International Journal of Advanced Innovative Technology In Engineering

Published by Global Advanced Research Publication House Journal

Home page: www.ijaite.co.in

Operation and Maintenance of Sewage Treatment Plant

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Article History

Received on: 5 April 2022

Revised on: 16 April 2022

Accepted on: 04 May 2022

Keywords: Sewage Treatment Plant, SBR, Activated Sludge Process, Operation, Maintenance,

e-ISSN: 2455-6491

Production and hosted by
www.garph.org

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ABSTRACT

Sewage treatment is a type of waste water treatment which aims to remove contaminants from sewage to produce an effluent that is suitable for discharge to the surrounding environment or an intended reuse application, thereby preventing water pollution from raw sewage discharges. Sewage contains wastewater from households and businesses and possibly pre-treated industrial wastewater. There are a high number of sewage treatment processes to choose from. These can range from decentralized systems to large centralized systems involving a network of pipes and pump stations, which convey the sewage to a treatment plant for cities that have a combined sewer, the sewers will also carry urban runoff to the sewage treatment plant. Sewage treatment often involves two main stages, called primary and secondary treatment, while advanced treatment also incorporates a tertiary treatment stage with polishing processes and nutrient removal. Secondary treatment can reduce organic matter from sewage, using aerobic or anaerobic biological processes.

1. INTRODUCTION

This Operation and Maintenance (O&M) is the basic reference for the operation and maintenance of the equipment and processes that comprise the Central Facilities Area (CFA) Sewage Treatment Plant (STP) at the Site. The manual is required by the facility's Municipal Wastewater Reuse Permit. Managers, operators, and maintenance personnel use this manual and associated company and equipment manufacturer's procedures to operate the STP in support of CFA activities and permit requirements. The Laboratory Instructions (LI) listed below provide additional step-by-step instructions for operating specific components of the STP and laboratory equipment are prepared and cancelled as needed to provide directions for operating and maintaining STP equipment.

The CFA STP has been designed to effectively treat raw wastewater by biologically digesting the majority of the organic waste and other major constituents, thereby producing a treated wastewater suitable for reuse via land application.

This system depends on physical and biological processes to treat wastewater. Once applied to land using the pivot irrigation system, evapotranspiration is the principal mechanism for the final disposition of wastewater.

2. Need for Operation & Maintenance

According to the National Urban Sanitation Policy (NUSP), the proper operation & maintenance of all sanitary installations requires a Promoting proper usage, regular upkeep, and maintenance of the household, community, and public sanitation facilities b. Strengthening ULBs to provide or cause provide, sustainable sanitation services delivery There is an O&M manual by CPHEEO for water supply systems, but there is no such manual for sewerage systems. Moreover, unless there is an O&M manual, ULBs cannot justify budget allocations to meet their obligations under such a manual. The net result is this lack of attention to the important aspect of O&M of sewerage systems leads to deterioration of the useful life of the systems necessitating premature replacement of many system components and also affecting overall sanitation. As such, even after creating the assets by investing millions of rupees, they are unable to provide the services effectively to the community for which they have been constructed, as they remain difunctional or underutilized most of the time. Some of the key issues contributing to the poor O&M have been identified as follows:

1. Lack of finance and inadequate data on O&M.
2. Multiplicity of agencies, overlapping in their responsibilities.
3. Inadequate training of personnel.
4. Lesser attraction to maintenance jobs in career planning.
5. Lack of performance evaluation and regular monitoring.
6. Inadequate emphasis on preventive maintenance.
7. Lack of operation manuals.
8. Lack of appreciation of the importance of facilities by the community.
9. Lack of real-time field information, etc.
10. O&M contractors do not have permanent staff.
11. Connection of road gullies to sanitary sewer systems, which are major contributors of silt and floating matter such as plastic bags, wood pieces, papers, etc.
12. Lack of storm sewer system.
13. Wastage of potable water, due to supply of unmetered water supply at cheap water tariff and free water connections, which add to a load of domestic sewage.
14. The silting of sewer systems is a common phenomenon and is compounded by low per capita water supply. Therefore, there is a need for clear-cut sector policies and legal framework and a clear demarcation of responsibilities and mandates within the water supply sub-sector.

3. The main Objectives of study

Quality maintenance of sewerage treatment system consists of the optimum use of labour, equipment, and materials to keep the system in good condition so that it can accomplish efficiently its intended purpose of collection and transportation of sewage to the treatment plant.

- Optimization of the different parameters to be varied, to find the equilibrium values, in order to get maximum efficiency.
- To protect the environment; social economic and public health from the pollutants.
- To reduce the transmission of infectious diseases to an acceptably low level.
- To make wastewater usable for other purposes.
- Preservation of water quality of natural water resources.

4. METHODOLOGY AND COMPONENTS

Proper operation and maintenance of wastewater treatment plants are critically important in securing compliance with standards.

The components of STP that need O & M are:

- ❖ HT Receiving / LT Sub-station including Transformer
- ❖ Receiving Chamber
- ❖ Coarse Bar Screens
- ❖ Fine Screens
- ❖ Grit Removing Channel
- ❖ Flow Distribution Chamber
- ❖ Sequencing batch reactor (SBR)
- ❖ Chlorine Contact Tank / Treated Water Tank

A. The Operating Units for SBR Plant

First of all, let us understand the underlying concept of a sewage treatment plant.

Conceptually, the process is extremely simple: A small number of microorganisms converts a large mass of polluted water into clean water. This process also produces a co-product of a vastly reduced, compact solid biomass (the excess microorganisms produced by the growth and multiplication of the original population of microorganisms).
However, translating this simple principle into a properly designed and engineered STP is a real challenge. It requires sound knowledge of the biology of the microorganisms, chemical and

mechanical engineering principles, and an equally large dose of common sense.

We need an STP that-

- Achieves the desired results on a consistent and sustained basis.
- Is robust and reliable, and lasts for at least 10-15 years without major repairs.
- Needs minimum amounts of money, energy, and chemicals to achieve the desired treated water quality.
- Is easy to operate and maintain.

B. Bar Screen Chamber

The function of the bar screen is to prevent the entry of solid particles/ articles above a certain size; such as plastic cups, paper dishes, polythene bags, condoms, and sanitary napkins into the STP. If these items are allowed to enter the STP, they clog and damage the STP pumps, and cause a stoppage of the plant. The screening is achieved by placing a screen. made out of vertical bars, placed across the sewage flow.

Operation and Maintenance Considerations

- Check and clean the bar screen at frequent intervals.
- Do not allow solids to overflow/escape from the screen.
- Ensure no large gaps are formed due to corrosion of the screen.
- Replace corroded/unserviceable bar screen immediately.

C. Grit Chamber

A grit chamber is placed at the discharge point to arrest solid and fatty matter at the source. The wastewater output from this unit is taken to the sequencing batch reactor (SBR) is a modification of a conventional activated sludge plant. The solids and fats that are separated in this unit are disposed of along with other biodegradable waste and can be used as feed for piggeries.

Operation and Maintenance Considerations

- Check and clean traps at frequent intervals.
- Remove both settled solids (at the bottom) and the floating grease from the top if any.
- Do not allow solids to get washed out of the trap.

D. Sequencing Batch Reactor (SBR)

The sequencing batch reactor (SBR) process is a modification of a conventional activated sludge plant. The SBR process allows the unit processes of reacting, settling, and discharging to occur sequentially in one basin. Thus, the “footprint” of an SBR is typically much smaller than that of a conventional activated sludge plant. The Intermittent Cycle Extended Aeration System (ICEAS) process is a modification of a conventional SBR.

The ICEAS process allows continuous inflow of wastewater into the treatment basins during all phases of the cycle. The continuous inflow is an advantage over conventional SBRs in that it optimizes biological treatment by supplying a constant food source for the process and equalizes the flow loadings in multiple-basin systems. A cycle consists of different phases (react, settle, and decant) during which treatment takes place. The cycles operate continuously in each basin to meet the treatment goals of the plant.

Basin Design: An ICEAS basin has two compartments: a pre-react zone and a main-react zone. The pre-react zone acts as a biological selector and receives the continuous influent flow. The two compartments are separated by a baffle wall that spans the tank width and has openings on the basin floor. The baffle wall prevents short-circuiting and allows the two zones to be hydraulically connected as it directs the flow to enter the main-react zone at the bottom of the basin.

ICEAS Process Overview: The following is a brief process overview of the three phases common to all Sanitaire cycles:
1.) React, 2.) Settle and 3.) Decant.

React Phase: During the react phase, raw wastewater flows into the pre-react zone continuously to react with the mixed liquor suspended solids.
Depending on the process scheme, the basin contents are aerated, anoxically mixed, allowed to react anaerobically, or a combination thereof. As the basin continues to fill, biological oxidation/reduction reactions take place simultaneously to treat the wastewater.

Settle Phase: During the settle phase, basin agitation from the react phase (i.e., aeration or mixing) is stopped to allow the solids to settle to the bottom of the basin. Raw wastewater continues to flow into the pre-react zone as the main-react zone settles. As the solids settle, a clear layer of water will remain on top of the basin.

Decant Phase: During the decant phase, the decanter rotates downward to draw off the clarified supernatant and discharge it to the effluent line. Raw wastewater continues to flow into the pre-react zone as the main-react zone is decanted. Sludge is typically wasted from the basin during this phase in the cycle.

Basin Layers: The picture illustrates the three stratified layers that are formed in each basin at the end of the settle phase and the beginning of the decant phase. The sludge blanket forms on the bottom of the basin as the mixed liquor suspended solids (MLSS) settle. A buffer zone of three feet acts to buffer the sludge blanket from the volume that will be removed during the decant phase. The drawdown is the top layer of a clear liquid that remains after the MLSS settles and is the maximum volume that will be drawn off during the decant phase.

E. Basin Hydraulics and Loading

During all phases of the ICEAS cycle, raw influent flows into the basin. To allow equal loading, flow is split equally to all basins by a splitter box. Since the influent flow is continuous, the ICEAS process can be operated in a single basin allowing for basins to be taken out of service during low flow/loading conditions.
The ICEAS basins are designed to handle the average dry weather flow (ADWF), and the peak dry weather flow (PDWF) as specified in the design parameters. Flow enters the basin continuously and the treated effluent leaves the basin intermittently (only during the decant phase). Two time-based cycles are used to hydraulically process the flow. The normal cycle will process the ADWF and peak for PDWF.

F. Nitrification Denitrification Process Operation

The nitrification-denitrification (NDN) process operates to remove BOD, TSS, ammonia-nitrogen (NH3-N) through nitrification, and nitrite-nitrogen (NO2-N)/nitrate-nitrogen (NO3-N) through denitrification. In the NDN process, the react phase consists of alternating periods of aeration and anoxic mixing. The aeration periods supply oxygen to the biomass for BOD oxidation and nitrification. The anoxic mixing periods provide minimal oxygen and mixing of the biomass for denitrification.

G. ICEAS Cycle Time - 2 Basins

The ICEAS process is designed with a normal cycle of 240 minutes or 4.0 hours. Each cycle has 140 minutes of reacting phase, which is divided into 20 minutes of the Anoxic phase and 120 minutes of the aeration phase with doing control to achieve simultaneous nitrification and denitrification, The remaining time is made up of 40 minutes of the settle phase, and 60 minutes of decant phase. The High Flow cycle is 180 minutes (3.0 hours) in duration as shown in the cycle charts below. The High Flow cycle has time periods that are proportionally reduced to the normal cycle time periods. The total reactions, settle and decant times per day remain the same as the normal cycle. It is only the duration per cycle that is changed to accommodate higher flows and process more flow in a shorter amount of time, without sacrificing oxidation time.

Table 1: ICEAS Cycles

	Normal	High flow	Time
Total cycle time	240 4.0	180 3.0	Minutes hours
Anoxic / Anaerobic	20	15	minutes/cycle
Aeration	120	90	minutes/cycle
Settle	40	30	minutes/cycle
Decant	60	45	minutes/cycle

H. SBR Equipment Operation

The following sections contain brief descriptions of the equipment operation for the ICEAS process.

Control System: The control system for the ICEAS process has a control panel, which contains the programmable logic controller (PLC), a SCADA, control switches, indicator lights, power connection, etc. The motor starters and variable frequency drives (VFDs) for the equipment are also mounted in the control panel. The PLC contains the logic to operate the process equipment when the equipment is in automatic control. Local and/or remote-control switches are provided for equipment operation when taken out of automatic control. The SCADA is an operator interface that communicates with the PLC to display system status, allow setpoint adjustments, and perform alarm handling.
The SCADA system is an operator interface and graphical representation of the plant-wide control. From the SCADA system, the operator can navigate through the display screens to monitor and make setpoint changes. From the alarm screen, the operator can acknowledge, clear, and reset faults. The SCADA system will also perform data trending of various process parameters selected by the operator and has report preparation capabilities.

Decanters: Each basin has a decanter installed on the wall opposite the pre-react zone. The decanter operates to remove clarified effluent from the top layer of the basin (drawdown) during the decant phase of the cycle. The drawdown is defined by the top water level (TWL) and the bottom water level (BWL). When the decanter is not operating, it remains in a parked position above the TWL, which eliminates the possibility of solids carryover during other phases in the cycle. In the park position, the decanter can act as a clarifier weir in the event of a power outage.

The decanter is mechanically operated using an electro-mechanical actuator that is mounted on the basin walkway for easy access. The actuator moves the decanter between the top and bottom limit switches whenever the decanter is in operation. The decanter speed is controlled using a variable frequency drive (VFD). Thus, the decanter discharge rate will be relatively constant from the time the decanter enters the water to the time it reaches the BWL. During the end of the settle phase, the decanter will travel from the park position to the TWL. When decant phase is started, the decanter will travel from the TWL to the BWL in the allotted time to remove the drawdown volume from the basin. Since influent flow to the plant varies, the water level in the basin at the start of each decant phase will be at differing levels above BWL. Consequently, during the decant phase, the decanter will travel downward for a period before reaching the water surface. Also mounted on the decanter in front of the weir is a floatable scum guard that operates to exclude floating material during the decant phase.

Blowers: 2-Basins

Three positive Root blowers can operate to supply air to the aeration systems in the basins. One blower has a VFD for controlling the output airflow. Each blower can deliver 50 percent of the air requirements to the process for a pair of basins. Two blowers operate together to provide 100 percent of the air requirements to the process in a pair of basins at a time. For a pair of basins, one blower operates as the "Lead Duty" blower and the second one operates as the "Lag Duty" blower. & The third blower operates as the "Standby" blower if one of the "Duty" blowers is not available. The "Duty" blowers can alternate duty on a weekly basis.

Air Valves: 2-Basins

Each basin has a motorized air valve, which will operate to allow air to enter a basin at certain time. The two air valves for basin #1 and #2 will operate in an alternating sequence during blower operation; when one valve is open, the other one is closed, etc. The air valves divert air between this pair of basins when blower operation is required in the cycle.

Aeration Systems: Each basin has a complete fine bubble aeration system, which operates to deliver diffused air to the process. The aeration system only receives air when the air valve for the basin is open. A solenoid valve connected to the aeration system periodically opens and closes to allow the aeration system to purge and depressurize. The duration that the solenoid valve is open for purging and depressurizing is operator adjustable through the SCADA. In addition to the automatic purge, the aeration system has a manual purge valve that the operator can use as needed.

Influent Valves (Motorized Isolation Gate Valves): Each basin has a motorized influent valve, which will operate to allow influent wastewater to enter the basin.

Surplus Activated Sludge (SAS) Pumps: Each basin has a submersible pump, which operates to waste sludge from the basin during the decant phase of the cycle. The surplus activated sludge (SAS) pump starts and run times are adjustable through the SCADA located on the ICEAS control panel to adjust the amount of sludge wasted. The sludge from the SBR basins is pumped directly to Sludge thickener thru a common header pipe.

Level Sensing Equipment: A level transducer and float switch are installed in each basin. The level transducer continuously indicates the basin water level at the HMI. The PLC uses the water level reading to calculate the corresponding flow rate into the basin. If the basin water level indicates that a flow above the PDWF is entering the basin, the system will transition into the Peak cycle.

ICEAS- The float switch has two functions. One function is to signal a high level in the basin and force the system into a settle phase to allow a minimum of 30 minutes of settle time prior to the water level overtopping the decanter. The second function is to signal that the system must transition into the Peak cycle if the level transducer has not already signalled this to take place.

Dissolved Oxygen (DO) Control System: The dissolved oxygen (DO) control system regulates the DO in the basin by controlling the blower operation. Each basin has a DO probe and analyser. The analyser sends the signal received from the probe in the basin to the PLC indicating the DO concentration in parts per million (ppm), which is the same as milligrams per litre (mg/L). High, low, and target DO set points in ppm are selected and entered at the HMI. Blower operation is regulated by the PLC based on the DO set points. When the high DO set point has been reached, there is a time delay before the blower will respond that is operator adjustable through the HMI. The goal of the system is to achieve a constant DO concentration without over- or under-aerating the process during the aeration periods in the react phase.

5. RESULTS ANALYSIS

Table 2: Test results of 4 no's of STPs for the month of Feb 2022

Sr. No	Parameters	Units	STP 1 Feb-22		STP 2 Feb-22		STP 3 Feb-22		STP 4 Feb-22	
			Inlet	outlet	Inlet	outlet	Inlet	outlet	Inlet	outlet
1	pH	-	7.44	7.33	7.76	7.44	7.81	7.40	7.76	7.37
2	COD	mg/l	330.22	28.66	257.77	20.63	292.21	24.44	290.05	23.23
3	BOD	mg/l	187.73	7.9	99.19	7.33	150	7.9	134.47	7.44
4	TSS	mg/l	70	10	43	3	50	9.77	52	8
5	Ammonia N	mg/l	9.1	1.44	6.22	1.77	8.8	2.21	7.88	1.14
6	Total Nitrogen	mg/l	11.05	1.75	7.73	1.54	12.61	2.17	9.95	1.61
7	Phosphorus P	mg/l	8.68	0.8	8.98	0.67	5.33	1.11	7.73	0.91
8	Facial Coliform	MPN/100	5442	91	4552	66	3199	92	3098	76

CONCLUSION & RECOMMENDATIONS

The STP is currently working well and farmers can use this water, as it cannot harm the crops, even increase the yield of crop. However, the irrigated crops should be of commercial purpose as people strongly opposed to use this water for farming food. The STP produced biogas, which can help in meeting about its 75%-80% energy requirement for Operation and Maintenance. The concept of waste to energy of the designer is a subject of appreciation. The treated water can also be used for recharging groundwater or for horticulture and planting trees on both sides of road of the area. This practice will definitely again help in reducing power consumption as no need for pumping water from ground for planting trees and for commercial crops irrigation. This type of STP should setup on large scale so they will help India in improving health and sanitation with sustainable development. The survey report shows the open mind of majority of the subjects who take part in this survey enthusiastically.

1. The project deals with design parameters of sewage treatment plant.
2. The design has been done for predicted population of 30 years.
3. Although the project and the data help in Design of Sewage Treatment Plant in future.
4. The plant is designed perfectly to meet the needs and demands population with a very large time period.
5. The treated sewage water is further used for the irrigation, fire protection, and toilet flushing in public, commercial and industrial buildings and if it is sufficiently clean, it can be used for groundwater recharge.

RECOMMENDATIONS

The view of the whole STP and its confined region and collect local views for analysing the problem and try to give best solution. The STP's recommended to establishing a storage tank for proper utilization of treated water. It is also advices to use chlorination and tertiary treatment of water to reduce its smell and to avoid problem of eutrophication. In view, the water should be used in agriculture, horticulture.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FUNDING SUPPORT

The author declare that they have no funding support for this study.

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5. Water Supply & Treatment.
6. Operation & Maintenance of Water Supply Systems.