© July 2024| IJIRT | Volume 11 Issue 2 | ISSN: 2349-6002

Treatment of municipal sewage and reuse of Treated sewage at Industries in place of raw water by using UF and RO Technologies

A Narayanan[1], Chitranjan Kumar[2]
[1] *PG Research Scholar, M.Tech (Environmental Engineering) Department of Civil Engineering, Shri Venkateshwara University, Uttar Pradesh, India*
[2]*Assistant Professor, Department of Civil Engineering, Shri Venkateshwara University, Uttar Pradesh, India*

***Abstract* — This project aims to reduce the industry's freshwater usage by supplying treated sewage water, ensuring more raw water for households. Sewage from municipal areas is pumped to the bar screen chamber for large debris removal. The water then moves to a collection sump for equalization before being pumped to the grit chamber to remove heavy materials, followed by a primary clarifier for suspended solids and FOG removal. Next, the aeration tank reduces BOD and COD using fine bubble diffusers. Overflow water goes to a secondary clarifier, where biomass settles. The supernatant is disinfected with sodium hypochlorite and filtered through sand and carbon filters. Ultra-filtration removes fine solids before the water is treated in an RO plant to reduce TDS for industrial reuse, such as in cooling towers, boilers, chillers, and compressors.**

***Index Terms* — *Freshwater reduction, Treated sewage water, Raw water conservation, Industrial water reuse, Municipal sewage treatment*.**

I. INTRODUCTION

In an effort to address the critical issue of freshwater scarcity, this project focuses on reducing industrial freshwater consumption by utilizing treated sewage water. By implementing a comprehensive sewage treatment process, the project aims to conserve raw water for household use. This innovative approach involves a series of advanced treatment stages, including debris removal, sedimentation, biological treatment, disinfection, and filtration, ensuring the treated water meets the quality standards required for industrial applications. The treated water can be effectively reused in various industrial systems such as cooling towers, boilers, chillers, and compressors, demonstrating a sustainable solution to water resource management.

In an effort to address the critical issue of freshwater scarcity, this project focuses on reducing industrial freshwater consumption by utilizing treated sewage water. Freshwater scarcity has become a global challenge due to factors such as population growth, industrialization, and climate change. With increasing demand and decreasing supply, innovative solutions are needed to ensure sustainable water management practices. This project is a step towards addressing this pressing issue by diverting treated sewage water for industrial use, thereby conserving precious raw water for household consumption.

The core objective of this project is to implement a comprehensive sewage treatment process that transforms municipal sewage into water suitable for industrial applications. By doing so, it not only alleviates the demand on freshwater resources but also promotes the reuse of wastewater, contributing to environmental conservation and sustainability.

The sewage treatment process begins with the collection of sewage from municipal areas. This sewage is pumped directly to a bar screen chamber, where large debris such as plastic bags, sticks, and other floating materials are removed. This initial stage is crucial as it prevents blockages and damage to subsequent treatment equipment. The bar screen chamber acts as the first line of defense, ensuring that only water with smaller particles proceeds to the next stages.

Following debris removal, the water moves to a collection sump. This sump serves as an equalization basin, where the flow of sewage is regulated to ensure a consistent and manageable rate through the treatment process. In this sump, various streams of sewage are blended, equalizing their composition and flow rate. Equalization is important because it mitigates the impact of fluctuating sewage inflows, which can otherwise disrupt the efficiency of downstream processes.

II. METHODOLOGY OF SEWAGE TREATMENT PLANT

The objective of sewage treatment is to produce a treated Sewage without causing harm to the surrounding environment, Lakes, River and Ground water, prevent pollution and also reuse of treated sewage at Industries in the place of raw water by using UF and RO Technologies. By removing contaminants from sewage, we can reduce the risk of water pollution, the spread of waterborne diseases and also we are reclaiming the water by removing impurities in water which is suitable for Industries for their process like Cooling, Power generation, Processing and Cleaning activities. Treatment Plant also produce an environmental friendly Solid waste (or treated Sludge) suitable for disposal or reuse (usually as farm Fertilizer).

A. Principle behind treatment

The principle of a Sewage Treatment Plant (STP) involves the treatment of wastewater through a series of physical, biological, chemical, Filtration and Reverse Osmosis processes to remove pollutants and contaminants and also reduce TDS suitable for reuse at Industries. The primary principle is to mimic and enhance natural processes that occur in the environment to purify water and the Secondary principle is to reuse the treated sewage at Industries to reduce raw water consumption.

B. Process Criteria

A sewage treatment plant (STP) processes wastewater through multiple stages. After preliminary filtration, the treatment involves three main stages: primary, secondary, and tertiary, with the third stage dedicated to polishing, as detailed in the Main Project. In the primary treatment, physical solid-liquid separations take place, including screening and grit removal, to separate large floating particles and inert inorganics.

The wastewater then reaches the primary clarifier, where fats, oils, and grease (FOG) are skimmed off the top, and sludge is removed from the bottom. The secondary treatment stage involves biological processes, such as the activated sludge process, Moving Bed Biofilm Reactor (MBBR), or Sequencing Batch Reactor (SBR), to remove BOD and COD. The treated sewage is then disinfected before moving to the tertiary treatment stage.

During tertiary treatment, fine suspended solids, color, and odor are removed using pressure sand filters and activated carbon filters. Colloidal materials and ultra-fine suspended solids are eliminated using an ultra filter, and total dissolved solids (TDS) are reduced through a reverse osmosis system.

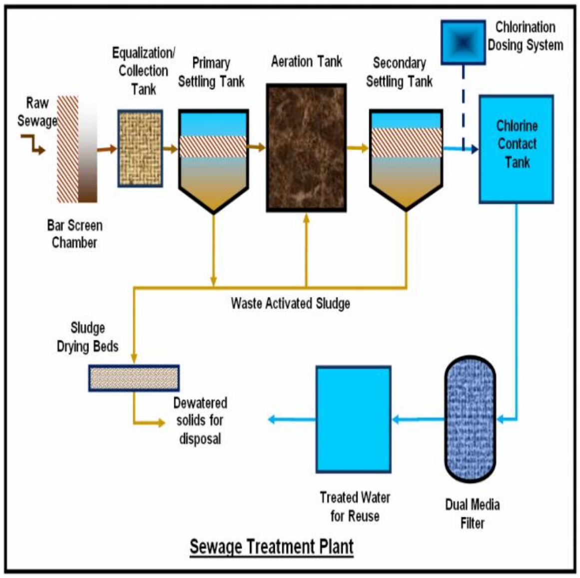

Fig: 1 Process Flow Diagram of STP

C. Main Constituents in Sewage

The main constituents in sewage can be broadly categorized into several groups:

- Physical Constituents
- Chemical Constituents
- Biological Constituents
- Gaseous Constituents
- Miscellaneous Constituents

III. TREATMENT SCHEME AND SEWAGE TREATMENT PROCESS

The treatment process uses physical, biological, and adsorption methods. Raw sewage enters the collection and equalization sump through a bar screen, trapping debris. The screened sewage flows to the collection and equalization tank, where air blowers ensure homogeneous mixing.

The sewage is pumped to the primary clarifier, where fats, oils, and grease (FOG) are skimmed off, and sludge settles at the bottom. The clarified water flows to the aeration tank, where fine bubble diffusers introduce oxygen to degrade organic pollutants by microorganisms. This biological reaction is enhanced by diffused aerators.

IV. TREATMENT PHILOSOPHY FOR TERTIARY TREATMENT PLANT (TTRO)

STP treated water received under pressure (approx. 1 kg/cm2) is routed to the Secondary Sewage Collection Sump. Secondary Treated Sewage Sump provided with 4 Nos Submersible pump with level transmitter. Based on the characteristics of feed, three stages of treatment are envisaged.

- Pre-treatment
- Secondary Treatment stage
- Tertiary Treatment Stage

Suspended solids removal through Rapid Gravity Dual Media Filters. The chlorinated water from the Pre - Chlorination Tank to the Rapid Gravity Dual Media Filter through Filter Feed Channel. The Filters are designed such that the incoming water is uniformly distributed between the various filters and individually on each filter bed via overflow weirs.

Fig. 2 Rapid Gravity Filters building

V. UF – RO SECTION

A. *Ultrafiltration System*

The filtered water will be pumped to the ultrafiltration skid through basket strainers. Basket Strainers are filtered Water from filtered water storage tank will be pumped through UF Feed pump. Manual basket strainers which are provided as safeguard for ultrafiltration system. These strainers are in manual mode. Since the frequency of leakage of media from Gravity filter is very low, generally the manual backwash is done once in a month or two. However, the manual valves are provided for backwashing of basket strainers. Backwash waste is routed to Disposal blending Tank.

B. Ultra-Filtration System

The UF system consists of the three modes of operation:

- Pre-treatment
- Filtration
- Backwash/Chemical Enhanced Backwash (CEB)

Fig 3 Ultra Filtration System

C. *RO SECTION*

From the UF Permeate Tank the UF permeate water will be pumped to the Cartridge filter of MCF feed Pump.

D. *Chemical dosing for RO system:*

It is done for the removal of remaining chlorine after escaping Rapid Gravity Dual Media Filters and UF. This will be done by Sodium Meta bisulfite (SMBS) dosing which is commonly used for removal of free chlorine acting as a reducing agent. A separate SMBS dosing tank along with SMBS dosing pump is provided. SMBS provision kept before UF permeate tank to remove free chlorine from RO feed water.

E. *Reverse Osmosis System*

The reverse osmosis membrane system is the core process unit of the TDS removal process. The principle of operation of the reverse osmosis process is to reverse the natural osmosis phenomenon. Osmosis is the phenomenon in which fluid permeates through a semi-permeable barrier (the membrane) from the diluted side to the higher concentrated side in order to equalize concentrations. The salts or other larger molecules remain behind the barrier. The chemical potential that causes the fluid to pass from the diluted side to the higher concentrated side is termed osmotic pressure. The higher the content of dissolved solids, the higher the osmotic pressure.

In tertiary treatment reverse osmosis, concentrated brine TDS is approximately 8,000 ppm and permeate TDS is approximately 70 ppm. Permeate pressure is 1.5 bar. High pressure pumps supply the pressure to drive the water through the membranes at 10-17 bar, to overcome the large osmotic pressure and to compensate for pressure losses.

Fig. 4 RO Skid

E. *RO Membrane Clean-In-Place System*

Although the proposed pretreatment is able to provide high water quality to the RO membranes, where membrane technologies are used for desalination, the presence of organic materials and biological microorganisms in the feed water have the potential to substantially increase the frequency and severity of membrane biofouling, and consequently the downtime and maintenance costs associated with operating treatment plants. To mitigate the potential for and occurrence of biofouling in membrane plants, cleaning chemical methods are required to maintain membranes in optimum service condition.

The plant is supplied with a complete RO clean-in-place (CIP) system, including cleaning tank, cleaning pumps, cartridge filter and permanent piping with valves and fittings (removable fittings are not suitable).

F. *Treated Water Storage Tank and Transfer Pumps*

The treated water storage tank receives the RO permeate after Activation Filtration System. Treated water from the treated water tank is further transferred to the pipeline network for routing it to various industrials by means of Treated water pump of Submersible type VFD operated.

Fig. 5 Treated water storage Tank

VI. CONCLUSION

Implementing sewage recycling systems is a vital strategy for sustainable water management, offering extensive environmental, economic, and social benefits. By treating and reusing wastewater, communities can safeguard public health by reducing the risk of waterborne diseases and contaminants entering natural water bodies. Additionally, this process conserves precious water resources, making more water available for essential uses, such as drinking and agriculture. Promoting environmental sustainability, sewage recycling helps protect ecosystems by reducing the discharge of untreated or partially treated wastewater, thus preserving aquatic life and maintaining the natural balance. This holistic approach addresses immediate water needs while ensuring long-term environmental health. The transition towards widespread adoption of sewage recycling systems is crucial in addressing the global challenges of water scarcity and pollution.

As freshwater sources become increasingly strained due to population growth, industrial demands, and climate change, recycling wastewater provides a viable alternative to meet the water needs of both communities and industries. For industries, utilizing treated sewage through advanced technologies like ultrafiltration (UF) and reverse osmosis (RO) can replace raw water in various processes, such as cooling towers, boilers, chillers, washing, and quenching. This shift not only conserves enormous amounts of raw water from surface sources but also reduces operational costs and enhances sustainability. By integrating these systems, industries contribute to a circular economy, ensuring that water is reused and recycled efficiently, thereby mitigating the impacts of water scarcity and promoting a resilient and sustainable future.

REFERENCES

[1] Chan, S. S., & Wu, J. H. (2022). Improving the Performance of the Reverse Osmosis Process with Fiber Filter and Ultrafiltration: Promoting Municipal Sewage Reclamation and Reuse for Industrial Processes. Sustainability, 14(9), 5443. doi:10.3390/su14095443.

[2] Kazancoglu, I., Kazancoglu, Y., Yarimoglu, E., & Kahraman, A. (2020). A conceptual framework for barriers of circular supply chains for sustainability in the textile industry. Sustainable Development, 28(4), 1477-1492. doi:10.1002/sd.2100.

[3] Nasr, F. A., El-Shafai, S. A., Abdelfadil, A. S., & others. (2019). Potential use of treated domestic sewage for cultivation of biofuel crops in Egypt. International Journal of Environmental Science and Technology, 16(7), 7433-7442. doi:10.1007/s13762-018-2101-4.

[4] Natarajan, P., Jayavel, K., Somasundaram, S., & Ganesan, S. (2020). Integrated catalytic oxidation and biological treatment of spent caustic wastewater discharged from petrochemical industries. Energy Ecology and Environment. doi:10.1007/s40974-020-00178-y.

[5] Lahnsteiner, J., & Mittal, R. (2010). Reuse and recycling of secondary effluents in refineries employing advanced multi-barrier systems. Water Science and Technology, 62(8), 1813-1820. DOI:10.2166/wst.2010.382.

[6] Alghobar, M. A., & Suresha, S. (2014). Evaluation of the impact of treated wastewater irrigation on soil properties and crops grown under different irrigation systems in Saudi Arabia. Arabian Journal of Geosciences, 7(2), 211-220. DOI:10.1007/s12517-012-0748-4.

[7] Soni, M., Soni, M., & Kumar, A. (2020). Wastewater treatment and reuse: A review of its applications and health implications. Water, Air, & Soil Pollution, 231(5), 228. DOI:10.1007/s11270-020-04577-1.

[8] Fuchs, F. (2017). Industrial reuse of municipal effluent: "Designer Water". Workshop presentation at the 11th IWA international conference on water reclamation and reuse, Long Beach, July 23–27, 2017.

[9] Lahnsteiner, J., Andrade, P., & Mittal, R. (2015). Recycling of refinery effluents – two case studies in India. Water Practice and Technology, 10(3), 573-582. DOI:10.2166/wpt.2015.065.

[10] Global Water Intelligence (2019). Portugal unveils national wastewater reuse vision. GWI Brief (367), March 28, 2019.

[11] Mittal, R., Lahnsteiner, J., Andrade, P., & Gosh, R. (2013). Recycling of secondary refinery and naphtha cracker effluents employing advanced multi-barrier systems. In V. Lazarova, T. Asano, A. Bahri, & J. Anderson (Eds.), Milestones in Water Reuse: The Best Success Stories (pp. 225-234). IWA Publishing. DOI:10.2166/9781780403965.

[12] Gunasekar S, N Ramesh, G Shivani, “Effective utilisation of construction and demolition waste (Cdw) as recycled aggregate in concrete construction–a critical review, International Research Journal of Multidisciplinary Technovation, Volume 1, Issue 6, Pages 465-469.

[13] P Parthiban, Saurav Kar, Anup Kumar Mondal, S Gunasekar, VS Shaisundaram, “Stress–strain behaviour of (hpfrc) high-performance fibre reinforced concrete: An experimental study”, Materials Today: Proceedings, Volume 80, Pages 3119-3123.