



SEQUENCING BATCH REACTOR: A PROMISING TECHNOLOGY IN WASTEWATER TREATMENT

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ABSTRACT

Wastewater contains elements toxic to humans and the ecosystem discharge of domestic and industrial wastewater of surface or groundwater very dangerous to the environment. Therefore, treatment of any kind of wastewater to produce discharge of good quality is necessary. As such, choosing an effective treatment process is very important. Sequencing Batch Reactor (SBR) is modification of activated sludge process, which has been successfully used to treat municipal and industrial wastewater. SBR process due to its operational flexibility and excellent process control possibilities is being extensively used for treatment of wastewater. The process is applied to remove nutrients high biochemical oxygen demand, chemical oxygen demands, toxic material such as cyanide, copper, chromium, lead, nickel, total dissolved solids etc. As the SBR process can be effectively automated, it is known to save significant operating expenses and is able to achieve high effluent quality in a very short aeration time. The process advantages are single tank configuration, small foot print, easily expandable, simple operation and low capital costs. SBR process is gaining immense popularity in the recent years and many researches and investigations have been conducted on this treatment technology.

Key words: Sequencing Batch Reactor, Domestic Wastewater, Industrial Wastewater, Organic removal, Nutrients removal.

INTRODUCTION

A supply of clean water is an essential requirement for the establishment and maintenance of diverse human activities. Water resources provide valuable food through aquatic life and irrigation for agriculture production. However, liquid and solid wastes produced by human settlements and industrial activities pollute most of the water sources throughout the world. As the environmental discharge standards are getting more and more stringent, the traditional continuous flow-based biological wastewater treatment process faces severe challenges. The sequencing batch reactor (SBR) technology is a modification of the much popular activated sludge process (ASP). Such a conversion of the continuous nature of the ASP-based treatment process to a batch process as in SBR helps introduce various process flexibilities and alternatives in process controls and design so as to better achieve the latest effluent discharge standards. The term SBR was originally coined by R.L. Irvine. 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 India 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. The SBR process is often preferred over Continuous Flow Process (CFP) due to reduction in energy consumption and enhancement in the selective pressures for BOD, nutrient removal, and control of filamentous bacteria. Due to these reasons, SBR process is gaining immense popularity in the recent years. The SBR technology has been undergoing several minor and major modifications over the past few years to be able to effectively treat the exponentially increasing number of new pollutants in wastewater. This article provides an insight into the technology as well as reviews the recent advances in the design and application of SBR technology.

The Process

In an SBR process, all these unit processes take place within a single tank for their specific duration and intervals, sequentially spaced over a span of time. Thus, SBR provides in time the same treatment what the CFP provides in space. The SBR technology basically incorporates a fill-and-draw type biological wastewater treatment process, functionally resembling to an activated sludge process. Depending on the scale of operation, the SBR system, along with its variants and hybrids, may involve single or multiple tanks, each of which features five basic operating modes, namely, Fill, React, Settle, Draw, and Idle. Being a batch process, the time duration of each mode within a tank can be adjusted to meet the different treatment needs, such as low COD in the effluent, biological nutrient removal, etc.

SBR Operating Principles

In its most basic form, the SBR system is a set of tanks that operate on a fill-and draw basis. Each tank in the SBR system is filled during a discrete period of time and then operated as a batch reactor. After desired treatment, the mixed liquor is allowed to settle and the clarified supernatant is then drawn from the tank. The cycle for each tank in a typical SBR is divided into five discrete periods: Fill, React, Settle, Draw and Idle. There are several types of Fill and React periods, which vary according to aeration and mixing procedures. Sludge wasting may take place near the end of React, or during Settle, Draw or Idle. Central to SBR design is the use of a single tank for multiple aspects of wastewater treatment. SBR operation for each tank for one cycle for the five discrete time periods of Fill, React, Settle, Draw, and Idle (Irvine and Ketchum, 2004).

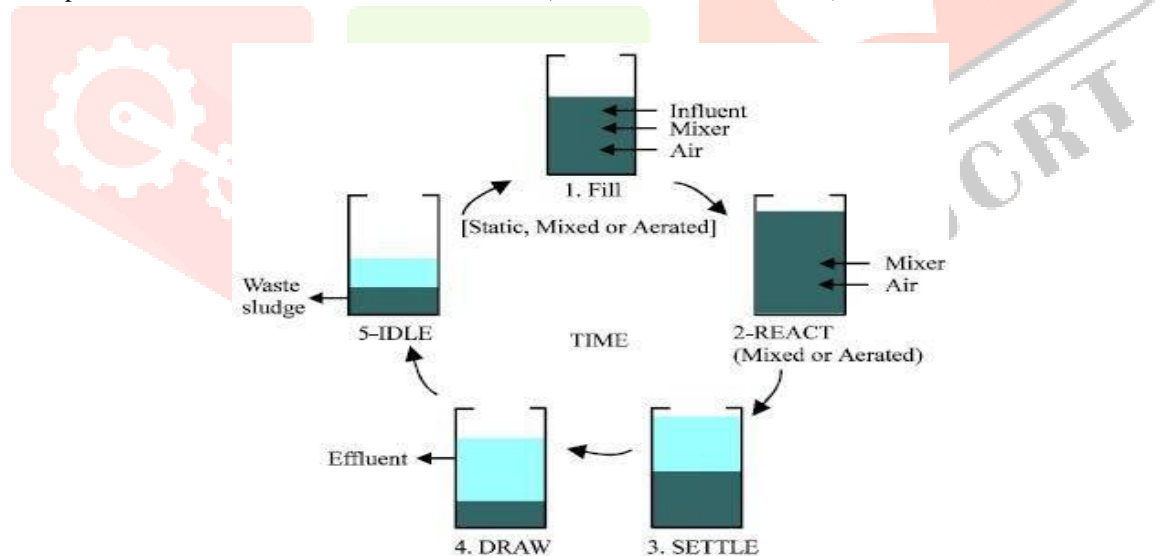


Fig. 1: A typical Cycles in SBR

Fill

The influent to the tank may be either raw wastewater (screened and de gritted) or primary effluent. It may be either pumped in or allowed to flow in by gravity. The feed volume is determined based on a number of factors including desired loading and detention time and expected settling characteristics of the organisms. The time of Fill depends upon the volume of each tank, the number of parallel tanks in operation, and the extent of

diurnal variations in the wastewater flow rate. Virtually any aeration system (e.g., diffused, floating mechanical, or jet) can be used. The ideal aeration system, however, must be able to provide both a range of mixing intensities, from zero to complete agitation, and the flexibility of mixing without aeration. Level sensing devices, or timers, or in-tank probes (e.g., for the measurement of either dissolved oxygen or ammonia nitrogen)

can be used to switch the aerators and/or mixers on and off as desired.

React

Biological reactions, which were initiated during Fill, are completed during React. As in Fill, alternating conditions of low dissolved oxygen concentrations (e.g., Mixed React) and high dissolved oxygen concentrations (e.g. Aerated React) may be required. The liquid level remains at the maximum throughout react, sludge wasting can take place during this period as a simple means for controlling the sludge age. By wasting during React, sludge is removed from the reactor as a means of maintaining or decreasing the volume of sludge in the reactor and decreases the solids volume. Time dedicated to react can be as high as 50% or more of total cycle time. The end of React may be dictated by a time specification (e.g. the time in React shall always be 1.5 h) or a level controller in an adjacent tank.

Settle

In the SBR, solids separation takes place under quiescent conditions (i.e., without inflow or outflow) in a tank, which may have a volume more than ten times that of the secondary clarifier used for conventional continuous-flow activated sludge plant. This major advantage in the clarification process results from the fact that the entire aeration tank serves as the clarifier during the period when no flow enters the tank. Because all of the biomass remains in the tank until some fraction must be wasted, there is no need for underflow hardware normally found in conventional clarifiers. By way of contrast, mixed liquor is continuously removed from continuous-flow activated-sludge aeration tank and passed through the clarifiers only to have major portion of the sludge returned to the aeration tank.

Draw (Decant)

The withdrawal mechanism may take one of several forms, including a pipe fixed at some predetermined level with the flow regulated by an automatic valve or a pump, or an adjustable or floating weir at or just beneath the liquid surface. In any case, the withdrawal mechanism should be designed and operated in a manner that prevents floating matter from being discharged. The time dedicated to draw can range from 5 to more than 30 % of the total cycle time. The time in Draw, however, should not be overly extended because of possible problems with rising sludge.

Idle

The period between Draw and Fill is termed Idle. Despite its name, this "idle" time can be used effectively to waste settled sludge. While sludge wasting can be as infrequent as once every 2 to 3 months, more frequent sludge wasting programs are recommended to maintain process efficiency and sludge settling. SBR technology has the advantage of being much more flexible than Conventional Activated Sludge Processes (CASP) in terms of matching reaction times to the concentration and degree of treatment required for a particular wastewater. For example, the SBR process allows for the following adjustments to be made in addition to those (such as sludge age and operating mixed liquor solids concentration) that can be made in an equivalent conventional process: total cycle duration of each phase within the process cycle pattern of inflow dissolved oxygen profile during aeration operating top water level operating bottom water level.

Flow Diagram

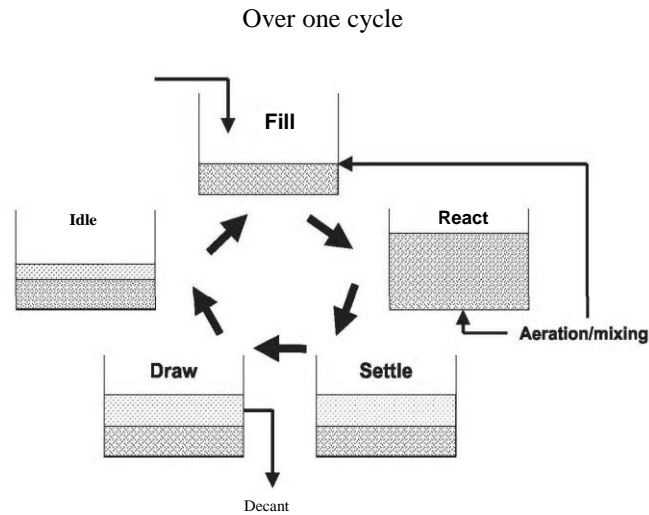


Fig. 2: A typical SBR over One Cycle

Advantages

The primary advantages of the SBR process are:

- Equalization, primary clarification (in most cases), biological treatment, and secondary clarification can be achieved in a single reactor vessel.
- Small space requirements.
- Common wall construction for rectangular tanks.
- Easy expansion into modules.
- Operating flexibility and control.
- Controllable react time and perfect quiescent settling.
- Elimination of return sludge pumping.
- Potential capital cost savings by eliminating clarifiers and other equipment.

Disadvantages

The primary disadvantages of the SBR process are:

- 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.
- Installed aeration power based on percent toxic of the treatment time.
- Batch feeding from storage or bios electors required to control bulking.

SBR Process Configuration

The essential components of SBR are:

- Reactor basin Waste sludge draw-off mechanism.
- Aeration equipment.
- Effluent decanter.
- Process control system

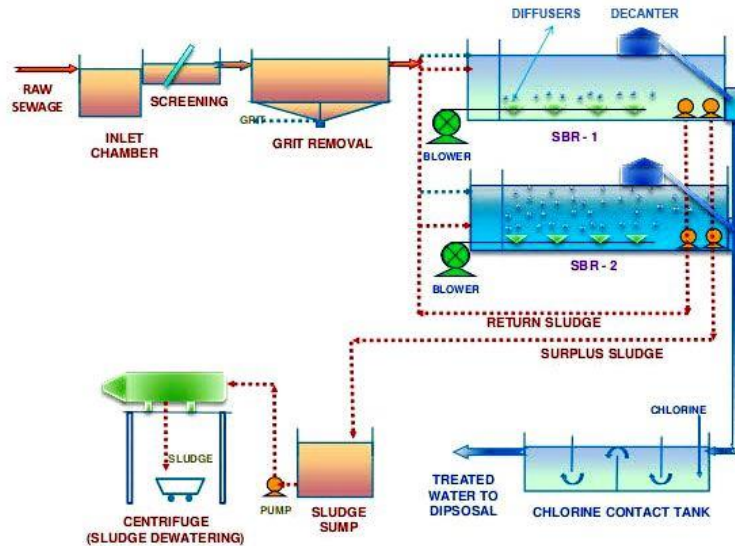


Fig. 3: SBR - Process Configuration Flow Diagram

To accommodate continuous inflow of wastewater, the SBR system generally comprises either a storage/equalization tank and a single SBR tank or a minimum of two tanks. As with conventional activated sludge treatment systems, conventional screening and grit removal are usually provided as preliminary treatment. A primary sedimentation stage is not usually required with SBR processes unless the influent suspended solids are excessive. Settled sewage may also be treated if the SBR is installed downstream of existing primary settlement tanks. Reactors are usually simple circular, square or rectangular tanks and may be constructed from concrete or steel. Lagoon structures can also be used and existing tanks, for example, primary sedimentation tanks, can be retrofitted. Since the tank serves as an aeration tank and a final clarifier, fewer structures are used for the treatment plant as a whole and a more compact layout for the site can be obtained. Extensions to the plant by the addition of modular basins using common wall construction can easily be designed for future loading conditions.

The wasting of microorganisms is done once per cycle during the react phase in high yielding multiple tank system while the frequency of wasting may be as low as once every 2 weeks for low yielding single tank operation. The simultaneous aeration, mixing, reaction, and settling occurring within the SBR tank obviate the requirement of a separate clarifier unit. The duration of Fill and React phases can be adjusted to impart the SBR system. The SBR system provides major operational flexibilities like internal equalization and control of biological reactions through regulation of aeration. The presence of microorganisms in high concentrations right from the Fill phase reduces the treatment duration significantly. The ability to control the substrate availability by varying the aeration duration during Fill provides a high degree of flexibility in controlling the filamentous organism population and concentration of nitrogen. Anoxic period during the React phase is useful in nitrogen removal from the system.

Review of Related Literature

The SBR technology is being applied in a large number of treatment processes owing to the operational flexibility it offers. The ability of SBR to perform flow equalization, biological treatment, and secondary clarification within a single tank by varying the duration of each phase and aeration period makes it a versatile treatment technology. In the recent years, the combination of different treatment technologies has been tested at lab scale to extend the application of SBR technology further. A variation of SBR is a sequencing batch bio film reactor (SBBR), which is a Combination of Suspended and Attached Growth (CSAG) system. Bio film grows at a solid–fluid interface by attachment to a support material. It provides a chance to slow growing microorganisms to proliferate, irrespective of the HRT, and sedimentation characteristics of the bio-aggregates. The selection of support material and its size depends on the characteristics of the wastewater and the treatment objectives. The reactor may be packed with the support material or it may be suspended in the reactor fluid. A typical SBBR cycle has Fill, React, and Draw phases only. Plug flow conditions exist within an SBBR. The time required for washing of the support media may be considered analogous to the settling time in an SBR. Due to the excessive head loss and sloughing off risk, the SBBR systems are unsuitable for influent with high TSS and when excessive microbial growth is expected. There have been numbers of installations after the first pilot scale SBBR was used to treat leachate from the Georgswerder landfill, Germany. The immobilization of microorganisms on a carrier media reduces the microbial washout, protects them from toxic constituents, pH, and temperature extremes. As the media is retained, a shorter HRT is possible that results in smaller reactor size or higher treatment capacity with the same size reactor compared to conventional SBR. Bio film configured systems are more resilient and are well suited for treating wastewater with highly variable quality with low sludge production. When chosen judiciously, the media may help absorb shock loads, for example, activated carbon for high organic load or zeolite for high ammonia in influent. These buffers temporarily absorb the shock load-causing constituent and later gradually desorb the pollutants along with their simultaneous or subsequent biodegradation. The powdered activated carbon (PAC) for treatment of raw landfill leachate demonstrated better NH₃-N, color, and COD removal than conventional SBR. The use of intelligent dynamic control systems over the conventional time control system has shown to improve the COD, TP, and TN removal efficiencies with considerable energy savings. A modified SBR system with bio-floc technology (BFT) has found interesting application in aquaculture where protein feed for fish as well as treatment of wastewater are considered to be cost-inhibiting. Bio-floc refers to a special kind of macro aggregate of microorganisms which are able to take up nitrogenous compounds present in wastewater and to convert it to microbial protein. Bio-floc organisms can be used as food to the fishes. It has been shown at the lab-scale that SBR envisaged as external growth reactor for bio-floc was able to attain nitrogen removal efficiency of up to 98 % when an optimal C/N ratio between 10 and 15 was maintained. It has also been demonstrated that the BFT in SBR reactor also enabled conversion of nitrogen in aquaculture suspended solids into bacterial biomass, which could potentially be used to feed fish, thereby increasing the efficiency of nitrogen—nearly reaching 100 % nitrate removal within 6 h. SBR and SBBR were used to treat industrial wastewater containing phenolic compounds, such as p-nitrophenol (PNP) which is a hazardous chemical widely used in agricultural, pharmaceutical, and dye industries as a synthetic intermediate in the manufacturing process. Complete removal was demonstrated for PNP removal up to 350 mg/L influent concentration (loading rate of 0.368 kg/m³day⁻¹) by SBR and SBBR (with polyethylene rings). However, the average NH₃-N removal efficiency for the SBR and SBBR was only slightly compromised; it reduced to 86 and 96 %, respectively. SBR has been successfully applied for wastewater with high nitrogen content and low COD such as anaerobic SBR (ASBR)-based simultaneous partial nitrification, anaerobic ammonium oxidation, and denitrification (SNAD) system that was applied to treat the opto-electronic industrial wastewater with C/N ratio of nearly 0.2. A similar study was performed by for the treatment of wastewater from production of thin-film transistor liquid crystal display (TFT-LCD) which contained chemicals like dimethyl sulfoxide (DMSO), monoethanolamine (MEA), and tetra-methyl ammonium hydroxide (TMAH). Two different SBR systems, aerobic and anoxic/oxic (A/O), were used. Effective MEA degradation could be easily achieved under all three conditions examined, while efficient DMSO and TMAH degradation could be attained only under anaerobic and aerobic conditions, respectively. These days, hybrid systems like the Porous biomass carrier SBR (PBCSBR) are being investigated to achieve improved nutrient removal efficiency using time-sequenced anoxic/oxic phases and high biomass [18]. In another study, a new biomass retention strategy using natural fibers as biofilm carriers was utilized to treat dairy manure. The concept, evaluated for treating flushed dairy manure in a psychrophilic ASBR, showed higher methane yield despite short HRT (6 days) and low temperature. ASBRs are known to be capable of uncoupling HRT with SRT for biomass retention. Additionally, a particular sequence of operation of ASBR was used to exert selection pressures on microbes for immobilization. Aerobic SBR process, coupled the photo-fenton process and reverse osmosis (RO), was used to reclaim wastewater from textile industry enabling complete internal reuse of water.

SBR operating conditions such as cyclic feast and famine regimes, high shear stress, and short settling time promote formation of floc granules which are nothing but dense microbial consortia consisting of different bacterial species that perform different roles in degrading the complex wastes. Alternating anoxic/oxic condition combined with step-feeding mode (AASF) was proved to be an efficient method for nitrogen removal in Granular SBR (GSBR). Aerobic granular sludge presents several advantages over activated sludge, such as excellent settling properties, high biomass retention and biosorption, and ability to deal with high organic loading rates and to perform diverse biological processes simultaneously, such as COD, N, and P removal. The utility of aerobic granular sludge in SBR for degradation of toxic organ fluorine compounds such as 2-fluorophenol (2-FP) has been demonstrated. The fluoroaromatic compounds are usually biodegraded via halo-catechols. The maintenance of a good population of halo-aromatics degraders in bioreactors is highly desirable due to the low concentration discontinuous nature of these compounds. The GSBR provides high biomass retention and thus is extremely promising for the treatment of effluents containing toxic compounds. Conventional SBRs treating wastewaters with flocculating sludge can be converted to granular SBRs by reducing the settle time. A study with wastewater containing azo dyes attempting for simultaneous bio-decolorization and COD removal in SBR having a combination of anoxic-aerobic React phase revealed the following: (a) longer anoxic React phase promotes decolorization, while (b) COD removal was better with shorter anoxic phase. The granular-activated carbon-SBR (GAC-SBR) has shown promising results for the treatment of textile wastewater containing dyes where the dye was removed by GAC via physical adsorption mechanism. Addition of extraneous organic carbon increased the removal efficiency of direct dye. In recent years, the presence of endocrine disruptor compounds (EDCs) in surface water, public water supplies as well as in wastewater has generated much public concern. EDCs are a group of different chemical substances that even in low concentrations such as sub- $\mu\text{g/L}$ level in water may interfere with the normal functioning of human endocrine system and animals. SBR process presents an attractive avenue for the removal of EDCs from wastewater due to its ability to provide anoxic/anaerobic/aerobic conditions within the same basin. Maintenance of such dynamic environmental conditions inside the SBR process tank provides ample scope for the microorganisms capable of degrading EDCs to utilize them. Longer SRT and HRT have been observed to cause greater degree of removal of EDCs primarily because such conditions allow for the proper growth of the slow growing microorganisms capable of utilizing the EDCs. Table 2 summarizes brief details of some of the recent studies performed on the efficiencies of different SBR configurations for the removal of EDCs commonly occurring in wastewater. Ozonation and other polishing steps are suggested after proper study of final products in critical cases where significant dilution of STP effluent does not occur.

OBJECTIVE OF THE STUDY

1. Designing of treatment process using Sequential Batch Reactor (SBR) for Waste Water Treatment.
2. Physio-Chemical characterization of pre and post treatment of Sewage and Waste Water.
3. Performance assessment and hydrodynamic analysis by developing a dynamic model of Sequential Batch Reactor (SBR) and investigate the properties and behavior of Sequential Batch Reactor (SBR) under different inputs and operating conditions.
4. Removal and recovery of nutrient by fill and draw activated Sludge System to remove undesirable components of waste water.
5. Energy conversation potential and economic evaluation of Sewage and Waste Water.

RESEARCH METHODOLOGY

Site of Sewage Treatment Plant, Haryana Shehari Vikas Pradhikaran, Sector-25, Rohtak has been chosen for sample collection. A pilot scale study using Sequential Batch Reactor (which works on Fill and Draw operation) with Sewage Waste Water has been conducted. The raw feed of sewage collected in tank which has aeration system (e.g. Diffused Floating Mechanical or Jet) is used. Biological reaction takes place and the sludge is removed from reactor. Again the tank is filled with some Sewage Waste Water sample and the same process will be repeated based on the sizing calculation of treatment plant. The waste water is passed through a pipe and the waste sludge remains in the tank.

The Sequential Batch Reactor which is established according to the précised particulars, so the outcomes are very accurate and the outcome was more than expectations. The sludge took a little more time for settling.

ANALYSIS AND INTERPRETATION OF DATA

PH	BOD	COD	TSS	NITROGEN TOTAL	PHOSPHOROUS TOTAL	FECAL COLIFORM
5.5-9.0	≤10	≤250	≤100	≤20	≤5	≤100

1. RAW WASTE WATER

Sr. No.	Test Parameters	UNIT	Results	Testing Methods
1.	pH Value	-	7.21	IS 3025(P-44)-1983
2.	Total Suspended Solids	Mg/l	148.0	IS 3025(P-17)-1984
3.	Biochemical Oxygen Demand (BOD- 3 DAYS at 27° C	Mg/l	125.0	IS 3025(P-11)-1993
4.	Chemical Oxygen Demand	Mg/l	462.0	IS 3025(P-58)-2006

2. TREATED WASTE WATER

Sr. No.	Test Parameters	Unit	Results	Testing method
1.	pH Value	-	7.88	IS 3025(P-11)-1983
2.	Total Suspended Solids	mg/l	26.3	IS 3025(P-17)-1984
3.	Biochemical Oxygen Demand (BOD- 3 DAYS at 27° C	mg/l	2.5	IS 3025(P-44)-1993
4.	Chemical Oxygen Demand	mg/l	117.0	IS 3025(P-58)-2006
5.	Total Phosphorus (as P)	mg/l	0.76	IS 3025(P-31)-1988
6.	Total Nitrogen (as N)	mg/l	12.4	IS 3025(P-34)-1988
7.	Faecal Coliform	MPN/100ml	70	IS:1622-1981

3. STP SLUDGE RESULT

Sr. No.	Test Parameters	Unit	Results
1.	Color	-	Light Gray
2.	Odor		Slight Odor
3.	Bulk Density	g/cm ³	1.06
4.	Moisture	%	18.68
5.	pH	-	6.72
6.	Organic Carbon	%	9.78
7.	Total Nitrogen (as N)	%	1.32
8.	Total Phosphorous (as P)	%	0.16
9.	Total Potassium (as K)	%	<0.1
10.	Conductivity	dSm-1	2.77
11.	C/N Ratio	-	0.13
12.	Arsenic (as As)	mg/kg	ND
13.	Cadmium (as Cd)	mg/kg	ND
14.	Chromium (as Cr)	mg/kg	ND
15.	Copper (as Cu)	mg/kg	ND
16.	Lead (as Pb)	mg/kg	ND
17.	Mercury (as Hg)	mg/kg	ND
18.	Nickel (as Ni)	mg/kg	ND
19.	Zinc (as Zn)	mg/kg	ND

EXPECTED OUTCOMES OF STUDY

Wastewater treatment involves breakdown of complex organic compounds in the wastewater into simpler compounds that are stable and nuisance-free, either physico-chemically and/or by using micro-organisms (biological treatment). The adverse environmental impact of allowing untreated wastewater to be discharged in groundwater or surface water bodies and or lands are as follows:

1. The decomposition of the organic materials contained in wastewater can lead to the production of large quantities of malodorous gases.
2. Untreated wastewater (sewage) containing a large amount of organic matter, if discharged into a river/stream, will consume the dissolved oxygen for satisfying the Biochemical Oxygen Demand (BOD) of wastewater and thus deplete the dissolved oxygen of the stream, thereby causing aquatic species kills and other undesirable effects.
3. Wastewater may also contain nutrients, which can stimulate the growth of aquatic plants and algal blooms, thus leading to eutrophication of the lakes and streams.
4. Untreated wastewater usually contains numerous pathogenic, or disease causing microorganisms and toxic compounds, that dwell in the human intestinal tract or may be present in certain industrial waste. These may contaminate the land or the water body, where such sewage is disposed.

CONCLUSION

For the above-mentioned reasons the treatment and disposal of wastewater, is not only desirable but also necessary. Need for recycling of treated wastewater in many parts of the world has necessitated the introduction of newer stringent standards for treated wastewater. Unlike the conventional wastewater treatment plants, SBR-based wastewater treatment plants can achieve better treated water quality with no or minor modification in the installed infrastructure, only by simple alteration of the process control parameters in one or more of the phases of the treatment cycle. The SBR process offers smaller foot-print 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. Although the SBR process is well developed, and different variants are continuously evolving, there are issues that need to be addressed further.

Ensuring process reliability for simultaneous N and P removal in SBR requires further work towards clear understanding of the microbial diversity of the system with an emphasis on its dynamics under different changing process situations. The study and improved design may follow the principles of ecologically engineered processes that derive stability from the presence of multiple species that accumulate phosphorus (functional richness). This may make the system more resilient with each species showing differential sensitivity to variations in the environmental conditions such as temperature and pH swings, toxic pollutants, presence of nitrite and nitrate, prevalence of VFAs, etc.

Appropriate process control is the heart of the SBR process as it important in ensuring removal of the target contaminants from the wastewater. PLC-based pre-programmed control strategies are popular. Introduction of real-time control strategies can enable SBR process to achieve better robustness, reliability, and optimized operation. This will enhance energy efficiency and also shall help widen the areas of application of the SBR process. Future studies on SBR control strategies would include the development of intelligent control system, which is a real-time control strategy working on feedback-based control. This shall make the SBR process adaptive to changing environmental conditions and to varying wastewater quality so that optimum effluent quality is maintained with high degree of reliability.

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