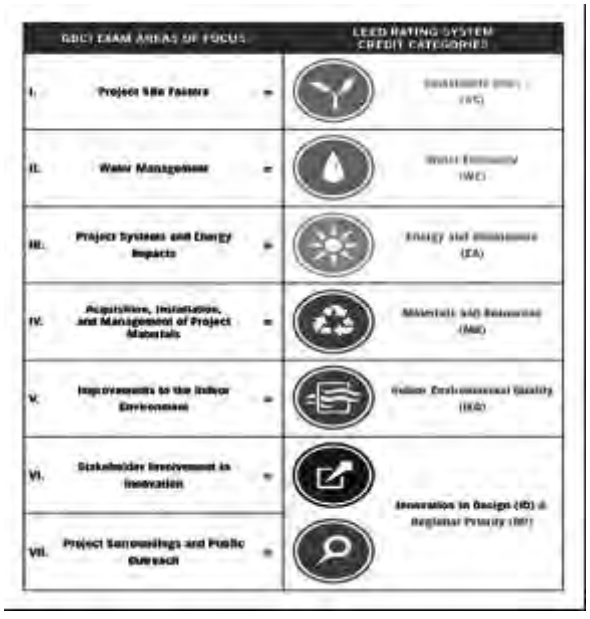


Figure 2: LEED rating system credit categories

Environment; Indoor Environmental Quality; Conservation of Materials and Resources; Innovation and design process. This information supports of the use of the USGBC LEED Green Building Rating System, but focuses on principles and strategies rather than specific solutions or technologies, which are often site specific and will vary from project to project.

B .Overview of Credit Categories [19]

?Sustainable Sites: Construction related pollution prevention, site development impacts, transportation alternatives, stormwater management, heat island effect, and light pollution. The Sustainable Sites (SS) category rewards decisions about the environment surrounding the building, with credits that emphasize the vital relationships among buildings, ecosystems, and ecosystem services. It focuses on restoring project site elements, integrating the site with local and regional ecosystems, and preserving the biodiversity that natural systems rely on.

?Location and Transportation: This category rewards thoughtful project team decisions about the location of tenant space, with credits that encourage compact development, alternative transportation, and connection with amenities, such as restaurants and parks. The LT category is an outgrowth of the Sustainable Sites category, which formerly covered location-related topics. Whereas the SS category now specifically addresses on-site ecosystem services, the LT category considers the existing features of the surrounding community and how this infrastructure affects occupants' behaviour and environmental performance.

? Water Efficiency: Landscaping water use reduction, indoor water use reduction, and wastewater strategies. The Water Efficiency (WE) section addresses water holistically, looking at indoor use, outdoor use, specialized uses, and metering. The section is based on an “efficiency first” approach to water conservation. As a result, each prerequisite looks at water efficiency and reductions in potable water use alone. Then, the WE credits additionally recognize the use of non potable and alternative sources of water.

?Energy and Atmosphere: Commissioning, whole building energy performance optimization, refrigerant management, renewable energy use, and measurement and verification. The Energy and Atmosphere (EA) category approaches energy from a holistic perspective, addressing energy use reduction, energy-efficient design strategies, and

renewable energy sources.

?Materials and Resources: Recycling collection locations, building reuse, construction waste management, and the purchase of regionally manufactured materials, materials with recycled content, rapidly renewable materials, salvaged materials, and sustainably forested wood products. The longest part of a building's life cycle is the use phase, commonly referred to as the operations phase. To target environmental impact reductions during building operations, the Materials and Resources (MR) credit category focuses on the constant flow of products being purchased and discarded to support building operations. The life cycle of these products and materials—from extraction, processing, and transportation to use and disposal—can cause a wide range of environmental and human health harms. To reduce these burdens and thus the overall impact of a building during its operations phase, project teams should take a close look at the purchasing and waste management operations in existing buildings.

?Indoor Environmental Quality: Environmental tobacco smoke control, outdoor air delivery monitoring, increased ventilation, construction indoor air quality, use low emitting materials, source control, and controllability of thermal and lighting systems. The Indoor Environmental Quality (EQ) category rewards decisions made by project teams about indoor air quality, thermal and visual comfort, and occupants' satisfaction. Green buildings with good indoor environmental quality protect the health and comfort of building occupants. High-quality indoor environments also enhance productivity, decrease absenteeism, improve the building's value, and reduce liability for building designers and owners.

?Innovation and Design Process: Innovative strategies for sustainable design. Sustainable design strategies and measures are constantly evolving and improving. New technologies are continually introduced to the marketplace, and up-to-date scientific research influences building design strategies. The purpose of this LEED category is to recognize projects for innovative building features and sustainable building practices and strategies.

?Regional Priority: Because some environmental issues are particular to a locale, volunteers from USGBC chapters and the LEED International Roundtable have identified distinct environmental priorities within their areas and the credits that address those issues. These Regional Priority credits encourage project teams to focus on their local environmental priorities.

C . Certification of Levels

By referring above information during the application of LEED to the existing building we should get the number of points a project earns determines the level of LEED certification.

There are four levels of certification - the number of points a project earns determines the level of LEED certification that the project will receive. Typical certification thresholds are:

? Sustainable Sites 10 Points

? Location and Transportation 15Points

? Water Efficiency 12 Points

? Energy & Atmosphere 38 Points

? Materials & Resources 8 Points

? Indoor Environmental Quality 17 Points

? Innovation and Design Process 6 Points

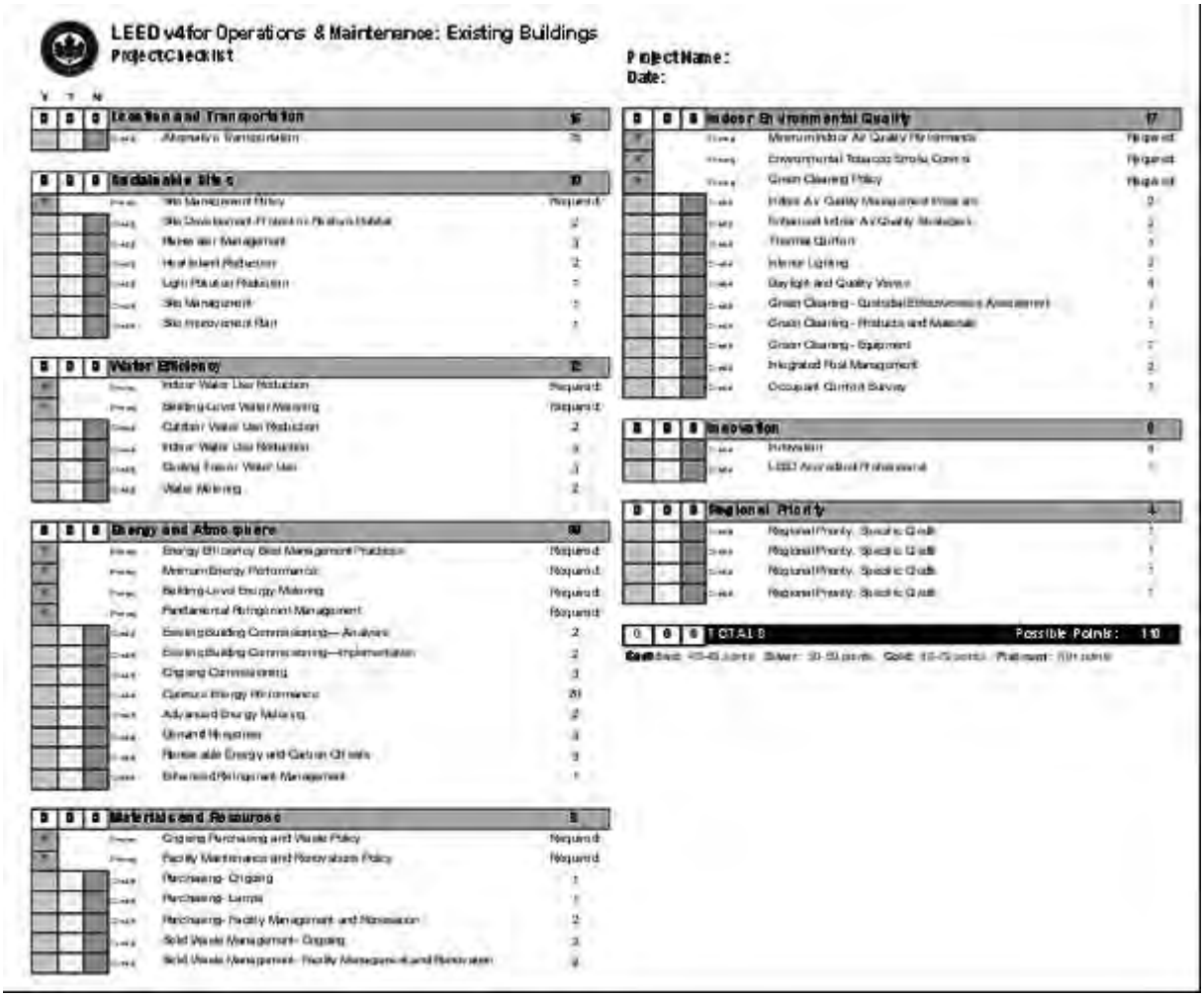
? Regional Priority 4 Points

TOTAL LEED Points 110 Points

D. Levels of Rating

The following are the different levels of LEED-EXISTING BUILDINGS: OPERATIONS & MAINTENANCE rating awarded to projects.

Figure 3: Levels of LEED for Existing Buildings: Operations & Maintenance (V4)


LEED v4for Operations & Maintenance: Existing Buildings
Project Name:
Date:

Total number of available points is 110 with 8 prerequisites.

LEED rating system credit categories has six major areas of focus which are having checklist as per below: [6]

Conclusions

Significant opportunities to improve the three pillars' of sustainability lie within the existing building stock. The LEED certification program for existing buildings provides a useful framework to achieve sustainability goals that are economic, social, and environmental in scope. The LEED Portfolio Program will facilitate the process by providing economies of scale in the certification process and supporting the implementation of green practices across entire portfolios of buildings, which will result in the re-training of real estate professionals. Tackling the challenges and roadblocks present in existing buildings is the realistic alternative to the unrealistic option of replacing every traditional building with a cutting-edge, high performance structure. In applying green features for existing building we understood the basic awareness of LEED rating system credit categories, its features, methodology and importance of this organization. LEED therefore, have significant role in the process of assessing the sustainability criteria in existing buildings.

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Treatment of Domestic Waste Water by Non-mechanised System of Stabilisation Tank

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Abstract

Rapid urbanization and industrialization has been resulting into ever increasing quantities of wastewater. As against this, the infrastructure facilities provided are inadequate. Hence most of the sewage finds its way in the rivers and joins the river untreated. This has adverse impact on the environment. The downstream users get severely affected due to this. The local bodies like municipal corporations are not able to cope up with the ever increasing quantities of waste getting generated. This demands for onsite management of wastewater. The studies carried out reveal that the mechanized systems that are provided for wastewater management become unaffordable on time scale and in most of the cases become defunct in 3-4 years. This demands for simple onsite wastewater management systems that are sustainable. Few of such technologies have been developed by earlier which are very effective for peri-urban and rural areas. If these systems are to be used in urban areas, they will require some modifications to suit the requirements. This project is an attempt to study the feasibility of such modified system. The study will be conducted through the proposed experimental model which is a modified version of stabilization tank developed by the researchers. This is achieved by giving long detention time and zig-zag flow pattern to the waste water. For this, the whole system is divided into five compartments in the form of circular pipes and detention time of one day is provided for each compartment. As the result of this, the suspended solids will get settled at the bottom of tank in first two compartments. By this attempt, reduce the Biochemical Oxygen Demand and Chemical Oxygen Demand load on receiving of can be reduced water bodies.

Keywords: *Biochemical Oxygen Demand, Chemical Oxygen Demand, Stabilization Tank, Sustainable System.*

Introduction

Domestic wastewater is defined as wastewater coming from household activities; it consists of human body wastes (faeces and urine) and the water used for flushing toilets, and sullage, personal washing, laundry, food preparation, vegetable peelings, tea leaves, and soil particles. The chemical components of domestic wastewater are detergents, soaps, fats and greases of various kinds, pesticides. Variations in characteristics of the domestic wastewater are depend upon daily per capita use of water, quality of water supply, the type of activity and habits of the people.

Fresh domestic wastewater is grey and turbid and it has an earthy odour. The Total Solids (TS) present in the domestic wastewater are divided into Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). Further the TSS consists of organic solids, inorganic solids, settleable solids and colloidal suspended solids. The chemical components of domestic wastewater are carbohydrates, fats, oils, grease, proteins, surfactants, volatile organics, chlorides, nitrogen; phosphorus

Analysis of Samples

For technical comparison the results from the analysis of the wastewater is necessary. For this analysis, samples are taken from inlet and outlet. The parameters for analysis are taken as BOD, COD, TSS, TDS, and TS. From the BOD we will get to know the biodegradable matter present in wastewater. The test is carried out for 3 days at

270° C temperature.

Sampling Site Details

Grey water sample is collected from the STES Staff Quarters, Ambegoan, Pune. Site separate arrangement is made for collection of grey water. Sewage sample is collected from river Mutha near Vitthalwadi, Pune. The samples from both sites were collected for period of two months and analysis was done. Sampling was done daily between 10 am to 1 pm.

Materials and Construction Details

In present study, the proposed stabilization tank is divided in five compartments of one day detention time each. Before these compartments, intercepting tank is provided to store the waste water to feed the system. The circular PVC pipes are used to make all the compartments of

Figure 1: Complete arrangement of Stabilization Tank

stabilization tank. The size and shape of all the compartments is same. The length of compartment was kept more than the depth, so as to get proper contact time between air and waste water. Two end caps are required to each compartment. These caps are fixed to the compartments with the help of sealing material to avoid the leakages. The arrangement of valve is required to the intercepting tank to control the velocity of flow from the tank. To connect all compartments to each other, interconnecting pipes are required. The interconnection pipes are also made from PVC. The length of each interconnecting pipe is about 0.3 m. The length of interconnecting pipe is kept small, so as to provide the proper stability to the tank. For first compartment, inlet is provided at some distance from the bottom and outlet is provided at top. The interconnecting pipes necessarily will be of smaller diameter than that of the stabilization tank. Sufficient free board was provided to each compartment to create the aerobic conditions. Two air vent pipes are provided to each compartment, for removing the gases that are generated in the system. The diameter of air vent pipe depends on the diameter of compartment. In first two compartments, sludge may settle at bottom. For removal of this sludge valves are provided to first two compartments.

Procedure

This study mainly focuses on the analysis of the wastewater generated in the urban, peri-urban or rural areas. Stabilization tank is the low cost treatment unit which can be used not only in the isolated areas but for any building. The whole

Figure 2: Grey Water Inlet and Outlet

stabilization system works on the basis of settlement and degradation of the solids from the waste water. In this system, whole tank was divided in the five compartments which are

Figure 3: Sewage Inlet and Outlet

equidisequidistant from each other. When flow comes to the intercepting tank, the solids having specific gravity greater than waste water, settle at the bottom of intercepting tank. Then water is diverted to the first compartment with controlled velocity within one day detention time. Proper velocity control is required, so that the particles which have already settled at bottom will not get disturbed. It is observed that small amount of solids gets settled at the bottom of the first compartment. The remaining amount of solids get settled in the second compartment. Sludge which was settled at the bottom of tank gets digested either an-aerobically or aerobically. The sludge which may settle in the first two compartments was removed with the help of sludge valve. Thus the first two compartments act as the settling zone for the sludge. In third and fourth and subsequent compartments, some amount of dissolved solids gets removed. Thus due to this zig-zag flow pattern, the waste water (grey or black water) is treated to such a level that it can very well be used for non consumptive uses such as flushing, floor washing, gardening or even for ground water recharge (after minimal disinfection if required).

Results and Discussion

Total Solids

Untreated grey water from the building contained total solids up to 850 to 1480 mg/lit. When this untreated effluent was passed through stabilization tank, the total solids were reduced up

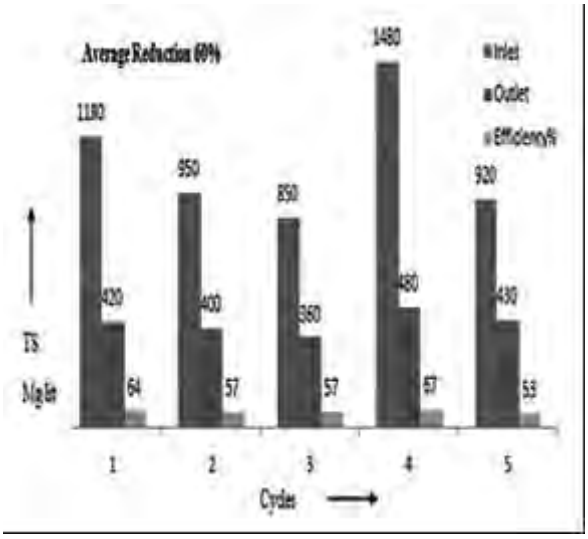

Figure 4: TS Variation of Greywater

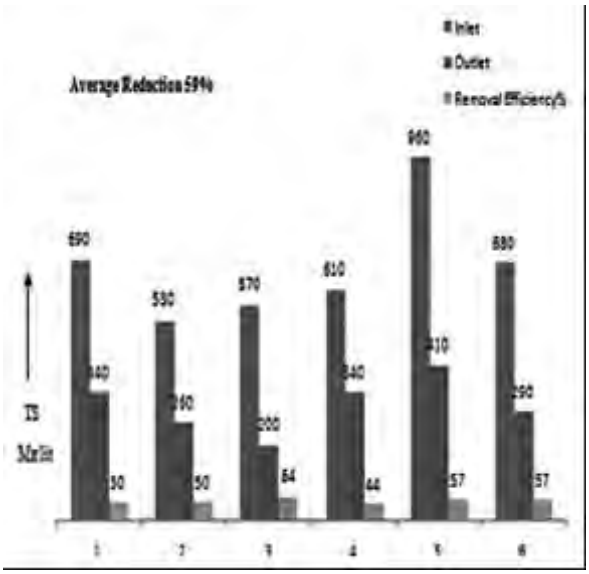

Figure 5: TS Variation for Sewage

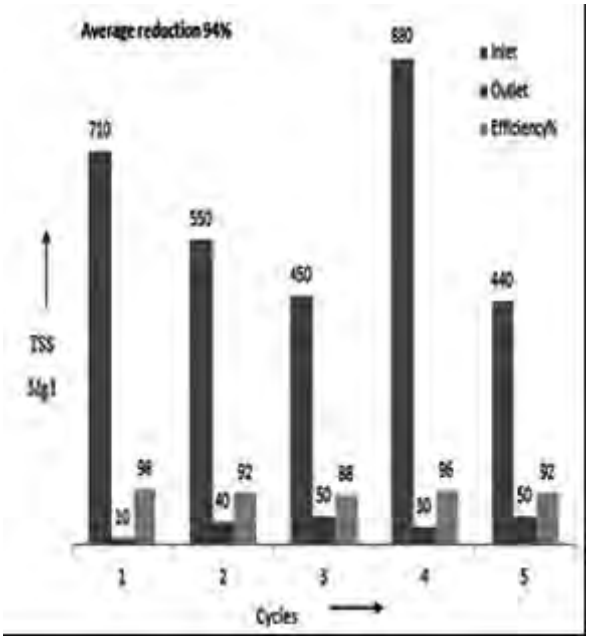

Figure 6: TSS Variation of Grey Water

to 360 to 480 mg/lit. Untreated sewage contains total solids up to 530 to 980 mg/lit, after treatment they were reduced up to 200 to 390 mg/lit.

Total Suspended Solids

Untreated grey water contained total suspended solids is found up to 440 to 710 mg/lit. When this untreated effluent was passed through the stabilization tank, the solids were reduced by 94%. For untreated sewage sample solid found up to 210

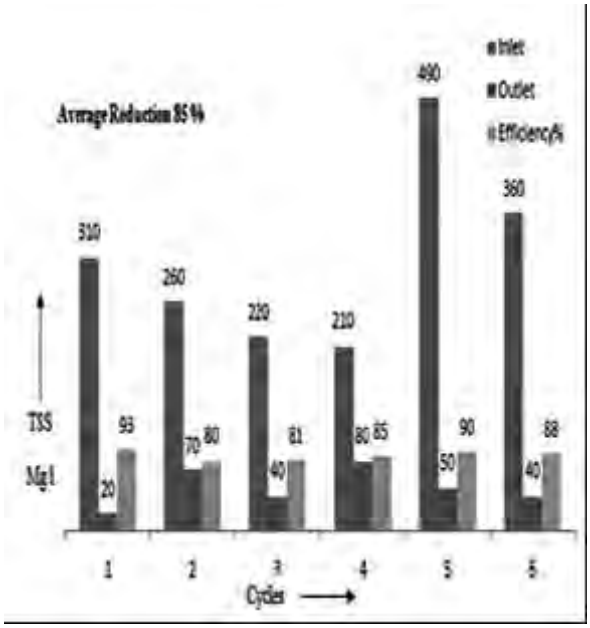

Figure 7: TSS Variation for Sewage

to 490 mg/lit, after treatment it was reduced by 90%.

Total Dissolved Solids

Total dissolved solids represent the combined content of organic and inorganic substances in thewastewater. Untreated grey water contains total dissolved solids up to 400 to 600 mg/lit, after treatment it was reduced up to 17%. Untreated sewage sample contains total dissolved solids up

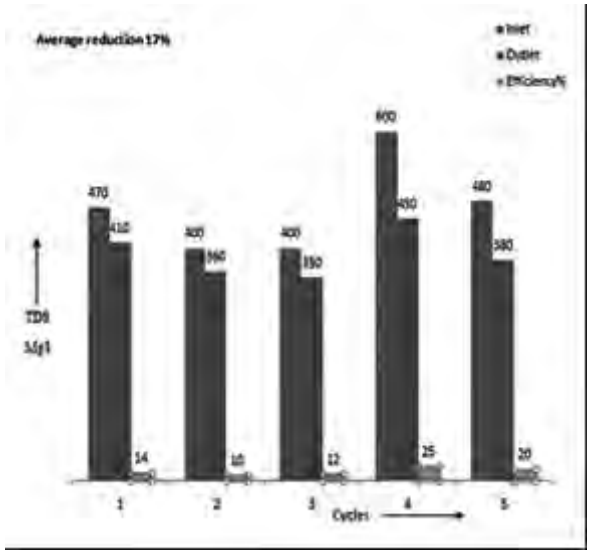

Figure 8: TDS Variation for Grey Water

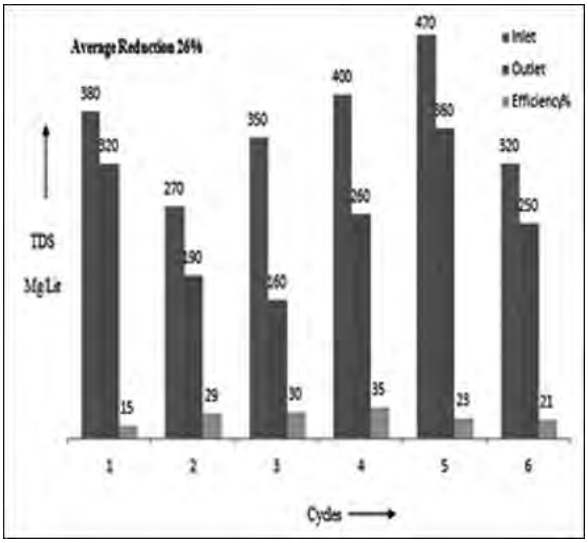

Figure 9: TDS Variation forSewage

to 270 to 470 mg/lit and after treatment it was reduced up to 28%.

Biochemical Oxygen Demand

BOD is the measure of amount of oxygen required to oxidize the biodegradable organic matter present in the wastewater. For untreated grey water, BOD varies from 130 to 148 mg/lit. After treatment, it was reduced up to 14 mg/lit. For untreated sewage BOD value were found to vary from125 to 152 mg/lit. When it was passed through the proposed system BOD was reduced up to 6 mg/lit.

Chemical Oxygen Demand

COD is a measure of the total quantity of oxygen

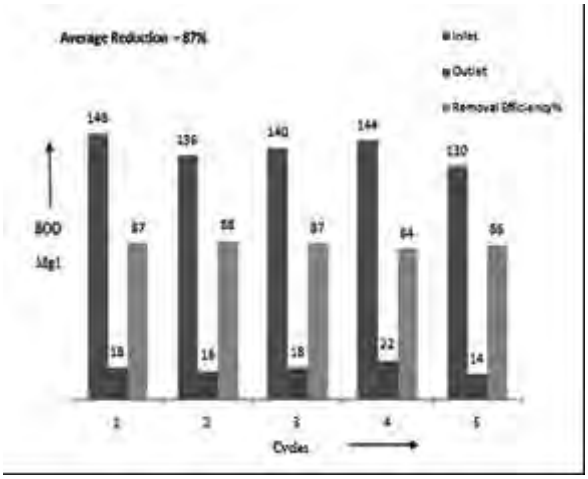

Figure 10: BOD Variation for Greywater

required for oxidation of nearly all oxidisable organic and inorganic compounds in wastewater. Untreated grey water from the building contained COD up to 290 to 320 mg/lit, and after treatment it was reduced by 78%. For, sewage treatment efficiency was found up to 65%.

Conclusions

In present study, work was carried out for studying the feasibility of grey/ sewage treatment by modified stabilization tank. Following were the major investigations of this study

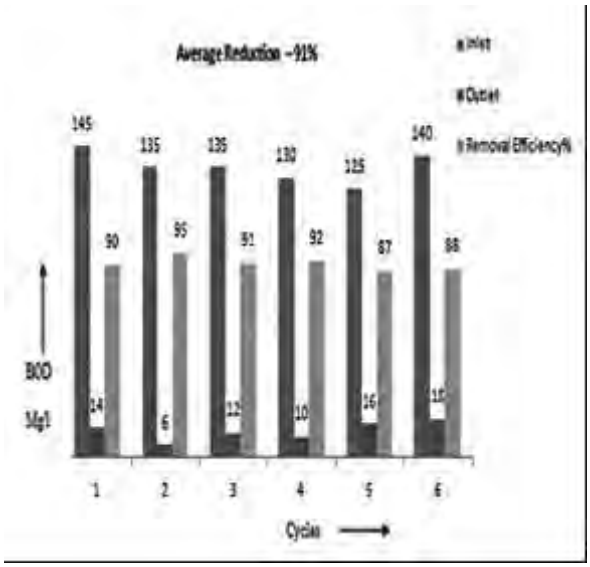

Figure 11: BOD Variation for Sewage

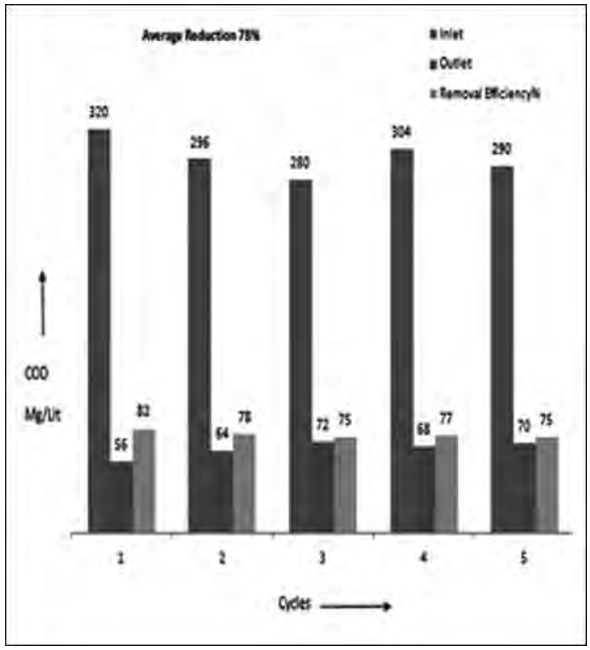

Figure 12: COD Variation for Greywater

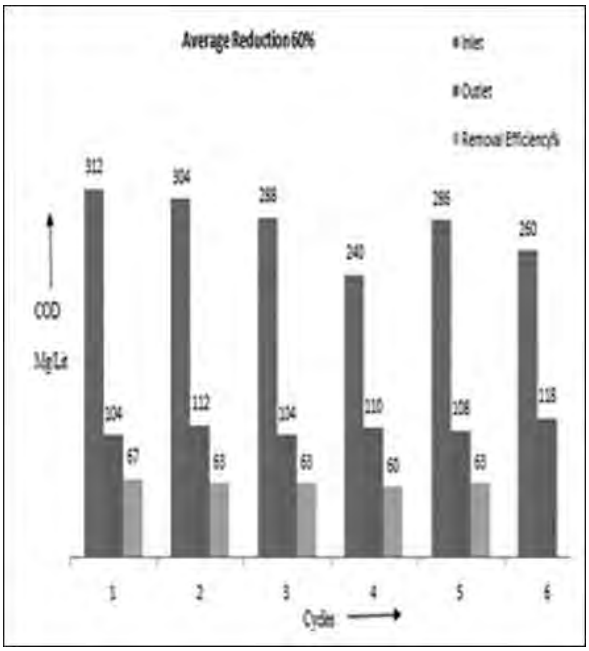

Figure 13: COD Variation of Sewage

- A system suitable for treating both grey water and / or sewage treatment is developed in the modified stabilization tank for the urban, peri urban and rural areas, for on-site waste management.
- The modified stabilization tank treats both sullage and sewage with presence of aerobic or anoxic conditions which is provided by means of air vent pipes.
- It consists of five interconnected tanks of circular shape which are made from PVC pipes or any other readily available material which reduces the cost of the waste water treatment process.
- This system is easy to assemble or lay or construct in the side margins of the area available as per the site conditions.
- This system having five compartments (or 5 days detention time) reduces the area required (being underground), which again helps to minimize the space availability problems at in-situ conditions, particularly in urban or peri-urban areas.
- This system has a big advantage of minimum operation cost, as it does not require any work to

be done specially by any skilled labour or skilled person. Further, no specific chemicals are required to be added.

• This system does not require any type of internal or external energy source for its working i.e. Electricity, which again saves a lot of cost required for treatment which is required for mechanized sewage treatment plants.

• The treated effluent (collected after five days) is of such a quality that it can be easily used for non-consumptive uses such as gardening, flushing, ground water recharge, firefighting, floor cleaning etc which finally helps in saving of need of fresh water, hence reducing the water scarcity problem.

• The treated effluent is under acceptable limits of pollution parameters such as BOD, COD, etc so that we can directly discharge this effluent in to the natural water bodies such as lakes, streams or rivers etc. Further it is free from abnoxious odour.

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Wastewater Treatment for Sustainable Development

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Abstract

Handling of wastewater streams from various industries (including water and sewage treatment plants) and the measures they took to minimize pollution and recover water and other useful byproducts has been briefly described in this presentation.

Keywords: *Reduce, Reuse, Recycle, Recover and Replace, Zero Liquid Discharge.*

Introduction

The aim of wastewater treatment is to remove pollutants and contaminants from the used water and to render it fit for either safe discharge to the environment or for reuse and/or recycle in order to conserve the natural resource viz water. Wastewaters are generated whenever water is used for domestic, commercial, industrial, agricultural, recreational, navigational purposes. Such uses add organic, inorganic, inert, recalcitrant and 'difficult to degrade' pollutants and contaminants to the water, thereby rendering it unfit for any purpose, unless it is treated adequately in order to meet these demands. With increasing population, increased industrialization and higher standards of living, the presently available resource i.e. water, is subjected to great strain. It must be realized that the quantum of water available on the earth has not changed since its birth. No technological advancements have succeeded in producing "new" water. It is, therefore, imperative to subject water to repeated use.

Sustainable Development

It is defined as 'development that meets the needs of the present without compromising the ability of the future generations to meet their own needs' [1].Practising the 5'R', i.e. Reduce, Reuse, Recover, Recycle and Replace will help greatly in achieving sustainable development.

Sources of Waste Waters

(a) Water treatment for domestic use and industrial consumption produces waste waters in the form of

- Filter backwash water,
- Desludge water from clarifiers
- Regeneration and rinse water from ion exchange beds,
- Cleaning of tanks and vessels used for storing and feeding chemicals during treatment,
- Rejects from reverse osmosis units.

(b) Sewage and industrial waste water treatment generates

- Supernatant from anaerobic digestion,
- Centrate and filtrate from sludge dewatering equipment such as centrifuges, vacuum filters, belt filter presses, sludge drying beds etc.,
- Cleaning of storage tanks for chemicals used in treatment,
- Boiler and cooling tower blowdowns,
- Rejects from reverse osmosis units,
- Regeneration and rinse waters from demineralization plants etc.

(c)Unsewered areas produce

- septic tank effluents and
- septages, when septic tanks are emptied as an essential step in their operation and maintenance. Septic tanks provide only partial treatment to the sewage and need further treatment before they can be discharged to the environment.

(d) Solid waste disposal processes such as landfills and dumping grounds generate leachates.

(e)Air pollution control equipment such as wet scrubbers produce waste waters which need treatment.

(f) Ballast water from ships while they are in ports of call.

(g) Agricultural runoffs from fields.

These effluents vary over a wide range in volume, flow rate, quality and frequency of peak flow rates; hence the design of the treatment plants for them has to be capable of handling the variations within reasonable limits and produce consistently, effluents which will meet the stipulated standards, either for safe discharge to the environment or for recycling and reuse.

Methods of Treatment

Various unit operations and unit processes have to be used in order to treat wastewaters economically and effectively. In order to design an appropriate system of treatment, it is necessary to know the quality characteristics, flow rates, total flow and peak factors of the water and wastewater to be treated. Physical, chemical, biological methods and their suitable combinations result in an effective treatment scheme. It is necessary to conduct characterization studies, treatability studies and in a few cases, pilot plant studies to arrive at a proper scheme of treatment. Moreover, it is also necessary to know the quality requirements of the treated effluent, so that the designer knows the level of treatment needed. This aspect has a direct impact on the cost of treatment.

Water Treatment Plants

Conventional method of treatment consists of aeration, sedimentation, filtration, and disinfection for municipal supplies. Industrial consumption may require softening, heavy metals removal, deaeration, demineralization, dissolved solids removal in addition to the conventional method. Economy in the treatment can be achieved by employing the principles of Reduce, Reuse, Recycle, Recover and Replace, taking care to see that these steps do not compromise the quality of the finished product.

Alum is a common coagulant used in water treatment. It is possible to recover it from the sludge which settles in the clarifier. [12,3,4,5]. Recycling a part of the sludge to the raw water (especially water of low turbidity) helps to improve the settling property of the suspended solids in the raw water. It helps to reduce coagulant consumption to some extent.[6,7]Discharging a part of the water treatment plant sludge into the inlet of a sewage treatment plant results in reducing the phosphorus content of the raw sewage- a pollutant responsible for causing eutrophication in the receiving body of treated wastewater.[8]A mixture of sludge and brick dust is useful for reducing the fluoride content of raw water.([9]

Water treatment plants which practise lime-soda softening combined with suspended solids removal, produce a sludge which can be recirculated to the softening unit to increase $CaCo_3$ precipitation without increasing the dose of softening chemicals. If an industrial water treatment plant is working ion exchange on hydrogen cycle, the regeneration water can be mixed with lime sludge to achieve mutual neutralization. [10]

Filter backwash water and desludge water from clarifiers can be economically recycled to the raw water in a treatment plant.[11,12].This practice offers savings in pumping cost of raw water.

Sewage Treatment Plants

Conventional sewage treatment consists of screening, grit removal, primary settling, biological treatment, secondary settling and aerobic or anaerobic digestion of the sludge generated during treatment. Biological treatment includes activated sludge process and its modifications, trickling filtration and modifications, activated sludge followed by trickling filtration or trickling filtration followed by activated sludge, aerobic/anaerobic digestion, waste stabilization ponds, aerated lagoons, vermiculture, hyacinth and duckweed ponds, constructed wetlands etc. If the treated sewage meets stipulated standards (depending on the mode of disposal), it can be discharged into inland surface sources, or into the sea or on land for irrigation. It can be used for other nonpotable purposes provided it is subjected to tertiary treatment. It is necessary to note that domestic sewage is an unfailing source of raw water, because it contains 99.8+% water and the rest consists of organic and inorganic impurities, which can be effectively removed and disposed of.

An important step in conserving water is to use treated sewage for

• agriculture and horticulture from sewered areas,

• industrial and commercial consumption,

• augmenting public water supplies,

• groundwater recharge,

• preventing sea water intrusion,

• making up evaporation losses from lakes.[13]

Sewage treatment plant sludges can be disposed of by:

• land application,

• Landfilling,

• Incineration,

• Ocean disposal,

• Distribution of sludge products such as vitamin B12, [14,15]

• As an additive in other products such as cement,

•Land reclamation in mining operations [16]

• Composting with organic matter such as wood chips [17].

Industrial Wastewater Treatment Plants

Industries produce a variety of waste waters which must be adequately treated before they are discharged into the environment. An ideal condition would be for an industry to eliminate generation of waste waters, which is difficult to achieve. But the least that can be done to reduce the severity of pollution is (i)to reduce the volume and strength of the wastewater streams, (ii) to substitute less polluting chemicals in the manufacturing processes,(iii) to change the manufacturing process, (iv) to maintain good housekeeping practices. In addition, proper treatment and disposal of sludges (after recovery of usable components) generated during treatment is an essential step. A few examples of industries practising the 5 'R' are given below.

Cotton textile: (A) Cotton dust produced during spinning and weaving- used as boiler fuel, or for filling quilts, or composted with cow dung or anaerobically digested with it to get gas and digested sludge as soil conditioner; [18,19,20] (B) Recovering NaOH from spent caustic stream in mercerizing, starch paste from sizing, dyes from dyeing and printing;(C) Recycling boiler condensate as boiler feed, using boiler blowdown for floor washing [21].

Woollen mill : Grease recovery from wool scouring process.[22, 23, 24, 25]

Rayon manufacture: NaOH and zinc recovery. [26]

Jute production : Lime treated waste water used for fish breeding.[(27]

It is a common practice of using countercurrent washing in textile industry.

Dairy : Produce whey, casein,lactose and butter oil from soured milk. [28]

Slaughterhouses : Recover blood, tissues, fat, bone dust, grease fat, horns, hooves, hide trimmings, these being useful as raw materials in other industries. Anaerobic digestion of liquid wastes for gas production. [29, 30]

Fish processing : Production of fish meal and fish solubles. [31]

Tannery : (A) Salt recovery from soaking ponds of raw hides,(B)Hexavalent chromium from chrome tanning, (C)Fleshings for producing chicken feed, (C) Hairs for making industrial brushes, (D) Hide trimmings for making leather boards, (E) Lime sludge for neutralizing acidic soils, (F) Exhausted tan bark from vegetable tanning as boiler fuel, (G) Recovering sulphur from pickling in chrome tanning process for production of H_2SO_4. [32,33]

Sugar production : (A) Bagasse for paper making, or as fuel, or for producing furfural, or for gas production, or for making compost with spent wash from distilleries, (B) Recovery of sugar by Stefan's process from beet molasses.[34,35,36]

Paper making : (A) Recovey of lignin, turpentine and tall oil from black liquor,(B) Fine fiber and water recovery from paper machines, (C) Growing Torula yeast from sulphite liquor, single cell protein from wastewaters of small mills, (D) Countercurrent washing during manufacture.[37]

Pharmaceutical industry : (A) Mycelium for producing chicken feed, (B) Recovery of water and finished product from spent broth, (C) Solvent recovery, (D) Use of exhaust air from fermenters for aeration in activated sludge process. [38, 39,

40, 41]

Distilleries and wineries : (A) Spent wash for anaerobic digestion and gas production, (B) Composting with bagasse from cane sugar industry, (C) Yeast production,(D)Potash recovery by incineration of concentrated spent wash, (E)Recovery of potassium tartarate from winery waste,(E)Production of earthworms. [42 ,43, 44, 45, 46-50, 51,52]

Engineering industry : Mining: Recovery of fine coal from coal washing operations and recycling of wash water;[53, 54] Coke ovens: Recovery of tar, light oils, benzene, toluene, xylene, Recycling of treated coke oven waste water for coke quenching; [55, 56]

Ferrous and nonferrous ore mining : Recycling of water from tailings ponds, recovery of metals such as copper, zinc, gold, uranium. [57]

Iron and steel making : Using hot blast furnace gases for firing coke ovens, returning solids separated by dry gas scrubbers and wet scrubbers to blast furnace and sintering plants. [58]

Aluminium smelting : Red mud formed during smelting of bauxite can be disposed of in landfill, or by use in the manufacture of cement, or converting into bricks, roofing sheets or polymer doors. It is also useful for treatment of acidic soils on account of its high alkalinity; it is used in flue gas desulphurization, removal of heavy metals from industrial wastes and as a coagulant in water treatment. [59, 60]

Pickling,plating : Recovering FeSO4 and HCl from spent pickling baths, recovery of precious metals from spent plating baths, recycling wash and rinse waters from plating operations. [61, 62, 63]

Petroleum refining : Recovering drilling muds for reuse and using oil field brines for recovery of bromine, iodine and magnesium. [64, 65, 66]

Petrochemicals industry : Generation of activated carbon from acidic sludge, recovery of glycerine from waste stream containing inorganics and polyglycerines using reverse osmosis. [67, 68, 68A]

Fertilizers and pesticides : Using fluoride-bearing effluent for recovery of fluosilicic acid or further conversion to sodium or magnesium silicofluoride, recycling and reuse of treated effluents to reach 'zero discharge'status. [69-72]

Vegetable oil, food and allied industries : Making activated carbon from rice hulls.[73,74].Recovery of starch and power generation from effluent. [75, 76, 77].

Zero Liquid discharge (ZLD)

Industries are required to observe this condition so that (a)Severity of environmental pollution is reduced, (b) they can reduce their fresh water consumption and (c) they can recover usable components from their wastewater streams.

The attributes of a ZLD scheme are: (i) It should not produce additional pollutants, (ii)It should transfer the pollutants into solid form such as powder, sludges etc and (iii)It should have provision to store the powders, sludges etc in a secured landfill. These are achieved by judicious use of the 5'R'. A few textile mills, distilleries, aerated drinks industries, pharmaceutical producers and a coal-based thermal power plant have successfully reached the ZLD status.

It may be said in conclusion that sustainable development can be achieved if sincere efforts are made by all stakeholders to not only control pollution, but also to eliminate it at source wherever feasible. Extensive use of the 5'R' will be helpful in this regard.

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Waste Management in Karnataka

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Abstract

In this study, secondary information available in public domain was reviewed to understand the current status of Municipal Solid Waste Management (MSWM) in Karnataka and problems faced during handling, transporting, storing and disposal of Municipal Solid Waste. This study revealed that in Karnataka, over 50% of the municipal solid waste is generated in six municipal corporations i.e. Bengaluru, Mysuru, Hubballi - Dharwad, Belgaum, Mangalore & Dharwad; door to door collection has been introduced only in few wards of Mysuru and Bengaluru, the bulk of the solid waste is still collected in community bins; segregated waste are getting mixed up during transportation; intermediate storage points are not established. In most parts of the state, wastes are not processed properly and enforcement with respect to segregation of waste at source is very poor except in core areas of Bruhat Bengaluru Mahanagara Palike.

Keywords: *Bruhat Bengaluru Mahanagara Palike (BBMP); Biomedical waste; Common Biomedical waste treatment facility; Municipal solid waste*

Introduction

In the year 2013 – 14, Karnataka state had generated about 8784 tonnes/day of MSW out of which.

- BBMP generated 3500 T/D of MSW and collected 3000 T/D (85%) of MSW.
- Other 218 local bodies generated 5284 T/D and collected 4602 T/D (87%) of MSW.

House to house collection has been partially started in all the local bodies. Some local bodies have even provided two bins to each house to collect organic and inorganic waste separately from the households. However, Karnataka State Pollution Control Boarb (KSPCB) study has revealed that segregated waste is getting up mixed while transporting MSW to landfill sites.

Government and private health care establishments including clinics with less than 1000 patients are handing over BMW to 29 KSPCB authorized CBMWTF to avoid littering of treated/untreated Biomedical Waste in the garbage.

Household BMW such as syringes, sanitary napkins, expired medicine, bandages etc., are not collected separately and are getting mixed up with other solid waste. Hence, a separate collection system is required to collect household BMW so that segregated BMW can be transported to KSPCB authorized CBWTF's for further treatment.

Auto tippers and hand driven push carts are provided by the local bodies to collect and transfer the waste from the households to the transfer points.

Segregation of Waste

Only households in the core area of BBMP are segregating the waste into organic and inorganic before handing over it to the waste collectors. In other parts of the state, local bodies have to enforce the practice of waste segregation at household level. Strict enforcement is also required to avoid mixing up of waste during transportation.

Storage of Waste

Major roads and vacant sites are used as intermediate storage points and also to transfer waste from one vehicle to another. This practice is causing problem to public in terms of odor, aesthetics etc., Local bodies should look forward

to establish intermediate storage points in way that will not cause any nuisance to public.

Transportation of Waste

Uncovered vehicles results in the spillage of waste during transportation hence "Department of Ecology and Environment" had issued orders in 2004 to restrict the use of common vehicles for transporting the waste.

Waste spillage during transportation can be avoided by using covered vehicles with hydraulic compacters. Only registered vehicles with KSPCB are being used for transporting waste.

Processing of Waste

Landfill sites with basic infrastructure facilities such roads, weight bridge etc., have been provided in most of the local bodies but the wastes are not processed properly in these landfill sites. This means that wastes are only being dumped without any treatment.

In small local bodies such as town municipal councils, taluk panchayat's etc., waste can be easily processed if the wastes are segregated into organic and inorganic. Koppal Method of Composting is the best and simple technique for composting waste in small local bodies.

13 bio-methanization plants has been set up by BBMP for the processing of waste.

Disposal of Waste

Life of the landfill sites are becoming short and lands available for the processing of waste are very scare. Under this background, 80 % of the waste needs to be reused/ recycled/ re-processed. Only 15-20 % of the inert wastes that cannot be either reused / recycled must be disposed in landfill sites.

BBMP has identified seven Nos. of landfill sites exclusively for dumping using engineering method of landfilling operation.

Conclusion

Waste management can be successful if the waste are segregated into organic and inorganic at the source itself. Since the life of the landfill sites is getting shortened and land available for waste processing is scare 4R method must be adopted i.e. reduce, recycle, reuse and recover.

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