RECYCLE AND REUSE OF TREATED SEWAGE WITHIN POLLUTER’S BOUNDARY FOR SUSTAINABLE WASTEWATER MANAGEMENT: A CASE STUDY, PUNE, INDIA

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Received April 05, 2012
Accepted September 05, 2012

ABSTRACT
Waste water management in India is gaining more importance due to pressure from the common man and mainly from the stakeholders who suffer due to uncontrolled and haphazard discharge of waste into the natural water bodies. The statistics show that in India, hardly 25-30% waste water is getting treated to the satisfactory level. Although the central and state governments are pumping huge money in the sanitation sector, unless some policy changes such as, making it mandatory for all Urban Local Bodies (ULBs) to utilize their treated waste within their boundaries, there will not be any significant change in the wastewater management scenario in India, especially in the urban sector. Even in big cities like Pune, sewage collection and treatment is not up to the mark. Although Pune Municipal Corporation has developed a master plan for collecting and treating 100% of the sewage likely to be generated by 2015, practically it seems to be impossible, taking into consideration the present haphazard and unplanned growth of the city. Also, no thought is given at the PMC level for developing appropriate decision making system for selection of technologies or treatment options for Sustainable Waste Management. A research study was carried out for Pune wherein, the Multi Criteria Decision Making (MCDM) approach was applied for arriving at the Sustainable Wastewater Management Option for Pune City. It was found that recycle and reuse within the polluter’s boundary was the most preferred option for Pune city. This paper highlights one such detailed study for one of the sewage treatment plants in Pune city.

Key Words: Sustainable Waste Water Management, Recycle and reuse of treated wastewater, Urban Local Bodies (ULBS)

INTRODUCTION
Pune city is located at 560 m (1,840 ft) above mean sea level on the western margin of the Deccan plateau. It is situated on the leeward side of the Sahyadri mountain ranges (the Western Ghats), which separates it from the Arabian Sea. It is a relatively hilly city, with its tallest hill, vetal hill, rising to 800 m (2,600 ft) above mean sea level. Just outside the city, the Sinhagad fort is located at an altitude of 1300 m. The geographical area of the city is 243 sq. km after merger of fringe areas into the corporation limits. river Mutha is the main river flowing through Pune city, which is the tributary of river Bhima, the major river in Maharashtra, India which in turn is the tributary of river Krishna. The river Mutha carries partially treated domestic as well as the industrial waste from Pune city which ultimately goes to river Bhima, finally empounding into Ujjani dam.1

In order to study the feasibility of sustainable wastewater management for Pune city, as a part of on-going research, the detailed study was carried out. It was based on the outcome of multi criteria decision making, an analytical tool used for this research. The research revealed that recycling and reuse of treated wastewater within polluters boundary is the most sustainable
wastewater option for Pune city. Based on this, the detailed study was carried out. This comprised of studying the wastewater generation and management scenario for Pune city and carrying out the detailed study for one of the sewage treatment plants in Pune city i.e. Viththalwadi STP in Pune city. The same is discussed in this paper.

Waste water generation and management scenario in pune city

Pune city has total population of about 35 lakhs and the total water supply is 1050 MLD. Required per capita water supply as per standard Indian norms for A class cities is 135 lpcd whereas PMC provides 229 lpcd of water. (Considering about 20% losses, which comprise of 16% losses in distribution and 4% losses during treatment). About 80 % water supplied to consumers get converted in sewage in Indian metropolitan cities. According to estimate Pune generates more than 567 million liter sewage per day. This is less than a normal figure of 80% due to non-consumptive use of water which does not get reflected in sewage as well as due to non-metered water supply, making the actual water supply as well as wastewater generation a suspect.

METHODOLOGY

Study area

Collection of sewage in Pune city

For the proper collection of the sewage from different areas of Pune city, PMC has developed the sewage collection system. The details are as follows

- Total sewage collection: 567 MLD. (domestic 510 MLD and commercial 57 MLD)
- Catchment area: 199 Sq. km (as per environmental Status report 2009-10)
- Total no. of sewage treatment plants (STPs): 7 working
- Total installed capacity of STPs: 382 MLD
- Total sewer line: 2200 km
- Total pumping stations : 10

Although the PMC has made huge investment in the treatment of sewage, there are lacunas in the waste water management. The main could be summerised as follows

1. 100% sewage which is generated within the city is not getting collected. Hence the untreated sewage finds its way into the river course directly through many non point sources. This unaccounted for sewage makes the overall figure of sewage generation less than 80% of the water supplied. (Fig. 1)

2. In some cases, the treatment plant receives more water than the design flow. Hence, more than 50% raw sewage goes directly to the river. The treated waste from the STP gets mixed with this surplus flow and just carries out the dilution. But all the efforts taken in treatment are lost. (Fig. 2).

3. There is a big lapse between waste water generation and collection and treatment. The city population is growing by lips and bounds whereas the collection, conveyance and treatment facilities are much less than required, making the entire waste water management unsustainable in the city. As per the Environmental Status Report of PMC (year 2009-10), the annual rate of growth for Pune city is estimated to be 5%. However, the infrastructure required for managing the wastewater that will be generated due to such a rapid increase in the population is not in accordance with the rate of population growth of the city.

RESULTS AND DISCUSSION

Sewage projects: Master plan in pune city

Considering the likely increase in the area under the jurisdiction of PMC (430 sq.km) and a rapid rise in population, the project plan for water supply and sewerage services was revised and completed in the year 2005.

PMC has constructed 7 sewage treatment plants (STPs) along with the STP at Naidu Hospital at Koregaon Park (Bhairoba Nala), Erandwane, Tanajiwadi, Viththalwadi, Mundhawa and Bopodi. The total 567 MLD of sewage is generated in PMC limit, out of that 382 MLD (i.e. @ 67%) is treated by the 5 STPs and the treated effluent is discharged into Mula Mutha Rivers. For the treatment of the remaining 185 MLD sewage generated, 3 more STPs are proposed:

1. In the premises of the existing Naidu STP (115 MLD) – Under construction
2. At Baner (30 MLD) - Proposed
3. At Kharadi (40 MLD) - Proposed
As seen from the Table 1, it is evident that the PMC is spending a huge amount on construction as well as O and M of the STPs. However, it is found that due to non-point sources, the river water quality is much below than that required for the intended use of the river downstream of Pune city.

As per the public notice issued by the Government of Maharashtra Pollution Department, dated 09/08/2008, the rivers are classified based on their designated use as follows (Table 2). Depending upon the category of the river classified as follows (Table 3). It is to be specially noted that with respect to the above norms, the Maharashtra Pollution Control Board has categorized the various stretches of river Mutha and the same are depicted in Table 4.

Recycle and reuse within / outside the polluters boundary

Recycle and reuse of wastewater for irrigation is a common practice in developing countries. It also helps in the water scarce regions. As per the agreement between the Pune Municipal Corporation and the Water Resources Department (WRD) of Government of Maharashtra, Pune receives 11.5 TMC of water annually and it is supposed to give back 6.5 TMC of water back to the WRD. In Pune, treated wastewater is used either in agriculture or directly discharged in Mula Mutha river. From 130 MLD Bhairoba STP only 45 MLD treated wastewater goes for the irrigation purpose through a canal system known as Sade Satara Nali canal.

In spite of ill effects of untreated wastewater on human health and the environment, the treated wastewater is highly reliable, nutrient rich and can be used for agriculture. It will provide a year-round income, employment to local people along with food security to the urban and peri-urban local people. While the problems associated with wastewater reuse and recycle in Pune arise from its lack of treatment and the will power of PMC. Besides this, PMC has 83 gardens in Pune city and the total area of all these gardens is about 268.2 acres. The treated waste water can be used for these gardens. The treated waste water can also be used for fire fighting. PMC has 10 fire
# Table 1: Details of sewage treatment plants in Pune

<table>
<thead>
<tr>
<th>S/N</th>
<th>Description</th>
<th>Bopodi</th>
<th>Tanajiwadi</th>
<th>Erandwane</th>
<th>Viththalwadi</th>
<th>Dr. Naidu Hospital</th>
<th>Bhairoba</th>
<th>Mundhwa</th>
<th>Kharadi (Proposed)</th>
<th>Baner (Proposed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Capacity of plant</td>
<td>18 MLD</td>
<td>17 MLD</td>
<td>50 MLD</td>
<td>32 MLD</td>
<td>115 MLD</td>
<td>130 MLD</td>
<td>45 MLD</td>
<td>40 MLD</td>
<td>30 MLD</td>
</tr>
<tr>
<td>2.</td>
<td>Treatment facility</td>
<td>Extended aeration</td>
<td>Bio tower followed by diffused aeration</td>
<td>Modified activated sludge reactor</td>
<td>Sequential reactor</td>
<td>Activated sludge process</td>
<td>Activated sludge process</td>
<td>Sequential reactor</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>4.</td>
<td>Total area</td>
<td>1.5 hectare</td>
<td>0.72 hectare</td>
<td>0.8 hectare</td>
<td>NA</td>
<td>4.6 hectare</td>
<td>8 hectare</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>5.</td>
<td>Catchment area</td>
<td>15 sq.km</td>
<td>18 sq.km</td>
<td>26 sq km</td>
<td>14 sq km</td>
<td>37 sq km</td>
<td>82 sq km</td>
<td>23 sq km</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>6.</td>
<td>Cost in crores (INR)</td>
<td>5.69</td>
<td>6.75</td>
<td>11.12</td>
<td>NA</td>
<td>NA</td>
<td>37.54 / 7.508 M</td>
<td>32 / 6.4 M</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>7.</td>
<td>Power consumption KWH</td>
<td>2300</td>
<td>4050</td>
<td>11000</td>
<td>NA</td>
<td>15700</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>8.</td>
<td>Population in catchment area</td>
<td>1.25 lakh</td>
<td>1.33 lakh</td>
<td>3.70 lakh</td>
<td>2.2 lakh</td>
<td>6.66 lakh</td>
<td>9.62 lakh</td>
<td>2.8 lakh</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA - Data not available
<table>
<thead>
<tr>
<th>Classes</th>
<th>No. development zone for any type of industries</th>
<th>Only green and orange category of industries with pollution control devices</th>
<th>Type of industries (red, orange, green) with pollution control devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-I</td>
<td>3 Km on the either side of river</td>
<td>From 3 Km to 8 Km from river (H.F.L.) on either side</td>
<td>Beyond 8 Km from river (H.F.L.) on either side.</td>
</tr>
<tr>
<td>A-II</td>
<td>1 Km on the either side of river.</td>
<td>From 1 Km to 2 Km from (H.F.L.) on either side</td>
<td>Beyond 2 Km from river (H.F.L.) on either side.</td>
</tr>
<tr>
<td>A-III</td>
<td>1/2 Km on the either side of river</td>
<td>From 1/2 Km to 1 Km from river (H.F.L.) on either side</td>
<td>Beyond 1 Km from river (H.F.L.) on either side.</td>
</tr>
<tr>
<td>A-IV</td>
<td>1/2 Km on the either side of river</td>
<td>From 1/2 to 1 Km from river (H.F.L.) on either side</td>
<td>Beyond 1 Km from river (HFL.) High Flood Line on either side.</td>
</tr>
</tbody>
</table>
stations in Pune city with total water storage capacity of 7.75 lacks liters. These fire stations can also use the treated waste water.

A study was carried out for one of the Sewage treatment plants located in Pune, Viththalwadi STP which has been designed for an average flow of 32 MLD. After treatment, the treated sewage finds its way into the river Mutha and it gets mixed with the untreated sewage joining the river through non point sources as depicted in Fig.1. To curb pollution of rivers, it is very much essential that all such non point sources be curbed. The PMC is taking measures for the same and a separate pipeline is being laid in the river bed which will convey the sewage joining the rivers through such non point sources. However, there is some opposition to this project from some groups of citizens and the environmentalists. Although a very practical solution, it is uncertain whether such kind of construction will be permitted in future. Hence there is a need for paradigm shift and as a part of research, using multi criteria decision analysis; it was found that recycle and reuse was the most preferred option.

**Review of similar works done in past**

An exhaustive literature survey was carried out for the present work. Also, sampling work was carried out for river Mutha alongwith the performance assessment of the existing STPs, assessing the feasibility of sustainable wastewater option for Pune city use of multi-criteria decision making: Tool for wastewater management In Pune city. It is specifically to be mentioned that on carrying out the performance evaluation studies of few of the STPs in Pune, it is concluded that the STPs are performing satisfactorily, however the wastewater management policy needs a paradigm shift. The same was revealed through the ongoing research pertaining to use of multi criteria decision making: tool for wastewater management in Pune city. Based on the above study, it was found that recycle and reuse of treated wastewater within the polluter’s boundary is the most sustainable option for Pune city. Hence a separate study was carried out for one of the STPs in Pune to check the suitability of the same.
Viththalwadi sewage water treatment plant
Location: - Rajaram Bridge Sinhgad Road, Pune
Capacity - 32MLD (Average Flow) and 72MLD (Peak Flow)
Technology Used : Activated Sludge Process
Constructed By, Ramky Infrastructure Ltd (Fig. 3)

Description of the Plant
1. Design basis of the STP
The flow characteristics i.e. various parameters of the sewage when it comes into the STP and after treatment of the wastewater when it comes out. As shown in Table 5.

Fig. 3 : Viththalwadi STP, Pune

Table 5 : Inlet and outlet characteristics for raw and treated effluent

<table>
<thead>
<tr>
<th>S/N</th>
<th>Parameter</th>
<th>Inlet value</th>
<th>Outlet value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>pH</td>
<td>7 to 8</td>
<td>7 to 8</td>
<td>——</td>
</tr>
<tr>
<td>2.</td>
<td>BOD</td>
<td>200-250</td>
<td>&lt;20</td>
<td>Mg/ℓ</td>
</tr>
<tr>
<td>3.</td>
<td>TSS</td>
<td>250-300</td>
<td>&lt; 30</td>
<td>Mg/ℓ</td>
</tr>
<tr>
<td>4.</td>
<td>Oil and grease</td>
<td>30</td>
<td>&lt;10</td>
<td>Mg/ℓ</td>
</tr>
</tbody>
</table>

Components of the plant
1. Raw sewage pumping station
Coarse screening
Wet wall
Raw sewage pumps
2. Sewage Treatment plant
Primary treatment
Biological treatment
Chlorination and disinfection
3. Sludge handling
Thickener
Digester
Centrifuge

Flow diagram for main pumping station
Key features of the pumping station
1. The water entering the plant is first passed through screening. The coarse particles are first screened through 40mm opening.
2. The water then enters the second screening where the fine particles are separated under mechanical rotary drum which has an opening of 6mm.
3. After the screening is done the water then goes to the wet well which has a capacity of 80MLD with 2 compartments of 48MLD and 32MLD.
4. 3 pumps are used to pump the water during peak flow- 32MLD.
5. 2 pumps are used to pump the water during half flow- 16MLD
6. The rising main has a diameter of 1200mm. (Fig. 4)

![Flow Diagram for main pumping station](image)

**Fig. 4 : Flow Diagram for main pumping station**

**Biological treatment unit**
1. Aeration tank which is circular in shape.
2. Retrievable diffused aeration system
3. Air blowers
4. Secondary settling tanks
5. Sludge recirculation system

**Disinfection unit**
1. Chlorine tank
2. Chlorination system
3. Safety equipments

**Reuse of treated sewage water need for reuse**
1. The capacity of the Viththalwadi STP is 32MLD, 32MLD of sewage is treated and it is again left back into the river.
2. As the treated water again mixes with the untreated sewage flowing through the river originating from non point sources. Thus, it gets contaminated leading to wastage of efforts taken in treating the wastewater and the money used for the entire treatment, including sewers as well. Thus, it leads to unsustainable wastewater management.
3. To overcome this, the reuse of the water should be well planned. As PMC is supposed to give back more than 55% of water it receives to the water resources department, it will be a good way to recycle and reuse within its boundary for parks etc or give it back to the irrigation canal.

**Flow diagram for the sewage treatment plant**
The diagram clearly shows that the water is first passed through the inlet chamber to the STP. From the inlet chamber the sewage undergoes screening (coarse and fine). After the screening it undergoes grit removal where the oil and the grease are separated from the sewage. Then it is let into the primary clarifier which then leads it to the aeration tank. In the aeration tank the water is treated and the treated water then further moves to the chlorination tank where it is disinfected. The sludge obtained from the aeration tank then moves to the thickener, and then towards the digester then later it is centrifuged where flocculation takes place and the particles are suspended. The sludge thus produced gets stored in the sludge sump then taken to the waste management plants and further treated. Poly-electrolyte dosing system is also used to handle the sludge. *(Fig. 5 to Fig. 8)*
Fig. 5: Flow diagram for sewage treatment plant

Fig. 6: Secondary biological treatment – view of aeration tank

Fig. 7: Biological treatment unit – view of secondary settling tank
Ways of reuse of treated sewage water

The recycle and reuse of the treated sewage is the best option for achieving sustainability in wastewater management. The treated sewage can be used in industries or can be used for irrigation\textsuperscript{11-13}. However, the final selection is case specific and needs to be studied according to the situation. The Treated sewage water can be again reused in the following ways: 32 MLD sewage is treated in the STP, out of which about 12 MLD can be let into the river Mutha for maintaining the base flow and the remaining 20 MLD treated wastewater can used in the following manner. (Fig. 9 and Fig. 10)

1. By pumping it to the nearby parks or gardens
2. By pumping it to the nearby industrial clusters/pumping it to nearby forest area.
3. By pumping it to the irrigation canal through pipeline to the nearest possible location.

Fig. 8 : Chlorine house

Fig. 9 : View of the proposed pipeline connecting the treated sewage to the irrigation canal
Details of the system

- Sump- RCC and size 7m diameter and 2m SWD
- Pipe line details
  1. Individual pipe diameter- 350mm
  2. Header pipe diameter- 450mm
- Pipe material- cast iron- DIK9 pipe
- Pump capacity- 417 m³/hr for 24 hrs
- Total 3 pumps- 2 pumps in use and 1 standby
- Power consumption- 1650 KW/Day
- Provide weir at outlet pipe for separation of water.
- The total cost of installation and construction (block cost estimates) = 30-40 lacs.

It is the responsibility of the polluter as per the principle of “Polluter Pays” to take appropriate measures to keep the pollution generated to a bear minimum level. All the ULBs shall take appropriate measures to recycle and reuse the treated waste water within their boundaries. As seen form the above case study, it is revealed that Recycle and Reuse of the treated domestic wastewater is the best option for the Viththalwadi STP. This will help to achieve the goal of sustainable development. This will also help for maintaining the quality of our water bodies and will help the downstream users who are the sufferers of such pollution created by their upstream counterparts. This will also help to achieve sustainable development. Pune Municipal Corporation shall think of maximum utilization of treated sewage within their boundary as well as shall give back the treated sewage to Water Resources Department. This will also help to reduce burden on already stressed water resources in the area.

CONCLUSION

Wastewater management is a challenging task and all the ULBs are faced with the burgeoning task of achieving 100% collection, conveyance and treatment of the domestic waste. In most of the cities, the common scenario is that after the treatment of sewage, it is discharged normally into the rivers. Thus, the treated sewage gets mixed with the untreated sewage and thus the whole efforts – physical as well as monitory, are lost. If it is made compulsory for all the ULBs to recycle and reuse atleas 50% of the sewage produced by them, it will help conserve the nature in many ways such as.

It will help to reduce the dependency on fresh water, thus more and more population can be supplied with fresh and non polluted water.

It will help to curb the river water pollution, as more and more treated wastewater will be recycled and reused within the polluter’s boundary.

As the treated sewage will not get mixed with the untreated sewage, the efforts put-in, the resources used and the money invested in creating these treatment facilities will be utilised optimally, thus helping the ULBs to achieve sustainable wastewater manage-ment.

ACKNOWLEDGEMENT

The authors are thankful to Pune Municipal
Corporation, Pune, India for providing the data pertaining to STPs in Pune. We would also like to thank Mr. Bipin Patel (Executive Director – RAMKY Group, India) and our students Mr. Amey Patel, Mr. Mukund Pawar and Mr. Bhaskar for data collection, compilation, design and cost estimates for this project.

REFERENCES