

# ENERGY EFFICIENT APPROACH FOR WASTE WATER TREATMENT PLANT

Renuka A. Godbole\*, Manjiri S. Kulkarni\*\*, Dattatray D. Balsaraf\*\*\*, Yogesh P. Nerkar\*\*\*\*

**Abstract** *An ambitious programme of 100 smart cities has been announced by government of India. A speedy upgrade in infrastructure and online services that too enabled by Information Technology is expected to be witnessed by the state capitals, tourists and heritage cities. Frameworks would be developed in consultation with a wide cross section of industry members and Government stakeholders and its partners. As a step towards building a digital India, the NDA government has proposed (in the latest budget) to earmark Rs. 7,060 Crores towards building of 100 smart cities across the country. These 100 smart cities are expected to provide sustainable and healthy living spaces in order to deliver greater efficient basic infrastructure services along with highly efficient environmental and economic resource use. One vital concern is the provision and usage of water. This paper argues that an integral role will be played by the energy efficient decentralised wastewater treatment facilities in coming years in smart cities. In particular, it focuses on two main points. First, there will be huge increase in use of waste water treatment for recycling and reuse of water streams so as to meet increasing water demands. Second, decentralised approach will be strongly favoured over centralised approach of waste water infrastructure due to the need of recycling and reuse at the point of usage. A case study of Pune city sewage disposal scheme is presented in this paper. Analysis of different types of energy associated with such system is done.*

## INTRODUCTION

So as to make our Pune city healthy and environment friendly, the Pune Municipal Corporation has been working on many plans in all possible ways. One of the most important aspects of the entire planning is the Sewage Treatment Projects (STP).

In the year 2005, Pune Municipal Corporation had completed phase I. Phase-II was completed during the year 2010. Phase-III Sewage disposal project of Pune city is likely to be completed by 2025. Sewerage system consists of collection network, conveyance lines, pumping stations and Sewage Treatment Plants. Collection network collects sewage from houses, apartments, commercial complexes etc. or from source. This collected sewage is further carried to pumping stations or STP via conveyance lines. Pumping stations pump the sewage to STP, where primary & biological secondary treatment is given to sewage water before discharging into any natural water course. The very first sewerage system for Pune city was designed in 1928. Preliminary treatment like screening and grit removal was given to the collected sewage

at Bhairoba Nala and then it was used for the purpose of irrigation by pumping to 17 ½ Nalli canal area. To cater to the ultimate capacity i.e. for the population of 0.26 million, this system was designed for 31.8 MLD (One Mega Liter per Day =  $10^6$  L/day). Considering the adjoining areas, wherein population was expected to increase, a complete collection and disposal system was planned in the year 1981. A 90 MLD STP was constructed at Dr. Naidu I. D. Hospital. The treated sewage is let off into the Mula-Mutha river. Sewage is pumped from intermediate pumping station at Kasaba Peth having 90 MLD capacity, to STP at Dr. Naidu Hospital. In all of the zones of old Pune city limit, the total main sewer length was approximately 146.83 Km. till the year 1997. Dr. Naidu Sewage Treatment Plant with full-fledged primary and secondary sewage treatment facility was treating 90 MLD sewage. Bhairoba Nala sewage treatment plant with primary sewage treatment facility was treating 32 MLD sewage. Sewerage system converts unhealthy conditions to healthy and clean environment

1. Coarse Screen Removes large size garbage.
2. Pumping station collects sewage and pumps to STP.

\* Accountant, PVG's College of Engineering and Technology, Pune, Maharashtra, India.  
Email: renuka27pune@yahoo.com

\*\* Assistant Librarian, PVG's College of Engineering and Technology, Pune, Maharashtra, India.  
Email: manjiri73@yahoo.co.in

\*\*\* Principal, Indrayani Mahavidyalaya, Talegaon Dabhade, Pune, Maharashtra, India. Email: prin.ddbalsaraf@gmail.com

\*\*\*\* Principal, PVG's College of Engineering and Technology, Pune, Maharashtra, India. Email: ypnarker@yahoo.com

3. Screw conveyor removes grit low measurement bio towers oxidation of organic matter.
4. Primary settling tank removes suspended solids.

### DATA COLLECTION

During this research work detailed information about water requirement for Pune city, future expansion, present scenario of waste water treatment plant and associated issues are studied. Details are presented here.

### Difficulties Faced to Operate Systems at the Maximum Efficiency

- Inadequate/old conveyance or transmission lines causing sewage to flow in Nallas.
- Problems with the collection system (unconnected areas, leaking main lines etc)
- Insufficient treatment capacity
- Space availability at the right locations for sewage treatment.
- Sewage flows from upstream outskirts of the city.

### Key Focus Areas for Successful Operation of STP

1. Awareness
2. Container free city
3. Alert System
4. Promotion of decentralized waste processing system
5. Practice of four R- Reject, Reduce, Reuse and Recycle.
6. Comprehensive solution for the centralized waste processing.

**Table 1:** Facts about Water Supply and Sewage Generation in Pune City

	Phase I (2005)	Phase II (2010)	Phase III (2025)
Water supply (MLD)	791	1050	1506
Sewage Generation (MLD)	567	700	1090

**Table 2:** Existing sewage treatment plants funded by Pune Municipal Corporation

.Sr.No.	Name of the Sewage Treatment Plant	Capacity MLD
1.	Dr.Naidu (Existing)	90

2.	Bhairoba	130
3.	Tanajiwadi	17
4.	Erandwane	50
5.	Bopodi	18
	Total	305 MLD



Fig. 1: 60 MLD Sewage Treatment Plant at Erandwane

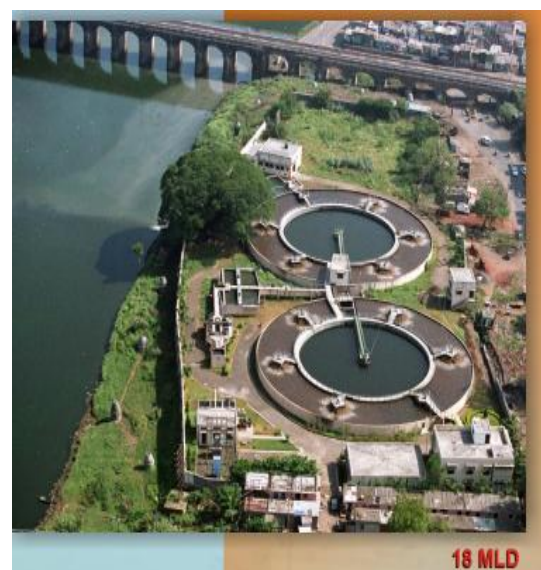


Fig. 2: 18 MLD Sewage Treatment Plant at Bopodi



Fig. 3: 130 MLD Sewage Treatment Plant at Tanajiwadi

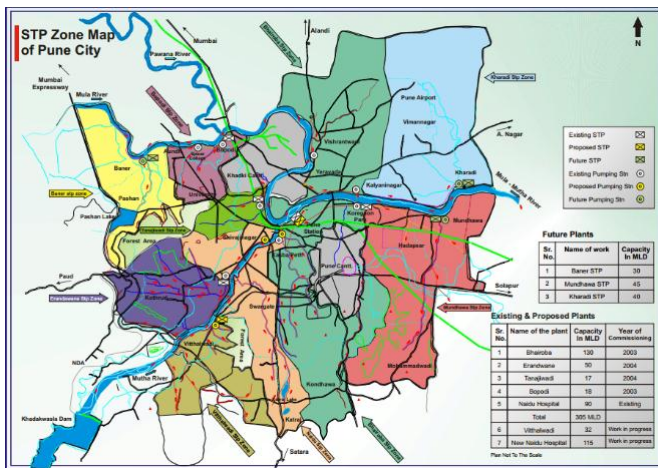


Fig. 4: Sewage Treatment Project Map of Pune City

## ANALYSIS AND DISCUSSIONS

In this research work, detailed study of completed as well as proposed sewage treatment plants is carried out. Following are the remarks based on these studies.

1. For both conveyance and treatment, the dependency of urban water system has increased on energy due to the growing scarcity of water.
2. Access to energy can become a limitation for the sustainable urban cities causing scarcity of water resources as well as water pollution.
3. Energy saving, energy efficiency and energy substitution have become a common development principle all over the world due to the rising climate concerns.
4. In coming years, substantial energy will be required in the sector of urban sanitation and will become one of the most important factors in power demand estimation.
5. In decision making of such projects, consideration will be mainly focused on the capital and operating costs, skillsets required for operation, simplicity of technology and its adaptability in local conditions.
6. Energy substitution and climate change mitigation are the two advantages which can be gained by inclusion of energy considerations in these decisions, as both of them are the most significant ingredients of eco-city development program, especially in countries where energy is scarce.
7. Four forms of energy i.e. electrical, manual, chemical and petroleum are used in a Waste Water Treatment Plant (WWTP). Research on studies of energy analysis of a WWTP has considered only the electrical form of energy. For exploring openings in energy substitution and energy efficiency, a comprehensive analysis of rest of the forms of energy consumption is required

to be done. Various forms of energy with respective intensity at different stages of treatment process are required to be included in such analysis.

8. The methodological framework revealed from such studies can be replicated to extract data at various scales of treatment and for varied technologies used.
9. With the help of this information, tools can be planned to find answers for the debate of water energy nexus. Also energy efficiency benchmarks can be developed for urban water sector as well as potential opportunities can be ascertained to replace conventional forms of energy by renewable energy.
10. Chemical energy shall be considered as indirect energy, human / manual energy as renewable energy and others as non-renewable energy.
11. Each form of energy consumption has been calculated in terms of kWh/m<sup>3</sup> of waste water treated.
12. Collection of primary data has been done through field monitoring, and then it is further verified with historical data collected from discussions with plant operators. For validation, transaction records and Log-books have also been referred.
13. Field monitoring was carried out for 15 days spread over 2 months. While monitoring days equal representation of weekdays and weekends is considered. Stopwatch is used for time measurement.

## Estimation of Electrical Energy Input

The electrical energy input is estimated by considering the electrical load of the pump/motor (kW), time in hours (h) for which the motor is operated and total amount of waste water treated (Eq. 1).

$$E_p = P \times T \quad Q = P \times T \quad (1)$$

where,  $E_p$  is the electrical energy kWh/m<sup>3</sup>,  $Q$  the total flow of waste water in m<sup>3</sup>/day,  $P$  the rated power of the electrical motor in kilo Watt (kW), and  $T$  is the operation hours in a day (h/day). The motor efficiency is assumed as 80 %.

## Estimation of Manual Energy Input

For different activities on field manual energy is required. The activities which require manual energy are like operating the switches, opening/closing of the sludge valves, cleaning of the tanks, operating valves to remove the sludge from the tank and collection of sludge in gunny bags to send it to the nearby horticultural garden. Manual energy consumption is a function of the gender of the labor and the nature of activity. Based on these considerations, the manual energy is calculated using Eq. 2. In the study plant, no female labor is engaged.

$$E_m = \sum_{i=1}^n \sum_{j=1}^m E_{ij} N_{ij} T_{ij} \quad (2)$$

where,  $E_m$  is manual energy in kWh/m<sup>3</sup>,  $n$  the number of nature of activities (light, active, and heavy),  $m$  the number of gender (male, female),  $E$  the human power equivalent (kW),  $N$  the number of persons engaged in an activity and  $T$  is the total time devoted in the activity (h/day).

### Estimation of Fuel Energy

Mechanical energy ( $E_f$ ) in kWh/m<sup>3</sup> is calculated using Eq. 3.

$$E_f = 15.64 D Q \quad (3)$$

Where, 15.64 is the unit energy value of diesel in kWh/l.  $D$  is the amount of diesel consumed in l/day. Diesel consumption is found to be 5 l/month for oiling and repairing of machineries.

### Estimation of Chemical Energy

Energy considered in this study is the energy released or absorbed during a chemical reaction. Chemical energy is calculated by estimating the standard enthalpy (heat) of reaction ( $\Delta H$ ) of the chemicals during a reaction.

Chemical energy ( $E_c$ ) in kWh/m<sup>3</sup> is calculated using Eq. 4.

$$E_c = n [\sum \Delta H_p - \sum \Delta H_r] Q \times 0.000278 \quad (4)$$

where,  $n$  is the number of moles (mol/day), 0.000278 is the conversion factor from KJ to kWh,  $\Delta H_p$  the enthalpy (heat) of formation of products (kJ/mol), and  $\Delta H_r$  is enthalpy (heat) of formation of reactants (kJ/mol).

## CONCLUSION

Sewage disposal units fabricated and utilized by Pune Municipal Corporation are studied during this research work. After analysis of data collected from various sewage disposal plants following conclusions are drawn.

1. For less resource intensive, more cost effective and sustainable urban water management, decentralized wastewater treatment has more potential to provide hygiene than centralized approaches.
2. In a decentralized waste water reuse scheme, water reuse and nutrient recovery can be facilitated. This reduces ecological risks such as failure of waste water system and the community health risk.
3. If reuse is intended, very high operational reliability for adequate treatment can be gained from a effectively designed plant of decentralized waste water treatment system.

4. Considerations on effectiveness have been extended to the terms of water loss and even to the nutrient recycling in this research work.
5. With an effective decentralized system, Water loss can be reduced by minimizing evaporative and leakage losses, and maximizing the amount of recycled water
6. Depending on the use intended, decentralized treatment system will have to be competent to process nutrient recycling by conservation or elimination of nutrients
7. Efficiency of the systems can be increased to a great extent by conserving nutrients in mineral forms.
8. For effective integration of a decentralized waste water treatment system, acceptance of the public, the local communities is required. The design of the system should be such that it integrates seamlessly in to the rest of the built environment. While framing design strategies consideration should be given to points like functionality, space required odors and aesthetics.
9. Assessment of the efficiency of the decentralized system can be very easily done on four parameters viz. performance of the treatment, land use footprint, maintenance requirements and efficient use of energy. Of course each of these four varies marginally upon the site of installation selected.
10. For costs and safety, maintenance requirements are the major drivers. This point towards a stable and easily monitored design system.
11. Decentralized systems are positioned nearby the point of waste water generation. It optimizes the land use footprint, which is of greater importance in a smart cities context.
12. In urban planning processes, integrated decentralized water and waste management concepts have several key advantages over centralized approaches.
13. Water and nutrient recycling of water are the two most promising advantage of decentralized waste water management.
14. Development of new systems seems to have sparked because of recent technological advancement in information technology. A combination of ecological waste water treatment with information technology can produce new promising systems which can be integrated in upcoming smart cities.
15. Characteristics of decentralized approaches are:
  - Recycling of waste water is possible at the point of waste water generation. Fresh water will be saved in large quantum due to elimination of big sewers and centralized treatment plants.
  - Upon the specific type of waste water, treatment facilities can be customized, which in turn will enable stable and safe results. This will give advantages of

variable approach towards treatment capability. As it can be developed on the basis of the actual needs, it will help in reducing the sunk cost and ensure certainty of planning.

- Well-developed maintenance strategies and operational control will be required.
16. Advanced information technologies are taking root in the smart cities initiatives. Decentralized waste water treatment systems can be easily implemented even to large scale applications with the help of existing SCADA based systems or with more advanced systems based on IOT i.e. 'Internet of Things'.

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