Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 2, Number 15; April-June, 2015 pp. 1255-1259

http://www.krishisanskriti.org/jbaer.html

# Urban Waste Water: Treatment & Re-use: A Theoretical Perspective

**Susmita Mukherjee[1], Subhro Chakraborty[2], Surajit Sur[3], Md Iqbal Ahmad[4] and Aritra Guin[5]**

[1]*Dept. of Social & Management Science, Indian Institute of Engineering Science & Technology, Shibpur, West Bengal, India*
[2,3,4]*University Of Engineering And Management, Jaipur, India*
[3]*University Of Engineering And Management, Jaipur, India*

**Abstract—***Urban waste water management is a global concern. All human activities result in generation of waste and with increase in global population and economic activities the amount of waste water generation has increased. According to water report of United Nations Environment Programme (UNEP) & UN Habitat (2010) up to 90% untreated waste water is generated in highly populated cities and due to lack of sewage treatment facility this untreated waste water is thrown into the nearby rivers and lakes resulting into pollution of the receiving water bodies. Rapid urbanization has led to increased volume of urban sewage generation leading to increased cost of treatment. An estimated 38354 million litres per day (MLD) sewage is generated in major cities of India, but the sewage treatment capacity is only of 11786 MLD. Similarly, only 60% of industrial waste water, mostly large scale industries, is treated. It is obvious that, if this huge volume of untreated waste water is recycled then it would be a help towards addressing water scarcity at the same time avoiding pollution of the receiving water bodies. The treated waste water can complement the water requirement in agriculture, aquaculture and industry. One major intervention towards dealing with urban waste water can be, to consider the waste not as a noxious material but as a resource. India being a tropical country has the potentiality to utilize the solar radiation to convert the waste in to resource through stabilization pond method (shallow depth pond where waste is treated mainly with sunlight).*

*The present study approaches to establish the gap between waste water generation and availability of conventional treatment facility in urban areas, to analyze and explore the possibility of converting waste to resource by stabilization pond method, as an alternative, with special reference to East Kolkata Wetlands, West Bengal, India, and also to recommend for such a technology, which apart from being indigenous and environment friendly has got economic importance too.*

**Keywords***: stabilization pond, waste water, conventional sewage treatment, East Kolkata Wetlands*

## 1. INTRODUCTION

For all Indian cities waste water is generally a combination of domestic effluent which includes black water (toilet waste water) and grey water (bathroom & kitchen waste), water from commercial places & institutions and industrial waste water. This situation makes the waste water management more difficult. Unplanned & rapid urbanization, people's inclination towards city are making the situation fierce leading to increased cost of sewage treatment. In urban India, per capita cost of conventional sewage treatment is Rs 4704 (Source: Anon 2011, Report of Indian Urban Infrastructure & Service, the high powered expert committee for estimating the investment requirement for urban infrastructure service, JNNURAM, Ministry of Urban development, GOI, New Delhi). Cities like New Delhi or Mumbai have 40% sewage treatment capacity by conventional method.

This reflects that, the conventional waste water treatment facility is not up to the requirement and consequently lot of untreated waste water is thrown into the natural water bodies causing damage to the ecosystem. Hence an effective waste water management plan is the need of the time. This can be planned with the realization that waste water is a resource and if managed properly can supplement water requirement in agriculture, fishery, industry etc. Wastewater reuse in aquaculture is a reality in several Asian countries including Bangladesh, China etc. In India, West Bengal is pioneer in practice of converting waste to resource for further utilization by non-conventional method. The most accepted one in India is the stabilization pond method. The technology is indigenous it treats the waste by maintaining the balance and harmony of nature and is low cost.

This paper is an effort to analyze with facts and Fig. ures the present situation of waste water management, the considerable gap between demand & supply i.e. the dearth of conventional sewage treatment facility and obviously creating a space for substitute. In this paper waste water fed fishery has been discussed as the substitute. India being a tropical country has enough of sunny days where stabilization pond method can be a successful alternative approach. One remarkable example of this is the resource recovery region of East Kolkata Wetlands, West Bengal, India. The service provided by these wetlands is beyond cleaning city sewage it also provides livelihood to a large group of people. Unfortunately such invaluable service is not given deserving attention. The time has come to draw the attention of the policy makers towards enhancing the potentiality of this service.

## 2. WASTEWATER PRODUCTION AND TREATMENT

With rapid expansion of cities and domestic water supply, quantity of wastewater is increasing in the same proportion. As per CPHEEO estimates about 70-80% of total water supplied for domestic use gets generated as wastewater. The per capita wastewater generation by the class-I cities and class-II towns, representing 72% of urban population in India, has been estimated to be around 98 lpcd while that from the National Capital Territory-Delhi alone (discharging 3,663 mld of wastewaters, 61% of which is treated) is over 220 lpcd (CPCB, 1999). As per CPCB estimates, the total wastewater generation from Class I cities (498) and Class II (410) towns in the country is around 35,558 and 2,696 MLD respectively, while the installed sewage treatment capacity is just 11,553 and 233 MLD respectively thereby leading to **a gap of 26,468 MLD in sewage treatment capacity**. Maharashtra, Delhi, Uttar Pradesh, West Bengal and Gujarat are the major contributors of wastewater (63%; CPCB, 2007a). Further, as per the UNESCO and WWAP (2006) estimates (Van-Rooijen et al., 2008), the industrial water use productivity of India (IWP, in billion constant 1995 US$ per m3) is the lowest (i.e. just 3.42) and about 1/30th of that for Japan and Republic of Korea. It is projected that by 2050, about 48.2 BCM (132 billion litres per day) of wastewaters (with a potential to meet 4.5% of the total irrigation water demand) would be generated thereby further widening this gap (Bhardwaj, 2005). Thus, overall analysis of water resources indicates that in coming years, there will be a twin edged problem to deal with reduced fresh water availability and increased wastewater generation due to increased population and industrialization.

In India, there are 234-Sewage Treatment plants (STPs). Most of these were developed under various river action plans (from 1978-79 onwards) and are located in (just 5% of) cities/ towns along the banks of major rivers (CPCB, 2005a). In class-I cities, oxidation pond or Activated sludge process is the most commonly employed technology, covering 59.5% of total installed capacity.

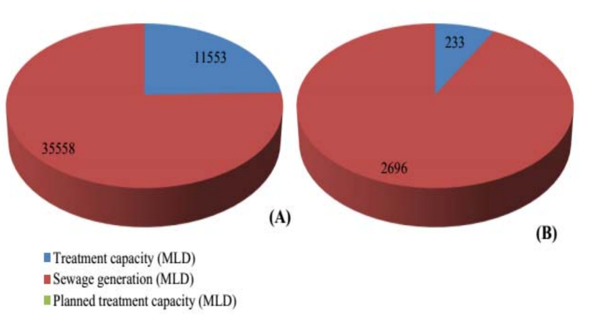


**Fig. 1: Sewage Generation and Treatment Capacity in 498 Class I Cities and 410 Class II Towns In India**

This is followed by Up-flow Anaerobic Sludge Blanket technology, covering 26% of total installed capacity. Series of Waste Stabilization Ponds technology is also employed in 28% of the plants, though its combined capacity is only 5.6%.

Apart from domestic sewage, about 13468 MLD of wastewater is generated by industries of which only 60% is treated. In case of small scale industries that may not afford cost of waste water treatment plant, Common Effluent Treatment Plants (CETP) has been set-up for cluster of small scale industries (CPCB, 2005b). Treated industrial waste water from CETPs mixed disposed in rivers. For example, 10 CETPs from Delhi with capacity of 133 MLD dispose their effluent in Yamuna River.

The conventional wastewater treatment processes are expensive and require complex operations and maintenance. It is estimated that the total cost for establishing treatment system for the entire domestic wastewater is around Rs. 7,560 crores (CPCB, 2005a), which is about 10 times the amount which the Indian government plans to spend (Kumar, 2003). Table 1 illustrates the economics of different levels of treatments through conventional measures (CPCB, 2007b).

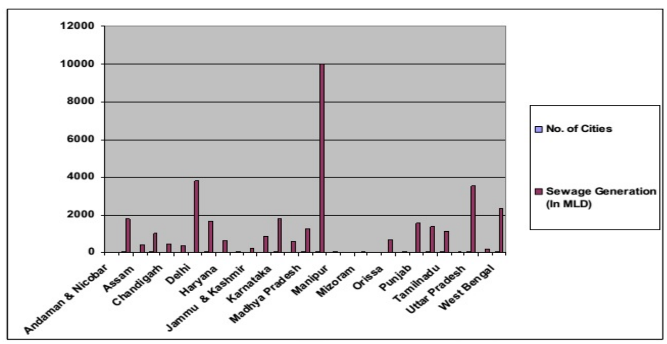


**Fig. 2: Sewage Generation of Class I Cities**

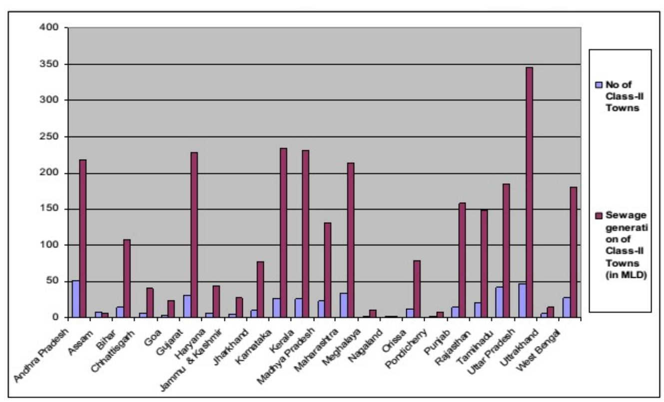


**Fig. 3: Sewage Generation of Class II Towns**

The sludge removal, treatment and handling have been observed to be the most neglected areas in the operation of the sewage treatment plants (STPs) in India. Due to improper design, poor maintenance, frequent electricity break downs and lack of technical man power, the facilities constructed to treat wastewater do not function properly and remain closed most of the time (CPCB, 2007b). Utilization of biogas generated from UASB reactors or sludge digesters is also not adequate in most of the cases. In some cases the gas generated is being flared and not being utilized.

**Table1: Economics of Different Levels of Treatment through Conventional Measure**

| Particulars | Primary treatment system | Primary + ultra filtration system | Primary + ultra filtration system + reverse osmosis |
|---|---|---|---|
| Capital cost (Rs lakhs) | 30.0 | 90.64 | 145 |
| Annualized capital cost (@15% p.a. interest & depreciation | 5.79 | 18.06 | 29.69 |
| Operation and maintenance cost (lakhs/annum) | 5.88 | 7.04 | 12.63 |
| Annual burden (Annualized cost +O&M cost) Rs. Lakhs | 11.85 | 27.1 | 42.5 |
| Treatment cost Rs./kl (Without interest and depreciation) | 34.08 | 52.40 | 73.22 |

**Table2: Waste Water Generation And Treatment Capacity In Urban Centr**

| *Parameters* | *Class I cities* | | | | | *Class II towns* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *1978–9* | *1989–90* | *1994–5* | *2003–4* | *2009* | *1978–9* | *1989–90* | *1994–5* | *2003–4* | *2009* |
| Number | 142 | 212 | 299 | 423 | 423 | 190 | 241 | 345 | 498 | 498 |
| Population (millions) | 60 | 102 | 128 | 187 | 187 | 12.8 | 20.7 | 23.6 | 37.5 | 37.5 |
| Water Supply (mld) | 8638 | 15,191 | 20,607 | 29,782 | 44,448 | 1533 | 1622 | 1936 | 3035 | 3371 |
| Wastewater Generated (mld) | 7007 | 12,145 | 16,662 | 23,826 | 35,558 | 1226 | 1280 | 1650 | 2428 | 2696 |
| Wastewater treated (mld) (per cent) | 2756 (39) | 2485 (20.5) | 4037 (24) | 6955 (29) | 11,553 | 67 (5.44) | 27 (2.12) | 62 (3.73) | 89 (3.67) | 234 |
| Wastewater untreated (mld) (per cent) | 4251 (61) | 9660 (79.5) | 12,625 (76) | 16,871 (71) | 24,004 | 1160 (94.56) | 1252 (97.88) | 1588 (96.27) | 2339 (96.33) | 2463 |

**Table3: Waste Water Generation For Urban Centres: (Projections For 2051)**

| *Year* | *Urban population (million)* | *Wastewater generation lpcd* | *Gross wastewater generation (mld)* |
|---|---|---|---|
| 1977–8 | 72.8 | 116 | 7007 |
| 1989–90 | 122.7 | 119 | 12145 |
| 1994–5 | 151.6 | 130 | 16662 |
| 2003–4 | 243.5 | 121 | 26254 |
| 2009 | 316.15 | 121 | 38254 |
| 2051 | 1000 (Projected) | 121 (Assumed) | 120000 (Projected) |

One of the major problems with waste water treatment methods is that none of the available technologies has a direct economic return. Due to no economic return, local authorities are generally not interested in taking up waste water treatment. A performance evaluation of STPs carried out by CPCB in selected cities has indicated that out of 92 STPs studied, 26 STPs had not met prescribed standards in respect to BOD thereby making these waters unsuitable for household purpose. As a result, though the waste water treatment capacity in the country has increased by about 2.5 times since 1978-79 yet hardly 10% of the sewage generated is treated effectively, while the rest finds its way into the natural ecosystems and is responsible for large-scale pollution of rivers and ground waters (Trivedy and Nakate, 2001).

## 3. LOOKING FOR AN ALTERNATIVE APPROACH: THE NON-CONVENTIONAL METHOD

Enormous amount of waste water should not remain unutilized or create health hazardous, rather be returned to the ecosystem for various benefits. This is the basic of converting waste to resource. In India waste water reuse is practiced majorly by stabilization pond method. A World Bank Report (Shuval et al. 1986) advocated strongly in favour of stabilization ponds as the most suitable wastewater treatment system in developing countries, where land is often available at reasonable opportunity cost and skilled labour is in short supply. Waste water is reused in different sectors but one major practice is through waste water fed fishery. Most of the waste water fed aquaculture in the world is practiced in Asian countries especially India, China, Bangladesh. In Bangladesh waste water reuse in aquaculture is not a traditional system, though in Dhaka, 50 hectors of sewage-fed lakes and ponds are used for the same (Rahman, 1992). In China it started with Hangkou fish farm in Wuhan in 1980. Later on (Li. S. F, 1996) it was found that two major constraints for waste water fed aquaculture are, eutrophication and industrial pollution caused by rapid urbanization and industrialization. In China & Indonesia waste water fed pisiculture produces several species of carps. In Vietnam, waste water reuse is a traditional practice. African country Egypt has a chronic shortage of fresh water and research conducted on the feasibility of waste water fed aquaculture. Tilapia culture in secondary-treated effluent is practiced in Cairo, and chemical analysis for heavy metals and microbial analysis for bacteria were found to be acceptable for human consumption (Khalil & Hussein, 1997). In Germany, waste water fed aquaculture was not successful because of increased land values, increased costs of salaries of fish farmers and need of alternative treatment process in winters of temperate climate. In Latin American countries Tilapia culture is practiced in waste water.

In India waste water fed aquaculture is practiced majorly in Kerala and West Bengal. West Bengal provides world's largest waste water fed fishery, the East Kolkata Wetlands, in the eastern part of the city (Nandeesha, 2002), a unique example of waste to resource conversion and recognized as Ramsar site. Demographically East Kolkata Wetlands (EKW) include, 100 villages some urban areas, a total population of 107442 and 264 commercial fisheries of which 89% is more than 20 hector size and 11% is less than 20 hector (data source: Survey by Creative Research Group, 1997). The wetlands act as a sink for the city of Kolkata, around 3500 tons of municipal waste and 680 million litres of raw sewage enter the wetland system every day providing livelihood option to 53% families (according to the household survey conducted in 2005-06). This wetland area of 3500 hector generates approximately 2 tonns of fish per day which is 18% of the city's demand of fish (Nandeesha 2002). The fish pond ecosystems here naturally treat the effluent released by Kolkata Municipality and thus save around Rs1300 million per year and for the fish farmers using sewage as fish feed in their production, an expenditure of Rs 60 million is averted per year ( Ghosh, 2005).

**Fig. 4: EKW fish pond**

The experience of the farmers who developed this technology over the past few decades has been replicated in three municipalities within the Kolkata Metropolitan area, under Ganga Action Plan. This has reduced the adverse environmental impact due to discharge of municipal wastes in the river Ganga and also to have benefit of avoiding further construction of capital intensive sewage treatment plant.

## 4. THE TECHNOLOGY OF STABILIZATION POND WITH REFERENCE TO EKW

The technology of resource recovery is indigenous and developed by the fish farmers over the years. The whole resource recovery region of EKW comprises of canal systems and the fish ponds. There are two major canals, DWF (Dry Weather Flow) & SWF (Storm Weather Flow), the network of distribution canals known as Fishery Feed Canals (FFC). The DWF canal carries the waste water to the resource recovery zone from the pumping stations, in normal days and during monsoon time the excess water is flown through SWF canals, the FFCs carries waste water from DWF canals to fish ponds (locally known as bheri), which perform the role of stabilization ponds. The waste water from DWF canal through ancillary canals (FFD) is introduced in the fish ponds as readily available fertilizer.

The waste water is generally introduced twice a week (it varies depending on availability of wastewater & seasonally) in the fish ponds. The water with organic waste material is detained in the fish ponds for few days during this period the wastes get decomposed and mineralization happens and these minerals through food chain enter in to fishes' system. Thus the BOD (Biochemical Oxygen Demand) i.e. organic loading of the waste water decreases and the treated water passes out of the pond and reaches to final discharge point again trough canal system. In conventional sewage treatment usually three ponds are used sedimentation (anaerobic), facultative and aerobic, each has a separate role but the uniqueness in EKW fish ponds is that it is single pond treatment (Metacaffe 1972).

**Fig. 5: The main DWF canal entering in the EKW area**

## 5. THE CONCERNS IN STABILIZATION POND METHOD

This stabilization pond method of treating waste water has got many folds benefits but it deserves attention to make it sustainable. One major challenge faced by peri-urban wetlands, the natural stabilization ponds is conversion for commercial purposes. The nature of waste water is another problem, in India unplanned and indiscriminate industrial discharge in the city waste water degrades the quality of waste leading to decrease in the yield both qualitatively and quantitatively. This also poses threat to the sustainability of this process of fish cultivation. The possibility of wastes containing heavy metals and toxic materials cannot be ignored in such cases and this gives rise to concern about bioaccumulation through food chain. Hyper-eutrophication is a major problem in the waste-fed fish ponds. Waste water on its way from pumping station to the fish ponds flows through canal system. During this process the waste water undergoes self–rectification thus the BOD (organic loading) gets decreased prior entering the stabilization pond which affects the productivity. Apart from that in this process of mineralization the degraded or half degraded material settles at the bottom and years after years this goes on resulting into siltation in the canal system which reduces the normal flow of the waste water. As a result waste cannot flow and cannot enter the ponds by gravity, hence the waste water needs to be pumped into the ponds incurring huge cost. The siltation in the stabilization pond causes decrease of depth of stabilization pond which in turns effect productivity.

## 6. CONCLUSION

Presently there are no separate regulations/ guidelines for safe handling, transport and disposal of wastewater in the country. The existing policies for regulating wastewater management are based on certain environmental laws, certain policies and

Constitutional Provisions. Though there are central schemes, such as National River Conservation Plan, National Lake Conservation Plan, Jawaharlal Nehru National Urban Renewal Mission, and Urban Infrastructure Scheme for Small and Medium Towns (MoEF, 2012). However, operation and maintenance of sewerage infrastructure including treatment plants are responsibilities of State governments/urban local bodies and their agencies. In developing countries like India, the major problem associated with urban wastewater arises from its lack of treatment facility, which generatess to a huge gap between the existing facility and the requirement. It has been discussed that stabilization pond method can be successfully implemented in India. The challenge thus is to make it viable. The use of constructed or natural wetlands is now being recognized as an efficient technology for wastewater treatment. Compared to the conventional treatment systems, constructed wetlands need lesser material and energy, are easily operated, have less sludge disposal problems and can be maintained by untrained personnel. Further these systems have lower construction, maintenance and operation costs as these are driven by natural energies of sun, wind, soil, microorganisms.

Hence, for planned, strategic, safe and sustainable use of wastewater there seems to be a need for policy decisions and coherent programs encompassing low-cost decentralized waste water treatment technologies. To make the non-conventional waste water treatment viable government support is required to promote this among farmers, connecting them to financial assistance, helping the farmers to form cooperatives, making them more organized etc. More research is also required on how to make this system more productive beyond just an alternative sewage treatment mechanism towards sustainability of the same.

## REFERENCE


[1] Billore, S.K., Singh, N., Sharma, J.K.,Nelson, R.M., Dass, P. (1999). Horizontal subsurface flow gravel bed contructed wetland with Phragmites karka in Central India. Water Science and Technology. 40: 163-171.

[2] Billore, S.K., Singh, N., Ram, H.K., Sharma, J.K., Singh, V.P., Nelson, R.M., Dass, P. (2001). Treatment of molasses based distillery effluent in a contructed wetland in Central India. Water Science Technology. 44: 441-448.

[3] Billore, S.K., Ram, H., Singh, N., Thomas, R., Nelson, R.M., Pare, B. (2002). Treatment performance evaluation of surfactant removal from domestic wastewater in a tropical horizontal subsurface constructed wetland. In: Proceedings of the 8th International Conference on Wetland Systems for Water Pollution Control, University of Dar-es-Salaam, Tanzania and IWA, pp. 393399.

[4] CGWB. 2011. Ground Water Year Book - India 2010-11. Central Ground Water Board, Ministry of Water Resources. Government of India. http://www.cgwb.gov.in/documents/Ground%20Water%20Year%20Book-2010-11.pdf

[5] CPCB (1999). Status of water supply and Wastewater Collection Treatment & Disposal in Class I Cities-1999, Control of Urban Pollution Series:CUPS/44/1999-2000. CPCB. 2005a. Parivesh Sewage Pollution – News Letter. Central Pollution Control Board, Ministry of Environment and Forests, Govt. of India, Parivesh Bhawan, East Arjun Nagar, Delhi 110 032 http://cpcbenvis.nic.in/newsletter/sewagepollution/contentsewagepoll-0205.htm

[6] CPCB. 2005b. Performance status of common effluent treatment plants in India. Central Pollution Control Board, India.

[7] CPCB. 2007a. Evaluation of Operation and Maintenance of Sewage Treatment Plants in India2007, Control of Urban Pollution Series: CUPS/68/2007. Central Pollution Control Board, India.

[8] CPCB. 2007b. Advance methods for treatment of textile industry effluents, Resource Recycling Series: RERES/&/2007. Central Pollution Control Board, India.

[9] CPCB. 2009. Status of water supply, wastewater generation and treatment in Class I cities and Class II towns of India. Series: CUPS/70/2009-10. Central Pollution Control Board, India.

[10] CWC. 2010. Water and related statistics. Water Planning and Project Wing, Central Water Commission, India.

[11] Ghosh D., 2005, Ecology & Traditional Wetland Practice: Lessons from waste water utilization in East Kolkata Wetlands (book), Worldwide, Kolkata, India

[12] Jayakumar KV and Dandigi MN. 2002. A cost effective environmentally friendly treatment of Municipal wastewater using contructed wetlands for developing countries In: Proceedings of the 9th International Conference on Urban Drainage, Portland, Oregon, USA.

[13] Juwarkar AS, Oke B, Juwarkar A and Patnaik SM. 1995. Domestic wastewater treatment through constructed wetland in India. Water Science and Technology 32: 291-294.

[14] Kaur R, Dhir G, Laishram G, Ningthoujam D, Kumar P. 2012. Nutrient and trace metal removal efficiency of small scale (batch fed) vertical flow municipal wastewater treatment wetlands (REF NO: ECOS2012_0163). Accepted for Oral Presentation at 4th International Eco-Summit on Ecological Sustainability-Restoring the Planets Ecosystem Services. www.ecosummit2012.org/conference-venue-columbus.html

[15] Khali MT and HA Hussein, 1997, Use of waste water for aquaculture, An experimental field study at a sewage treatment plant, Egypt, Aquaculture Research, 28,859-865

[16] Li S.F., 1996. Aquaculture & its role in ecological waste water treatment. In: C Etnier and B. Guterstam (eds) Ecological Engineering for waste water treatment, Proc. Int. Conf. At Stensund Folk College, Sewden, March24-28, 1991, CRC Press, Boca Raton,second edition, 37-49pp.