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SBR SEWAGE TREATMENT PLANT AUTOMATION USING PLC AND SCADA**Dhandapani Aravind¹, V. Ganeshram², S. Thangalakshmi^{3*}, C.P. Balaji⁴, Rajendran Govindarajan⁵, Perumal Rajkumar⁶**^{1,6}University Science Instrumentation Centre, Madurai Kamaraj University, Madurai, Tamil Nadu, India^{2,3,4}School of Marine Engineering and Technology, Indian Maritime University, Chennai Campus, Tamil Nadu, India⁵Department of Chemical Engineering, Hindustan Institute of Technology and Science, Chennai, Tamil Nadu, India

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Abstract: Today's never-ending industrial expansion and the sharp rise in urban pollution have led to environmental and water contamination. The industrial sewage water gets mixed with streams, ocean and ponds etc. that causes several ailments in living things. Proper treatment of sewage can prevent these problems. Sewage treatment is the process of removing contaminants from industrial/domestic wastewater. Physical process (such as filtration, sedimentation and distillation), chemical processes (such as flocculation and chlorination) and biological process (slow sand filters or biologically active carbon) are used to remove contaminants so that water becomes safe enough to get released into the environment. By using these sewage processes we can not only avoid the diseases but also we can recycle the industry wastewater (sewage process) for further uses (garden, car cleaning, etc.). There are conventional methods for sewage treatment, which occupies more spaces as well as involve higher constructive cost. The activated sludge process is modified by the "fill and draw" Sequencing Batch Reactor (SBR). The complete treatment procedure takes place in one tank as opposed to separate tanks for each process. The benefits include less expensive plant construction due to tank reduction and smaller footprint compared to alternative treatment options. This paper aims to monitor and automate various stages of sewage treatment carried through sequencing batch reactor. In general, industrial automation refers to the use of technology for process control in a variety of operations, including chemical and petrochemical, power, iron, and steel, food and beverage, waste water treatment, and other plants. One of the main needs that reduces the need for labour is plant automation. Currently, SCADA systems and programmable logic controllers are widely employed in industry. In order to improve the efficiency of the sewage treatment process, the application of PLC is investigated in this study.

KEYWORDS: PLC, SCADA, SBR Sewage Treatment Plant.

I. INTRODUCTION

Uncontrolled wastewater discharge into the environment results in the transfer of microbiological contaminants to humans and animals. The deployment of adequate purifying systems with high microbiological agent elimination performance is required for environmental protection [1]. According to one study on residential wastewater management in Greece, the average daily wastewater output was 210 litres per capita, and the total quantity of greenhouse gas released by

treatment facilities was 892,454 tCO₂e every year. It is also advised that Greece assure the effective functioning of smaller treatment plants and incorporate reductions in greenhouse gas emissions while boosting wastewater reuse [4]. Wastewater treatment and proper sludge disposal are necessary for ecological safeguard due to the perilous influences of urban, industrial, and hospital wastewater on water, land, air, and agricultural products [2-3]. Sewage treatment is the removal of impurities from urban wastewater, which mostly comprises of domiciliary sewage and some industrialized effluent. Physical, chemical, and biological approaches are used to expel impurities and produce treated wastewater (or treated effluent) that is safe for discharge into the surroundings. Sewage sludge is a semi-solid waste or mire that results from sewage treatment. The sludge must be treated further before it can be disposed of or released to land. [5]. "Sewage Treatment Plants" exhibit varying physical, chemical, and microbiological efficiencies based on influent sewage characteristics, hydraulic retention time, percent of capacity utilisation, and so on. As a result, a requirement exists to define a single common attribute that can establish the total efficiency of the plant in relation to the physical, biochemical, and microbiological removal efficiencies. The measure will also aid in the decision-making process for effective effluent reuse. This general efficiency metric is used to compare complete plant performance. The term "general efficiency" refers to the average of total suspended solids, chemical oxygen demand, biochemical oxygen demand, and ammonia removal efficiencies [6-9].

The process of sewage purification is most frequently carried out in waste water treatment facilities that are in operation all over the world. These facilities might be very large municipal facilities or smaller ones for a house, farm, plant, or area. The primary goal of sewage treatment procedures is to create water or fluid waste that may be put to use in a variety of ways [14].

II. AUTOMATION IN SEWAGE TREATMENT

Because control breakthroughs in wastewater treatment systems are increasingly expected, the globe is currently confronting serious difficulties connected to sewage management in smart cities. Electrical and mechanical energies are the most expensive components of any wastewater treatment plant or industrial process, and energy is one of the specific indicators where automation may significantly cut costs. To conserve energy and decrease sample and reagent consumption, chemical feed in coagulation, flocculation, and sludge dewatering can also be automated [10-12].

Automation is a process of making a machine to work independently without any manual interference. Nowadays, automation of process control industries makes the work faster with precision along with increases in profitability involving less investment [13]. This research paper presents a control process with PLC as a heart of the system involved. Businesses nowadays must adopt a realistic approach to productivity, product quality improvement, operating time reduction, and cost reduction due to current economic and environmental issues.

Automation of sewage treatment plants is one of the major needs that raises effluent quality. Our STPs are built to meet the demand for automating sewage treatment plants and streamlining plant operations.

Process Control:

Process control is a field that is concerned with the methods and strategies for keeping the throughput of a specific process within a specified range. A Programmable Logic Controller, or

PLC, is used to peruse a range of digital and analogue inputs, relate a sequence of logic assertions, and generate an array of analogue and digital output values. More networks can indeed be supervised and directed by a SCADA system. We need automation tools for controlling industrial machines and processes.

Following are some of the commonly used automation used in the industries:

1. PLC – Programmable Logic Controller
2. HMI – Human Machine Interface
3. DCS – Distributed Control System
4. SCADA – Supervisory Control and Data Acquisition
5. LIMS – Laboratory Information Management System
6. PAC – Programmable Automatic Controller
7. MES – Manufacturing Execution System

III. BLOCK DIAGRAM

The various functions carried out in SBR method of sewage/waste water treatment are described through the block diagram as shown in Fig. 1. The components used in the block diagram are discussed below.

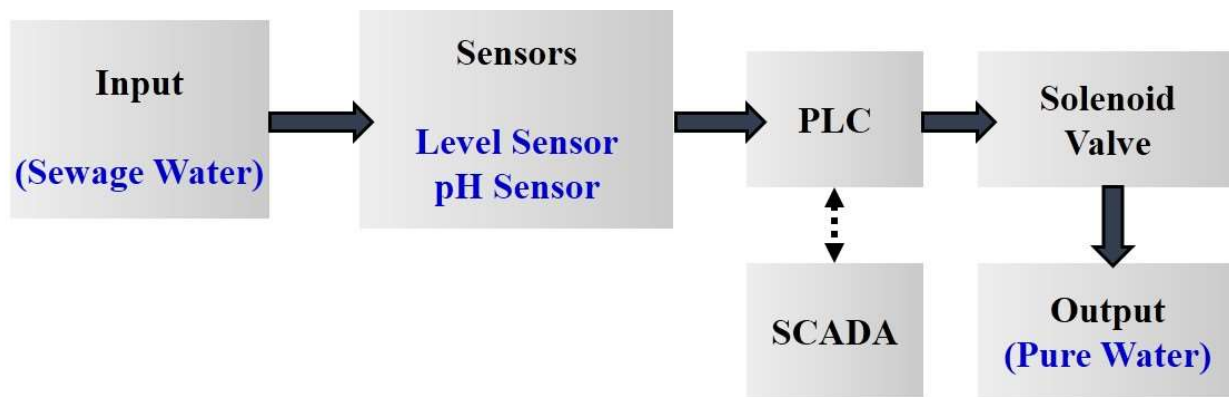


Fig. 1. Various Functions of SBR Sewage Water Treatment

Input (Sewage):

Wastewater produced by a community of people is known as sewage. The images of Sensors, PLC, and Electric Valve are displayed in Fig. 2-5.

Sensors:

A. Level Sensor:

For many automation processes, level is a crucial control variable. It serves as a sensing component in sewage treatment clarifiers, as well as sedimentation basins, settling tanks, air flow basins, and so on.



Fig. 2. Level Sensor

B. pH Sensor:

Acidity and alkalinity, or the caustic and base present in a given solution, are measured using pH, a term that is frequently used to describe water measurements. Usually, it is described using a numeric scale with values ranging from 0 to 14 [15]. Neutrality is represented by the number 7. The pH of untreated sewage typically ranges from 5.5 to 8.



Fig. 3. pH Sensor

C. Siemens PLC S7-200:

The term "programmable logic controller" is abbreviated as "PLC." Its primary method of operation is based on internal processes. PLC detects input from the operating panel button and input from various types of sensors to regulate whether the equipment runs or stops, as well as its speed.

Due of its small size, the S7-200 is referred to as a micro PLC. The power supply and I/O are on board because the s7-200 has a brick design. Smaller, standalone applications like elevators, car washes, and mixing machines can make use of the S7-200. Additionally, it can be applied to more sophisticated industrial applications like bottling and packing equipment.

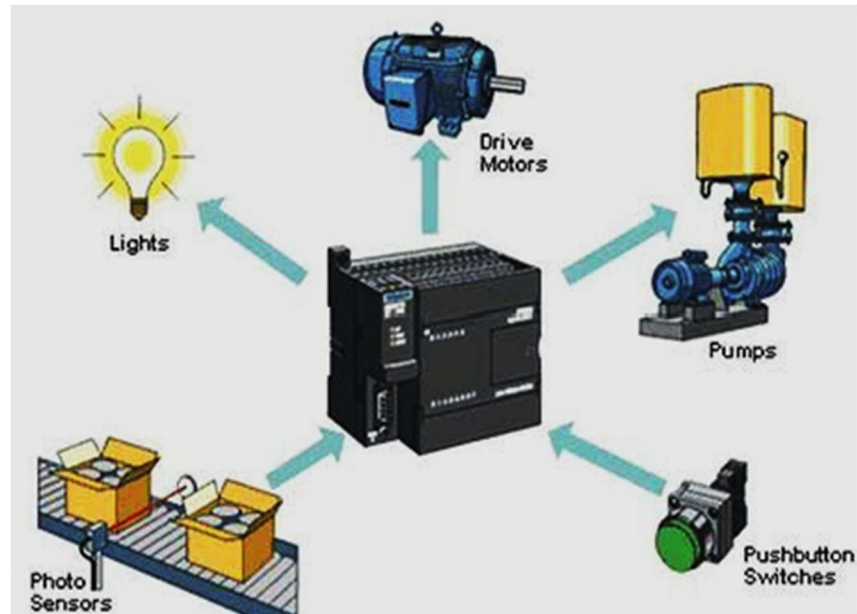


Fig. 4. Programmable Logic Controller

D. SCADA:

The acronym SCADA stands for supervisory control and data acquisition. It regulates flow rates, tank levels, and process temperatures and pressures while keeping them constant. They mostly use Boolean logic to optimise the starting and halting of pumps, the closure and opening of valves, and perhaps other discrete operations.

E. Electric Valve:

The solenoid valve has two ports. To turn on and off conditions, it will be used. The solenoid valves are connected to the PLC output. For the primary solenoid valve, a 24 V supply is provided. The PLC's output is in the region of 24 V DC. When the storage tank fills to 80%, the main solenoid valve automatically opens. For a solenoid valve, the set point is fixed. The solenoid valve is switched off if either of its valves, or both of its valves, reach the predetermined point.



Fig. 5. Electric Valve

F. Output (Pure Water):

Water that can be reused for other uses is transformed into recycled water. The reuse process might involve watering farmland and gardens.

IV. TREATMENT TECHNIQUES

The various sections of treatment are explained as given under.

Tertiary Treatment:

The treated sewage is polished to the point of reuse in the tertiary treatment using filters (DMF & ACF). Here, the BOD and COD levels are further reduced to allow for the reuse of the treated water. Water that has undergone tertiary treatment can be reused in a variety of settings, including car washes, gardens, cooling towers, etc. If additional treatment is necessary, this water can also be recycled for use in other process applications.

Sequencing Batch Reactor (SBR):

A variant configuration of the traditional activated sludge method for the treatment of wastewater is the sequencing batch reactor (SBR), in which the process is carried out in batches in the same reactor and each batch is sequentially processed through a number of treatment stages. Sedimentation, biodegradation, and bio-solid separation are all accomplished in the same reactor but at various times. Fig. 6. depicts the Sequencing Batch Reactor.

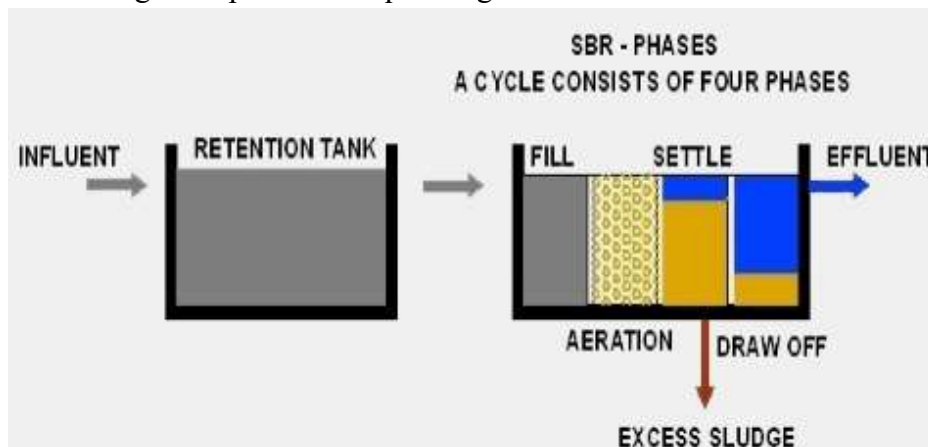


Fig. 6. Sequencing Batch Reactor

SBR Operating Principles:

Using SBR technology, all stages of the wastewater treatment process take place in turn inside the same tank. The batch reactor for sequencing is an activated sludge fill-and-draw system. To eliminate unwanted components, wastewater is put to a single "batch" reactor in this method before being released.

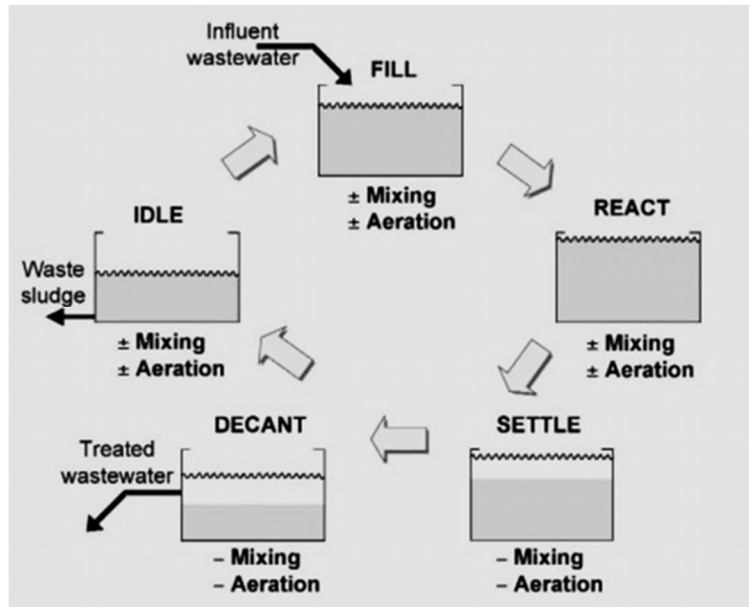


Fig. 7. SBR Operation Cycle

Phases in the SBR operation Cycle:

SBR consist of four stages viz. Fill, React, Settle, and Idle. The SBR operation cycle is given in Fig. 7.

Fill:

To produce the various situations, the mixing and aeration of the influent wastewater received in the basin can be altered during the fill phase. There are many kinds of “Fill” available, few of which are discussed below. The Figs. 8-11 show respectively the filling, react, settle, and decant processes.

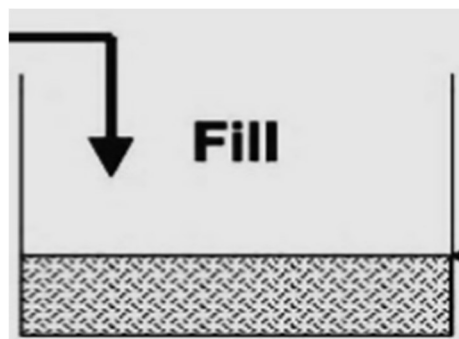


Fig. 8. Filling Process

Static Fill:

There is no mixing or aeration of the influent wastewater as it enters the tank. It is applied during the preliminary startup phase of a facility or at plants where it is not necessary to nitrify or denitrify.

Mixed Fill:

The use of mechanical mixers results in a homogeneous mixture of influent wastewater and biomass, but the aerators remain off. Because there is no aeration, an anoxic or anaerobic condition prevails promoting denitrification and release of phosphorus.

Aerated fill:

Both the mechanical mixing device and the aerators are turned on. Intermittent aeration of the basin's

contents creates both anoxic and aerobic conditions.

React:

Rapid removal of carbonaceous BOD from the react phase is made possible by biological processes. While the majority of denitrification occurs in the mixed fill phase, nitrification happens when the mixing and aeration are allowed to continue. During the react phase, the phosphorus that was released during mixed fill as well as some extra phosphorus is picked up.

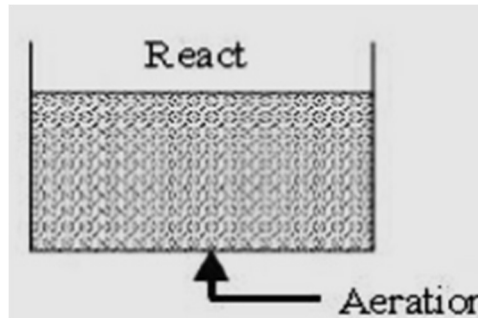


Fig. 9. React Process

Settle:

At this stage, activated sludge is permitted to settle under controlled situations. The flocculent bulk tends to settle out on the activated sludge, creating a distinct interface with the clear supernatant. The term "sludge blanket" refers to the mound of mud. This step of the cycle is crucial because if the solids settle out too quickly, sludge washout may occur in the subsequent decant phase, lowering the effluent quality.

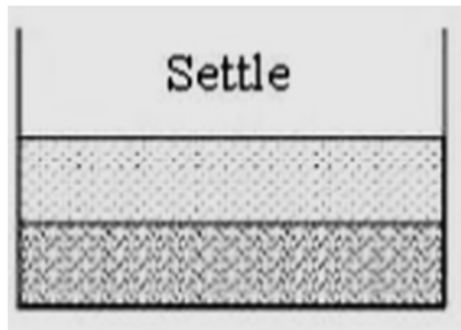


Fig. 10. Settle Process

Decant:

The clear supernatant effluent is taken out of the phase using a decanter. An effluent-discharge valve will open after the settle phase is finished thanks to a signal transmitted to the decanter. Both floating and fixed arm decanters keep the entrance orifice just below the water's surface to reduce the amount of solids removed from the effluent. Fixed arm decanters give the user the option to adjust the decanter's level. To prevent the unwanted disturbances, especially to the settled biomass, the vertical distance from the decanter to the bottom should be increased.

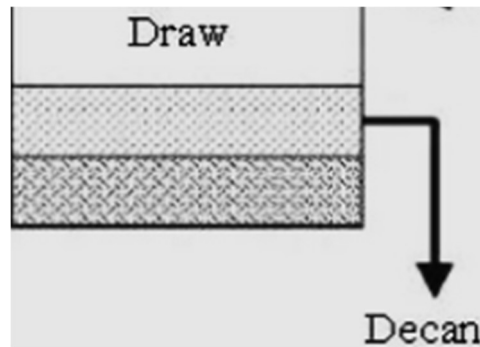


Fig. 11. Decant Process

Idle:

Between the decant and fill phases, there is this step. The operating method and influent flow rate both affect how long it takes. A little percentage of the activated sludge at the bottom of the SBR basin is pumped out during this phase, which is a wasteful practice.

Pressure Sand Filter:

Remaining suspended solids are removed using pressure sand filters made of various grades of pebbles and sand.

Activated Carbon Filter:

Carbon filtering is a method of filtering that uses a bed of activated carbon to remove contaminants and impurities, using chemical adsorption. Carbon filters are most effective at removing chlorine, particles such as sediment, volatile organic compounds (VOC), taste and odor from water.

Merits and Limitations of SBR:

There are many advantages in using SBR scheme of sewage water treatment, which include, minimum land requirement, superior effluent quality and the process is fully programmed and automated. It is also possible to use using biogas from anaerobic sludge digestion in which case SBR can be used as a mechanism of producing electricity. However, SBR suffers from a few problems such as, requirement of constant energy supply, need for sophisticated machinery, and additional treatment is necessary for sludge and effluent.

V. PROCESS AND SIMULATION

The various process involved in SBR is given in the Fig. 12 as a Flow-Diagram and the Simulation for Sewage Treatment Plant Using SBR Techniques is shown in Fig. 13.

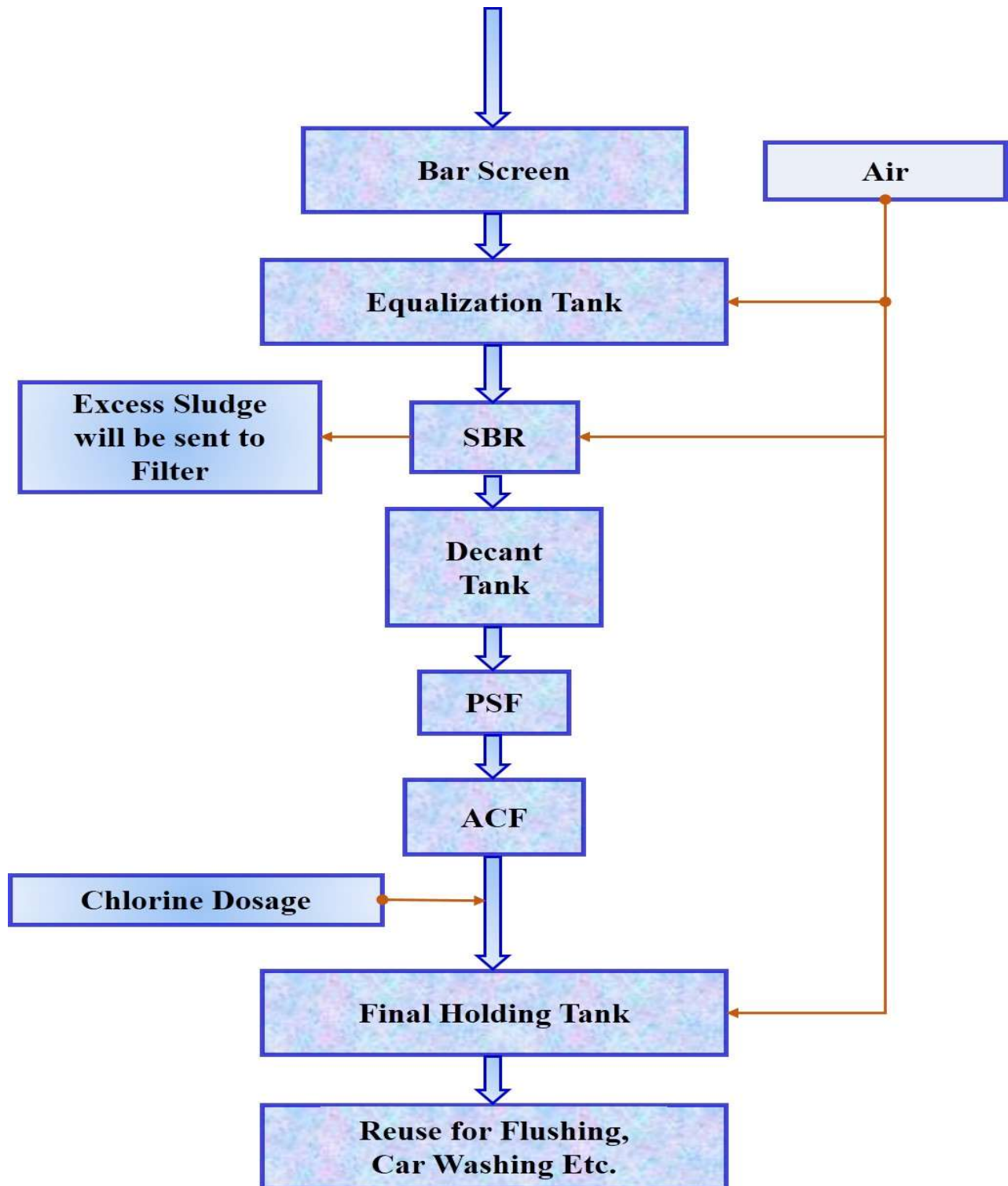


Fig. 12. Flow Chart to Describe the Various Process and Sequence of SBR

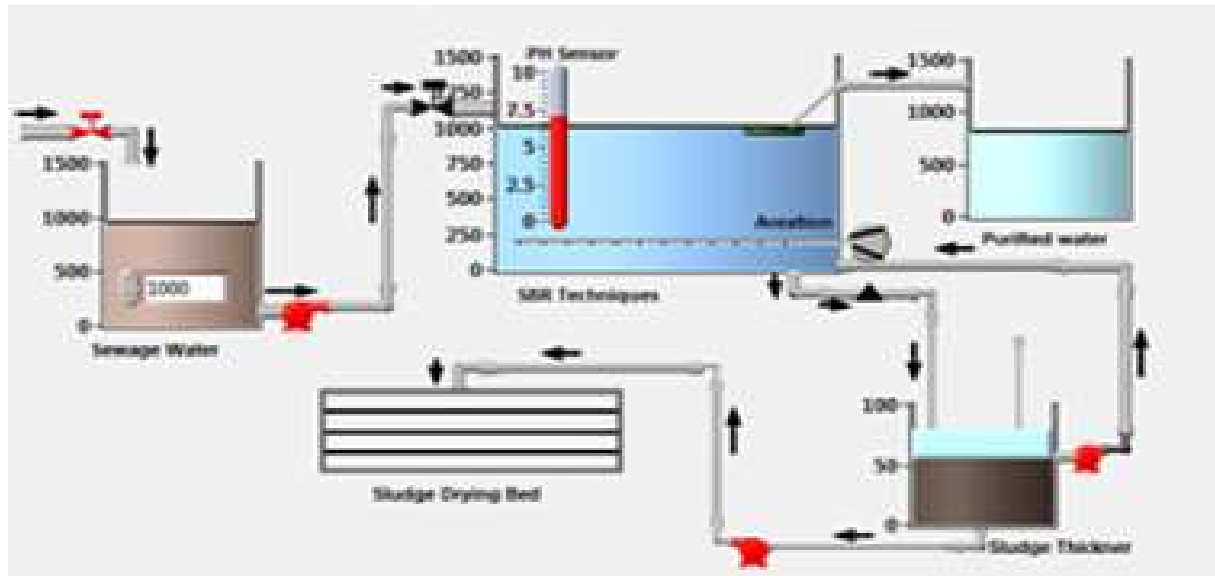


Fig. 13. Simulation Diagram for Sewage Water Treatment using SBR Method

VI. CONCLUSION

According to government regulations, sewage water treatment is required in almost all industries, as well as to prevent public health hazards. The contaminants should be removed from the industrial waste water that is produced by many of the industry's processes. In this day and age, where there are many high rise and commercial buildings, sewage water treatment can even be used in the home. Many traditional methods are in place, but incorporating new techniques would improve the system's efficiency. For environmental reasons, it is also necessary to reduce CO₂ production in the treatment plant while treating waste water. The Sequencing Batch Reactor (SBR) method is presented in this paper, in which the activated sludge exercise is altered by the "fill and draw" method. In contrast to traditional techniques, which use separate tanks for each process, the entire treatment process is contained within a single tank. In comparison to the other schemes, reducing the number of tanks obviously reduces manufacturing costs and also reduces the carbon footprint to a greater extent. However, using manual and semi-automatic monitoring will be time consuming and ineffective, especially when dealing with large amounts of sewage/waste. Chemical feed in coagulation, flocculation, and sludge dewatering are automated to save energy and reduce sample and reagent consumption. For SBR sewage water treatment, a PLC controller with necessary sensors and a SCADA arrangement are used. This paper has discussed the necessary specifications, working, flowchart, and so on. In addition to treating sewage water, the SBR method reduces carbon footprint.

REFERENCES

- [1] Aghalari, Z., Dahms, H. U., Sillanpää, M., Sosa-Hernandez, J. E., & Parra-Saldívar, R. (2020). Effectiveness of wastewater treatment systems in removing microbial agents: a systematic review. *Globalization and health*, 16(1), 1-11.
- [2] Ikehata, K., Liu, Y., & Sun, R. (2009). Health effects associated with wastewater treatment, reuse, and disposal. *Water Environment Research*, 81(10), 2126-2146.
- [3] Choudri, B. S., Al-Awadhi, T., Charabi, Y., & Al-Nasiri, N. (2020). Wastewater treatment, reuse, and disposal-associated effects on environment and health. *Water Environment Research*,

92(10), 1595-1602.

- [4] Koutsou, O. P., Gatidou, G., & Stasinakis, A. S. (2018). Domestic wastewater management in Greece: Greenhouse gas emissions estimation at country scale. *Journal of Cleaner Production*, 188, 851-859.
- [5] Khalil, N., Sinha, R., Raghav, A. K., & Mittal, A. K. (2008, March). UASB technology for sewage treatment in India: experience, economic evaluation and its potential in other developing countries. In *Twelfth International Water Technology Conference (Vol. 12, pp. 1411-1427)*.
- [6] Jamwal, P., Mittal, A. K., & Mouchel, J. M. (2009). Efficiency evaluation of sewage treatment plants with different technologies in Delhi (India). *Environmental Monitoring and Assessment*, 153(1), 293-305.
- [7] Kumar, P. R., Pinto, L. B., & Somashekar, R. K. (2010). Assessment of the efficiency of sewage treatment plants: a comparative study between nagasandra and mailasandra sewage treatment plants. *Kathmandu university journal of science, engineering and technology*, 6(2), 115-125.
- [8] Chatterjee, P., Ghangrekar, M. M., & Rao, S. (2016). Low efficiency of sewage treatment plants due to unskilled operations in India. *Environmental chemistry letters*, 14(3), 407-416.
- [9] Brown, H. G., Hensley, C. P., McKinney, G. L., & Robinson, J. L. (1973). Efficiency of heavy metals removal in municipal sewage treatment plants. *Environmental letters*, 5(2), 103-114.
- [10] Prabavathi, R., Duela, J. S., Chelliah, B. J., Saranya, S. M., & Sheela, A. (2021). An intelligent stabilized Smart Sewage Treatment Plant (STP). *2021 4th International Conference on Computing and Communications Technologies (ICCCT)*. <https://doi.org/10.1109/iccct53315.2021.9711758>
- [11] Sathiyakala, R., Grace, S. F., Maheswari, P., Bhanu, S. M., & Lakshmi, R. M. (2016). Smart sewage cleaning system. *International Journal of Innovative Research in Computer and Communication Engineering*, 4(49).
- [12] Cicceri, G., Maisano, R., Morey, N., & Distefano, S. (2021, August). A Novel Architecture for the Smart Management of Wastewater Treatment Plants. In *2021 IEEE International Conference on Smart Computing (SMARTCOMP)* (pp. 392-394). IEEE.
- [13] Olsson, G., Nielsen, M., Yuan, Z., Lynggaard-Jensen, A., & Steyer, J. P. (2005). *Instrumentation, control and automation in wastewater systems*. IWA publishing.
- [14] Bouwer, H., & Idelovitch, E. (1987). Quality requirements for irrigation with sewage water. *Journal of irrigation and drainage engineering*, 113(4), 516-535.
- [15] Ganeshram, V., & Aravind, D. (2022). Development of pH Value Detection Sensor for Water to Detect and Automate Water Neutralization Process. *International Journal of Research and Analytical Reviews*, 9 (2), 924 – 929.