Comparative Study between Conventional Activated Sludge System & Sequential Batch Reactor

Puneet Sharma, Er. Bhavana Arora, Dr. D.P.Gupta

***Abstract*—** Two percent of the water on earth is glacier ice at the North and South Poles. This ice is fresh water and could be melted; however, it is too far away from where people live to be usable.

Less than 1% of all the water on earth is fresh water that we can actually use. We use this small amount of water for drinking, transportation, heating and cooling, industry, and many other purposes.

The fresh water used by per capita per day is 20 percent and rest 80 percent gets wasted. This waste water must be treated so as to reuse of waste water. Thus Sewage Treatment Plants are constructed to get clean water out of the waste water. Sewage Treatment can be done by different several technologies. But the latest technology nowadays used is Sequential Batch Reactor (SBR).

The object of this project is to represent the information regarding Sewage Treatment Plant integrated with latest treatment technology named as Sequential Batch Reactor (SBR). We will discuss about Technologies and its useful Management along with their Results.

Keywords: Conventional Sewage Treatment Plant; Sequential Batch Reactor, Management.

SUB Area – Construction Technology & Mgmt.

Broad Area- Civil Engg.

I. Introduction

Aim of Wastewater Treatment

The traditional aim of wastewater treatment is to enable wastewater to be disposed safely, without being a danger to public health and without polluting watercourses or causing other nuisance. Increasing another important aim is to recover energy, nutrients, water and other valuable resources from wastewater.

Conventional Treatment Plants

Waste water influent from Houses, Schools, Colleges, Hospitals, Hotels, Industries like Paper, Pulp, Pharmaceuticals, Sugar, Slaughter houses, Dyeing, Powder coating consists of various parameters which are harmful for Public Health and Watercourses. Wastewater Treatment are widely used for its treatment, but they all are based on conventional space sequence of continuous-flow systems. Conventional Treatment Plants is a continuous flow, an aerobic biological process that employs suspended growth microorganisms to biodegrade organic contaminants. The influent is introduced in aeration basin and is allow to mixing with the contents by mechanical mixing or by turbulence induced by diffused aerators. A series of biochemical reactions takes place in basin were the organics are degraded and new biomass are generated. After a specific period the mixture is passed to a settling tank or a clarifier where microorganisms are separated from treated water. Major portion of settled sludge is recycled back to aeration tank to maintain a desired concentration of microorganisms in the reactor and remainder of the settled solids are sent to Sludge drying bed.

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Sequential Batch Reactor

The major differences between SBR and conventional continuous-flow, activated sludge system is that the SBR tank carries out the functions of equalization aeration and sedimentation in a time sequence rather than in the conventional space sequence of continuous-flow systems. In addition, the SBR system can be designed with the ability to treat a wide range of influent volumes whereas the continuous system is based upon a fixed influent flow rate. Thus, there is a degree of flexibility associated with working in a time rather than in a space sequence.

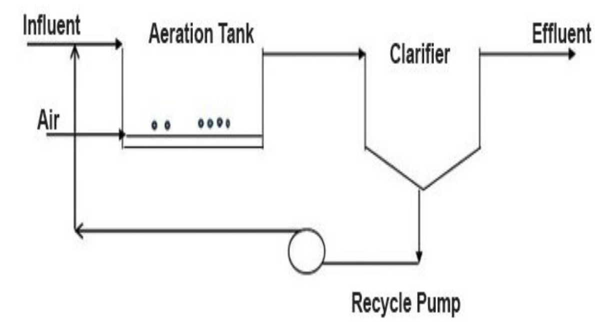
SBRs produce sludge with good settling properties providing the influent wastewater is admitted into the aeration in a controlled manner. Controls range from a simplified float and timer based system with a PLC to a PC based SCADA system with color graphics using either flow proportional aeration or dissolved oxygen controlled aeration to reduce aeration to reduce energy consumption and enhance the selective pressures for BOD, nutrient removal, and control of filaments. An appropriately designed SBR process is a unique combination of equipment and software. Working with automated control reduces the number of operator skill and attention requirement.

The majority of the aeration equipment of sequencing batch reactors consists of jet, fine bubble, and coarse bubble aeration systems. The main focus of this report is a jet aerated sequencing batch reactor activated sludge system with a PLC to a PC based SCADA system.

Conventional Activated Sludge Process (ASP) System:

This is the most common and oldest bio-treatment process used to treat municipal and industrial wastewater. Typically wastewater after primary treatment i.e. suspended impurities removal is treated in an activated sludge process based biological treatment system comprising aeration tank followed by secondary clarifier. The aeration tank is a completely mixed or a plug flow (in some cases) bioreactor where specific concentration of biomass (measured as mixed liquor suspended solids (MLSS) or mixed liquor volatile

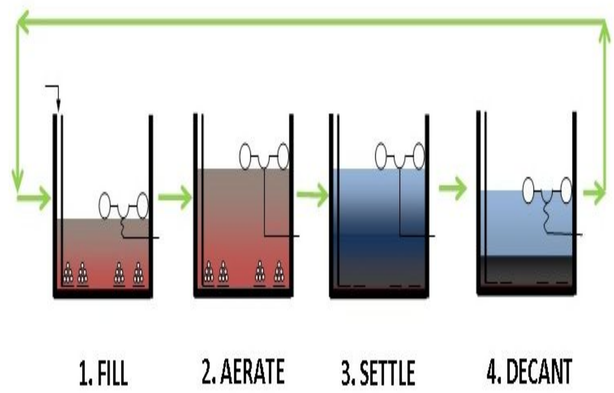
suspended solids (MLVSS)) is maintained along with sufficient dissolved oxygen (DO) concentration (typically 2 mg/l) to effect biodegradation of soluble organic impurities measured as biochemical oxygen demand (BOD5) or chemical oxygen demand (COD).
The aeration tank is provided with fine bubble diffused aeration pipe work at the bottom to transfer required oxygen to the biomass and also ensure completely mixed reactor. Roots type air blower is used to supply air to the diffuser pipe work. In several older installations, mechanical surface aerators have been used to meet the aeration requirement. The aerated mixed liquor from the aeration tank overflows by gravity to the secondary clarifier unit to separate out the biomass and allow clarified, treated water to the downstream filtration system for finer removal of suspended solids. The separated biomass is returned to the aeration tank by means of return activated sludge (RAS) pump. Excess biomass (produced during the biodegradation process) is wasted to the sludge handling and dewatering facility.



Conventional *ASP System*

Sequential Batch Reactor (SBR)
The sequencing batch reactor system features time-managed operation and control of aerobic, anoxic and anaerobic processes within each reactor. Equalization and clarification takes place within a reactor itself. The SBR system utilizes five basic phases of operation to meet advanced wastewater treatment objectives. The duration of any particular phase may be based upon specific waste characteristics and/or effluent objectives:

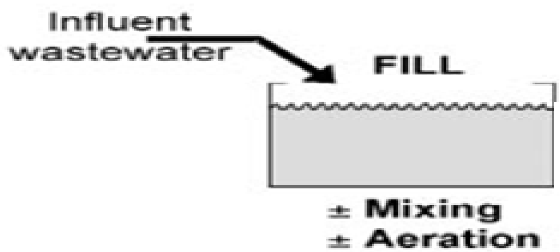
A. Fill
B. Aerate
C. Settle
D. Decant
E. Idle



A. Fill
During the fill phase, the basin receives influent wastewater from different streams such as Toilets, Bathrooms, Urinals, Kitchen etc. The influent contains Phosphorous, Nitrogen, Carbohydrates and other useful things which act as food to the microbes in the activated sludge, which creates a suitable environment for biochemical reactions to take place. Mixing and aeration can be variable during the fill phase to create the following three different scenarios which are as under:

Static Fill –Static fill is used during the initial start-up phase of a plants in which there is no mixing or aeration is required while influent is entering and filling of influent is under progress. So during such period the mixers and aerators remain off.

Mixed Fill – During mixed-fill phase, the mechanical mixers are active, but the aerators remain off. The mixers blend influent wastewater and biomass uniformly. But during mixing anaerobic condition could take place because aerators are still switched off (which provides Oxygen for microbial growth) which promotes denitrification. Anaerobic conditions can also occur during the mixed-fill phase. Under anaerobic conditions the biomass undergoes a release of phosphorous. The released Phosphorous during anaerobic conditions is reabsorbed by the biomass once aerobic conditions are reestablished.
Aerated Fill – During Aerated-fill phase, both the aerators and the mechanical mixer are activated. The basin is aerated & the conversion of the anoxic or anaerobic zone to an aerobic zone takes place. To achieve denitrification, it is necessary to switch the oxygen off to promote anoxic conditions for denitrification. By switching the oxygen on and off during this phase with the blowers, oxic and anoxic conditions are created which creates nitrification and denitrification conditions in the basin. Dissolved oxygen (DO) should be monitored during this phase so it does not go beyond 0.2 mg/L. This ensures that an anoxic condition will occur during the idle phase.

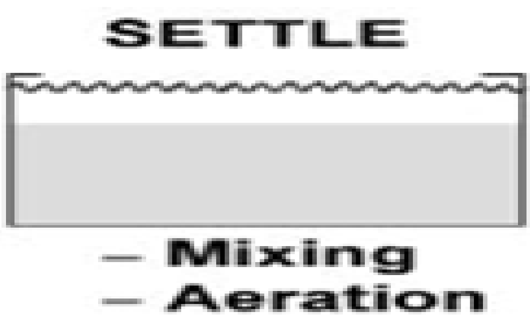


B. Aerate

In React phase further reduction of wastewater parameters takes place. During this phase, no influent is taken to the basin while mechanical mixers and aerators are switched on. Because of no additional volume of wastewater and organic loadings, the organic removal rate increases at faster rate.
Most of the carbonaceous BOD removal occurs in the react phase, while Nitrification continues to occur by allowing the mixing and aeration continuously. Most of the denitrification takes place in the mixed-fill phase. The phosphorus released during mixed fill, and additional phosphorus, is taken up during the react phase.

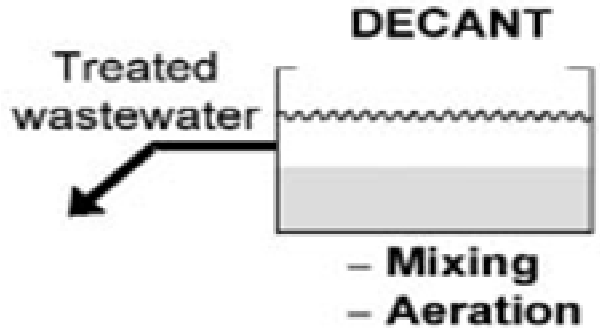
C. Settle

In this phase, activated sludge is allowed to settle under quiescent conditions. No wastewater flow is allowed to enter in the basin and aeration and mixing are switched off. The activated sludge settles down as flocs, which forms a top layer of the clear supernatant. The flocs settled down as sludge mass and thus called as sludge blanket. This phase is a critical part of the cycle because if the solids do not settle rapidly can result into floating of sludge which can be drawn out of the basin during Decant phase which further degrade the quality parameters of the effluent.



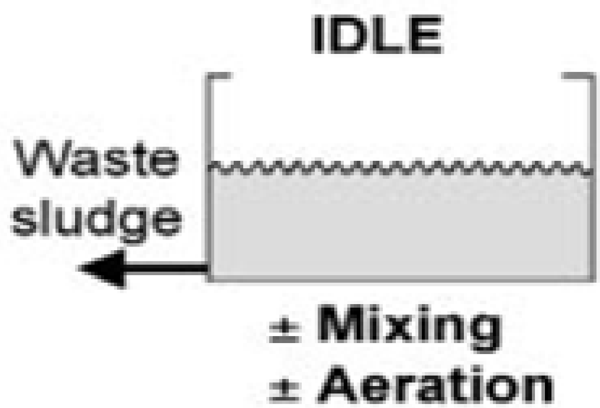
D. Decant

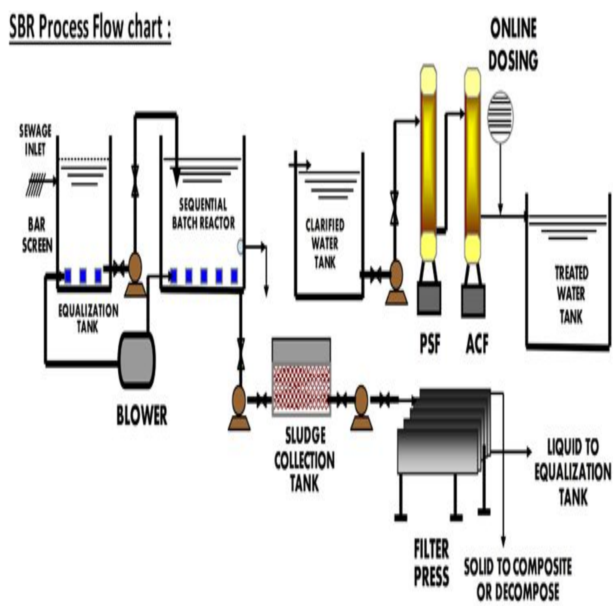
During Decant phase, a Decanter is used to remove the clear supernatant effluent which is accumulated after the completion of Settle phase, a signal is sent to Decanter to activate the effluent-discharge valve and make it Switched on. There are 2 arms of decanter, one is floating and the other is fixed-arm decanters. Floating arm of decanter maintain the inlet orifice just below the surface of supernatant so that the removal of solids, surface foam or scum in the effluent can be minimized during decanting. Floating decanters allows flexibility to fill and draw volumes of supernatant. Fixed-arm decanters are designed to lower or raise the level of the decanter. It is optimal that the decanted supernatant volume is the same as the Influent volume that enters the basin during the fill phase. The vertical distance from the decanter to the bottom of the tank should be maximized to avoid disturbing of settled biomass.

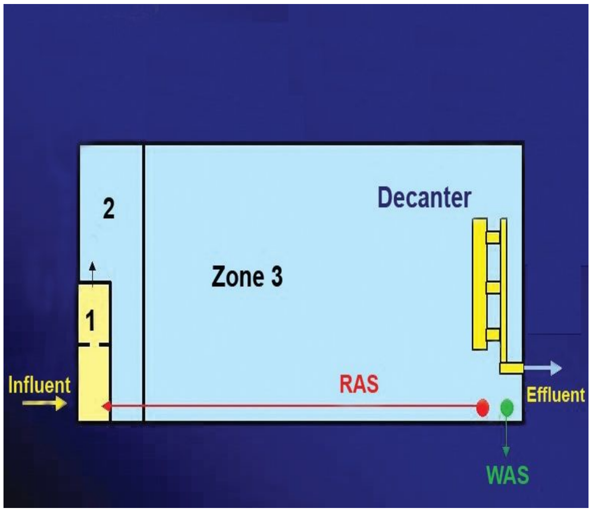


E. Idle

The Idle step occurs between the decant and the fill phases. The time variation can be based on the incoming influent flow rate and the operating time. During Idle phase, small amount of activated sludge at the bottom of the SBR basin is pumped out if MLSS quantity is greater than the 40% volume of the basin volume. This process of removing activated sludge is called as Wasting.







Typical Rectangular SBR basin layout

Parameters to Be Monitored by the Supervisory Control and Data Acquisition (SCADA) System.
Oxidation reduction potential (ORP), dissolved oxygen (DO), pH, and alkalinity are parameters that should be monitored by the Supervisory Control and Data Acquisition (SCADA) system. Manufacturers determine that what parameters can be monitored and controlled by the SCADA system. Monitoring of certain parameters is important, and the ability to adjust these parameters from a remote location is ideal. The operator needs to add chemicals to raise the alkalinity and subsequently the pH. The set point should be an alkalinity value rather than pH based. The operator should have the ability to fully control or modify the plant-operating parameters, such as cycle time, volume, and set point.

Alkalinity monitoring and addition ensures that pH of less than 7.0 does not occur. Nitrification consumes alkalinity, and with a drop in alkalinity, pH also drops. If a plant has adequate alkalinity, pH does not change, so it does not need to be raised chemically. Chemicals that raise alkalinity, such as sodium bicarbonate and soda ash, are recommended over sodium hydroxide.

For plants that nitrify and denitrify, ORP monitoring is desirable. ORP is the measure of the oxidizing or reducing capacity of a liquid. DO vary with depth and location within the basin. ORP can be used to determine if a chemical reaction is complete and to monitor or control a process.

Table 1: Treatment Efficiency of Activated Sludge and Sequential Batch Reactor plant at Case 1 operation.

Parameter	AS Plant			SBR Plant		
	Influent	Effluent	Removal Efficie	Influent	Effluent	Removal Efficien
	mg/l	mg/l	%	mg/l	mg/l	%
BOD	250	8	96.80%	250	7.7	96.92%
TSS	255	8.9	96.51%	255	18.5	92.75%
TKN	42	7.5	82.14%	42	6.4	84.76%
NH_3^+	35.2	3.7	89.49%	46	1	97.83%

The BOD removal efficiency for both Activated Sludge and Sequential Batch Reactor plant is approximately the same (BOD removal for both Activated Sludge and Sequential Batch Reactor systems equal to 96.8 %, 96.92 % respectively). The suspended solids removal for the AS plant is higher than the SBR plant. Whereas, the efficiency of the TKN and ammonia nitrogen NH_{3+} removal for the SBR plant is higher than the AS plant. The TKN removal efficiency for the AS and SBR are 82.14% and 84.76% respectively. The efficiency of ammonia NH_{3+} removal for the AS and SBR are 89.49% and 97.83% respectively. It can be concluded form these results that, the efficiency of nitrogen and ammonia removal for Sequential Batch Reactor system is higher than the Activated Sludge system under the same operation conditions.

Main Conclusion of the Study

Based on the observation and results obtained from this study, the following points are concluded:

1. The BOD removal efficiency of the Activated Sludge and Sequential Batch Reactor plant systems is similar during the all cases of operation (the BOD removal in both systems ranged between 96.75% and 97.86% respectively).
2. The Activated Sludge system has a higher ability to remove the suspended solids than the SBR system during all cases of operation (the maximum TSS removal for both systems 96.71% and 94.94 % respectively).
3. The SBR system has a higher ability to remove the total Nitrogen TKN concentration than the Activated Sludge system under all cases of operation (the TKN removal for SBR system ranged from 84.76% to 87.86%, and for Activated Sludge system ranged between 82.14% to 83.57%).
4. The SBR system has a higher ability to remove the Total Ammonia NH_{3+} concentration than the Activated Sludge system under all cases of operation (the NH_{3+} removal for SBR system ranged from 97.83% to 99.02%, and for Activated Sludge system ranged from 89.49% to 91.14%).

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