# Assessment of the Viability of Reuse of Secondary Effluent from STP

[1.] Akshay .G. Dighe, [2.] Prof. S. R. Korake

[1.] PG Student, Deparment of civil Engineering, Sanjivani College of Engineering, Kopargaon SPPU, Pune, Maharashtra, India, e-mail id: akshaydighe007gmail.com

[2.] Assistant Prof, Department of civil Engineering, Sanjivani College of Engineering, Kopargaon SPPU, Pune, Maharashtra, India, e-mail id: korakesandeepcivil@sanjivani.org.in

**Abstract**

*Population growth, urbanization, water resources pollution, environmental awareness, uneven distribution of water resources and water scarcity these factors have resulted in reuse of water especially from sewage treatment in water scare countries. In this work secondary effluent from Shirdi STP were collected and analyzed for physical, chemical and biological characteristics to assess the viability of water reuse. Available water reuse criteria for different reuse options were used to characterize the WWTPs secondary effluent for agricultural reuse. Some of the water quality parameters of the effluents from this plant were non-compliant to the requirements for maybe reuse for industries. However, the use of advance treatment technologies as part of the treatment train would address the water quality issues. From the analysis it is stated that the water is suitable for agriculture use as all its parameters are within the limit.*

**Keyword-** *Wastewater effluent, wastewater reuse, wastewater treatment plan*

## I. Introduction

Water stress has become a perennial concern in most Indian cities. With a growing population, the per capita availability of water has dropped from 1,816 cubic meters in 2001 to 1,545 cubic meters in 2011.The latest census reported that only 70% of urban households have access to piped water supply. The average per capita supply to these households is well below the recommended 135 liters per day in many cities. India is expected to add approximately 404 million new urban dwellers between 2015 and 2050.This rapid urban growth will be linked with higher industrial output and greater energy demand. There is a domino effect here, with water demand from households, industries and power plants growing simultaneously and adding to the urban water stress. This is particularly visible in industrial metros such as Chennai, Bengaluru, and Delhi, where acute water shortage has driven up the cost of fresh water production and Industrial water tariffs. To mitigate the severity of this impending crisis, there is a need for innovative alternatives to fresh water. Reuse of treated wastewater or reclaimed water is one such alternative that is gaining currency. Pilot wastewater reuse plants are already in operation in many states in India.

This paper highlights the key considerations while developing such projects to ensure viability and sustainability. We focus on projects in which municipal sewage is treated for supply to agricultural as well as other customers, which we believe have immediate potential in the Indian market. Other structures are possible industrial effluent could be used for input water, and the reclaimed water could be used for agricultural or domestic purpose but these project structures will take longer to gain traction in India.

Current status of municipal wastewater use for agriculture in India.

Use of municipal wastewater for farming, whether treated or not, is widespread in pre-urban areas in India. Although there are no comprehensive estimates of the total agricultural area using wastewater irrigation, several isolated studies indicate that this area is considerable. An IWMI study of five selected urban areas came up with a figure of about 50,000 hectares, while another study on Gujarat state alone came up with a figure of 38,000 hectares. It is not uncommon to find urban rivers to have minimal natural flow for much of the year due to upstream damming; treated or untreated sewage flows through these channels and is used by downstream farmers. Several factors influence the practice of sewage-based farming in pre-urban areas. These include: Availability of freshwater for irrigation at affordable rates: Where sufficient amounts of freshwater are available through canals or from groundwater pumping, it is typically preferred to wastewater. However, most urban areas in India are facing water shortages and any available freshwater, whether surface water or groundwater, is diverted exclusively for urban use. Groundwater pumping is restricted in many places, or the water table is too low making pumping expensive. Under these circumstances, pre-urban farmers have no choice but to depend on wastewater. Reliability of wastewater supply: Since wastewater generation from cities is guaranteed while freshwater availability is uncertain in many places, pre-urban farmers consider this a big advantage and are even willing to pay for it.

In most per-urban areas of India, untreated rather than treated sewage is used for irrigation because either adequate sewage treatment capacity is non-existent, or the farms in question are not located close to the outflow of the sewage treatment plant. In a few cases where treated sewage is used, it is used by farmers close to the sewage treatment plant, as in the case of famers close to the Keshopur and Okhla Sewage Treatment Plants (STPs) in Delhi. Wastewater irrigation in pre-urban farms can be direct or indirect: direct when sewage is used from a sewage channel close to adjacent to the field, and indirect when the sewage flows into a water body (lake/river) and water is taken from this polluted water body.

A variety of crops are grown through sewage-fed farming in pre-urban areas, the most prevalent being vegetables for the local urban market. Other common examples include rice, wheat, fruits, flowers/ornamentals, fodder/grasses, and in the unique case of the East Kolkata Wetlands (EKW), fish farming in wetlands fed by sewage, the largest such system in the world. One study in Gujarat found that low-income households were making a livelihood out of lifting and supplying sewage. In the EKW for example, the estimated production in 1999-2000 was 12.8 million kg of rice, 6.9 million kg of fish, and 69 million kg of vegetables, supporting a population of around 60,000.

*Study Area:*

The Shirdi WWTP is about 5 km from the location of Shirdi temple and it is situated at coordinates of $19^{o}$ 45’41” N $74^{o}$ 31’17” E. Shirdi WWTP is designed for 16 ML/day and is currently running over capacity at 14 ML/day. WWTP receives effluent from Shirdi town. It is classified as a medium sized plant. This plant will be able to treat 14 ML/day with the following units:


*Fig.1 process flow diagram of WWTP*

*Process of WWTP*

The plant work on the c-tech process C-Tech is a CYCLIC ACTIVATED SLUDGE TREATMENT process. It provides highest treatment efficiency possible in a single step biological process. The C-TECH – System is operated in a batch reactor mode this eliminates all the inefficiencies of the continuous processes. A batch reactor is a perfect reactor, which ensures 100% treatment. Two or more modules are provided to ensure continuous treatment. The complete process takes place in a single reactor, within which all biological treatment steps take place sequentially. No additional settling unit, secondary clarifier is required.

## II. Methodology

*Materials and Methods:*

The research approach followed was benchmarking through theoretical considerations of existing wastewater reuse philosophies for agricultural use. To assess the water quality suitability of the chosen study area of Shirdi municipality’s WWTPs, analyses of chemical, physical and biological parameters will be carried out and compared to existing wastewater standards. The following sections address the procedure carried out in sampling, laboratory and analyses of these parameters.

*Sampling and data collection:*

The main sampling is to be conducted in the Shirdi wastewater treatment plants to determine the various wastewater parameters. Appropriate sampling bottles were used for each of these parameters. A total 15 number of samples were taken over a period of 3 months.

*Sampling procedure:*

Sampling procedure for Shirdi municipality is explained below. Samples, if they are not analyzed immediately, they are to be stored in a cool room.

*Physical and chemical analyses:*

Organic chemistry analyses sample bottles used are 1 L glass bottles with scheduled numbers for scanning in and out of the laboratory. Bottles were rinsed with samples then samples were taken 10-15 cm below flowing water surface, filled to the brim and stored in a cooler box with frozen ice bricks.

| **Aggregate Parameter** | **Analytical method** | **Salinity parameter** | **Analytical method** |
|---|---|---|---|
| TSS | APHA | DO | Winkler method |
| BOD | Dilution method | Conductivity | Conductivity meter |
| COD | Dr. Lange method | Ph | pH meter |
| Turbidity | Turbidimeter | TDS | APHA |
| **Nutrient parameter** | **Analytical method** | | |
| Alkalinity | APHA | | |
| Chloride, | APHA | | |
| Total Hardness | APHA | | |

*Water quality parameters*

There are many ways to describe the quality of water. Depending on how the water is used and what you are looking for, different parameters are important. Here follows a short description of the parameters used in this work.

**pH** is an indicator of the acidity or basicity of a water. The normal pH range for irrigation water is 6.5 to 8.4. The pH is seldom a problem in itself. The main reason for pH measuring is to detect abnormal water, which may contain toxic ions or cause a nutritional imbalance the pH value is also important for aquatic fauna but waters with pH between 6 and 9 are not likely to be harmful to fish.

Electrical conductivity, **EC**, is used to estimate the amount of ions dissolved (water salinity). It measures the ability of a water sample to transmit electrical current, which is proportional to the ion content. The electrical conductivity is usually expressed as deciSiemens/meter (dS/m).

Total Dissolved Solids, **TDS**, is another measure of salinity. It shows the amount of dissolved substances in the water, both ions and uncharged molecules. TDS is directly proportional to EC and expressed as a concentration mg/l. The amount of dissolved salts in soil water is determined by the amount of dissolved salts in the irrigation water. In soil water with high salinity, the osmotic pressure increases and the plants use more energy to take up water. This results in an increase in respiration and a decrease of plant growth and yield.

The oxygen content of water can be expressed either as mg /l dissolved oxygen, **DO**, or percentage saturation. The water's ability to dissolve oxygen is temperature dependent. Dissolved oxygen is vital to the aquatic fauna, and many species of fish require DO contents above 5 mg/l, whereas coarse fish can survive in 2 mg/l. The oxygen is also used by bacteria to break down organic matter and thus anaerobic conditions can be found when the organic content is high (as in domestic sewage). When the dissolved oxygen is depleted the water becomes anaerobic and sometimes highly reducing.

The biochemical oxygen demand, **BOD**, is a measure of how much biodegradable organic matter a water sample contains but it is the amount of oxygen required to break down the organic matter in the sample that is measured. Usually this is measured during 5 days. The BOD is expressed as mg/l. The more oxygen required the more organic matter. Organic substances present in sewage are carbohydrates, lignin, fats, soaps, synthetic detergents, proteins and organic chemicals from process industries. A normal stream should have values of less than 5 mg/l and untreated sewage is normally between 220 and 500 mg/l.

**COD**, the chemical oxygen demand (mg/l) is a measure of the amount of organic matter that can be oxidised with a known strong oxidation agent under extreme conditions. The amount consumed oxidation agent is translated to mg Oxygen/l. The COD value is usually 2-3 times higher than the BOD value in settled, untreated wastewater.

Chloride, **Cl-**, is most occurring in the common salt form (NaCl). It can be found in brackish water contaminated by seawater or in groundwater aquifers with high salt content. Chloride may also indicate sewage pollution, as the chloride content in urine is high. Chloride can accumulate in plant leaves and is toxic to plants. The most sensitive crops are affected by concentrations of 3.3 mmolc/l (117 mg/l).

*Sampling procedure for soil*

The soil samples of the surrounding area of the wastewater treatment plant were taken. A total number of 10 samples were taken. The sample were randomly taken from any direction. A total number of 5 samples were taken from the field in which wastewater were used and another 5 samples from field without wastewater reuse i.e. surface or groundwater. A pit about 30 cm deep was taken. Soil from the walls of this pit was scraped. This soil was filled in polyethylene bags. The bags were duly labelled and send to the laboratory. The soil was then spread in thin layers on clean, paper sheet for drying in open air. On drying, the samples were re-filled in polyethylene bags and kept at room temperature for analytical work.

### III. Result and Discussion

Since many cities and towns in India are currently in the process of constructing or expanding their sewerage and wastewater treatment infrastructure, it would be wise to put systems in place with the goal of gainful treated water reuse. Experience has shown that a common constraint for wider use of treated wastewater is the location of farms. Decentralized siting of plants and outlet channels must be done with the goal of maximizing exposure to adjacent farms. Water Authorities typically consider new freshwater supply as less expensive than wastewater treatment. However, while a wastewater treatment plant is certainly very expensive, researchers argue that when valuing freshwater supply infrastructure, the entire system including the pipelines, canals, reservoirs, pumps and treatment plants should be taken into account. From this perspective, the cost of providing treated wastewater (at a non-potable standard) can be lower or at least competitive with that of providing freshwater as shown in the following study results. Following comparative cost data was obtain from the shirdi municipality.

*Table: Comparative costs of producing freshwater and sewage treated water (STW)*

| | Levelized | Cost |
|---|---|---|
| | STW | Freshwater |
| Public (Rs/L) | 4-14 | 11-44 |
| Private (Rs/L) | 5-17 | 13-50 |

If this costs is adopted by policy makers, treated wastewater will be rightfully seen as an economically viable resource with a higher priority over new freshwater supply for non-potable uses.

*Table: Parameters of waste water of Shirdi WWTP*

| PARAMETERS | AVERAGE | LIMIT | AGRICULTURE REUSE (WHO 2011) | REMARK |
|---|---|---|---|---|
| **pH** | 7.36 | 6.5-8.5 | 6-9 | Suitable |
| **BOD(mg/l)** | 34.33 | 30 | 25-50 | Suitable |
| **COD(mg/l)** | 61.6 | 75 | 100 | Suitable |
| **Turbidity(NTU)** | 53.93 | 70 | 100 | Suitable |
| **TDS(mg/l)** | 909.41 | 450 | 450-1000 | Suitable |
| **TSS(mg/l)** | 87.06 | 60 | 100 | Suitable |
| **EC(mS)** | 1.86 | 1-2 | 0.7-3 | Suitable |
| **DO(mg/l)** | 5.65 | 4 | >4 | Suitable |
| **Alkalinity (mg/l of $CaCO_3$)** | 396.06 | 350 | 200-400 | Suitable |
| **Chloride(mg/l)** | 322.93 | 150-250 | 200-500 | Suitable |
| **Total Hardness(mg/l)** | 743.86 | 525-700 | 525-1400 | Suitable |

Thus, from above table it can be understood that the wastewater from Shirdi municipality can be used for agriculture purpose. All the average parameters are within the limit provided by WHO (2011) and safe for the purpose of agriculture.

*Table: Parameters of soil tested.*

| Parameters | Average | | Standard Limit | Remark |
|---|---|---|---|---|
| | Without wastewater | With wastewater | | |
| **Organic carbon** | 38.2 | 68.4 | 40-60% | Increase above limit |
| **Ph** | 6.54 | 8.05 | 6-8.5 | Increase |
| **Phosphorus(P)** | 12.2 | 22.6 | 15-50 kg/ha | Increase |
| **Potassium(K)** | 254.4 | 306.6 | 150-250 kg/ha | Increase above limit |
| **Nitrogen(N)** | 251.6 | 361.6 | 280-420 kg/ha | Increase |
| **EC** | 0.77 | 1.296 | 1.0 ds/m | Increase above limit |

From above table it can be stated that the soil which was irrigated with wastewater tends to increase the N, P. values which are low in the surrounding region soil. Thus it increase the nutrient value of soil and make it more favorable.

*Soil characteristics*

The Kopargaon – Shirdi belt is part of the Godavari basin and is popularly known as the sugar belt of the region. It is one of the most fertile parts of the district. Soils in the region vary from Medium Soil to Deep Black Soil. Area under Medium Soil is 847.43 sq. km and that under Deep Black Soil is 107.37 sq. km. These two types of soils have good depths and thereby good moisture retention capacity. Medium Soils are 22 to 65 cm deep and have moisture saturation of 65 to 67 mm. The Deep Black Soils have depths above 60 cm and moisture retention up to 140 mm. The details of soil types and cropping pattern are given below.

*Discussion:*

From the wastewater analysis it is determined that the wastewater is suitable for the purpose of the agriculture as per the guidelines issued by WHO. Some parameters tends to increase the potassium (K) of the soil to a high side. These wastewater parameters improves the pH of the soil as the soil is of saline-alkaline nature. They also improve the organic carbon quantity in the soil also the Nitrogen (N) quantity is also increased. Due to them the Phosphorus (P) quantity is within the limit. Thus wastewater from Shirdi municipality helps on large scale to improve the quality of agricultural soil.

From the above soil analysis of parameters it is determined that the quantity of Potassium (K) exceeds the maximum limit of 250 kg/ha, it can be adjusted within the limit through application of the fertilizers. The Phosphorous (P) is very low but it is increased by use of wastewater. This soil is suitable for all kind of crops but some parameters needs to be improved. Thus, all these parameters should be accordingly adjusted by the farmer either by fertilizers in order for him to increase his crop yield.

## IV. Conclusion

As about 21.16% of the area is irrigated with the wastewater the region is widely dependent on the wastewater in summer season. The parameters tested state that there is wide increase in organic carbon of the soil due to reuse of wastewater also potassium(K) is crossing the standard limit which is not desirable thus, in order to get large yield from crop fertilizer should be used. India does not have water reuse guidelines. These guidelines could assist in the design strategy of water reclamation plants and urban infrastructure planning for future incorporation, reclamation and reuse of municipal secondary effluent. Agricultural reuse, which is the oldest and accounts for the largest reclamation and reuse worldwide is not fully exploited in India and the study area. This could be partly due to declining agricultural activity in the study area, non-existent current guidelines and standards and concerns of irrigation return flows. Aggregate, nutrient and ionic water quality parameters were analyzed for the WWTP in the Shirdi municipality. WWTPs comply with respect to most aggregate, nutrient and ionic parameters. The parameters were measured against worldwide water quality criteria as feed and final effluent for agricultural with emphasis on the study areas potential water reuse areas. Water quality guidelines, criteria and regulations are based on parameters that can be measured with affordable and dependable analytical monitoring tools and continuous technology improvement is required.

## V. Acknowledgement

I wish a true sense of gratitude to my project guide Prof. S. R. Korake and H.O.D of CIVIL Department Dr. M. S. Purkar and also Dr. M. V. Jadhav and our principal Dr. D. N. Kyatanavar who, at every discrete step of this project contributed their valuable guidance and helped to solve each and every problem that occurred during the project development. The curriculum has given me a good opportunity for me to develop a project report on "Assessment of the Viability of Reuse of Secondary Effluent from STP"I would extend my sincere thanks to all staff members for extending their kind support and encouragement during the completing of this project. I also express my thanks to all my friends who directly or indirectly supported me during the completion of this project.

## Vl. References

1. Asano, T. and Cotruvo, J.A. 2004. Groundwater recharge with reclaimed municipal wastewater: Health and regulatory considerations. Water Research, vol. 38, no. 8, pp. 1941-1951
2. Asano, T., Burton, F.L., Leverenz, H.L., Tsuchihashi, R. & Tchobanoglous, G. 2007. Water reuse: Issues, technologies and applications. United States: Metcalf & Eddy, Inc.
3. Bartram, J. and Ballance, R. 1996. Water Quality Monitoring-A practical guide to the design and implementation of fresh water quality studies and monitoring programmes. London: E & FN Spon.
4. Central water board. Sampling procedure for biology and chemistry, Rev. 3. Document no: 3.3.1.10.1. Vereeniging.
5. de Koning, J., Bixio, D., Karabelas, A., Salgot, M. & Schafer, A. 2008. Characterisation and assessment of water treatment technologies for reuse. Desalination, vol. 218, pp. 92-104.

6. Gugulethu Skosana, Hein H. du Preez1, "Assessment of the Viability of the Reuse of Sedibeng District Municipal Secondary Effluent in Southern Gauteng, South Africa"
7. J. de Koninga, D. Bixiob, A. Karabelasc, M. Salgotd, A. Schäfere (2008) "Characterisation and assessment of water treatment technologies for reuse"
8. María Fernanda Jaramillo and Inés Restrepo "Wastewater Reuse in Agriculture: A Review about Its Limitations and Benefits"
9. Mathew Kurian,V. Ratna Reddy,Ton Dietz,Damir Brdjanovic (2012) "Wastewater re-use for pre-urban agriculture: a viable option for adaptive water management?"
10. Moazzam Ali Khan, S. Shahid Shaukat and M. Altaf Khan (2003) "economic benefits from irrigation of effluent of waste stabilization pond"
11. Ozair Aziz, Arif Inam and Samiullah (1997) "utilization of petrochemical industry waste water for agriculture"
12. Rand Water. 2011a. Turbidity determination: Bench top instrument, Rev. 02. Document No: 1.1.2.19.1. Vereeniging, South Africa: Rand Water Analytical Services.
13. Rand Water. 2011b. the determination of oil and grease in water samples using Turbovap, Rev. 09. Document No: 2.2.1.02.1. Vereeniging, South Africa: Rand Water Analytical Services.
14. Rand Water. 2012 Determination of Total Dissolved Solids in water, Rev. 05. Document No: 2.1.2.04.1. Vereeniging, South Africa: Rand Water Analytical Services.
15. Rand Water. 2013. Determination of suspended solids dried at 100oC, Rev. 7. Document No: 2.1.2.05.1. Vereeniging, South Africa: Rand Water Analytical Services.
16. S. Dhanam, D. Arulbalachandran (2009) "effect of tanfac effluent on vartetal response of black gram"
17. S. Rathikaand T. Ramesh (2013) "Eco-friendly utilization of wastewater in agriculture"
18. Salgot, M. 2008. Water reclamation, recycling and reuse: implementation issues. Desalination, vol. 218, pp. 190-197.
19. United Kingdom, Water Industry Research (UKWIR). 2014. Establishing a robust case for final effluent reuse- An evidence base. UKWIR Report No. 14/WR/29/3.
20. United States Environmental Protection Agency (USEPA). 2012. Guidelines for water reuse. EPA/600/R-12/004. Washington, United States: USEPA Office of Wastewater Management. Available from: <http://nepis.epa.gov/Adobe/PDF/P100FS7K.pdf> [Accessed 24 August 2013].
21. Vinod Kumar and A.K. Chopra (2013) "Enrichment and translocation of heavy metals in soil and plant of Vicia faba L. (Faba bean) after fertigation with distillery effluent"
22. World Health Organization (WHO). 2009. Water Safety Plan Manual: Step-by-step risk management for drinking water supplies. Switzerland, Geneva: World Health Organization. Available from:<http://whqlibdoc.who.int/publications/2009/9789241562638_eng.pdf> [Accessed 05 November 2014].
23. Y. M. Makki, O. A. A1-Tahir & M. I. Asif (1986) "Effect of Drainage Water on Seed Germination and Early Seedling Growth of Five Field Crop Species"

## BIOGRAPHIES

**Mr. Dighe Akshay Gokul**
**Education:** M.E. (Environment Engineering) Pursuing, B.E. Civil First Class Distinction, Diploma in Civil Engineering First Class Distinction
**E- Mail id:** akshaydighe007@gmail.com

**Prof. Korake Sandeep Ramesh**
**Education:** Ph. D. (Environment Engineering) Pursuing, M.E. (Environment Engineering) First Class Distinction, B.E. Civil First Class Distinction
**E- Mail id:** korakesandeepcivil@sanjivani.org.in