Sequence Batch Reactor – A New Technology in Waste Water Treatment

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Abstract: A new emerging biological technology for waste water treatment, Sequence Batch Reactor (SBR) is discussed. General description of expected installation of reactor is given. The proposed results from different applications when used for domestic waste water will be discussed. Sequence Batch Reactor (SBR) technology presents some different operational advantages, compared to other conventional biological treatments. Different applications of this technology for small plants were studied, considering main investment and operating costs. Conditions which was studied, included BOD, COD, TSS removal, and nutrients removal, with suitable treatments process. SBR reactors treat waste water such as sewage or output from anaerobic digesters or mechanical biological treatment facilities in batches. Air is bubbled through the waste water to reduce biochemical oxygen demand (BOD) and chemical oxygen demand (COD) to make suitable for discharge into sewers or for use on land. In conclusion, the results can indicate that SBR possess great potential to be used for nutrients removal from wastewater. This study can be helpful to check possibility that the Sequence Batch Reactor (SBR) process may be used as an ideal and efficient option for the total nutrient removal from municipal wastewater.

Keywords: Waste water, Sequence Batch Reactor (SBR), Nutrient removal, Sewage, Treatment.

1. INTRODUCTION

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 [1]. 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 favourable biological conditions inputs in to the reactors should be controlled [3, 5]. SBRs are considered suitable system for small communities **(Irvine et al 1989)** but are relative new technology for agricultural application. Previous research on SBR for animals waste was primarily concentrated on swine wastewater treatment **(Li and Zhang, 2002)**

2. PROCESS CYCLE

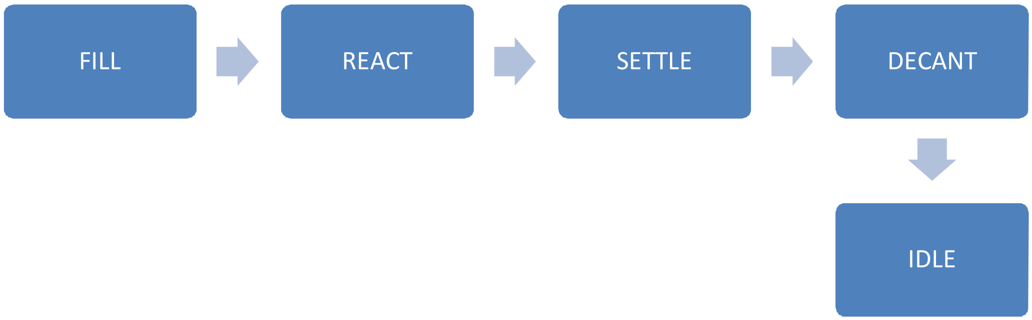

Figure 1: Process Cycle of SBR

2.1 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 favourable environment to procreation of microorganisms with good settling characteristics.

2.2 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.

2.3 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.

2.4 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.

2.5 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.

3. REMOVALS OF CONSTITUENTS

The addition of oxygen to the liquor supports the growth of aerobic bacteria and they consume the nutrients and supports nitrification process [4]. To remove phosphorus compounds from the liquor, aluminium sulphate (alum) is often added during this period. It reacts to form non-soluble compounds, which settle into the sludge in the next stage [2]. During this stage the sludge formed by the bacteria is allowed to settle to the bottom of the tank. The aerobic bacteria continue to work 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 [5]. Many of these and some of the bacteria's 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, di nitrogen gas, this is known as de nitrification[5]. 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 [2]. The decanting stage most commonly involves the slow lowering of a scoop or "trough" into the basin. This has a piped connection to a lagoon where the final effluent is stored for disposal to a wetland, tree growing lot, ocean outfall, or to be further treated for use on parks, golf courses etc.

4. REVIEWS OF RELATED ARTICLES

Table 1: Summery of previous studies [2]

SN	Wastewater	Study details	Results	References
1	Municipal wastewater	Chemical coagulation and SBR methods	Chemical coagulants alone remove COD and colour to 75 & 80%. Final effluent can be use in irrigation safely. Turbidity also reduce	Lin et al (2004)
2	Municipal/Ind	Study of SBR+	Neither E-coli nor faecal coli	Arrojo et al

	ustrial	membrane technology	forms are found. Removal efficiency of bacteria and SS found 100%.	(2005)
3	Dairy wastewater	SBR + membrane coupled.	Removal efficiencies of COD, BOD, Total Kjeldahl nitrogen and oil and grease are 89.3, 83, 59.4 and 82.4% respectively.	Sirianuntapiboon et al (2005)
4	Dairy wastewater	using aerobic granular sludge	Under different operational conditions average nitrification rates up to 5 gNH/(m^3*h) and de-nitrification rates up to 3.7 gNO/(m3*h) were achieved	Wichern .M et al (2008)
5	Pulp and paper mill wastewater	Performance of column type SBR to cheque biodegradability.	COD removal efficiency 87% is achieved, pH alkalinity are in permissible limits. Turbidity removal efficiency 95%.	Farooqi Haq Izharul et al (2011)
6	The swine wastewater	The reactor body was fabricated using a plexi glass cylinder and its total volume was 20L with 15L of working volume. The cycles of the SBR system were controlled by a designed on-site computer and custom software.	removal efficiencies of 61.0%, 31.2% and 54.5% for TN, NH3-N and NO_3--N and 61.4%, 62.8%, 77.6% and 73.2% could be obtained for TS, TVS, TSS and TVSS.	Park Keum. J et al (2011)
7	Municipal / Industrial	Use based on experimental results	MLSS concentration maintained at 5000mg/l,removal percentage was increased with initial concentration	Subbaramaiah and Mall (2012)
8	Domestic wastewater	Study of performance evaluation and	The removal efficiency of COD in the suspended	Pradyut Kundu, et al

		biodegradable kinetics	growth reactor system depends on COD : TKN ratio and obtained COD removal is less than 96% max	(2013)
9	Domestic sewage	Performance evaluation of STP	96 %. BOD removal, 92.74 % TSS removal, 75.67 % and 71.79 % TN and TP removal respectively.	Wakode N.Prachi (2014)
10	Municipal wastewater	Aerobic Sludge Granulation in a Full-Scale Sequencing Batch Reactor	Aerobic granulation was achieved in a 50,000 m3 d–1 SBR treating a town's wastewater. Bacterial species were distinct in sludge. Raw wastewater composition and SBR operating mode are key factors.	Li Jun et al (2014)

5. ADVANTAGES AND DISADVANTAGES:

5.1 Advantages

Equalization, primary clarification (in most cases), biological treatment, and secondary clarification can be achieved in a single reactor vessel.

- Operating flexibility and control.
- Minimal footprint.
- Potential capital cost savings by eliminating clarifiers and other equipment.

5.2 Disadvantages:

- 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 th aeration system used by the manufacturer.
- Potential requirement for equalization after the SBR, depending on the downstream processes**.**

6. EXPECTED RESULTS

Results obtained from SBR plants in respect of wastewater treatment of pollutants are depends on some factors like organic loading rate, hydraulic retention time (HRT), solids retention time (SRT), DO and influent characteristics such as BOD, COD, solid contents and C/N ratio. Depending controlling of these parameters, SBR can be designed to function, carbon oxidation, and nitrification, de-nitrification and phosphorous removal process **(Hisset et al 1982; Hanaki et al 1990).** Based on the previous research on SBR for wastewater treatment, some expected results are summarised below in table 2

Table 2 Parameters and their expected removal efficiencies & values [Riff: CPCB 2012 and USEPA 1992]

SN.	Parameters	Removal Efficiency	Expected Value
1	BOD	89-98%	<10mg/l
2	TSS	85-97%	<10mg/l
3	Nitrification	91-97%	
4	Total Nitrogen (TN)	>75%	<5-8mg/l
5	Biological Phosphorous	57-69%	<1-2mg/l
6	Suspended Solids (SS)		<5 mg/l
7	Total Cali forms (MPN/100 ml)		<10

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