# Sequencing Batch Reactor for Wastewater Treatment: Advanced Technology

[1]Parth B. Shah, [2]Shardul U. Tirlotkar, [3]Nikunj R. Parmar, [4]Shilpa Patil
[1, 2, 3] Student, [4]Asst. Professor
Department of Civil Engineering,
Universal College of Engineering Kaman, Vasai.

**ABSTRACT:** The need for wastewater treatment plants based on appropriate technologies and working effectively is rising rapidly on global scale, especially in those regions where availability of pure water is in challenging phase. Construction of sewage treatment plants (STPs) based on latest emerging treatment technologies in different parts of India is necessary and environmental friendly approach to reduce problem of water pollution. The Sequence Batch Reactor (SBR) technology is an emerging advanced wastewater treatment technology that has come into practice recently in many parts of the world. Sequence batch reactor (SBR) technology is being used successfully to treat both municipal and industrial wastewaters, particularly in areas characterized by low or varying flow patterns. Treated effluent is finally used for agriculture purposes and it meets guideline for reuse. Sludge generated is sold to farmers, and they use it as manure.

**KEYWORDS:** wastewater, sewage effluent, SBR, STPs, environment friendly approach.

## 1. INTRODUCTION

### 1.1- ABOUT SBR

Sequencing batch reactors (SBR) or sequential batch reactors are a type of activated sludge process for the treatment of wastewater. SBR reactors treat wastewater such as sewage or output from anaerobic digesters or mechanical biological treatment facilities in batches. Oxygen is bubbled through the mixture of wastewater and activated sludge to reduce the organic matter (measured as biochemical oxygen demand (BOD) and chemical oxygen demand (COD)). The treated effluent may be suitable for discharge to surface waters or possibly for use on land.

The Sequence batch reactor (SBR) treats wastewater by combining, primary settling, aeration, secondary settling and decanting; the treated sewage in a series of sequenced and or simultaneous reactions in the same basin on a time differed cycle. Thus, multiple basins are used because different processes associated in SBR treatment technology can run in different basin at the same time. High efficiency of aeration, without clogged membrane with fine bobbles, is preferred. To support different favorable biological conditions inputs in to the reactors should be controlled.[6]

While there are several configurations of SBRs, the basic process is similar. The installation consists of one or more tanks that can be operated as plug flow or completely mixed reactors. The tanks have a “flow through” system, with raw wastewater (influent) coming in at one end and treated water (effluent) flowing out the other. In systems with multiple tanks, while one tank is in settle/decant mode the other is aerating and filling. In some systems, tanks contain a section known as the bio-selector, which consists of a series of walls or baffles which direct the flow either from side to side of the tank or under and over consecutive baffles. This helps to mix the incoming Influent and the returned activated sludge (RAS), beginning the biological digestion process before the liquor enters the main part of the tank.

### 1.2- BACKGROUND

Opposed to the common belief of SBR being a new technology, the SBR-like fill and draw processes were popular during 1914–1920. The revival of interest in SBR technology in its present form occurred during the late 1950s and early 1960s due to the improvement in technology related with aeration and process control. In its initial years, SBR technology was mainly used by small communities for sewage treatment and for the treatment of high strength industrial wastes. Due to the design flexibility and better process control that can be achieved by the modern technology, the use of the SBR process has not been limited to the field of sewage treatment only; it has also found wide acceptance in biological treatment of industrial wastewater containing difficult-to-treat organic chemicals. As the SBR process can be effectively automated, it is known to save more than 60 % of the operating expenses required for a conventional ASP and is able to achieve high effluent quality in a very short aeration time. In densely populated countries such as Indian Subcontinent and regions such as Europe, SBR is being considered as a preferable technology due to its low requirement of area as well as manpower for operation.[4]

### 1.3- GENERATION OF SEWAGE

Sewage (or domestic wastewater or municipal wastewater) is a type of wastewater that is produced by a community of people. It is characterized by volume or rate of flow, physical condition, chemical and toxic constituents, and its bacteriologic status (which organisms it contains and in what quantities). It consists mostly of grey water (from sinks, tubs, showers, dishwashers, and clothes washers), black water (the water used to flush toilets, combined with the human waste that it flushes away); soaps and detergents; and toilet paper (less so in regions where bidets are widely used instead of paper).Sewage usually travels from a building's plumbing either into a sewer, which will carry it elsewhere, or into an onsite sewage facility (of which there are many kinds). Whether it is combined with surface runoff in the sewer depends on the sewer design (sanitary sewer or combined sewer). The reality is, however, that most wastewater produced globally remains untreated causing widespread water pollution, especially in low-income countries: A global estimate by UNDP and UN-Habitat is that 90% of all wastewater generated is released into the environment untreated. In many developing countries the bulk of domestic and industrial wastewater is discharged without any treatment or after primary treatment only.[8]

Domestic wastewater results from water use in residences, businesses, and restaurants. Industrial wastewater comes from discharges by manufacturing and chemical industries. Rainwater in urban and agricultural areas picks up debris, grit, nutrients, and various chemicals, thus contaminating surface runoff water. The spent water for all the above needs forms the sewage. Industries use the water for manufacturing various products and thus develop the sewage. Water supplied to schools, cinemas, hotels, railway stations, etc., when gets used develops sewage. Ground water infiltrates into sewers through loose joints.

### 1.4 EFFECT ON ENVIRONMENT

Unfortunately, the effects of sewage on the environment are largely negative. It needs to be properly treated before it can be disposed of – usually into the ocean. There are two problems, however. If sewage is only partially treated before it is disposed of, it can contaminate water and harm huge amounts of wildlife.

Oxygen depletion: When sewage decomposes it uses up oxygen from the surrounding water and if the discharged concentration are too great, the amount of oxygen available for fish and other aquatic animals and plants will be insufficient and they may die.

## 2. VARIOUS WASTEWATER TREATMENTS

**Primary Wastewater Treatment:-** Primary treatment of wastewater involves sedimentation of solid waste within the water. This is done after filtering out larger contaminants within the water. Wastewater is passed through several tanks and filters that separate water from contaminants. The resulting "sludge" is then fed into a digester, in which further processing takes place. This primary batch of sludge contains nearly 50% of suspended solids within wastewater.

**Secondary Wastewater Treatment:-** Secondary treatment of wastewater makes use of oxidation to further purify wastewater. This can be done in one of three ways:

**Bio-filtration:-** This method of secondary treatment of wastewater employs sand filters, contact filters, or trickling filters to ensure that additional sediment is removed from wastewater. Of the three filters, trickling filters are typically the most effective for small-batch wastewater treatment.

**Aeration:-** Aeration is a long, but effective process that entails mixing wastewater with a solution of microorganisms. The resulting mixture is then aerated for up to 30 hours at a time to ensure results.

**Oxidation Ponds:-** Oxidation ponds are typically used in warmer places. In addition, this method utilizes natural bodies of water like lagoons. Wastewater is allowed to pass through this body for a period of time and is then retained for two to three weeks.

**Tertiary Wastewater Treatment:-** This third and last step in the basic wastewater management system is mostly comprised of phosphates and nitrates from the water supply. Substances like activates carbon and sand are among the most commonly used materials that assist in this process.

## 3. COMPARISION

Since SBR is a batch process, consistent quality at the outlet is achieved as system can handle peak flows effectively. Main features of SBR plant is, the SBR plant is completely automatic and provided with remote monitoring facility to monitor its performance, whereas Activated Sludge Process plant is not fully automatic. It require additional investment to implement remote monitoring system. Complete SBR treatment is a single treatment unit with retention time around 7-12.5 hours whereas Activated Sludge Process takes around 15hrs.Land Require for construction is only up to 40% area as compared to conventional ASP due to compact scheme. It is single tank sludge handling system, whereas ASP requires further more area for additional treatment units for tertiary treatment. Low operating cost due to less number of treatment units and flexibility of operation, as an average ASP cost is high due to more number of treatment units. Power consumption is low because ASP plants are for larger aspects consume high power consumption.

## 4. SOLUTION: (SBR)

### 4.1- PROCESS

**Fill:** Fill process ends when tank is filled. Reactions which are starts during fill, ends during reacts face. Influent distributed manifolds are used to distribute influent wastewater over settled sludge and make better contact between micro-organisms and substrates. Most of this period occurs without aeration to create a favorable environment to procreation of microorganisms with good settling characteristics.[6]

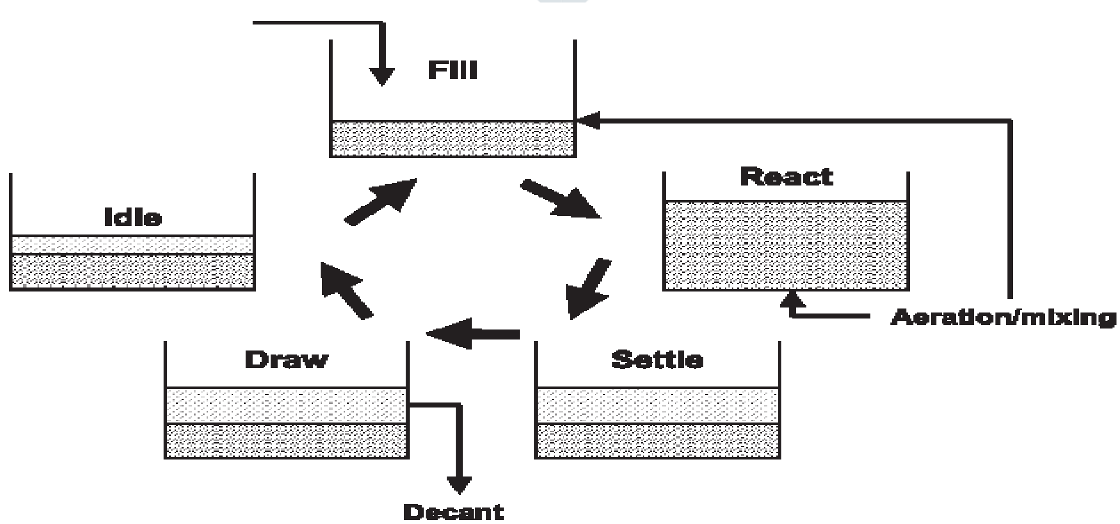
**React:** Sludge age is controlled by sludge wasting during react phase. The sludge age in days is inversely related to the fraction of the reactor liquid volume wasted each day. The end of react may be dictated by the time specification or a level controller in an adjacent tank. During this period aeration continues until complete biodegradation of BOD and nitrogen is achieved. After the substrate is consumed famine stage starts. During this stage some microorganisms will die because of the lack of food and will help reduce the volume of the settling sludge. The length of the aeration period determines the degree of BOD consumption.[6]

**Settle:** Aeration is discontinued at this stage and solids separation takes place leaving clear, treated effluent above the sludge blanket. During this settling period no liquids should enter or leave the tank to avoid turbulence in the supernatant. This major advantage in the clarification process results from the fact that the entire aeration tank serves as clarifier during the period when no flow enters the tank. The time in settle insures that the sludge blanket remains in the tank during draw and does not rise (because of gas formation) before DRAW is completed. The sludge can also be wasted during settle, instead of during react. Sludge wasted near the end of settle is more concentrated than that during react.[6]

**Decant:** During this phase treated water is withdraw from approximately 2-3 feet's from surface of water by the floating solids excluding decanter. Settled sludge must not be disturbed during this process.[6]

**Idle:** The time in this stage can be used to waste sludge or perform backwashing of the jet aerator. Sludge volume reduction is done in anaerobic digester. The frequency of sludge wasting ranges between once each cycle to once every two to three months depending upon system design.[6]

### 4.2- PROCESS CYCLE



## 5. TECHNOLOGY

### 5.1- REMOVAL EFFICIENCY

Aeration times vary according to the plant size and the composition/quantity of the incoming liquor, but are typically 60 to 90 minutes. The addition of oxygen to the liquor encourages the multiplication of aerobic bacteria and they consume the nutrients. This process encourages the conversion of nitrogen from its reduced ammonia form to oxidized nitrite and nitrate forms, a process known as nitrification.

To remove phosphorus compounds from the liquor, aluminum sulfate (alum) is often added during this period. It reacts to form non-soluble compounds, which settle into the sludge in the next stage. The settling stage is usually the same length in time as the aeration. During this stage the sludge formed by the bacteria is allowed to settle to the bottom of the tank. The aerobic bacteria continue to multiply until the dissolved oxygen is all but used up. Conditions in the tank, especially near the bottom are now more suitable for the anaerobic bacteria to flourish. Many of these, and some of the bacteria which would prefer an oxygen environment, now start to use oxidized nitrogen instead of oxygen gas (as an alternate terminal electron acceptor and convert the nitrogen to a gaseous state, as nitrogen oxides or, ideally, molecular nitrogen (di-nitrogen, $N_2$) gas. As the bacteria multiply and die, the sludge within the tank increases over time. The quantity or "age" of sludge within the tank is closely monitored, as this can have a marked effect on the treatment process. The sludge is allowed to settle until clear water is on the top 20%-30% of the tank contents.

### 5.2- ADVANTAGES AND DISADVANTAGES

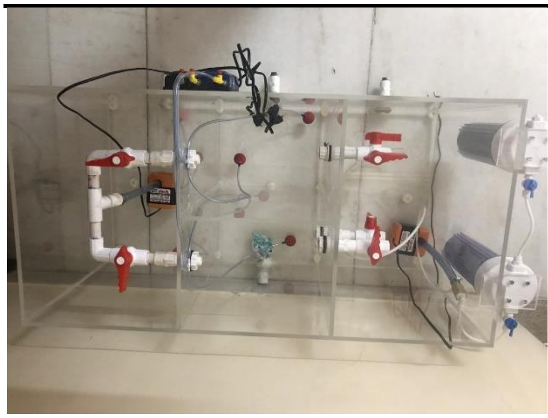
High treatment efficiencies possible for BOD, COD, TSS, Nitrate & Phosphorus. High flexibility in operating conditions. Possibility of producing electric energy from biogas (SBR + Anaerobic sludge digestion). Less land requirement due to compact tank construction. Equalization, primary clarification (in most cases), biological treatment, and secondary clarification can be achieved in a single reactor vessel. Equalization, primary clarification (in most cases), biological treatment, and secondary clarification can be achieved in a single reactor vessel. Requires less site work.[3,6

A higher level of sophistication is required (compared to conventional systems), especially for larger systems, of timing units and controls. Higher level of maintenance (compared to conventional systems) associated with more sophisticated controls, automated switches, and automated valves. Potential of discharging floating or settled sludge during the DRAW or decant phase with some SBR configurations. Potential plugging of aeration devices during selected operating cycles depending on the aeration system used by the manufacturer. Potential requirement for equalization after the SBR, depending on the downstream processes.

### 5.3 METHODOLOGY:

Following Sequencing Batch Reactor model is made without any desire dimensions in order to display broad idea about actual working of the SBR plant. Model consist of 5 section each of same size where the 5 stages of SBR such as Fill, React, Settle, Decant, Idle takes place. Testing of sample is yet to be done; local sewage sample will be taken in order to test the similar consumption of a waste in certain locality.

For this project work, SBR model used in order to practiced and understand the idea behind the wastewater treatment of particular locality or building. Firstly influent taken from building or nearby locality is taken and tested for BOD, COD, TSS, N and P. then the same effluent is allowed to pass through this SBR model. The flow of this wastewater is observed and final effluent is again tested for the same parameters. Thus we can calculate the efficiency of SBR model.



## 6. CONCLUSION

The result of this study can be demonstrated that the suspended growth SBR and attached cum suspended growth SBR were efficient for treating municipal sewage in terms of nitrogen, phosphorus and organic carbon removal. This experimental design method is useful for obtaining a rough selection for optimal controlling factors. As a result of this demonstration the SBR process has been shown to available option for best municipal wastewater. Unlike the conventional wastewater treatment plants, SBR-based wastewater treatment plant can achieved better treated water quality with no or minor modification in the installed infrastructure, only by simple alteration of the process control parameter in one or more phases of treatment cycle.

The SBR process offers smaller footprint area, lower investment cost, lower operation complexity, and significant control performance as compared to conventional treatment process. If properly designed, the process may achieve significant degree of biological nutrient removal too. It is found from the research papers that Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) & Total Suspended Solids (TSS) are the main process efficiency parameters that have been used for reused of wastewater. It can be concluded that the society may be convinced to re-used the wastewater for flushing and gardening purpose.

## 7. REFERENCE

[1] Ashutosh Pipraiya, Haryana 2007. International journal on Innovative Research in Science engineering and Technology, vol. 6, (6) (An ISO 3297 : 2007 Certified Organization), www.ijirset.com

[2] Nadeem Khan, Arshad Hussian, FazlollahChangani, Kausher Hussain,2017, REST Journal On Emerging Trends In Modeling and Manufacturing, vol. 3(4),2017, (ISSN 2455-4537), www.researchgate.net/publications/322819452

[3] Navdeep Kaur, D.R.Prajapati 2014, ROLE OF SBR TECHNIQUE IN WASTE WATER TREATMENT PLANTS:A REVIEW, 2014, Vol.48, pp 89-95.www.researchgate.net/publication/272742369

[4] Aparna Dutta, Sudipta Sarkar 2015, Sequencing Batch Reactor For Waste Water Treatment: Recent Advances ,Sept. 2015,Vol.1 ,Issue 3, pp 177-190, www.IITR.AC.IN

[5] Prachi N Wakode, Sameer U. Sayyad, Perfomance Evaluation Of 25 MLD Sewage Treatment Plant At Kalyan,Vol. 03, Issue 03, pp 310-316, ISSN: 2320-0936, www.ajer.org.

[6] Ashutosh Pipraiya, Diwan Singh, SK Patidar Sequence Batch Reactor – A New Technology in Waste Water Treatment Haryana

[7] https://en.wikipedia.org/wiki/Sequencing_batch_reactor

[8] https://en.m.wikipedia.org/wiki/sewage