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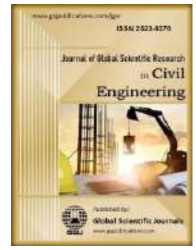

A Laboratory Investigation to Remove the Responsible of Eutrophication Phenomenon in Surface Water

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ABSTRACT

Eutrophication is a natural process that results from accumulation of nutrients such as (Nitrogen and phosphate compounds) in surface water. It is seen as an ecological problem that has a negative impact on both the aquatic ecosystem and the supply of potable water that humans depend on to survive continuously on Earth. The work was done to design and build a scale plant using a sequencing batch reactor (SBR) as part of the wastewater treatment process. AL-Muthanna wastewater treatment plant inlet samples were used to operate the scale plant. The experimental study consisted of 20 practical experiments with aerobic and anoxic conditions and different operational times ranging from 6-15 hours and over 3 months. The results showed that the removal efficiency of phosphate depends on the succession of anoxic and aerobic conditions, where the highest removal was found (99.9%) when the aerobic and anoxic conditions were equal. In contrast, nitrate removal effectiveness with time cycles of six and fifteen hours was 97.5%. It makes sense that a longer anoxic period (AN) throughout the fill and react cycle phases would result in a higher nitrate removal efficiency.

1. Introduction

Every community produces garbage, both liquid and solid, as well as air pollution. After being used for a variety of purposes, wastewater, also known as liquid waste, serves as the community's water supply. Wastewater is defined as a mixture of liquid or water-carried wastes removed from residences, places of business, and institutions, as well as any surface water, groundwater, and rainwater that may be present while taking into account the sources of generation. The progressively declining quality of the drinking water is becoming more and more obvious every day. Thus, the need to safeguard surface water from pollution has grown critical [1-3].

An increase in nutrient intake to surface waters to the point of over-enrichment, together with a matching rise in primary productivity and associated adverse impacts, is known as eutrophication [4]. As is widely known,

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eutrophication is a serious environmental issue primarily brought on by humans, or endogenous [5]. Starting with water as a material and molecule, the process of nutrient transport is examined, along with how it moves across the terrain to reach aquatic systems. There are two main nutritional cycles: nitrogen (N) and phosphorus (P). The Sequencing Batch Reactor (SBR) The concept of using batch reactors for sewage treatment was developed. According to this theory, following the reaction, the activated sludge settles, the effluent is removed, and fresh influent is introduced [6]. A cycle is the interval of time between two successive influent additions. One or more tanks can make up an SBR system. In the biological waste treatment system, there are five basic operating times for each tank. In chronological order, these phases are fill, respond, settle, draw, and idle. (Table 1) [7-9]

Table 1: The Sequencing Batch Reactor (SBR) phases

Phase	Explanation
Fill	In the fill phase, influent wastewater is introduced into the basin. The activated sludge's microorganisms receive food from the influent, which fosters the environment necessary for biochemical reactions. The three distinct scenarios can be produced by adjusting the mixing and aeration during the fill phase. Aerated, Mixed, and Static Fill.
React	The mechanical mixing and aeration machines are operating throughout this period, and no effluent is allowed to enter the basin. The rate of organic elimination rises significantly since there are no more volumetric and organic loadings. In the react phase, the majority of the carbonaceous BOD removal and further nitrification takes place. During the react phase, some more phosphorus in addition to that produced during mixed fill is absorbed.
Settle	Activated sludge is allowed to settle in a quiescent state throughout this phase. There's no aeration, no mixing, and no flow into the basin.
Draw	The clear supernatant effluent is removed in this phase using a decanter. Clear supernatant is released as effluent when the settle phase is over, and the decanter receives a signal to open an effluent-discharge valve.
Idle	This stage takes place in between the subsequent cycle's decant and fill phases. The operation strategy and influent flow rate determine the idle time. In this stage, the cycle's excess sludge, or concentrated solids, is pumped out of the SBR basin's bottom for additional processing and disposal.

2. Materials and Methods

2.1. Materials

Table 2 contains a list of the materials used in this work. The major sedimentation tank and SBR tank of a scale plant served as the venue for the experimental tests. The SBR tank includes two openings: one at the bottom for clearing out excess sludge, and another around 20 cm up from the bottom for releasing the liquid supernatant and removing samples for testing. A tube that runs the entire length of the SBR basin is where the ventilation unit stops.. The tube contains small openings in it that allow small bubbles to enter the basin, providing oxygen to the microbes in the phase of aerobic respiration. At the end of the mixing unit is a mechanical impeller. This impeller was made to run at the lowest possible speed. This minimum speed was required to achieve biological treatment by keeping the activated sludge suspended in all sections of the effluent.

Table 2: The materials that utilized of carried out this work.

Materials of scale plant and apparatus	**Information**
primary sedimentation tank (equalization process),	30cm length, 30cm width and 60cm height represents the source of untreated wastewater
SBR tank (fill, react, settle, draw, and idle processes)	20cm length, 20cm width, 40cm height. The effective depth of SBR tank was 35cm
ventilation unit	an air compressor and air pressure control meter where the required pressure was 0.2 MPa
mixing unit	a source of alternating current and a regulator of the voltage and electrical resistance
Laboratory materials and apparatus	**Information**
spectrophotometer	measuring (PO_4^{-1}) and (NO_3^{-1}), mg/L

2.2. Methods

Sludge from the Almuthanna wastewater treatment plant was used for the experiments. It reached a concentration of around 3895 mg/l, which fell between 2000 and 4000 mg/l [10]. As part of the development mechanism, wastewater from the original sewage treatment facility was periodically added to the sludge in the SBR basin, which was subjected to a sequence of aerobic-anaerobic conditions. Throughout a month, this process was continuing. Following that, raw wastewater samples were brought in every day for SBR to treat under various conditions and at different times. Table 3 contains a list of these samples' characteristics. Both raw and processed samples were treated with preservatives such chloroform and kept at 4°C as needed. Every parameter was measured in accordance with the specifications and directives offered in the AWWA, WPCF, and APHA tests and procedures[11].

Table 3: The characteristics of samples

Parameter	**Unit**	**Range**	**Average**
Potential of Hydrogen (PH)	-----	8.45-8.65	8.55
Electrical Conductivity(EC)	µs/cm	2212-2500	2356
Total Dissolved Solid (TDS)	mg/l	1073-2141	1607
Dissolved Oxygen (DO)	mg/l	2.62-3.50	3.06
Chemical Oxygen Demand(COD)	mg/l	150-450	300
Biological Oxygen Demand (BOD_5)	mg/l	170-227	199

The system was run in three cycles of six, eight, and twelve hours at laboratory temperature (16–25) ◦C. As shown in Fig.1, each of the five stages represented a set percentage of the cycle's overall duration.

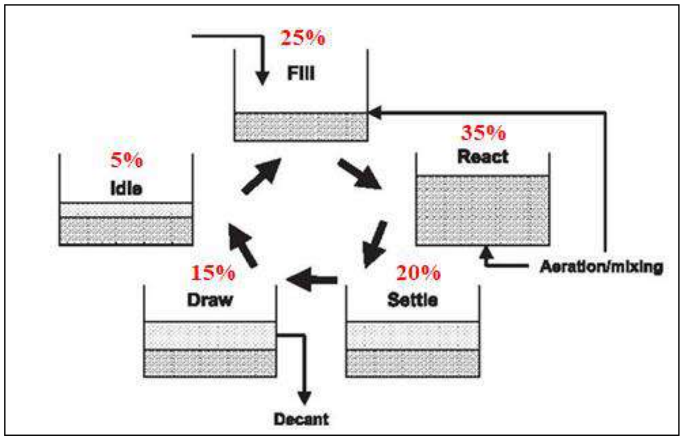

Fig.1: Phases Percentages of SBR [12].

3. Results and Discussion

3.1. Phosphate (PO_4^{-1}) Removal Efficiency

Microorganisms require approximately 50% of organic carbon and 15% of nitrogen for growth, whereas they only require 3% of phosphorus [13]. The process known as "luxury uptake" refers to the biological removal of phosphorus from bacterial cells by causing the microorganisms to collect more phosphorus than is needed for internal storage after it is absorbed through the outer wall. Acinetobacter was removing phosphorus; in the absence of nitrates and dissolved oxygen, it spread in aerobic and anoxic environments. Using the SBR, the biological removal of phosphorus was developed. The working conditions of the system, which include both aerobic and anaerobic conditions, have made the biological removal of phosphorus easier. Phosphates were released back into the wastewater as a result of excessive mixing and aeration [14].

When microorganisms consume more phosphorus than they require for sustenance, they store it in the cell as polyphosphate and are eventually eliminated from the treatment system when the sludge becomes rich in phosphorus. The operating cycles, which ran for 9, 10, and 6 hours, respectively, are depicted in Figs. 2, 3, and 4. As aerobic and anoxic conditions alternated during cycle phases, the concentration of PO4-1 dropped (Fig. 2). Figure 3 shows that there was a rise in PO4-1 concentration when there was no succession in aerobic (A) and anoxic (AN) conditions. Figure 5 illustrates the rise in PO4-1 concentration that occurred when there was no succession under aerobic (A) and anoxic (AN) conditions.

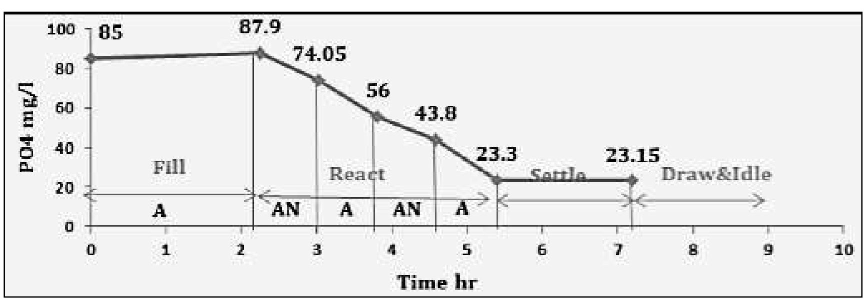

Fig.2: PO_4^{-1} Concentration at Cycle with Time 9hrs.

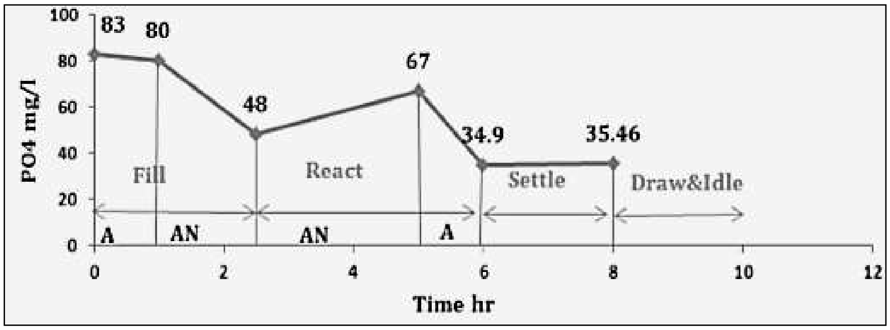

Fig.3: PO_4^{-1} Concentration at Cycle with Time 10hrs.

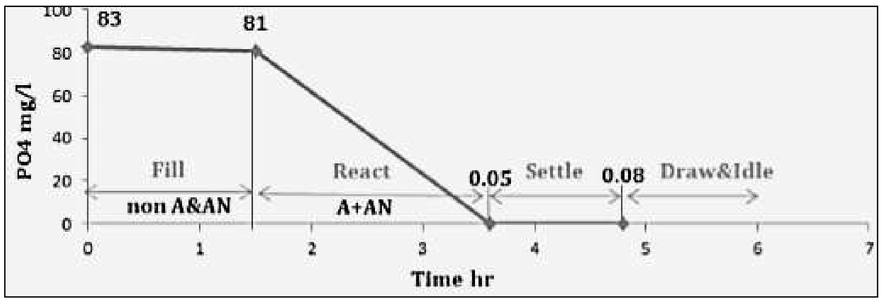

Fig.4: PO_4^{-1} Concentration at Cycle with Time 6hrs.

At the end of the react phase, when the aerobic (A) and anoxic (AN) conditions were equal, the minimum concentration of PO_4^{-1} was (0.05) mg/l, as indicated in Table 4.

Table 4: Removal Efficiency of PO_4^{-1} at Cycles with time.

Period	Aerobic (hr.)	Anaerobic (hr.)	Removal Efficiency (R.E%)
(6 hr.)	1.55	2.05	54.4
	2.1	2.1	99.9

3.2. Nitrate (NO_3^{-1}) Removal Efficiency

Nitrification and denitrification are two of the processes involved in the two-stage biological elimination of nitrogen compounds. Nitrosomonas bacteria carry out the aerobic nitrification process by converting ammonia to nitrite, whereas Pseudomonas bacteria, which mediate the denitrification process and require anoxic conditions, derive their energy from the organic component of wastewater. At the point in this process where the dissolved oxygen equals zero, nitrate is transformed into nitrogen gas [15, 16].

The cycles that ran for six and fifteen hours, respectively, are shown in Figs. 6 and 7. It is clear from these that In anoxic circumstances, the nitrate concentration decreases (AN). The process of denitrification is to blame for this, which occurs when anoxic circumstances cause nitrate to be transformed to nitrogen gas. At the end of the fill phase in the cycle with six hours, the nitrate concentration was 8.4 mg/l following 1.5 hours of anoxic conditions; at the end of the cycle with fifteen hours, the nitrate concentration was 2.89 mg/l following three and a half hours of anoxic conditions during the fill phase. The nitrate effluent concentrations at the end of cycles, when the influent value was on average 100 mg/l for 6 and 15 hours, respectively, were 11.22 and 2.5 mg/l.

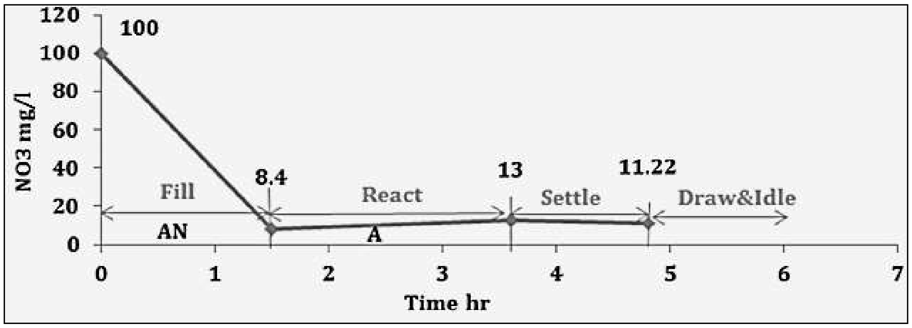

Fig. 5: NO_3^{-1} Concentration at Cycle with 6hrs.

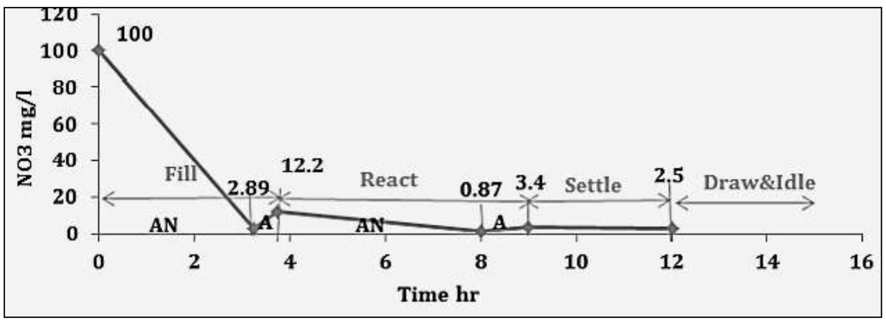

Fig. 6: NO_3^{-1} Concentration at Cycle with 15hr.

Table 5 depicts the nitrate removal efficiency calculated for cycles of six and fifteen hours, respectively. It is possible to explain why there was an increase in nitrate removal efficiency throughout the fill and react cycle phases when anoxic time (AN) increased.

Table 5: Removal Efficiency of NO_3^{-1} at Cycles with time.

	Aerobic (hr.)	**Anoxic (hr.)**	**Removal Efficiency (R.E%)**
Period (6 hr.)	2.1	1.5	88.8
	2.05	1.55	90.6
	1.55	2.05	94
Period (15 hr.)	6	3	89.8
	3.6	5.4	96
	1.5	7.5	97.5

4. Conclusion

The extensive loss of water quality linked to nutrient enrichment has made eutrophication a severe hazard to fisheries, recreational water bodies, and supplies of potable drinking water. The work encompasses the final thoughts, derived from the analysis of the SBR.. The results show that the removal efficiency of nitrate (NO3-1) was increased due to the conversion of nitrate to nitrogen gas under anoxic circumstances (maximum 97.5%) under anoxic conditions, whereas it was decreased under aerobic conditions because Nitrosomonas and Nitrobacteria bacteria converted ammonia to nitrate. During the cycle's phases, a series of aerobic and anoxic conditions improved the phosphate (PO4-1) removal efficiency. When aerobic and anoxic conditions were equal, the maximum removal efficiency of (PO4-1) was 99.9% since too much mixing and aeration caused phosphates to be released back into the effluent.

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