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Wastewater Treatment Technologies Adopted in different Sewerage Treatment Plants (STP's) of City Delhi: An Review

Prerna Sharma[1], Sudipta K Mishra[2] and Smita Sood[3]

[1]*Department of Basic & Applied Sciences, G D Goenka University, Gurgaon*
[2]*Department of Civil Engineering, G D Goenka University, Gurgaon*
[3]*Department of Basic & Applied Sciences, G D Goenka University, Gurgaon*
E-mail: [1]prerna.sharma@gdgoenka.ac.in, [2]sudipta.mishra@gdgoenka.ac.in, [3]smita.sood@gdgoenka.ac.in

Abstract—*This review paper emphases on the wastewater treatment technologies adopted in different Sewerage Treatment Plants (STP's) of city Delhi. Some of the Salient features of the STP's in context of their respective methodologies and functional units is being put forward. Factors affecting selection & design of Sewerage Treatment Plants are being highlighted. This paper also draws attention towards the waste water generation in Delhi along with Delhi Contribution to Pollution in Yamuna. Some of the work inculcated in the paper indicates the utilisation & application of the respective treatment technology. Environmental Problems related to STP's with respective treatment technique have been discussed. The paper ends with some of the future scope to improve the efficiency of the STP's which involves the simulation & modelling of the technologies used for the wastewater treatment.*

Keywords*: Wastewater Treatment, Sewerage Treatment Plants (STP's), Operational Units.*

1. INTRODUCTION

In early days waste products of the society including human excreta were been collected, carried & disposed of manually by the human beings and this system is called dry conservancy system. This system leads to bad smell and health hazard. Now days with the march of civilization & development proper disposal of waste done by a new system called sewerage system that had replaced the old dry conservancy system. In the sewerage system, the waste mixed with water is called sewage. Sewage carried through close pipes or lines called sewers to the place away from the residential area under the force of gravity to Sewerage Treatment Plant (STP). Here sewageis treated before disposing in the environment. Sewage includes dissolved and suspended organic solids, number of living microorganism, which lead into bad condition, odour and appearance. Microorganism may contain disease-producing (pathogenic) bacteria and viruses that can be readily transferred by sewage from sick individuals to well ones. So by removing it properly environment can be maintained in an acceptable and safe condition.

State and Local authorities with statutory authority in pollution control have established standards of purity that are necessary to prevent pollution of natural waters. When waste is discharged into controlled amount, the standards set by State and Local authorities are maintained. Domestic sewage consists of waste from toilets, lavatories, urinals, bathtubs, showers, home laundries and kitchens. It also includes similar wastes from medical dispensaries and hospitals.

2. PRESENT SCENARIO OF STP'S IN DELHI

2.1 Waste Water Generation

Large quantity of Sewage is generated in city Delhi. It is being estimated that the total quantity of sewage generated in the city is 2871 MLD & the total capacity of the Sewerage treatment plants (STP's) in Delhi is 1478 MLD. Rest of the 48% of untreated Sewage which is approximately 1393 is being disposed into Yamuna River through various 19 drains which is also receiving effluents from the industries. 2546.88 MLD of Sewage is generated in Delhi out of which only 885.3 MLD of Sewage is being collected through various sewage networks and 1661.84 MLD of Sewage flow in storm water drains.

2.2 Contribution to Pollution Yamuna

The Sewerage Treatment Plants (STP's) in Delhi contribute a lot towards the pollution of river Yamuna. Pollutions brings physical, chemical biological changes in the water of Yamuna damaging its quality & making it unfit for human consumption as well as other purposes. Although only one percent of the Yamuna catchment area is of the National Capital Territory but the intensity of the pollution caused by it very high. Studies says that 80% of the district of Delhi suffers because of the 22 km stretch where effluents pour into river. MPN that is the "Most Probable Number" which indicates the E.Coli have been found very high indicating the degree of pathogens in that one percent stretch of river Yamuna.

3. WASTEWATER TREATMENT TECHNOLOGIES ADOPTED AT DIFFERENT SEWERAGE TREATMENT IN DELHI.

Many researchers have conducted various studies on the treatment technologies used for the treatment of sewage/wastewater. Abid Ali Khan et al. (2011) studied that up flow anaerobic sludge blanket (UASB) process is reported to be a sustainable technology for domestic wastewaters treatment in developing countries and for small communities. Study on the filtration methods like MBBR, FBBR etc. have been made by various researchers. Wen K. Shieh and John D. Keenan (1986) found that the fluidized bed biofilm reactor (FBBR) represents a recent innovation in biofilm processes. A.P. Annachhatre and S.M.R. Bhamidimarri (1992) studied that optimal steady-state performance of any biofilm reactor requires a fully developed and mature biofilm. Markus Boller (1997) found that the three conferences on "Small Wastewater Treatment Plants" organized by the IAWQ Specialist Group demonstrate worldwide interest and activities in this matter and the need to exchange experience concerning planning, design, construction, operation, maintenance and control of small treatment plants. R.A. Barbosa and G.L. Sant' Anna Jr (1989) carried out a study in which the treatment of raw domestic sewage at ambient temperatures in an Upflow anaerobic sludge blanket (UASB) reactor with a volume of 120 l. and a height of 1.92 m was taken care off. Kwan Chow Lin et al. (1991) studied about a comprehensive review of the UASB wastewater Treatment process.[1-22]

3.1 Salient Features of the Sewerage Treatment Plants Evaluated by CPCB

Table 3.1: Source Central Pollution Control Board (CPCB)

S.No	Name of STP	Location	Core treatment Processes	Capacity /day	Year of Installation	Organizing and Managing Agency	Discharge / Reuse
1.	Coronation Pillar STP's 1) 10 2) 10+20	Coronation Pillar, Mukharji nagar, Delhi	Activated Sludge Process (ASP), Trickling Filter & ASP	45.46 45.46 90.92	1957	Delhi Jal Board	Najafgarh drain to Yamuna River
2.	Delhi Gate 2.2	Delhi Gate, Nalah, Delhi	High rate bio-filters Densadeg technology	10.00	1995	Delhi Jal Board	River Yamuna
3.	Ghitorni (5)	Ghitorni, Delhi	Activated Sludge Process	22.73		Delhi Jal Board	River Yamuna
4.	Keshopur STPs 1) 12 2) 20 3) 40	Keshopur, outer ring road, Delhi-18	All the three plants designed on Activated Sludge Process	54.55 90.92 181.84	1) 1956 2) 1976 3) 1986	Delhi Jal Board	Najafgarh drain to Yamuna river
5.	Kondli STP's 1) 10- Phase I 2) 25- Phase II 3) 10-Phase III	Kondli, Delhi	All three Activated Sludge Process	45.46 113.65 45.46	1) 1979 2) 1990 3) 1995	Delhi Jal Board	Shahdara drain to Yamuna River
6.	Mehrauli STP(5)	Mehrauli, New Delhi	Extended Aeration	22.73	2003	Delhi Jal Board	River Yamuna
7.	Najafgarh STP (5)	Najafgarh, New Delhi	Activated Sludge Process	22.73	2000	Delhi Jal Board	Najafgarh Drain to Yamuna river

8.	Nilothi STP (40)	Nilothi, New Delhi	Activated Sludge Process	181.84	2002	Delhi Jal Board	Najafgarh Drain to Yamuna river
9..	Narela STP (10)	Narela, New Delhi	Activated Sludge Process	45.46	2003	Delhi Jal Board	Najafgarh Drain to Yamuna river
10.	Okhla STP's 1) (12) 2) (16) 3) (30) 4) (37) 5) (45)	Okhla, Mathura Road, New Delhi-20	All the plants designed on Activated Sludge Process	54.55 72.73 136.38 168.20 204.57	1937-1990	Delhi Jal Board	New Agra Canal/Old Agra Canal near Jasola Village/Sarita Vihar Bridge
11.	Papankala n STP (20)	Papankalan, New Delhi	Activated Sludge Process	90.92	2002	Delhi Jal Board	Najafgarh Drain to Yamuna river
12.	Rithala STP's 1) (40) Old 2) (40) New	Sec-11, Rohini, Delhi	Activated Sludge Process & High rate aerobic ASP &biofor	181.84 181.84	1)1990 2)2002	Delhi Jal Board	Rohini/ Nangloi Drain Yamuna River, Wazirabad Barrage
13.	Rohini STP (15)	Rohini, Delhi	Activated Sludge Process	68.19	-	Delhi Jal Board	Supplementary drain to Najafgarh drain to Yamuna river
14.	Sen N.H. STP (2.2)	Sen N.H. Nalah, Ring Road, Delhi	High Rate Bio filter	10.0	1995	Delhi Jal Board	Yamuna River
15.	Timarpur O.P. (6)	Timarpur, Delhi	Oxidation Ponds	27.27	1980	Delhi Jal Board	Najafgarh Drain to Yamuna river
16.	Yamuna Vihar STP's 1)Phase I (10) 2) Phase II (10)	Yamuna Vihar, Delhi	Activated Sludge Process	45.46 45.46	1) 1998 2) 2002	Delhi Jal Board	Shahdara drain to Yamuna River
17.	Vasant Kunj STP's 1) (2.2) 2) (3.0)	Vasant kunj, New Delhi	ASP & Extended Aeration	10.00 13.63	1) 1992 2) 1998	Delhi Jal Board	Partly to Sanjay Van to Kushak drain

Lucas Seghezzo et al. (1998) conducted a study and observed that anaerobic treatment process is increasingly recognized as the core method of an advanced technology for environmental protection and resource preservation and it represents a sustainable and appropriate wastewater treatment system for developing countries. Amit Sonune and Rupali Ghate (2004) studied that Wastewaters are waterborne solids and liquids discharged into sewers that represent the wastes of community life. Some of the researchers have also done comparative analysis of sewerage treatment plants in Delhi. Priyanka Jamwal and Atul k.Mittal (2008) carried out a study on Physical, chemical and microbiological efficiencies of Sewage Treatment Plants (STPs) located in Delhi's watershed in context of different treatment technologies employed in these plants.

Bjorn Rusten et al. (1998) studied on the innovative moving bed biofilm reactor/solids contact reaeration (MBBR/SCR) process that has been chosen for a new waste water treatment plant serving a population of 2, 00,000 at Moa Point, Wellington, New Zealand. Because the MBBR/SCR combination was a new one hence a pilot-scale demonstration project was made part of the contract. Mark W. Fitch et al. (1999) carried out a study in which the work reviewed here was published during the catalogue/issue year 1999 and described research involving biofilms treating pollutants. H. Odegaard et al. (1999) studied a new biofilm reactor for wastewater treatment: The Moving Bed Biofilm. M.Ji et al (2001) studied that Starch, cellulose and polyvinyl alcohol (PVA) are common substrates of the slowly biodegradable COD (SBCOD) in industrial wastewaters.

In a study made by Madan Tandukar et al. (2006) A novel municipal wastewater treatment system, consisting of a combination of an upflow anaerobic sludge blanket (UASB) and down flow hanging sponge (DHS) post treatment unit, was continuously evaluated for more than three years with raw sewage as an influent. Sheng et al.(2006), South Korea conducted the study in order to treat pesticide wastewater having high chemical oxygen demand (COD) value and poor biodegradability. Fenton-coagulation process was first used to reduce COD and improve biodegradability and then was followed by biological treatment.

Enrique J. La Motta et al. (2007) done a study in which anaerobic pre-treatment followed by aerobic post treatment of municipal wastewater is being used more frequently. Muhammad Asif Latif et al (2011) observed that, the UASB process among other treatment methods has been recognized as a core method of an advanced technology for environmental protection. Hossein Hazrati and Jalal Shayegan (2011) studied on activated sludge systems they found that. Most of 200 Activated Sludge Plant in Iran are overloaded and as a result, their efficiency is low. Husham T. Ibrahim et al. (2012) made an effort to provide an overall vision of biofilm technology as an alternative method for treating waste waters. Ravichandran. M and Joshua Amarnath. D (2012) carried out a study on MEPZ, an industrial unit installed at Tambaram, Chennai, developed by the Ministry of Commerce and Industries, Government of India is discharging domestic waste water generated by the workers and treated in the 1.0MLD capacity Sewage Treatment Plant with Moving Bed Bio-film Reactor.

Chidozie Charles Nnaji (2013) conducted a study in which the upflow anaerobic sludge blanket (UASB) reactor has found wide acceptance in the treatment of industrial wastewaters since its development in the Netherlands. Madan Tandukar et al. (2007), Japan made an study which compares the performance of a pilot scale combination of UASB and DHS system to that of activated sludge process (ASP) for the treatment of municipal sewage. A.Tawfik et al. (2009), The Netherlands made a study to evaluate the performance of a laboratory-scale sewage treatment system composed of an up-flow anaerobic sludge blanket (UASB) reactor and a moving bed biofilm reactor (MBBR) at a temperature of (22–35) °C. In another study made by Ravi Kumar et al. (2010), Bangalore city hosts two Urban Wastewater Treatment Plants (UWTPs) towards the periphery of Vrishabhavathi valley, located in Nellakedaranahalli village of Nagasandra and Mailasandra Village, Karnataka, India.

Rakmi Abd. Rahman et.al (2010) studied that Biofilm reactors are increasingly used to treat industrial effluents with difficult components; this type of process has been applied to wastewaters containing various types of pollutants, such as those containing chlorinated organics. E. Hosseini Koupaie et al. (2011) carried out a studied in which the main objective of the work was to compare the overall performances of "moving-bed" and "conventional" sequencing batch reactor [29-38].

3.3. Salient Features: Depicting the Number of Unit operations, Environmental Impacts and applications at Sen Nursing Home STP.

The present capacity of this STP is 20 MLD & the treatment technology used for the treatment of wastewater/sewage is Physico-chemical Treatment. This involves pre-treatment viz. fine & coarse screening/aerated degriting: 1 operation unit, oil & grease trap: 1 operation unit, Biological aerated filters: 8units & sludge dewatering on filter press: 2 units. The environmental impact of this technology is that grit material is thrown directly to the near Nallah. Application of this technique is that it is used for the treating domestic & biodegradable waste water. Salient features of the plant includes higher BOD removal & also that the treated effluent is used in a nearby power plant.

3.4 Salient Features: Depicting the Number of Unit operations, Environmental Impacts and applications at Vasant Kunj STP

The total capacity of this plant is 10 MLD & the treatment method used in this plant is Extended Aeration. The various functional units in the plant are fine & coarse screening/aerated degriting: 2 operation unit, Aeration: 2 Units, Clarification: 1 unit, Sludge dewatering on Sludge drying Beds: 8 Units. There is no operational problem with this technology and application of technique is that it is only used for domestic sewage. Salient features of the plant includes decentralised system of treatment, minimal cost operation & maintenance cost.

3.5 Salient Features: Depicting the Number of Unit operations, Environmental Impacts and applications at Okhla STP.

It is plant of 16 MGD capacity working on the Conventional Activated sludge process. It includes pre-treatment: 4units by screening, Aerated grit chamber:2 Units, Clarifier:2 units, Aeration tanks: 2 units, secondary clarification: 2 units,Sludge dewatering on Sludge drying Beds: 8 Units. Environmental impact of this plant is the immense smell nuisance. This technology is used for treatment of both domestic & industrial waste water treatment.

3.6 Salient Features: Depicting the Number of Unit operations, Environmental Impacts and applications at Rithala, Phase-II STP.

Capacity of this STP is 40 MGD and is based on High Aeration and bio filtration technology. Functional Units includes pre-treatment viz. screening/aerated degriting and degreasing:2 units, Aeration (High load activated sludge process):4 Units, Clarification:4 units, Bio filtration: 20 Units, Sludge thickening using modern floatation technology:2 units, sludge digestion using gas mixing technology : 4 units, Sludge dewatering on mechanical belt filter press during monsoon: 4 units on sludge drying bed (rest of the Year):43 units, Electricity & heat production: 3 units of Biogas Production. Application of this technology is that it is used for the treatment of both domestic & industrial waste water.

The main advantage of this system is that lesser energy is required as compared to the conventional system and effluent obtained is of higher quality. Salient feature of the plant includes the minimal investment & operational cost, Substantial land saving & the plant is self-sustaining energy-wise, aesthetically & socially accepted, biogas is utilised for different purposes. The centralised system of the Sewage treatment through biogas technology is efficient to minimize financial burden to combat the pollution.

4. MODELLING & SIMULATION OF TREATMENT TECHNOLOGIES

Many researchers have worked with the simulation & modelling of waste water/sewage treatment technologies.MIYATAet.al. (2004) conducted a study on Wastewater Treatment Processing Simulation Technology Using "Activated Sludge Model" This paper has described the construction of a model for design support of oxidation ditch (OD) wastewater treatment facilities and the construction of a model for operation support of microbial carrier-type advanced treatment plants based on an Activated Sludge Model.N. Banadda1 et.al (2011) gave a review of modelling approaches in activated sludge Systems. In this paper, the general activated sludge process was introduced and discussedDwight Houweling et.al. (2007) worked on Modelling Nitrification of a Lagoon Effluent in Moving-Bed Biofilm Reactors. M. von Sperling*, V.H. Freire and C.A. de Lemos Chernicharo (2001), Recent research has indicated the advantages of combining anaerobic and aerobic processes for the treatment of municipal wastewater, especially for warm-climate countries.

Dalel Belhaja et.al (2014) gave the Descriptive and multivariable analysis of the water parameters quality of Sfax sewage treatment plant after rehabilitation. This study detailed the effect of simultaneous multiple intrinsic and extrinsic factors on the characteristics of Sfax activated sludge wastewater treatment plant (WWTP), located in Southern East Tunisia.

5. CONCLUSION

Various treatment technologies are being used in different STP's of city Delhi. These plants have their own advantages & disadvantages of using the respective treatment technique. Description of five treatment technologies viz. Conventional Activated sludge, High Rate Aeration with Bio filtration, Extended Aeration Process, Trickling Filters and Physico-Chemical Treatment with Bio filtration have been taken into consideration in this study. Out of these five methodologies followed in different STP's High Rate Aeration with Bio filtration was found to be more efficient in comparison to all other treatment techniques. The drawbacks of the other treatment methods can be overcome if modelling & simulation of the treatment technologies are applied in combination of treatment technologies rather than considering one technology at a time. So far this approach have not been followed in Delhi STP's to improve the efficiency of the Plants. Hence research should be done in this direction for the benefit of society & environment.

Future Scope: To improve the efficiency of the Sewerage Treatment Plants Modelling and Simulation method can be applied on the techniques with the combinations of these technologies as Aerobic & Anaerobic, Aerobic & Aerobic and Anaerobic & Anaerobic. The development of multiple regression model can be adopted for increasing the performance of the STP's in Delhi. Principal Component Analysis (PCA) can be used to determine the potential parameters affecting the performance of various STP's with different technologies followed by performance evaluation of various STP's being compared with the Central Pollution Control Board (CPCB) standards for Effluent Discharge on Inland Surface water as well as Land for Irrigation. The later one can be used to determine the reutilisation of effluents from respective STP's.So far in Delhi performance evaluation of

STP's have been done but the combined technologies have not been utilised to treat sewage /Wastewater. Finally a model can be achieved showing best combination of input variables giving optimal results. Hence research should proceed in this direction for the betterment of society & environment.

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