HCTL Open International Journal of Technology Innovations and Research (IJTIR)
http://ijtir.hctl.org
Volume 14, April 2015
e-ISSN: 2321-1814, ISBN (Print): 978-1-62951-946-3

Anatomy of an Urban Sewerage Scheme: A Case Study

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Abstract

The water which is supplied to a community consists of range of chemical substances and microbial flora. Due to these, the waste water acquires the potential to pollute the environment. The sewerage of an urban city flowing directly in river and via lake without treatment, is polluting these natural courses heavily and thus creating unhygienic condition within and around the city. This also contaminates the underground water. Treatment of this sewage is essential before its disposal to natural water bodies. . In the present work, sewage treatment scheme of an urban city in India has been analyzed and future projections have been made for the sewage generation. In the current study, future treatment requirement has been estimated on a medium term (target 2030) and long term (target 2045) basis. The results obtained are very much useful in identification and rectification of balance need for Sewage treatment plant and sewer network for the future expansion.

Keywords

Microbial flora, Sewerage, Inflation rate, Sewage treatment plant.

Introduction

Sewage

Wastewater, is defined as a mixture of the liquid or the water that carry wastes from residences, institutions, and commercial and industrial establishments, together with such groundwater, surface water and storm water as may be present. Thus, depending on their origin, waste water can be classified as sanitary, commercial, industrial, agricultural or surface runoff. Sewage is more than 99% water, the remainder consists of some ions, suspended solids and harmful bacteria that must be removed before the water is released into the sea. It is characterized by its volume or rate of flow, physical condition, chemical constituents and the bacteriological organisms that it contains.

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A significant volume of wastewater is not subjected to any treatment and discharged into surface water leading to reduction in dissolved oxygen level of the water body causing disappearance of aquatic flora and fauna and often mass death of the fishes. Communicable diseases of the intestinal tract such as cholera, typhoid, dysenteries and water borne diseases like infectious hepatitis etc., can be spread from uncontrolled disposal of wastewater. The safe treatment of sewage is very crucial for the health of any community and both physical and biological treatments should be rendered to make it biologically and chemically harmless. After treatment, sewage can be used for agriculture and aquaculture [1].

Large volumes of domestic, hospital and industrial wastewater are being produced in cities around the world. Cities in developing countries lack resources to treat wastewater before disposal. Even where expensive wastewater treatment plants are installed, only a small percentage of the total wastewater volume is treated resulting in severe contamination of rivers, lakes and aquifers .There is a great need to treat the sewage prior to discharge into any surface water body or disposal onto land so as to minimize the possibility of harm to either people or environment. The Institutional support and legislation for pollution control is weak. Only 4000 of 17,600 MLD waste water generated in India is treated. Approximately 30,000 MLD of pollutants enter in India's rivers including 10,000 million from industrial units alone [2,3].

According to the Central Pollution Control Board (CPCB), 35558 MLD of waste water is generated from class 1 cities (population > 100,000), and 2696 MLD from class 2 cities (population 50,000 – 100,000). Total sewage treatment capacity of class 1 cities is 11553 MLD which is 32% of the total sewage generation. And total sewage treatment capacity of class 2 cities is 233 MLD which is 8% of the total sewage generation. Treatment of waste water is very crucial which involves the breakdown of complex organic compounds into stable and nuisance-free simpler compounds. [4, 5]

The present paper deals with the sewage treatment scheme of Gorakhpur city in India. Future generation of sewage has been projected along with present capacity of sewage treatment plants in the city. The cost of the plant has been estimated to fulfill the treatment requirements of future on a medium term (target 2030) and long term (target 2045). The results indicate that the capacity of the 45 MLD STP (under construction) should be increased considering present and future needs.

About Gorakhpur- The Study Area

Gorakhpur, one of the most important cities of eastern Uttar Pradesh state has been selected as the study area. It is situated between longitudes 83°20' east and 83°25' east and latitudes 26°42' north and 26°47' north in the Terai Belt and located in the east of confluence of rivers Rapti and Rohini. It is the headquarter of North Eastern Railways. Gorakhpur Railway Station is very important junction of Northern Indian railway and became the world's Longest Railway platform with a length of 1,366m. [6]

Gorakhpur is an important educational centre. It has a university, a medical college and two engineering institutes. The city has some large perennial lakes, the most prominent being the Ramgarh Lake. It is situated in the south eastern part of Gorakhpur city covering an area of about 678 hectares. The lowest and highest reduced levels are 70.485 m and 74.500 m above mean sea level respectively. Figure 1 shows the location map of the Gorakhpur city. [7]

e-ISSN: 2321-1814, ISBN (Print): 978-1-62951-946-3

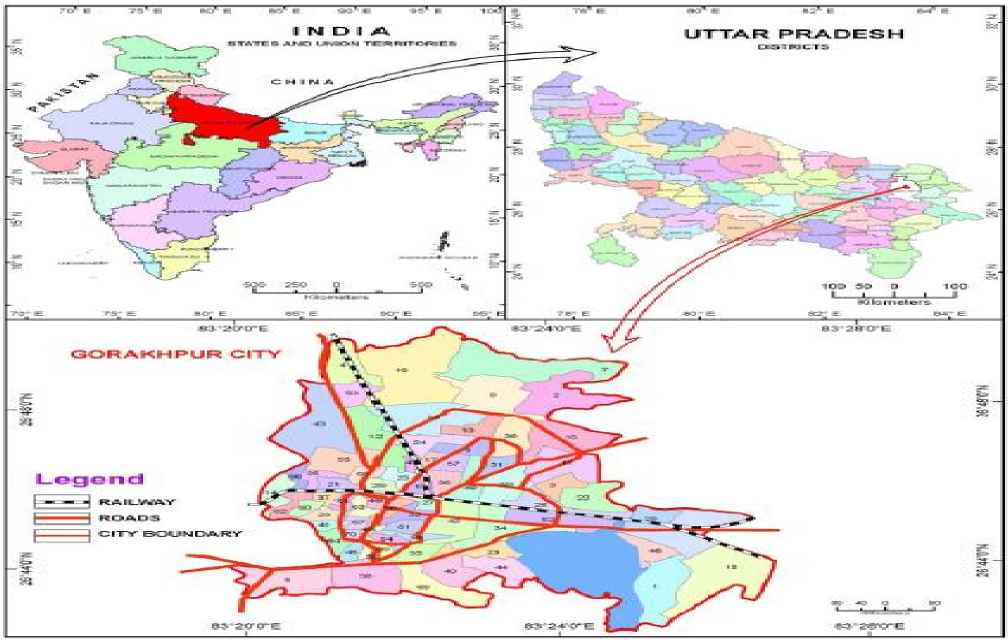

Figure 1: Location map in Gorakhpur city

Sewage Treatment in the Study Area

At present the sewerage of Gorakhpur town is flowing through different drains in river Rapti directly and via Ramgarh Tal without treatment which is polluting these natural courses heavily and creating unhygienic condition within and around the city also contaminating the underground water. Hence it is of extreme need to treat this sewage before its disposal to natural water bodies. The laying down of sewer lines in Gorakhpur city was proposed under National Ganga River Basin Authority (NGRBA). In the project "Pollution prevention and conservation of Ramgarh

Tal Lake at Gorakhpur Town" two sewage treatment plant is currently under construction at Maharwa ki Bari and Deoria bye pass area [8].
Lucknow-Barauni Rail Track divides the Gorakhpur city into two parts. These two parts are considered as two sewerage zones i.e. North zone and South zone. North zone cover Trans rail area and south zone cover Ciss rail area. North and South zones have been sub-divided into three sub-zones each. North zone consists of (1) Gorakhnath area (2) Medical College area (3) Sainik Vihar/ Nanda Nagar area. South zone consists of (1) Civil lines area (2) Mahadeo Jharkhandi area (3) Nausar area. Different sewerage districts in Gorakhpur are shown in figure 2.

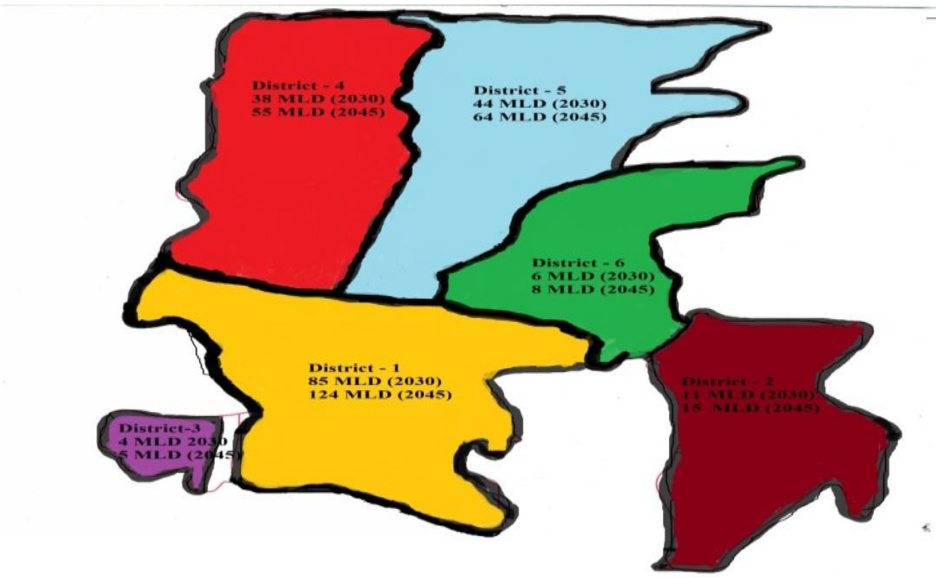

Figure 2: Different sewerage districts in Gorakhpur

Analysis for STP Facilities

Population projection

The population forecasting for Gorakhpur town has been carried out by using conventional methods. Considering the trend of growth of the town during previous decades, it is anticipated that the population projected by geometric growth rate will be suitable for the town [9]. Thus, the same has been adopted for the best projection of population of Gorakhpur in near future as shown in Fig 3 and Table 1.

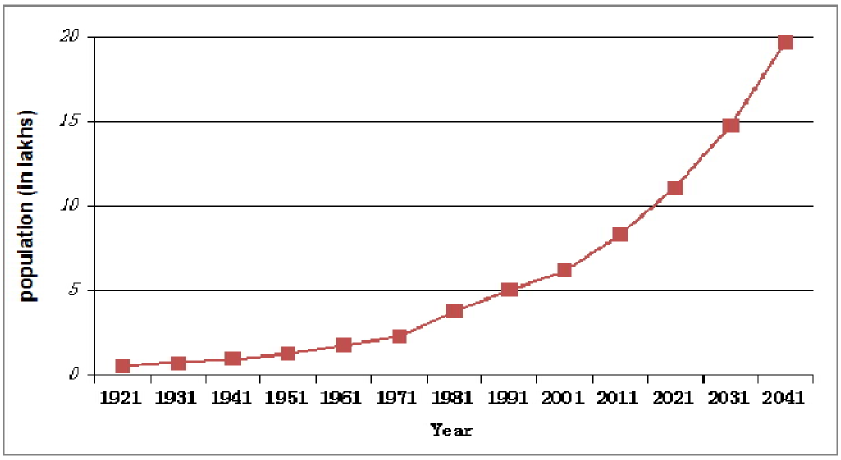

Figure 3: Population projection of Gorakhpur by Geometrical Increase method

Table 1: Predicted Population as per geometrical increase method

Year	Predicted Population
2010	807521
2015	932958
2020	1077879
2025	1245312
2030	1438753
2035	1662243
2040	1920448

Based on the above predicted population, wastewater generation has been calculated for the initial stage taken as year 2015, middle stage as year 2030 and ultimate stage as year 2045. The proposed capacity of the sewage treatment plant has been calculated accordingly and shown in Table 2. The peak factor and quantity of water supply is considered as 1.50 and 135 lpcd (Litres per capita per day) respectively. Zone-wise proposed treatment capacity and STP under construction is depicted in Fig 4. It is seen that the capacity utilization is maximum in the zone of Civil lines area and Medical College area.

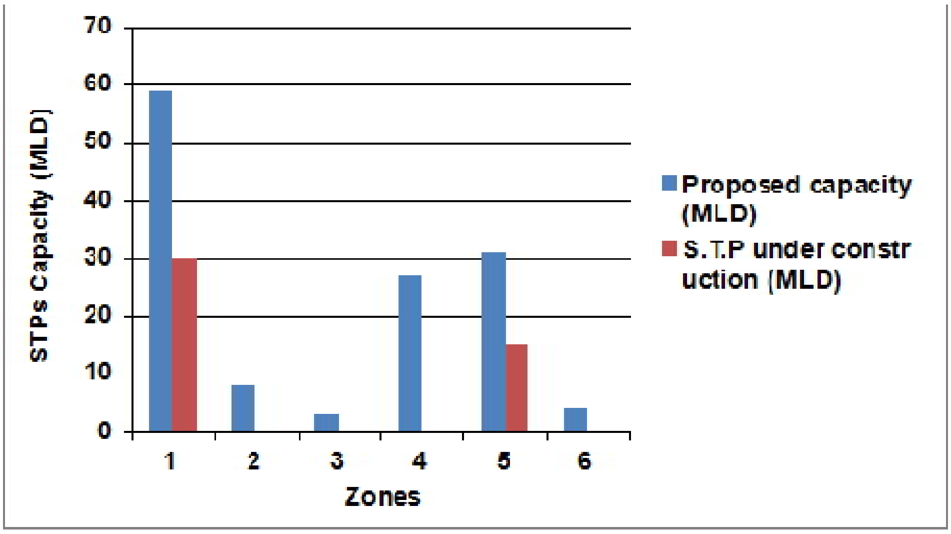

Figure 4: Zone-wise proposed treatment capacity and STP under construction

Table 2: Wastewater generation prediction as per geometrical increase method

Base Year 2015	Base Year 2030	Base Year 2045
$(932958 \times 1.50 \times 135)/10^6$	$(1438753 \times 1.50 \times 135)/10^6$	$(2218762 \times 1.50 \times 135)/10^6$
188.92	**291.34**	**449.29**

Current and Proposed Status of Sewage Treatment Facilities

In the Gorakhpur sewerage scheme two STPs having capacity of 15 MLD and 30 MLD are currently under construction stage. The 15 MLD STP is installed at 'Maharva Ki Bari' where as 30 MLD is located at 'Deoria Bypass' on southern side of the Ramgarh Lake. The STP at 'Maharva Ki Bari' was approved at an estimated cost of 2318.35 lakhs in July, 2012 and is under construction based on Sequencing Batch Reactor (SBR) activated sludge process with advanced treatments for removal of Nitrogen and Phosphorus. Provision of 15 MLD STP was made in such a way that the discharge of Kuda Ghat Nala and Gordhaiya Nala shall be brought near a bridge on National Highway through gravity pipes and then lifted to the Sewage Treatment Plant. The intercepted and diverted wastewater from these Nalas would be given Primary, Secondary and Tertiary Treatment. This treated wastewater would be either supplied for irrigation or discharged into the Ramgarh lake. After giving tertiary treatment to the wastewater, nitrogen and phosphorus levels of the treated sewage shall be brought down at such levels that they will not create any eutrophication problems in the lake. Table 3 shows the distribution of sewage treatment capacities in the 6 sewerage districts.

Table 3: Distribution of sewage treatment capacities in the 6 sewerage districts/areas

Zone No.	Description	STP under construction (MLD)	(Proposed capacity of STPs in MLD) 2015	(Proposed capacity of STPs in MLD) 2030	(Proposed capacity of STPs in MLD) 2045
1.	Civil Lines Area	30	59	85(59+26)	124(85+39)
2.	Mahadeo Jharkhandi Area	0	8	11(8+3)	15(11+4)
3.	Nausar Area	0	3	4(3+1)	5(4+1)
4.	Gorakhnath Area	0	27	38(27+11)	55(38+17)
5.	Medical College Area	15	31	44(31+13)	64(44+20)
6.	Sainik Vihar/ Nanda Nagar Area	0	4	6(4+2)	8(6+2)
	Grand total	45	132	188	271

The second STP of 30 MLD capacity would be a separated entity to be considered under the NLCP. It was approved at an estimated cost of 3763.86 lakhs in July, 2012 and is under construction based on Sequencing Batch Reactor (SBR) activated sludge process .This is located near Deoria Bypass in such a way that after rendering primary, secondary and tertiary treatments to the intercepted and diverted wastewater from Mohaddipur Power House Nala, Rafi Ahmed Kidwai High School Nala, Golf Ground Nala and Sahebganj Padley Ganj Nala , it could be directly discharged into the Ramgarh lake for maintaining lake water balance. This is of extreme importance since the lake water balance may have negative impact if all the ingress is diverted. The excess quantity of treated wastewater shall be discharged into the outlet drain of Ramgarh Lake, which would be further carried away to Gurrah Nalla, ultimately merging into river Rapti.

Assessment of Sewage Treatment Requirements

For the year 2015, the capacity of STPs under construction is found insufficient considering the actual requirement is (188.92-45) = 143.92MLD. By 2030, it has been proposed to increase the capacity of the 6 STPs, such that it will sum up to a total capacity of 188 MLD, whereas the actual requirement will be more than 291.34 MLD i.e. an additional requirement of (291.34-188)= 103.34 MLD will be there. According to the calculated value of wastewater generated, by middle term 2030; another STP of additional capacity of (291.34-45) = 246.34 MLD will be needed. Six STPs in District 1(85 MLD), District 2(11 MLD), District 3(4 MLD), District 4 (38 MLD), District 5(44 MLD) and District 6(6 MLD) have already been proposed. Their construction will sum up to a total capacity of 188 MLD (6 STPs) for the entire city whereas the actual need will be approximately 291.34 MLD i.e. the proposed construction will not be able to fulfill the desired requirement. By 2040, it has been proposed to increase the capacity of the 6 STPs, such that it will sum up to a total capacity of 271 MLD, whereas the actual requirement will be more than 449.29 MLD i.e. an additional requirement of (449.29- 271)= 178.29 MLD will be there.

It is suggested that due to current requirement of 143.92 MLD, the capacity of 15 MLD STP in District-5 should be increased. At the same time STP will also fulfill the additional need in 2030, after the construction of the proposed STPs in District 2, 3, 4 and 6. At the same time, by 2045 the capacity of SBR plant in District-5 should further be increased by 178.29 MLD. The capacity of SBR plant is increased in both the cases because the land required for SBR technology is already less as compared to other conventional technologies due to compact units of treatment. However, the plant at Vasna, Ahmedabad based on anaerobic sludge blanket reactor followed by coagulant aided tertiary sedimentation needs to be studied in detail for assessing its optimal efficiency, as this scheme also requires lesser land. Also in tertiary sedimentation better bacteriological quality may be achieved with the help of coagulants. [10, 11]

It is also suggested that for the design of SBR plant for municipal waste water treatment studies should be performed as the potential cost savings in both capital investment and operating expenses can be significant. Mass balance consideration should also be used to optimize the preliminary designs of SBR, just as done for conventional continuous flow constant volume activated sludge systems. [12-14]

The cost of increasing capacity of the SBR plant has been estimated considering the inflation rate of 6% per annum using the following formula [15] -

$$\mathbf{CV = RV \times (1+ i)^{n}}$$

Where;

CV = Current value or nominal value of rupee

RV = Real or purchasing value of rupee

n = Time period (in years)

i = Average inflation rate per annum

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Revenue Generation from the Extended Capacity of the SBR Plant

Land for sewage pumping stations and STPs shall be provided free of cost by Nagar Nigam, Gorakhpur. Approximate requirement of land (based on adoption of Activated Sludge Process or SBR) for STP in Civil Lines is 4.0 hectare, In Mahadev Jharkhandi Area 1.0 hectare, In Nausar Area 0.50 hectare, In Gorakhnath Area 2.50 hectare, In Medical College Area 2.50 hectare and in Sainik Vihar /Nanda nagar Area 0.50 hectare with 35 m × 35 m for each Sewage Pumping Station. Separate resolution of proposed land is to be taken from Nagar Nigam so that land can be acquired. There is no land available for its future extension as per the increasing requirements. The table 4 gives the estimated costs for revenue generation in case of the extended SBR capacity. It also provides information about the costs incurred in 2030 and 2045 considering the inflation rate of 6% p.a.

Table 4: Revenue generation in case of the extended SBR capacity

Description	Unit	STPs under construction in 2015	Additional need by 2030	With inflation rate of 6.0% p.a.	Additional need by 2045	With inflation rate of 6.0% p.a
Technology	-	SBR	SBR	SBR	SBR	SBR
Capacity	MLD	45	103.34	103.34	178.29	178.29
Construction cost (exc. Land)	Rs. Lakhs	3362.61	7722.04	18506.32	13322.66	76518.58
E/M Works	Rs. Lakhs	2719.6	6245.41	14967.49	10775.05	61886.4
Total	Rs. Lakhs	6082.21	13967.45	33473.81	24097.71	138404.98

Conclusions

The conclusions drawn from this study are as follows;

1. The capacity utilization of STP is maximum in the zone of Civil lines area and Medical College area in the Gorakhpur town.

2. State Government should realize the problem of pollution of water bodies of River Rapti and Ramgarh lake and pay attention to their liability to set up sewage treatment plants in cities and towns to prevent this pollution. This activity requires to be recognized as one of the most important indicators of overall development of the State. If not realized urgently, this problem is fast going to magnify to an unmanageable level.

3. By 2040, it has been proposed to increase the capacity of the 6 STPs, such that it will sum up to a total capacity of 271 MLD, whereas the actual requirement will be more than 449.29 MLD i.e. an additional requirement of (449.29- 271)= 178.29 MLD will be there.

4. State Government are also required to take up the sewage diversion and utilization schemes as an integral part of the sewage treatment schemes so that the conventionally treated sewage can be used for the irrigation of crops. Sewage diversion schemes should adopt at least 25-30 years plan period for design.

5. Resource can also be generated from sewage treatment plants such as bio-diesel, biogas, fertilizers and metals from inorganic materials, district-heating through sewage source (water source) heat pumps.

6. The municipalities can utilize the sewage sludge for biogas generation and for producing electricity. They can also bring into effective utilization of treated effluent for irrigation and reuse for industrial purposes. They can also sell the sludge cake as manure. Aquaculture can also be practiced and it will also increase the employment opportunities for young people and adults.

7. There is a need that persons having adequate knowledge and training to operate the STPs be engaged to manage STPs and an expert be engaged to visit the STPs at least once a month and advice for improvement of its performance. Auxiliary power back-up facility is required at all the intermediate (IPS) & main pumping stations (MPS) of all the STPs.

8. In treatment schemes employing activated-sludge-process, plant operators must recognize the importance of using Solids Retention Time (SRT) as a plant control parameter because treatment efficiency, sludge production, oxygen requirements and nutrients requirements are all dependent on SRT.

Acknowledgement

I thankfully acknowledge the use of facilities and data available at Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee, as well as Ministry of Human Resource and Development – Government of India for supporting this study.

References

1. K. Sundara Kumar, P.Sundara Kumar, Mr M.J. Ratnakanth Babu, 2010,’Performance evaluation of waste water treatment plant’ International Journal of Engineering Science and Tcehnology v.2, pg 7785-7796.

2. Eknath P.S, ’Conservation Plan for Godavari River’ M.Tech dissertation report AHEC, IIT Roorkee, 2009.

3. Sharma M.P, Arun Kumar and Shalini Rajvanshi, 2010 ‘Assessment of trophic state of Lakes: A case of Mansi Ganga Lake in India’ Hydro Nepal.

4. Gayathri Devi Mekala, Brian Davidson, Mardar Samad, Anne-Maree Boland, Wastewater reuse and recycling systems: a perspective into India and Australia, IWMI International Water Management Institute, 2007

5. Manekar. Pravin, Rima Viswas and Tapas Nandy ‘SBR system for agrochemical industry – Feasibility and Implementation’, CSIR- National Environmental Engineering Research Institute, Nagpur, 2013.

6. http://indiatoday.intoday.in/story/gorakhpur-all-set-to-have-longest-railway-platform-in-world/1/312591.html accessed on 10 .12.2014.

7. http://shodhganga.inflibnet.ac.in/bitstream/10603/16660/6/06_chapter%202.pdf accessed on 8-12-2014.

8. Presentation of progress of Gorakhpur Sewerage Scheme -June, 2012. Courtesy U.P Jal Nigam.

9. Population forecasting- NPTEL IIT Kharagpur, web courses (nptel.ac.in/courses/105105048/M5L5.pdf visited on 29-11-2014)

10. Kumar, D. Suresh and Dr V. Sekaran, 2012, 'Resource recovery from Sewage Treatment Plants', International Journal on Advanced Information Science and Technology v.6

11. Chennai Metropolitan Water Supply and Sewerage Board (CMWHSS Board), 'Sewage Treatment Plants Project Report 2006-2007'.

12. STP Technologies and Their Cost Effectiveness (http://www.cseindia.org/userfiles/arunabha.pdf visited on 8-12-2014).

13. Initial Proposal- Technological Solution for Sewage waste treatment and Reuse (http://www.gujaratcmfellowship.org/document/Fellows/Initial-Proposal-for-Sewage-Treatment_Shwetal-Shah_25 Jan 2011 pdf visited on 7-12-2014).

14. Status of STPs (http://www.cpcb.nic.in/statusSTP.php visited on 11.12.2014)

15. http://www.franklintempletonindia.com/en_IN/investor/investor-education/tools-and-calculators/inflation-calculator accessed on 7-12-2014.