SYSTEM OPTIMIZATION OF SEQUENCING BATCH REACTOR USING MUNICIPAL AND SYNTHETIC WASTEWATER

A

THESIS

Submitted in partial fulfilment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialisation in

ENVIRONMENTAL ENGINEERING

Under the supervision

of

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by

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HIMACHAL PRADESH, INDIA

May – 2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the project report entitled **"System Optimization of Sequencing Batch Reactor Using Municipal and Synthetic Wastewater"** submitted for partial fulfilment of the requirements for the degree of Master of Technology in civil engineering with specialisation in Environmental Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Mr Anirban Dhulia (Assistant Professor)**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Signature of Student

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May-2019

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"System Optimization of Sequencing Batch Reactor using Municipal and Synthetic Wastewater"** in partial fulfilment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialisation in Environmental Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Vishv Kumar (172752)** during a period from August, 2018 to May, 2019 under the supervision of **Mr Anirban Dhulia (Assistant Professor)** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat. The above statement is correct to the best of our knowledge.

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LIST OF ABBREVATIONS

BOD: Biochemical Oxygen Demand

COD: Chemical Oxygen Demand

NH_3N: Ammonia Nitrogen

SBR: Sequencing Batch Reactor

TSS: Total Suspended Solids

TDS: Total Dissolved Solids

MTBE: Methyl Tertiary Butyl Ether

SRT: Sludge Retention Time

TN: Total Nitrogen

TP: Total Phosphorous

AGS: Aerobic Granular Sludge

ASP: Activated Sludge Process

TS: Total Solids

DO: Dissolved Solids

ABSTRACT

Effective management of the water resources and control of its pollution are becoming increasingly more important for healthy environment. Because of the industrialization, urbanization water sources are dirtied to much an extent. Natural form of pollutants have always been present in the surface water bodies. But as the civilization evolved through, human activity levelled up the amount and changed the nature of pollutant entering the watercourses.

Sequencing batch reactor is a type of batch reactor with complete mixing and works on the principal of fill and draw basis. It has 4 basic cycles which goes on sequence wise i.e. fill, react, settle, decant. SBRs are the upgraded version of the conventional activated sludge process as it requires less space and is cost effective. In SBR equalisation, clarification and aeration is done in single basin and gives better efficiency than the conventional process. In SBR the returned activated sludge is not required as it contains sludge in the single basin.

In the present study we used laboratory scale SBR treating domestic and synthetic wastewater. The reactor was fabricated using transparent acrylic sheet. Height of the reactor is 21 cm and internal diameter is 19 cm in which the working height is 11 cm and 5 cm is for freeboard and 5 cm from the bottom for sludge. In the first phase of the study synthetic wastewater was used and was run for different cycle time i.e. (6h, 8h, and 12h). Different parameters were studied like COD & TDS with their maximum removal efficiency observed was 86.6 %, 88%, 90% & 82 %, 84%, 88%. Similarly for domestic wastewater the maximum removal efficiency for COD &BOD (4h, 6h &8h) was 84%, 87.2%, 90.7% & 87%, 90%, 93% respectively. Removal efficiencies for various parameters like TSS, TDS, TS, DO were also studied for both domestic & synthetic and we obtained justified efficiencies for both the wastewaters.

Keywords: sequencing batch reactor, equalisation, activated sludge.

CHAPTER 1

INTRODUCTION

From the mid 1970 to around 1980, wastewater treatment were depended principally on aesthetics and environmental concerns. That time priority was to decrease the concentrations of Bio-chemical Oxygen Demand (BOD), Total Suspended Solids (TSS) and pathogenic microorganisms forms contained however at more elevated levels. The removal of nutrients like nitrogen and phosphorous likewise started to be tended to, especially in a portion of the inland streams and lakes, and estuaries and bays. At the point when untreated wastewater was accumulated, permitted to go septic, deterioration of the organic matter that it contains will provoke annoyance conditions which incorporates the creation of gases. Besides, the untreated wastewater usually contain some of pathogenic microorganisms that sustains in the human intestinal tract. Wastewater furthermore contain nutrients which can hinder the growth of aquatic plants. Accordingly, annoyance free removal of the wastewater from its generation, trailed by suitable treatment is required. To ensure general wellbeing and condition, it is important to know about constituents (for example Contaminants or pollutants) of concern in wastewater, effect of these constituents when wastewater is discharged into the environment. Wastewater collected from the municipality and communities should at last be returned back to receiving water or to the land. The combined wastes from houses, commercial areas, industries and institutions, that might be present is known as wastewater. Its association with various types of sewage terms are used residential sewage (sanitary sewage), combined sewage, raw sewage, dilute sewage, fresh sewage and septic sewage. The treatment is done by four simple techniques i.e. biological treatment; chemical treatment; physical treatment methods, involved utilization of tanks and different structures intended to contain and to control flow of wastewater to enhance the removal of pollutants, and mechanical treatment methods, include the utilization of machineries which can be simple and complex in design and in operation. The biological treatment systems incorporates the activity of microbes and other microorganisms, which helps in removal of pollutants. Treatment techniques involved in chemical systems enhance the productivity of other processes and provides specialized treatment because of adding of chemicals at different treatment stages. The need of the sewage treatment before its discharge, emerges due to the putrescible matter in the sewage. The organic matter experiences decay because of bacteria and it is this deterioration that causes disturbance and troubles. A sequencing batch reactor (SBR) is a secondary wastewater treatment process that works on fill and draw mechanism. SBR system, that incorporate bacteria for the treatment of wastewater that is called as biological methods of treatment. Sequencing batch reactor follows a collective steps as it collects wastewater. The SBR performs equalization, sedimentation and aeration in a single batch reactor. The activated sludge process used for the wastewater treatment was first introduced as a batch reactor, but due to problems like blockage of diffusers then it was changed to continuous flow reactor. SBRs have increased fame for treatment of wastewater because of its systematic advancement, making it more effective than the conventional activated sludge systems. In SBR systems it is easy to upsurge the efficiency by changing the process parameters like dissolved oxygen and its cycle time etc.

1.1 OBJECTIVES

1. To study SBR performance for biochemical oxygen demand and chemical oxygen demand removal by varying its cycle time.

2. To examine the effect of the organic loading on removal efficiency of operational parameters.

3. To analyse the optimum operating conditions and to apply them for treatment of municipal wastewater.

CHAPTER 2

LITERATURE REVIEW

2.1 CHARACTERISTICS OF SEQUENCING BATCH REACTOR

SBRs are being used globally and have been around since last 10 decades. With their growing popularity they are successfully treating municipal and industrial wastewater, especially in the regions where the flow patterns are not variable. Municipalities, resorts, and various enterprises, including dairy, pulp, and textile are utilizing SBRs as wastewater treatment options. Upgrades in the equipment's and innovation of the SBR, particularly in the aeration devices and gadget control frameworks a possible decision over the conventional activated sludge systems. In regions where there is a constrained amount of space, treatment is done in single basin rather than the use multiple basins, taking into account a small footprint. The cycle time can be manually changed in accordance with aerobic, anaerobic conditions so as to accomplish biological nutrient removal with nitrification, de-nitrification, and phosphorus expulsion. Nitrogen limit of under 4 mg/L can be accomplished by aerobically converting ammonia to nitrates and anoxic transformation of the nitrates to gas (de-nitrification) inside a similar reactor. Effluent discharge limits are becoming more firm and SBR offer the cost-effective approach to obtain low effluent limits. In addition to that discharge limits which requires the higher level of treatment may require the addition of some tertiary filtration preceding the SBR treatment and it should be considered as a significant part of the design parameters.

2.2 SEQUENCING BATCH REACTOR

Primarily the SBR framework is a typical arrangement of tanks, that works on fill and draw mechanism. SBR basins are filled during the predetermined period and then operated as batch-reactor. After getting the treatment, the mixed liquor solids is permitted to settle and after that supernatant is formed and is drawn out from the basin. The basic and most important difference c between the sequencing batch reactor and ASP i.e. conventional activated sludge process is that each sequencing batch reactor does capacities, for example, equalisation, air circulation, and sedimentation in a single basin. In general, SBR systems requires relatively small areas as they are very useful where the land availability is less. They are also very useful in treating wastewater where the flow conditions are low/intermittent. The treatment cycles can also be adjusted to go anoxic, aerobic and anaerobic in order to successfully achieve nutrient removal.

Fill: In this Sludge and substrate (raw wastewater) is filled in the reactor. The fill procedure commonly permits the fluid level in reactor rises running from 75 % ability to 100 %. During the fill, it might be only mixed or mixed and given aeration to promote biological reactions with the substrate. Under the static-fill no mixing or aeration takes place while the influent is entering in the system. At the point when the mixing and aerators stay off, this situation has an energy saving condition. Under the mixed fill situation, mechanical mixing is active, yet the air circulation is off. The mixing activity creates a suspension of influent wastewater and biomass. The anaerobic conditions likewise can be accomplished during the mixed fill stage.

React: During this stage, the biomass use up the substrate under controlled environmental conditions. This stage takes into account the further decrease of effluent parameters. In this stage, no raw water enters into the reactor while the mixing and aeration system is on. By far most of BOD removal takes place in the react phase. Nitrification occurs by enabling the mixing and air flow to continue with the large parts of de-nitrification occurs in the mixed fill stage.

Settle: In this stage, activated sludge is permitted to settle under no flow (quiescent condition) and no air circulation and mixing happens. Activated sludge settles and makes a particular interface with the treated wastewater. This stage is very critical part of cycle, assuming the solid don't settle quickly, if some sludge is drawn out it can degrade the quality of effluent.

Decant/Draw: In this clear supernatant (treated wastewater) is drawn out of the reactor.

Idle: This is mostly the time between the cycles which is utilized by the SBR for next cycle. Amid this stage, small amount of the activated sludge in the base of the reactor is drawn out which is also known as sludge wasting as shown in (fig 2.1).

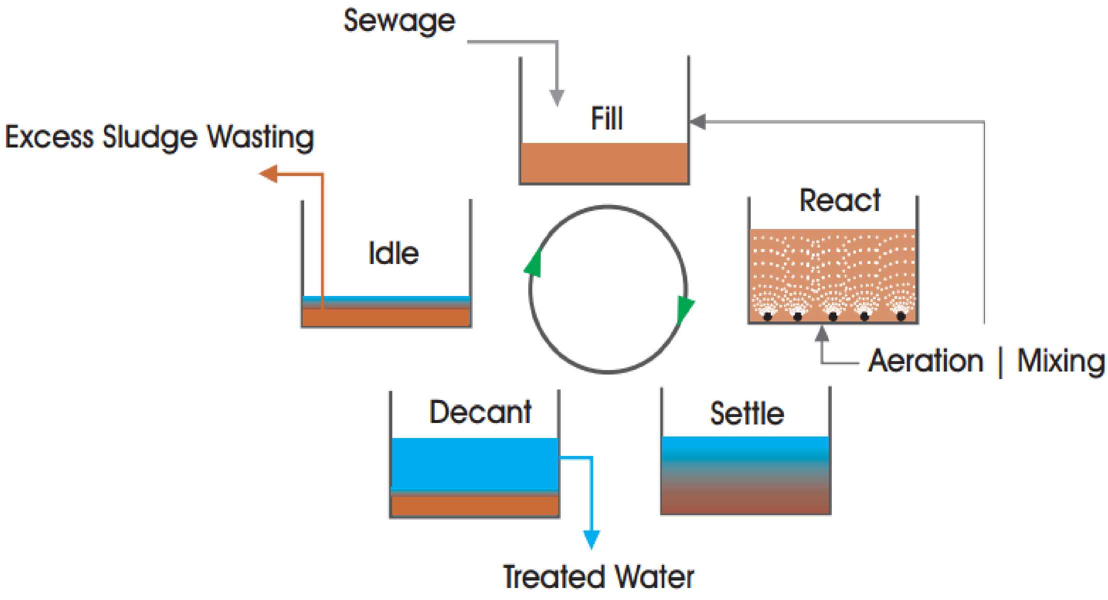

Figure 2.1 Schematic diagram of SBR operations

2.3 BACTERIAL GROWTH PATTERNS IN BATCH REACTOR

Bacteria itself replicates by binary fission, either sexual mode or by budding. A few species categories take even under 20 minutes while others may take days to grow. The growth pattern of microscopic organisms in batch reactor is described by the four particular development stages (fig 2.2).

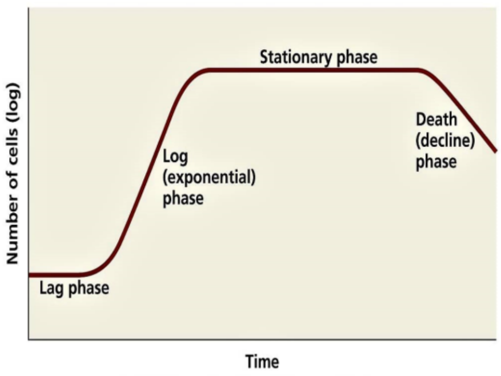

Figure 2.2 Bacterial growth curve

- The Lag Phase: By adding of the biomass, this represents to the time requirement by the organisms to adjust to new condition before the biomass generation and cell division occurs.

- The Exponential Growth Phase: During this bacterial cells increase takes place at the most extreme rate, as there is no restriction because of substrates. The biomass growth curves increases during this time.
- The Stationary Phase: In this the concentration of biomass remains stable with respect to time and the rate of progression decreases by the inactivity of cells.
- The Death (decline) Phase: In this phase, the substrate is being removed. An exponential decrease in the biomass is often observed.

2.4 BIOLOGICAL NITRIFICATION MECHANISM

Nitrification is an important component of biological degradation which generally starts taking place after the complete degradation of carbonaceous BOD (CBOD). The equation that the two forms is purely pH dependent and shown with the help of the following equation:

$NH_3 + H_2O \rightarrow NH_3^+ + OH$ (1)

The principal organisms related with nitrification forms of the bacteria Nitrosomonas and Nitrobacter. These are likely to be autotrophs and get vitality for development from oxidation of the inorganic nitrogen and carbon. Different types of metals and some of the organic compounds have been found to hinder growth of nitrifiers. Nitrobacter is constrained to oxidation of the nitrite to nitrate nitrogen. The oxidation of the NH_3-N to NO_2-N occurs in two steps and is represented by following:

$NH_4^+ + 1.50_2 \rightarrow 2H^+ + H_2O + NO_2$ (Nitrosomonas Bacteria) (2)

$NO_2^+ + 0.5\ 0_2 \rightarrow NO_2$ (Nitrobacter Bacteria) (3)

The final reaction is represented by adding Equations (2) & (3) we get

$NH_4^+ + 20_2 + NO_3^- + 2H^+ + H_2\ O$ (4)

2.5 BIOLOGICAL DE-NITRIFICATION REMOVAL

De-nitrification is microbial encouraged process where the nitrates are reduced and creates a nitrogen through a progression of intermediate gases and nitrogen oxide. The Facultative anaerobic microbes perform the de-nitrification process as some kind of the respiration that reduces the oxidized nitrogen because of the oxidation of electron donor. For the reduction to happen the DO level must be almost zero and the carbon supply must be promptly accessible to the microorganisms.

2.6 FACTORS AFFECTING SBR PERFORMANCE.

- pH: The results demonstrated that high pH improves the removal rate of ammonia nitrogen and shows decrease in the chemical oxygen demand value. When the influent pH was around 8.5 to 9.0, the removal efficiency of ammonia nitrogen was 90%, and the decrease in the COD value from its original value was 80%. Exactly when influent pH went from 6.5 to 8.5, the concentration of sludge from 2,351 to 3,997 mg/L in the reactor, and activities of Ammonium oxidizing bacteria and Nitrite oxidizing bacteria first increased and then suddenly decreased [1].
- Temperature: Progression of bacteria depends on temperature and very low temperature will diminish and decline the removal efficiency of SBR. The sludge settlement turned out to be worse when the temperature decreases. Autotrophic bacteria development rely on temperature and high temperature will lead to fast growth and low will prompt slower growth. In this study it was stated that the potential in accomplishing nitrogen removal from tannery effluent, a strong wastewater in terms of its high nitrogen content. SBR operation were studied with two cycles a day, secures an effective effluent of nitrate concentration of 11–14 mg/l and NH_3-N concentrations below 4 mg/l, at temperatures above 20°C [2].
- Dissolved oxygen: It is the most significant factor in the functioning of SBR bacteria. It consumes DO for the removal of bacteria present and likewise DO is significant in the nitrification procedure. DO is controlled and provided by the aeration devices. In this they studied two sequencing batch reactors with changing the DO levels in it. [3].
- Cycle time: The cycle for SBR is divided into five periods: fill, react, settle, draw and idle. They vary accordingly to their aeration and mixing procedures. The removal efficiencies can be increased by changing the time intervals of different phases in total cycle time, because of the availability of good amount of DO for autotrophs to remove nitrogen. [4].
- Sludge Retention time: Effects of SRT on the COD, nitrogen and phosphate evacuation were contemplated and the perfect sludge age was bringing about extraordinary removal was examined. The most elevated COD (90.22%), NH_4– N (87.26%) and PO_4– P (69.55%) expulsion efficiencies were obtained at the sludge age of 12 days, regardless

of the way that a sludge age of 16 days demonstrated lower esteems. Sludge age more unmistakable than 19 days accomplished lower efficiencies diverged from those at 11 or 16 days of sludge age. [5].

2.7 STUDIES RELATED TO SBR

Several types of study were conducted on the SBR technology treating different types of wastewater, and was efficient than the conventional activated sludge process. Different results were given by the researchers worldwide regarding the SBR technology which is discussed in detail below:-

[Mohan et al. (2016)] In this SBR was studied for the activated granular sludge capable for de-nitrification of high quality nitrates. Accumulation of huge amount of the nitrite was seen by incomplete de-nitrification once the SBR was feed with 5425 mg/ L with C/N proportion of 2. The outcomes demonstrate that substrate fixation plays very important role in de-nitrification of high quality nitrate by affecting nitrite accumulation. [Popple et al. (2016)] This investigation gives an account of the improvement of a research facility apparatus to recreate a SBR. The apparatus was utilized to research the radio-labelled propranolol. SBR with working volume 5 litres was operated on an 8 hours cycle along with sewage. Propranolol was dosed with single and continuous replacements were made with more than 12 SBR cycles. During constant dosing, 62 % to 73 % of propranolol was removed in the reactor, however under 4% of portion recuperated as 14 CO2, proposing that biodegradation was minor procedure and that adsorbed onto solids, offering ascend to collections inside biomass with the 17 days solids retention time in the SBR. [Bakare et al. (2017)] In this they study two lab-scale aerobic sequencing batch reactor which worked under constant low air circulation and cyclic air circulation for the treatment of wastewater from bottling work. Constant low air dissemination plot was relied upon to choose its effect on the execution of the reactor with natural evacuation with typical cyclic air flow reactor for natural expulsion. The execution of the two research scale reactor was chosen the extent that evacuation of synthetic oxygen request and bio substance oxygen request. These two principle parameters were picked since they are essential toxins and natural parts in refinery wastewater. The exploratory results demonstrated that diminishes in substance oxygen request and bio concoction oxygen request in wastewater produced from the packaging works can be successfully practiced using both air circulation structures. Regardless, the treatment efficiencies to the extent the expulsion of substance oxygen request was dependably kept up more than 91 % and for bio synthetic interest it apparently was more than 83 % with the reactor which worked under the consistent low air circulation performing fundamentally superior to the reactor which worked under the cyclic air circulation scheme. [Trelles et al. (2017)] In this, jar settling tests were done in a 1 L cylindrical tube. A basic technique predictable in getting settling velocities as a component of the sludge blanket produced. Moreover, an increasingly broad connection between sludge volume index and the proportion was acquired. The technique yields great outcomes for the estimations of sludge volume list somewhere in the range of 30 and 240 mL/g. [Tang et al. (2018)] a novel algal-bacterial advantageous interaction collaboration structure reliant on sequencing group suspended biofilm reactor was manufactured and in the meantime better nitrogen and phosphorus expulsion from residential wastewater was accomplished. Results exhibited that the TN and TP expulsion in A-SBSBR was expanded to 69.9 % and 94.8 %, individually. The examination demonstrated that TN expulsion fundamentally occurs in the non-air circulation organize, in addition, TP evacuation happened in the A-SBSBR. Appeared differently in relation to controlled SBSBR, TN expulsion by de-nitrification and anabolism in the A-SBSBR expanded from 12.7 %, 7.7 % and 50.13 %. [Neisi et al. (2018)] the fundamental point of this study was to check the biodegradation of the Methyl Tertiary Butyl Ether using aerobic sequencing batch reactor (SBR). The reactor was built by a 3 mm thick glass chamber with inner diameter of 120 mm and height of 600 mm. SBR worked in five phases. The primary stage was filling the reactor for around 600 seconds. The second was the primary power source organize for treatment of oil wastewater for around 22 h. The third stage was the sedimentation/settlement for 60 minutes. The fourth stage was tapping from the reactor for around 10 min. The last stage included inert for around 45 min. The preliminaries demonstrated that the blended microbial mass can get high gathering of methanol 255 mg/l, additionally, convergence of MTBE up to 72 mg/l for 24 h cycle. [Pulido et al. (2018)] dairy processing produces expansive volumes of wastewater that require broad nutrient reduction before release. Huge business openings exist subsequently for cost effective bio technologies equipped for accomplishing this necessity. In this the researchers assessed the utilization of SBR as single tank bio treatment system for the maximum removal of parameters like COD, nitrogen and phosphorus from dairy industry. Varying of SBR aeration rates, (0.7, 0.5 and 0.3 L/min), affected the respective nutrient removal efficiencies. Aeration rate of 0.6 L/min was best and brought about 90 % expulsion of orthophosphates and ammonium, COD. [Abedinzadeh et al. (2018)] In this they considered, the removal efficiencies for COD of paper wastewater using

SBR in mix with the oxidation forms at the lab scale. Reaction surface strategy (RSM) was used to check the SBR method. At the perfect conditions of starting COD (1100 mg/l), MLSS (3100 mg/L) and cycle length of 24 h, 75 % of COD, 58 % of shading expulsion and 85 mL/g of SVI were seen in the pre-treatment arrange. The use of Fenton oxidation as after treatment improved COD reduction and all the while shading evacuation [Hamza et al. 2018)] IN this the reactor was studied for 100 days, isolated into two essential periods according to the OLR. In the first time span, high-impact granules were created and allowed to settle at an OLR of 10 ± 2.5 kg COD/m^3 d till 41 days. In the second time period (from 42 to day 100), the connected OLR was 27 ± 3.51 kg COD/m^3 d. The COD evacuation productivity was 98 % amid 45 days of movement. Regardless, consequent to extending the OLR, the COD evacuation effectiveness decreased certainly to 64.77 % from the 46 to 64 days. The results from this show oxygen consuming granulation can give a high-quality natural wastewater treatment innovation.

2.7 SUMMARIES RELATED TO SBR (TABLE 2.1)

Table 2.1 Summary related to SBR

Sr.	Title of paper	Name of Author	Journal	Conclusion
1.	A sequential treatment of intermediate tropical landfill leachate using a SBR and coagulation.	Zi Jun Yong, Mohammed J.K. Bashir, Choon Aun NG, Sumathi SethuPathi	Journal of Environmental Management (2018	1. In this 6 SBRs were used each separately made capacity of a 1.5 L plastic bottle bio-reactors build using polypropylene. 2. Research was done for treating COD, NH3-N, and TSS parameters utilizing SBR pursued with coagulation utilizing Alum in it. 3. The two stage sequential treatment achieved removal

				up to 80%, 90%, 87%, for COD, NH_3-N and TSS.
2.	Treatment of tapioca processing wastewater in a SBR and mechanism of granule formation and performance.	Hong Thi Bich Truong , Phuoc Van Nguye, Phuong Thi Thanh Nguyen , Ha Manh Bui	Journal of Environmental Management (2018)	1. This study was did in the cylindrical column with the working volume of 3 L. 2. Granules matured of size 2.5 mm & SVI was somewhere 50 ml/g and the removal efficiency for COD was 92 % with nitrification and denitrification occurring at the same time. 3. For the TN and ammonium nitrogen removal efficiency was 91 % and 65 % resp.
3.	Simultaneous nitrification, de-nitrification and phosphorus removal in aerobic granular sequencing batch reactors with high aeration intensity.	Qiulai He, Li Chen, Shujia Zhang, Li Wang, Jiawen Liang, Wenhao Xia, Hongyu Wang, Jinping Zhou	Bio resource Technology (2018).	1 Three aerobic granular SBRs performs nitrification, de-nitrification and phosphorus removal with different aeration times i.e. (120, 90, and 60 min). 2 Efficient reactor performance was seen for carbon and phosphorus and increased nitrogen removal was also obtained by reducing the aeration time.

4.	Selenite reduction and ammoniacal nitrogen removal in an aerobic granular sludge sequencing batch reactor	Y.V. Nancharaiah, M. Sarvajith, P.N.L. Lens	Water Research (2018)	Investigated the removal of selenium rich wastewaters by the help of formation of aerobic granules. Firstly the selenium was converted into nanoparticles which got trapped in the aerobic granules. Removal of selenium was observed up to 13 mg/L.
5.	The key role of inoculated sludge in fast start-up of sequencing batch reactor for the cultivation of aerobic granular sludge.	Wang, Xiao-chun, Zhong-lin Chen, Jing Kang, Xia Zhao, Ji-min Shen, and Liu Yang.	Journal of environmental sciences (2018)	1. In this they took two inoculation sludge one was stored with granular sludge and other was stored with activated sludge. 2. It was seen that granular sludge as inoculation sludge produces more mature granular after operating it for 22 days has more bacteria accumulation and has better efficiency then the activated sludge.
6.	Biodiesel production from microbial granules in sequencing batch reactor	Lin Liu, Yuling Hong, Xin Ye, Lili Wei, Jie| Liao, Xu Huang, Chaoxiang Liu	Bio resource Technology (2018).	1. In this production of biodiesel was obtained by the help of aerobic granules and algae-bacterial granules. 2. It was seen that variables of biodiesel decreased in methanol quantity but the change in parameters were

				not seen affecting the properties of biodiesel. The biodiesel generated was about 66 mg/g by AGS significantly higher than the AG i.e. 32 mg/g.
7.	Development of aerobic granules from slaughterhouse wastewater in treating real dyeing wastewater by Sequencing Batch Reactor	Batoul Bashiri, Narges Fallah, Babak Bonakdarpour, Shilan Elyasi	Journal of Environmental Chemical Engineering (2018)	1. Synthetically prepared sample and real wastewater was used in this study. Carbon source added was Sodium acetate. 2. Results shows that maximum chemical oxygen demand (COD) removal was up to 88 %, while the % removal of dye was 40.5 %.
8.	Efficiency of sequencing batch reactor for removal of organic matter in the effluent of petroleum Wastewater.	Abdolkazem Neisi, Shirin Afshin, Yousef Rashtbari, Ali Akbar Babaei, Yusef Omidi Khaniabadi,AnvarA sadi, Mohammad Shirmardi, Mehdi Vosoughi	Journal Data in Brief (2018)	1. To investigate the biodegradation of MTBE using the aerobic SBR at a pilot-Scale with the capacity of 6 Litres. 2. Results demonstrated that mixed microbial mass degraded the methanol to 255 mg/L and similarly for MTBE up to 7.1 mg/L for 24 hours cycle time.

9.	Influence of temperature on an Anammox sequencing batch reactor (SBR) system under lower nitrogen load.	Quan Li, Shaopo Wang, Pengda Zhang, Jingjie Yu, Chunsheng Qiu, Jianfeng Zheng	Journal of the Bio-resources Technology (2018)	1. SBR with effective volume of 14 Litres was used. 2. Under the lower temperature the nitrogen removal and the Anammox activity hindered when the temperature dropped from 32 ± 1° C to 20° C.
10.	Evaluation of colour and COD removal by Fenton from Biologically (SBR) pre-treated pulp and paper wastewater.	Abedinzadeh, N., Shariat, M., Monavari, S. M., & Pendashteh, A. (2018).	Process Safety and Environmental Protection (2018)	1. Wastewater samples were collected from Iran Paper Industry and working volume was 3.5 Litres. 2. The utilization of Fenton oxidation increased COD reduction and colour evacuation. A level of 89.5 % COD decrease and 83.5 % of colour was accomplished at pH of 3.5 when the reaction was half an hour, while a sum of 99% decrease of COD and 95% removal of colour for the combined treatment was accomplished.
11.	Improving sludge settle ability by introducing an innovative,	Alattabi, A. W., Harris, C. B., Alkhaddar, R. M., Hashim, K. S.,	Journal of water process engineering (2017)	1. Values decreased from 41 ml/g to 30 ml/g by introducing it in the SBR.

	two-stage settling sequencing batch reactor	Ortoneda-Pedrola, M., & Phipps, D.		2. Homogenous filamentous growth was seen when the operation was carried out for more than 3 months.
12.	Brewery wastewater treatment using laboratory scale aerobic sequencing batch reactor.	Bakare, K.Shabangu, and M. Chetty	Chemical Engineering journal.(2017)	1. Two SBR operated under continuous low aeration and another under cyclic aeration. Working volume was 15 L and total was 25 L. 2. It was seen that the treatment efficiency under continuous low aeration is higher and above 90% and 80% for COD and BOD as compared to cyclic aeration.
13.	Improving municipal wastewater nitrogen and phosphorous removal by feeding sludge fermentation products to SBR.	YueYuan, Jinjin Liu, Bin Ma, Ye Liu, Bo Wang, Youngzhen Peng	Bio resource Technology (2016)	1. Two SBR which were contrasted one with sludge produced by fermentation products and the other lacking the sludge. Capacity of the reactor was 11 L. 2. TN removal was 82 % with sludge fed and without fed was 55 %.
14.	Effect of the different salinity adaptation on the performance in	Yuanyuan Zhao, Hee-Deung Park Jeong-Hoon Park, Fushuang Zhang, Chen Chen	Bioresource Technology (2016)	1. Demonstrated that the sludge is very sensitive to salinity varieties as far as pollutants removal.

	a sequencing batch reactor.	Xiangkun Li,Dan Zhao Fangbo Zhao		2. At 2.2 % salinity, the framework held a better performance, and 90 % removal of COD, BOD and TP could be accomplished.
15.	Treatment of Wastewater streams from hostel by sequencing batch reactor.	Dr.G.R Munavalli, NerlekarApurva	Journal of Indian Water Works Association (2016)	1. For grey water as organic load rate increases the COD removal efficiency decreases from 49 to 31 % and BOD removal is 60 to 75%. 2. For septic tank effluent COD removal was 52 to 67% and BOD removal was 75 to 85% and on combined wastewater COD removal efficiency was 42 to 62% and for BOD was 70 to 80%.
16.	Establishment and maintenance of partial nitrification for domestic wastewater treatment in a sequencing batch reactor.	S. Dixit, S. K. Patidar	Civil Engineering Conference-Innovation for Sustainability (2016)	1. One effluent was from UASB (UP flow anaerobic sludge reactor) and other was domestic wastewater. Seed sludge was added to increase the degradation process. 2. Total nitrogen and phosphorous removal was studied for 6h, 8h &12h cycles.

				3. Was seen that the total nitrogen and total phosphorous removal were maximum at 12hr cycle.
17.	Response of a sludge-minimizing lab-scale BNR reactor when the operation is changed to real primary effluent from synthetic Wastewater.	Pei Huang, Ramesh Goel	Wastewater Research (2015)	1. The sludge decrease in altered SBR when contrasted with control-SBR diminishes from 64 % to 40% when the feed was changed 100 % real wastewater.
18.	Use of sequencing batch reactor for biological De-nitrification of high nitrate-containing water.	Alemayehu Mekonen, Pradeep Kumar,and Arvind Kumar	Journal by American Society of Civil Engineers (2015)	1. Ethanol was found enough to reduce the nitrate concentrations to the acceptable levels. 2. Increasing of initial nitrate concentration Nitrate removal was high in range 85 – 91. %.
19.	Temperature effects on physiology of	Damir Brdjanovic, Mark C. M. van Loosdrecht, Christine M.	Journal by American Society of	1. Temperature sturdily affected at the energy forms underneath anaerobic just as oxygen consuming

	Phosphorus removal.	Hooijmans,3 Guy J. Alaerts, and Josef J. Heijnen	Civil Engineers (2014)	condition. The anaerobic phosphorous discharge rate affirmed a most extreme at 20°C. 2. Continuous increase was seen in 10- 25° C for the rate under aerobic conditions.
20.	Cultivation of aerobic granular sludge for rubber wastewater treatment.	Rosman, Noor Hasyimah, Aznah Nor Anuar, Inawati Othman, Hasnida Harun, Muhammad Zuhdi Sulong, Siti Hanna Elias, Mohd Arif Hakimi Mat Hassan, Shreesivadass Chelliapan, and Zaini Ujang .	Bio resource Technology (2013)	1. Aerobic granular sludge (AGS) was cultivated at 28 ° C and pH 6.5 when we treat rubber factory wastewater using a SBR having cycle time of 3 hrs. 2. A COD removal efficiency of 95.33 % was observed and ammonia removal rate of 93.78 %, nitrogen removal rate of 89.03 % were established.

CHAPTER 3

MATERIAL AND METHODS

3.1 EXPERIMENTAL SETUP

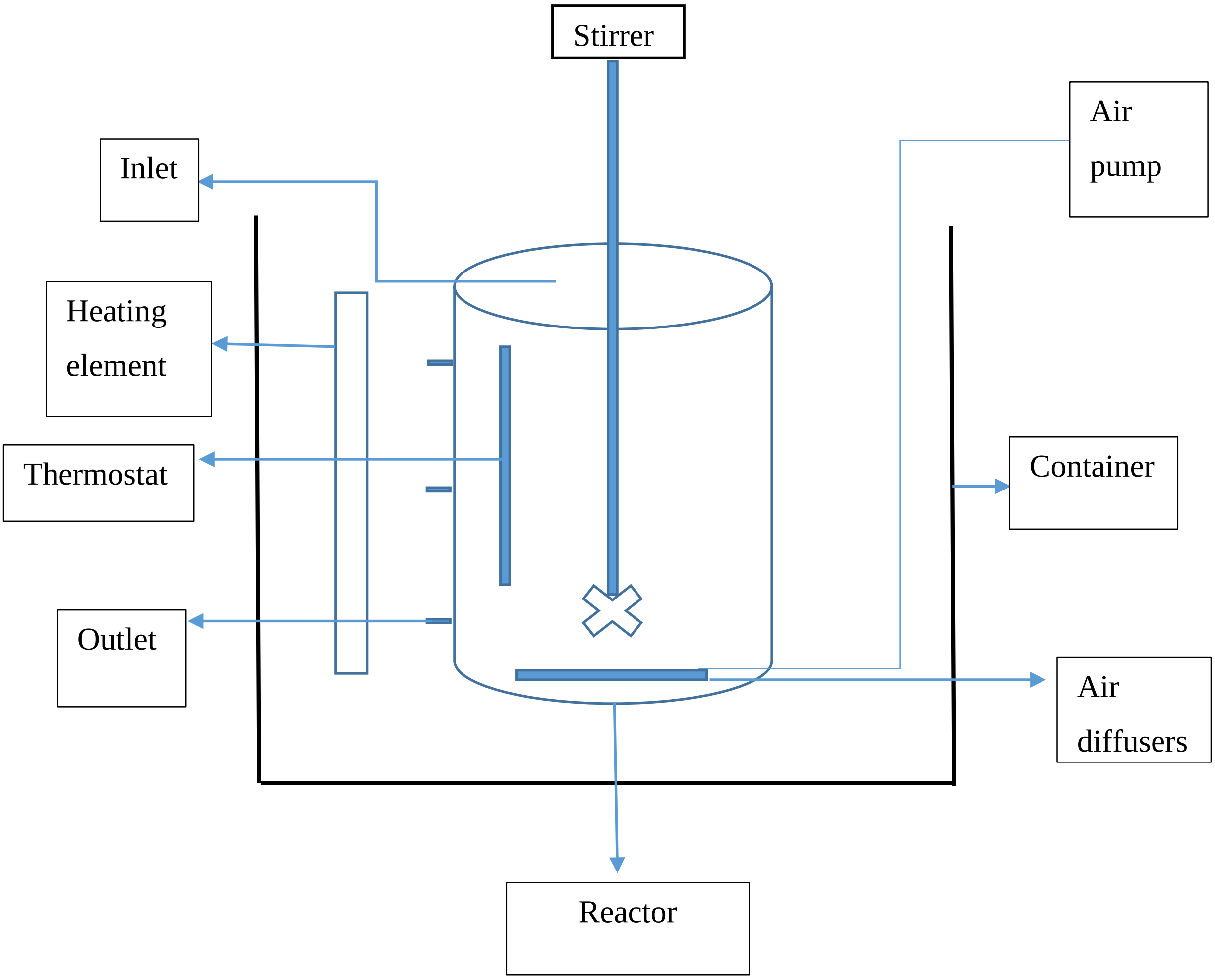

Figure 3.1 Reactor Diagram

3.1.1 Reactor-It is a basin in which the influent or raw wastewater is added and gets treated having capacity of 3 litres (fig 3.1).

3.1.2 Stirrer- Stirrer (fig 3.1) was used for mixing of sludge with wastewater and is placed at the centre in the reactor for mixing the content. The rotation per minute was used about (1500-3000).

3.1.3 Heating element- It was used in the study for maintaining the temperature of wastewater wired with the thermostat fixed at a temperature of (20 ºC ± 2 ºC).

3.1.4 Air Pumps- The air pump was provided to maintain the aerobic conditions within the reactor. Stone diffusers were connected to the air pumps for proper dispersion of air within the reactor. The aeration rate used was 1.5 litres/min (fig 3.1).

3.2 REACTOR DESIGN

A laboratory scale circular SBR with working volume of 3 litres will be used in the study. Aeration will be done using stone air diffusers. For mixing in anoxic phase laboratory stirrer will be used. The material of circular reactor is made by using transparent acrylic sheet. Height of the reactor is 210 mm and internal diameter is 190 mm in which the working height is 110 mm and 50 mm is for freeboard and 50 mm from the bottom for sludge. The reactor is made temperature controlled using a container filled with water and in this the water heating element is wired with the thermostat fixed at a temperature of (20º C ± 2º C). The ratio for seed sludge is 1:5. Aeration is done using aquarium pump capacity of 3litres/minute using stone diffusers. The SBR was installed in the environmental lab. It was operated for 5 phases and after that clear supernatant was observed (fig 3.2).

Figure 3.2 Experimental setup

3.3 WASTEWATER AND SEED SLUDGE

Wastewater used in the present study was domestic wastewater and other was synthetically prepared in the laboratory and the composition used is given in the (table 3.1). The domestic wastewater was collected from the JUIT treatment plant. The domestic and synthetically prepared wastewater was fed into the reactor for simultaneously for 3 months and after treatment the parameters were checked on the regular basis. The sludge was collected from the aeration tank of JUIT STP on regular basis and the ratio was 1:5 inoculated means one portion of sludge in five parts of the raw wastewater. Sludge plays an important role in the treatment process as it contains micro-organisms for the treatment of wastewater.

Table 3.1 Composition of Synthetic wastewater

Composition	**Concentration (mg/L)**
Sodium acetate	500
Glucose	200
Ammonium Chloride	80
Dihydrogen Phosphate	30
Sodium chloride	20
Manganese sulphate	20

3.4 REACTOR OPERATION

The study was carried out for 12 h, 8 h and 6h for synthetic wastewater and 4h, 6h, 8h for domestic wastewater. The SRT was maintained for 30 days in the reactor for the respective cycles. The temperature was controlled between ((20º C ± 2º C) from the day 1 onwards for both synthetic and domestic wastewater. DO was maintained at the rate of 1.5 litres/minute. The study was carried out in two phases. In phase 1, the synthetic wastewater was treated for the three cycle times and for phase 2, the domestic wastewater was studied for the respective cycles. Various cycle time and duration of each phase is shown in (table 3.2):

Table 3.2 Cycle time and phases

Cycle time	Fill (min)	React(min)	Settle(min)	Draw(min)
4h	40	320	80	40
6h	30	240	60	30
8h	40	320	80	40
12h	60	480	120	60

3.5 PARAMETERS TO BE ANALYSED

1) BOD
2) COD
3) TSS
4) TDS
5) TS
6) DO
7) pH

The above parameters were measured as per standard methods (APHA, 2005). DO was measured using the DO meter and pH with pH strips.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 RESULTS FOR SYNTHETIC WASTEWATER FOR 6 H CYCLE

4.1.1 Variation for COD removal

Organic matter is mostly evaluated in terms of oxygen required for completely oxidising the organic matter to carbon dioxide and water and other species. By the known formulas and concentrations of the chemical compounds mixed in the water we calculated the theoretical oxygen demand of the solution which came out to be 747 mg/L.

Initially, during the first few of the study the COD concentration removal was low due to the acclimatising process of the bacteria with the synthetically prepared wastewater after few days the aerobic granulation started to increase in reactor thus leading to the better removal of the COD concentration. The removal efficiency started to increase from 45 % to 86 % (fig 4.2).

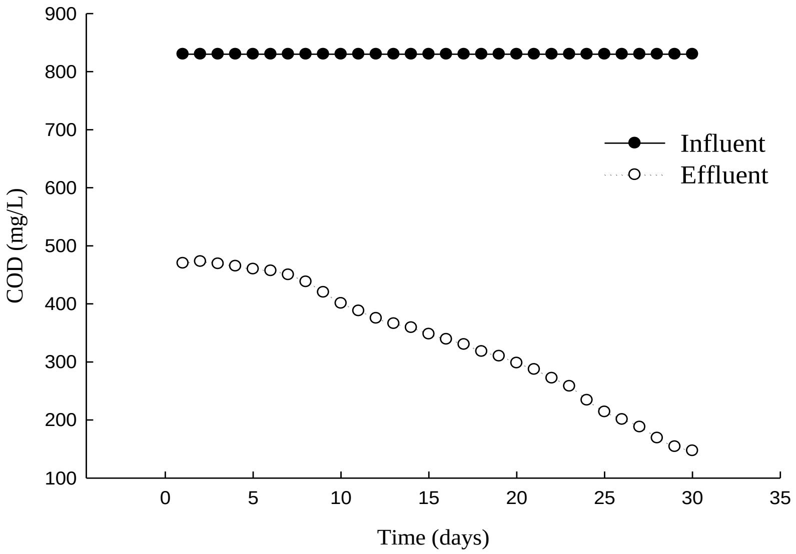

Figure 4.1 Variation for COD removal

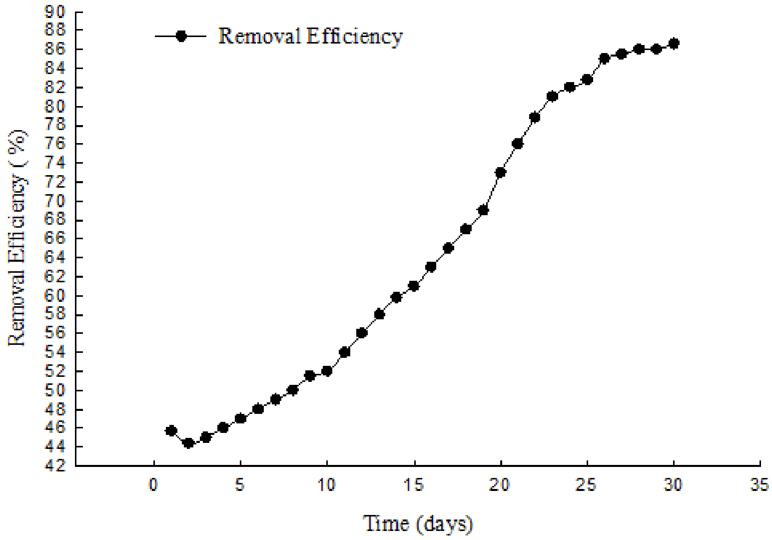

Figure 4.2 Removal efficiency for COD

4.1.2 Variations for TDS removal

TDS in the receiving waters are mainly agricultural and residential runoff, and wastewater discharge from industrial or sewage treatments plants. Common chemical found are calcium, phosphates, nitrates etc. Presence of dissolved and suspended solids are responsible for creating problems. So removal of these solids are very much important. Total dissolved solids (TDS) influent concentration was fixed to 830 mg/L as it was synthetically prepared and concentrations of chemicals were known. During the first phase of the study efficiency was low but after some period of time efficiency improves as aerobic granulation starts to rise in the reactor. The efficiency was ranging from 43 % to 82 % (fig 4.4) as biomass growth takes place which lead to reduction in nitrogen and phosphates which decreases the TDS concentrations. In this important point is that Suspended Solids were not present as the wastewater was prepared using distilled water and by this Total Solids were equal to the Dissolved Solids.

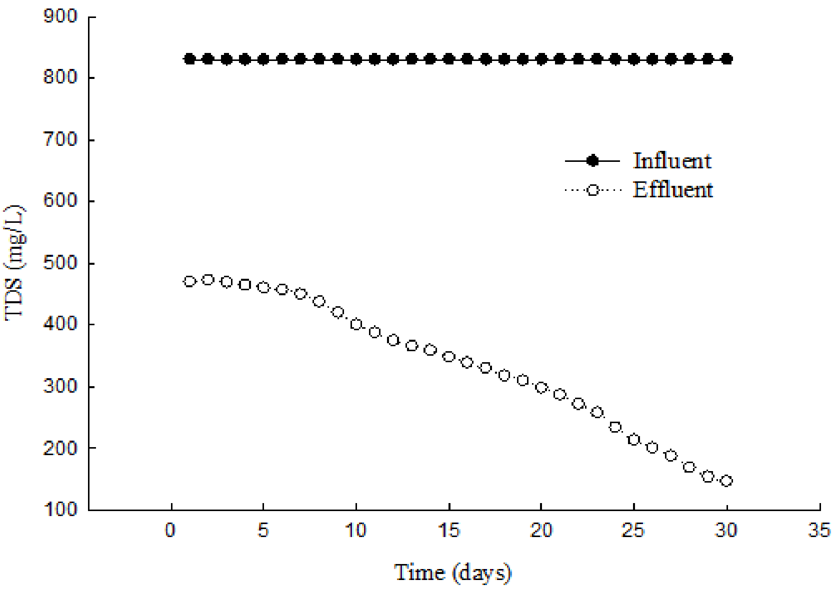

Figure 4.3 Variation for TDS removal

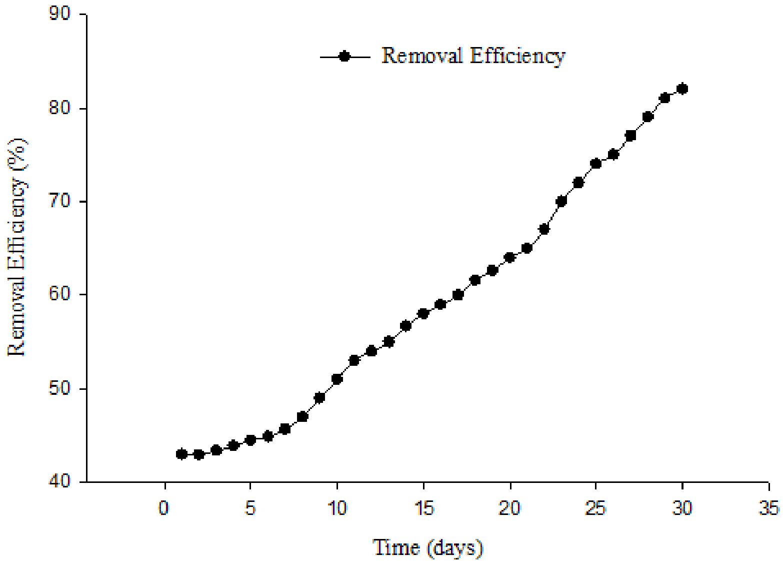

Figure 4.4 Removal Efficiency for TDS

4.1.3 Variations for DO

During the treatment the maximum influent DO was around 8.88 mg/L as it was distilled water and was mixed with chemicals. But after mixing it with the sludge microorganism in reactor starts to reproduce itself. These microorganisms require oxygen to breakdown organic matter that is why concentration of DO decreases during the mixing process reaching its saturation concentration around 3.08 mg/L. But after the settle phase the DO value decreases as the microorganism's breakdown the organic matter and utilizes the DO reaching minimum value of 0.88 mg/L as shown in (fig 4.5).

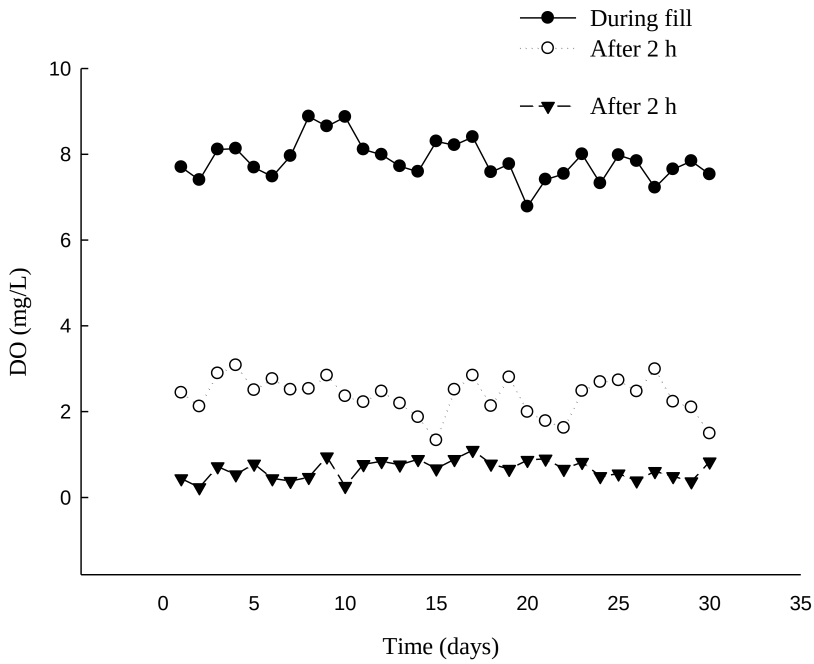

Figure 4.5 DO variations

4.2 RESULTS FOR SYNTHETIC WASTEWATER FOR 8 H CYCLE

4.2.1 Variations for COD removal

As in this case the cycle time is 8 h means the reaction time is increased as the microorganism starts to increase in the reactor the efficiency increases. During the initial days the efficiency was around 48 % but after the six days efficiency started to increase as the aerobic granulation started to increase the efficiency increases. Efficiency for this was increased to (48 % to 88 %) as shown in (fig 4.4).

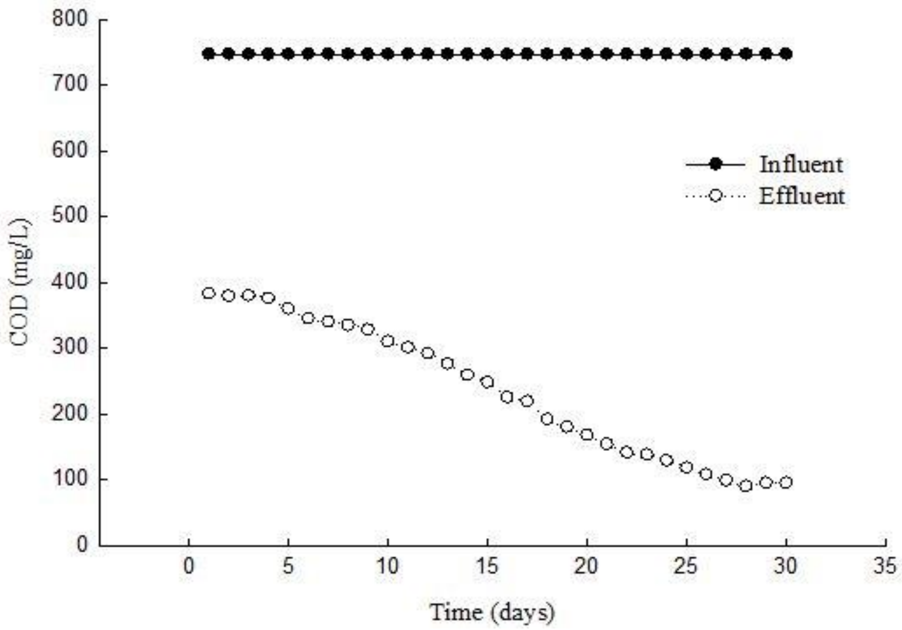

Figure 4.6 Variations for COD removal

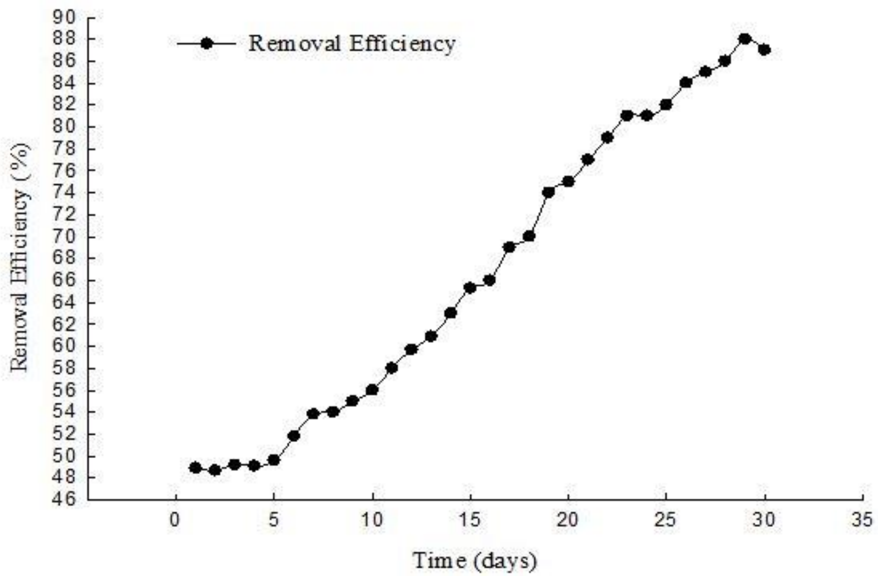

Figure 4.7 Removal efficiency for COD

4.2.2 Variations for TDS removal

During the first phase of the study efficiency was low but after some period of time efficiency improves as aerobic granulation starts to rise in the reactor. The efficiency was ranging from 45 % to 84 % (fig 4.9) as biomass growth takes place which lead to reduction in nitrogen and phosphates which decreases the TDS concentrations. In this important point is that Suspended Solids were not present as the wastewater was prepared using distilled water and by this Total

Solids were equal to the Dissolved Solids. In this case also the reaction time was increased so the efficiency was seen higher than the 6 h cycle.

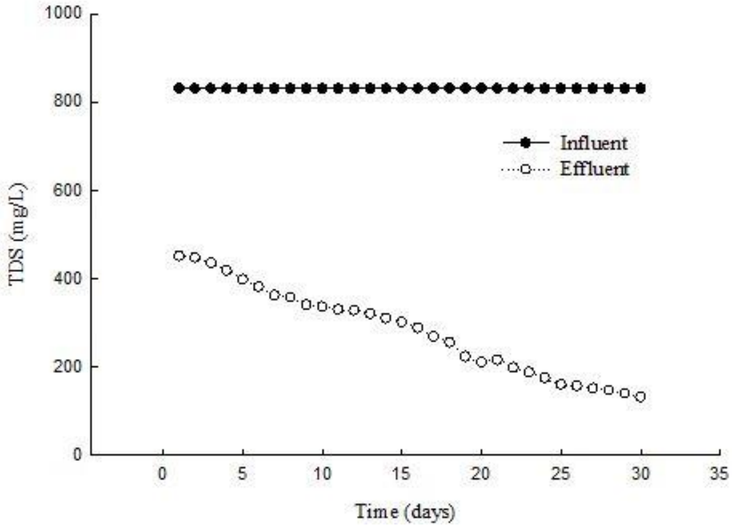

Figure 4.8 Variations for TDS removal

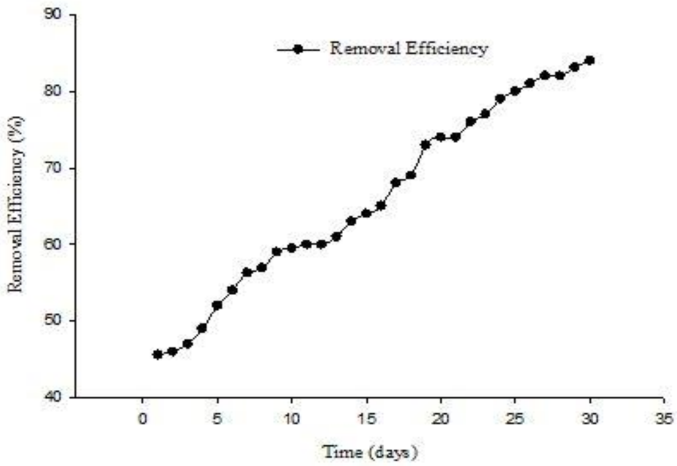

Figure 4.9 Removal efficiency for TDS

4.2.3 DO variations

As dissolved oxygen is very necessary for the bacteria for its growth here the reaction time was 320 minutes. As the mixing occurs the bacteria starts to consume oxygen gradually the DO concentration in the reactor decrease. During the saturation period the value of DO was around 4.85 mg/L and then after 2 h it was reduced to 3.1 mg/L. After the settle period the minimum DO was around 0.32 mg/L as shown in (fig 4.10).

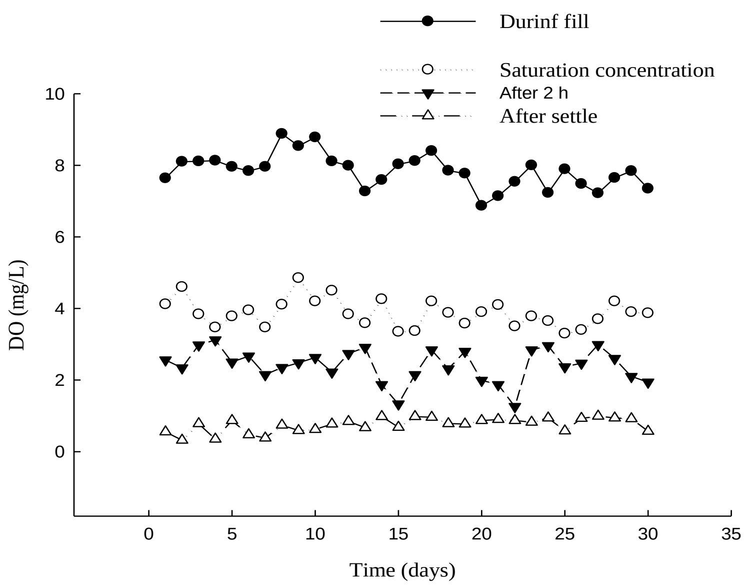

Figure 4.10 DO variation

4.3 RESULTS FOR SYNTHETIC WASTEWATER FOR 12 H CYCLE

4.3.1 Variations for COD removal

As in this case the cycle time is 12 h the reaction time is increased and the microorganism starts to increase in the reactor as a result the efficiency increases. During the initial days the efficiency was around 50 % due to the acclimatization of the bacteria with the wastewater but after the six days efficiency started to increase as the aerobic granulation started to increase the efficiency increases. As it was synthetic wastewater only inorganics particles were present. Efficiency for this was increased to (50 % to 90 %) as shown in (fig 4.12).

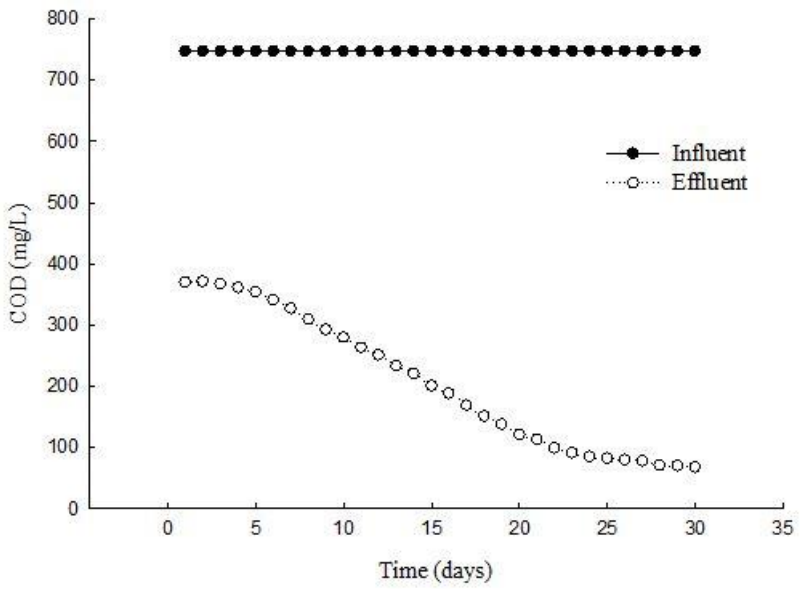

Figure 4.11 Variation for COD removal

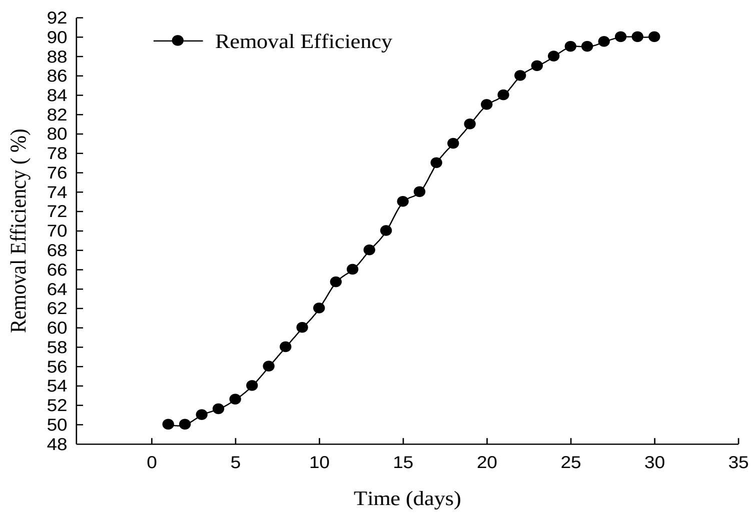

Figure 4.12 Removal efficiency for COD

4.3.2 Variation for TDS removal

Total dissolved solids (TDS) influent concentration was fixed to 830 mg/L as it was synthetically prepared and concentrations of chemicals were known. During the initial of the study efficiency was low but after some period of time efficiency improves as aerobic granulation starts to rise in the reactor. The efficiency was ranging from 46.7 % to 88 % as biomass growth takes place which lead to reduction in nitrogen and phosphates and other inorganic salts which decreases the TDS concentrations. In this important point is that

Suspended Solids were not present as the wastewater was prepared using distilled water and by this Total Solids were equal to the Dissolved Solids. In this case also the reaction time was increased so the efficiency was seen higher than the 8 h cycle as in (fig 4.14).

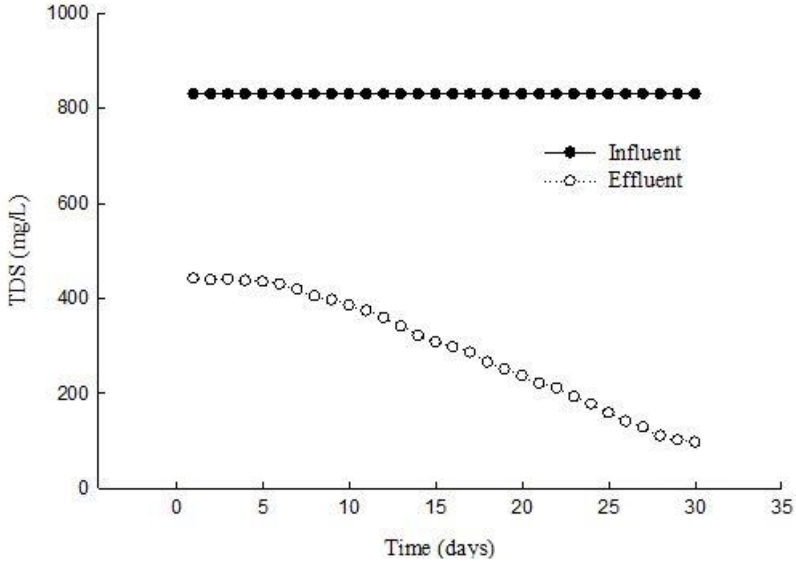

Figure 4.13 Variation for TDS removal

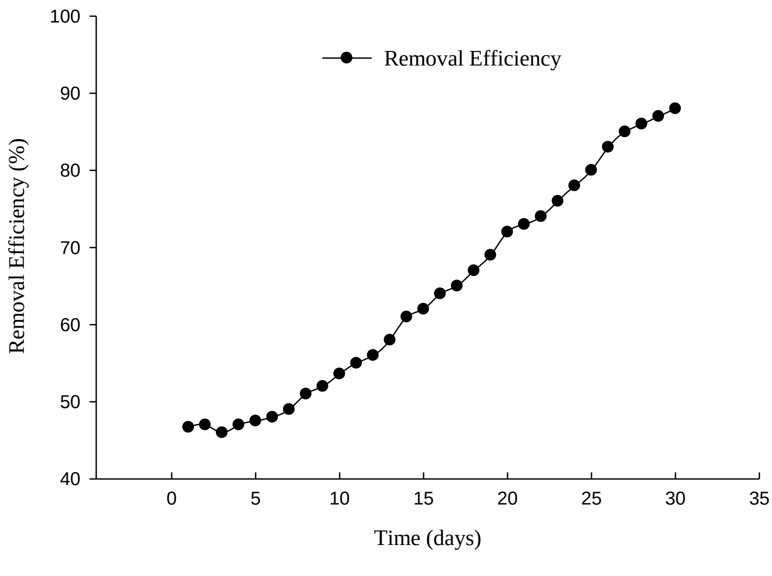

Figure 4.14 Removal efficiency for TDS

4.3.3 Variations for DO

As dissolved oxygen is very necessary for the bacteria for its growth here the reaction time was 480 minutes. As the mixing takes place bacteria starts to consume the oxygen gradually and the

DO concentration in the reactor decrease. During the saturation period the value of DO was around 4.56 mg/L and then after 2 h it was reduced to 2.18 mg/L again after 2 h it was reduced to 1.22 and after the settle period the minimum DO was around 0.18 mg/L as shown in (fig 4.15).

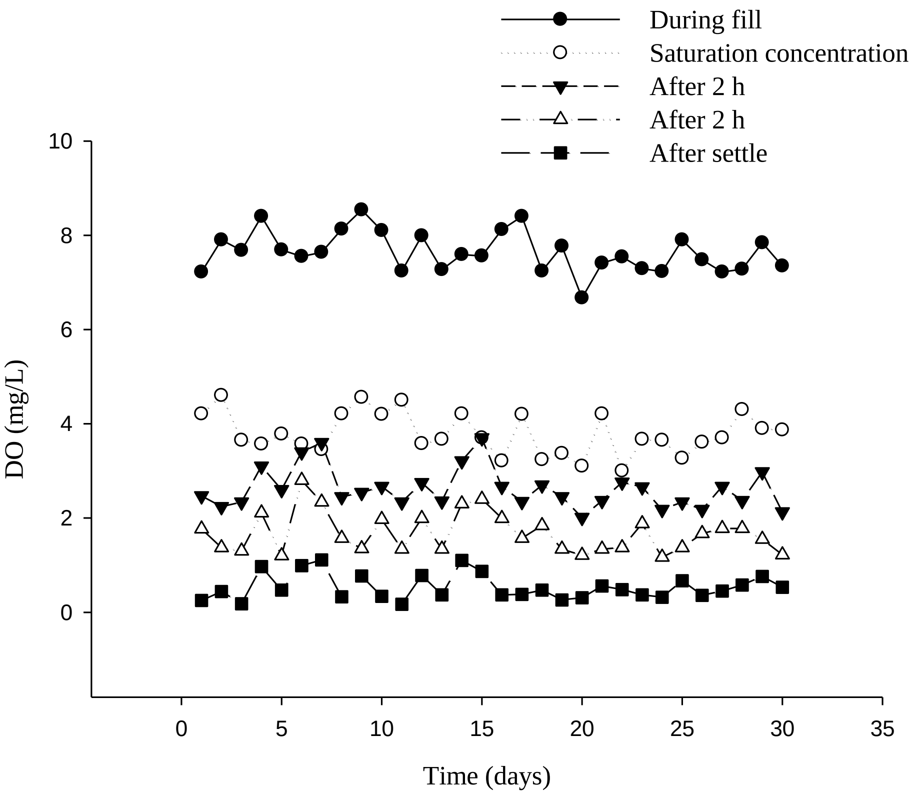

Figure 4.15 DO variation

4.4 RESULTS FOR DOMESTIC WASTEWATER FOR 4 H CYCLE

4.4.1 Variation for COD removal

Basically COD is the measurement of the non-biodegradable organics which is present in the wastewater. In this case the wastewater used is domestic as sludge affinity towards domestic wastewater is more compared to the synthetic wastewater. Here the removal efficiency started from 46.9 % in the first few days and maximum was 84 % as the reaction time was 160 minutes as in (fig 4.17).

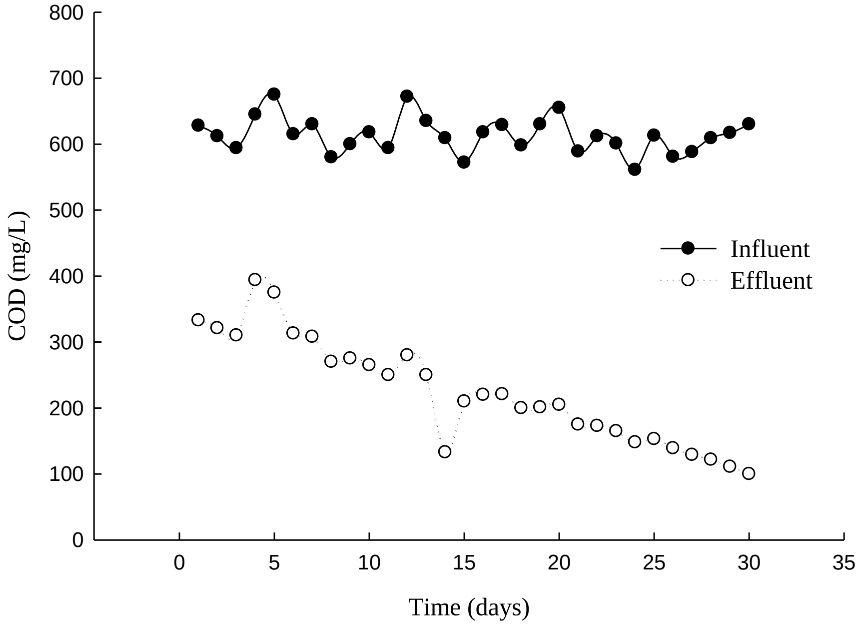

Figure 4.16 Variation for COD

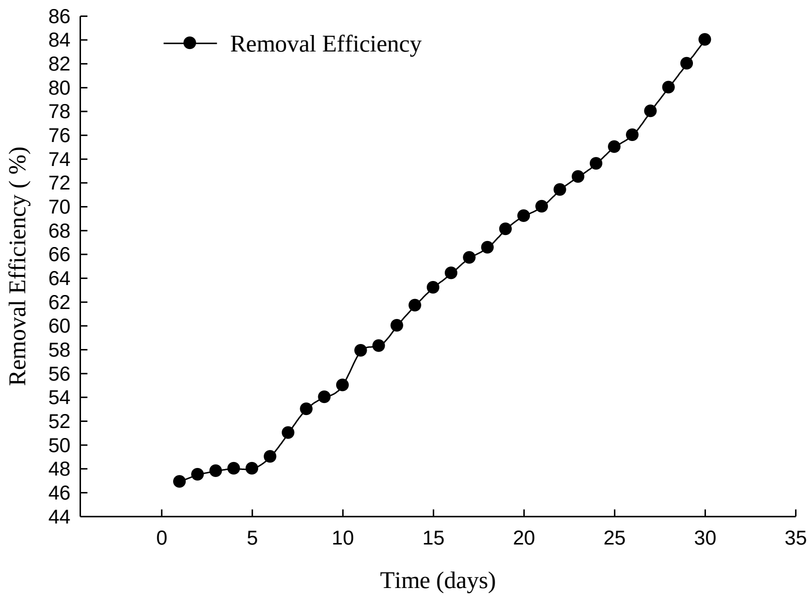

Figure 4.17 Removal efficiency for COD

4.4.2 Variations for BOD removal

BOD can be stated that the organics that can be used for food by the naturally occurring microorganisms. Here the BOD removal efficiency curve started from 49 % as during the initial days the bacteria replicate itself and starts consuming the substrate as its strength increases. As the aerobic granulation started to form the removal efficiency started to increase and gone maximum to 87 % as shown in (fig 4.19).

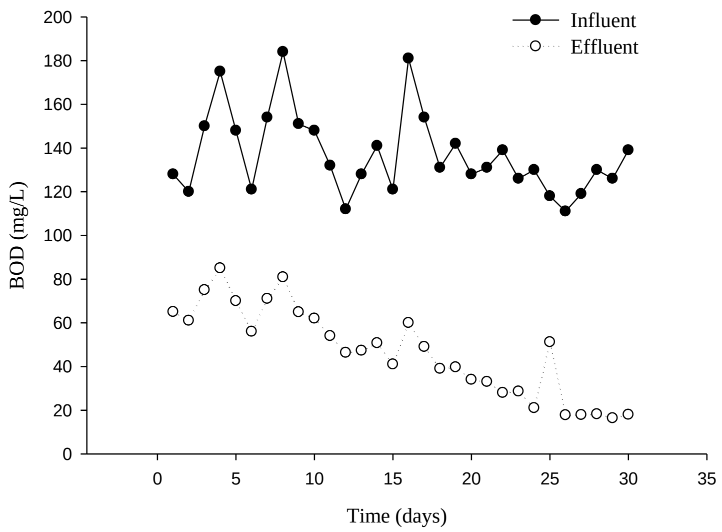

Figure 4.18 Variation for BOD removal

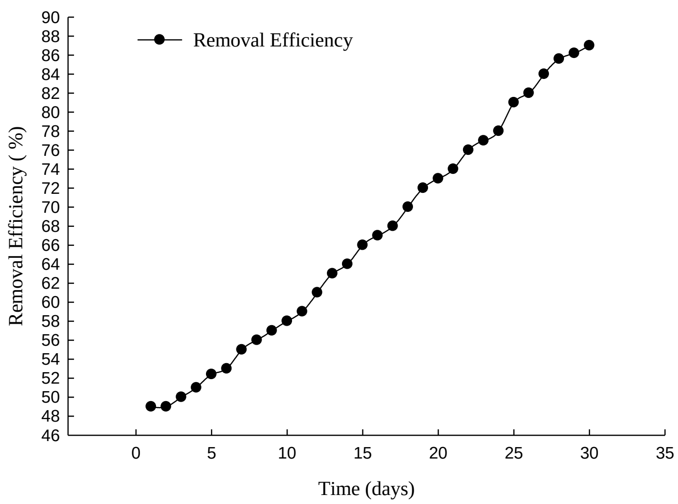

Figure 4.19 Removal efficiency for BOD

4.4.3 Variation for TDS removal

During the first few days, the reactor removal efficiency was low but as the time progresses the removal efficiency started to increase from 54 % to 85 %. This is due to the biomass growth and bacterial growth in the reactor as shown in (fig 4.21).

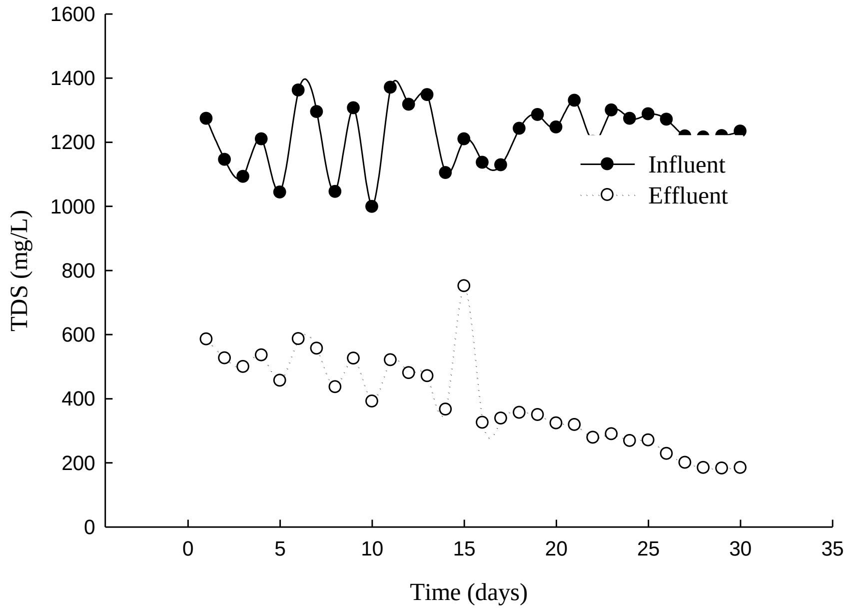

Figure 4.20 Variation for TDS removal

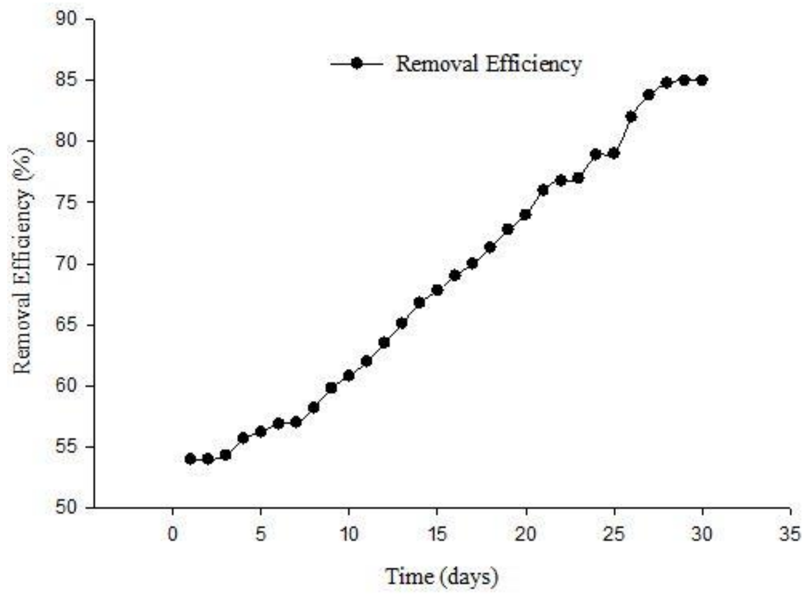

Figure 4.21 Removal efficiency for TDS

4.4.4 Variation for TSS removal

(TSS) vary from the removal efficiency of (fig-4.23) 51 % to range of (fig-4.23) 86.9 %. In first few days the removal efficiency was low but after increase of bacteria and the increase of bacteria concentration, the ability to settle aerobic granules with wastewater improved so the efficiency increases and resulted aerobic granule with good settling. Due to good separation of bacteria with the treated wastewater resulted in a clear supernatant in the reactor.

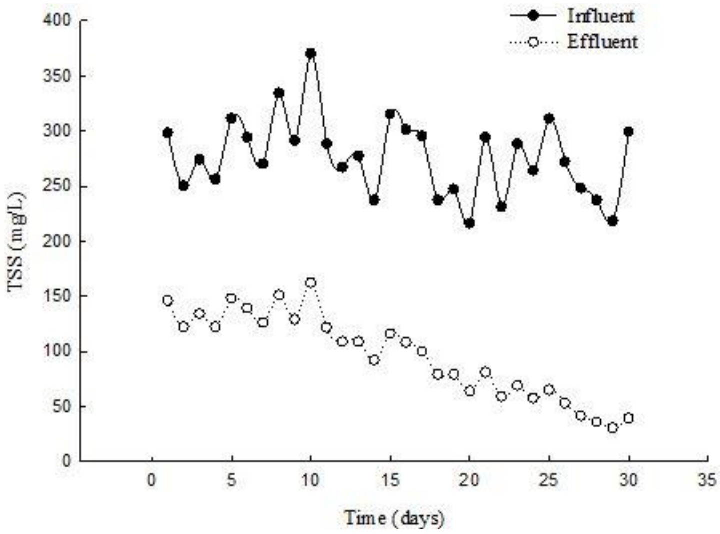

Figure 4.22 Variation for TSS removal

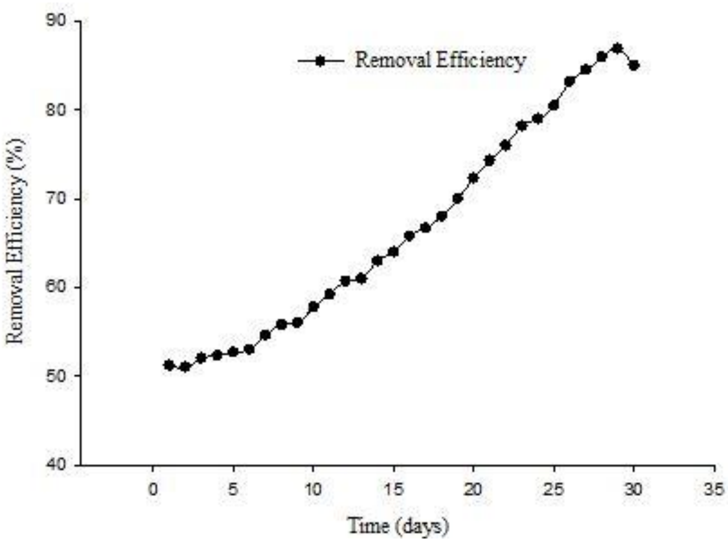

Figure 4.23 Removal efficiency for TSS

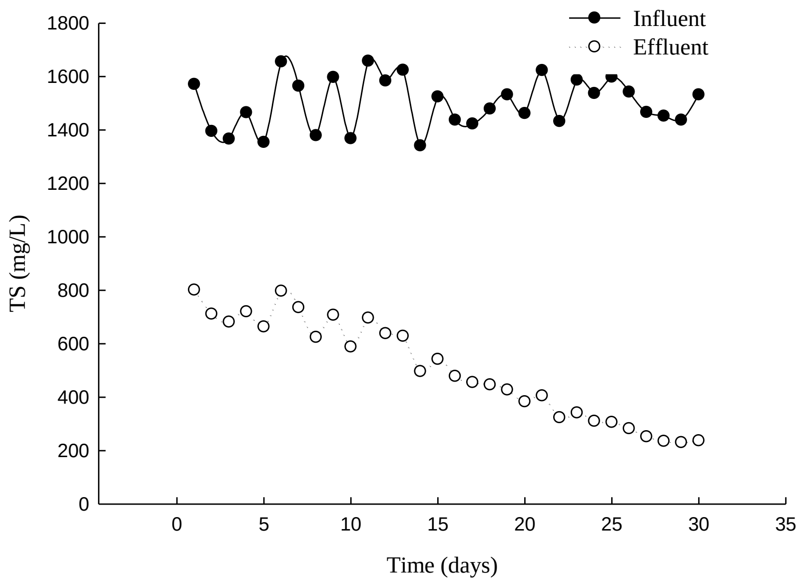

Figure 4.24 Variation for TS removal

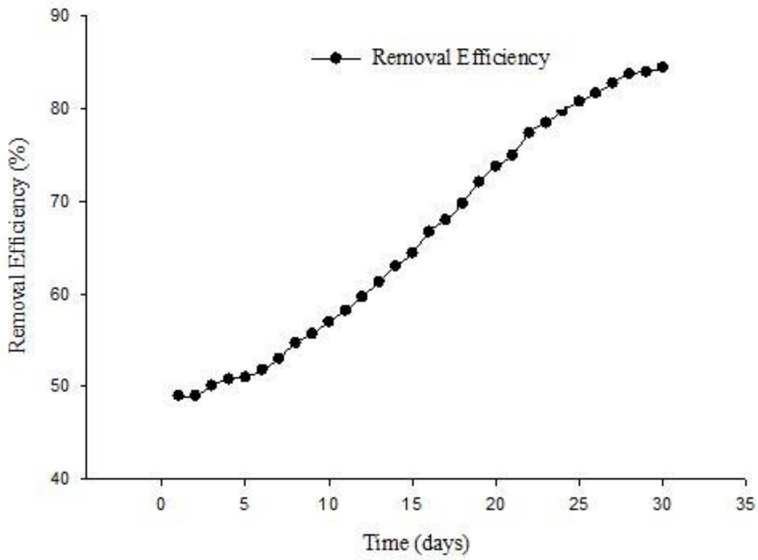

Figure 4.25 Removal efficiency for TS

4.4.6 Variation for DO

As dissolved oxygen is very necessary for the bacteria for its growth here the reaction time was 160 minutes. As the mixing takes place bacteria starts to consume the oxygen gradually and the DO concentration in the reactor decrease (fig 4.26).

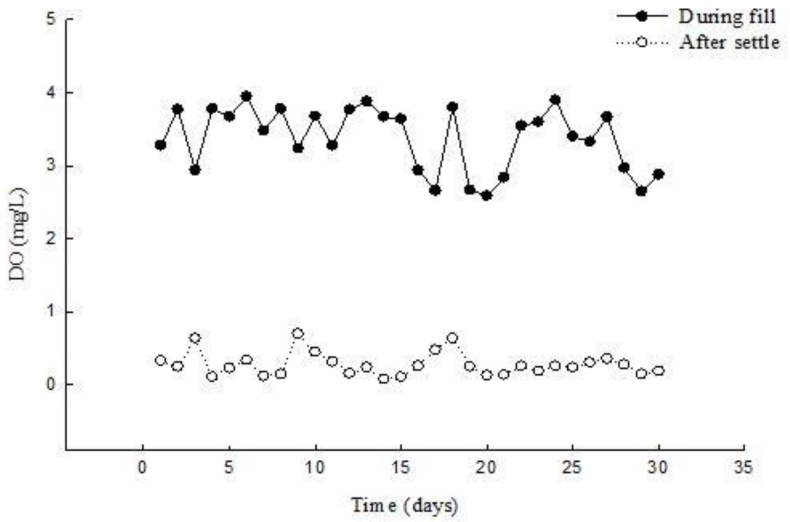

Figure 4.26 Variation for DO

4.5 RESULTS FOR DOMESTIC WASTEWATER FOR 6 H CYCLE

4.5.1 Variation for COD removal

Basically COD is the measurement of the non-biodegradable organics which is present in the wastewater. In this case wastewater used was domestic as sludge affinity towards domestic wastewater is more compared to the synthetic wastewater. Here the removal efficiency started from 48 % in the first few days and maximum was 87.2 % as the reaction time was 240 minutes as in (fig 4.28).

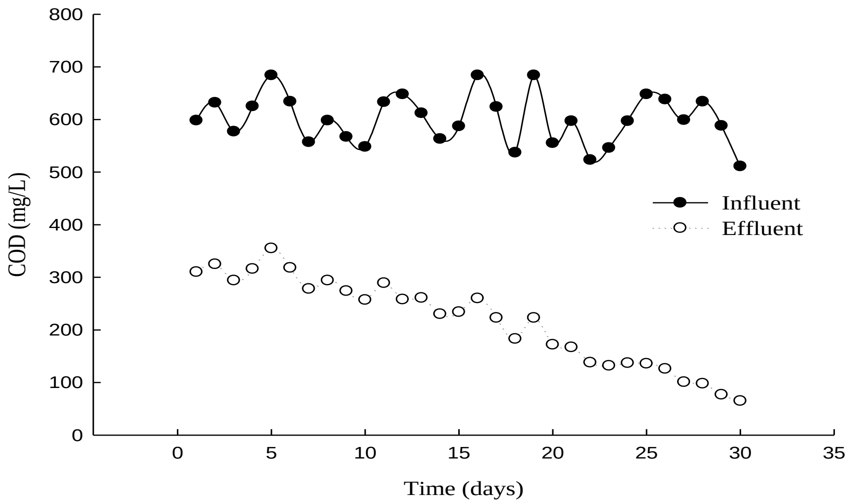

Figure 4.27 Variation for COD

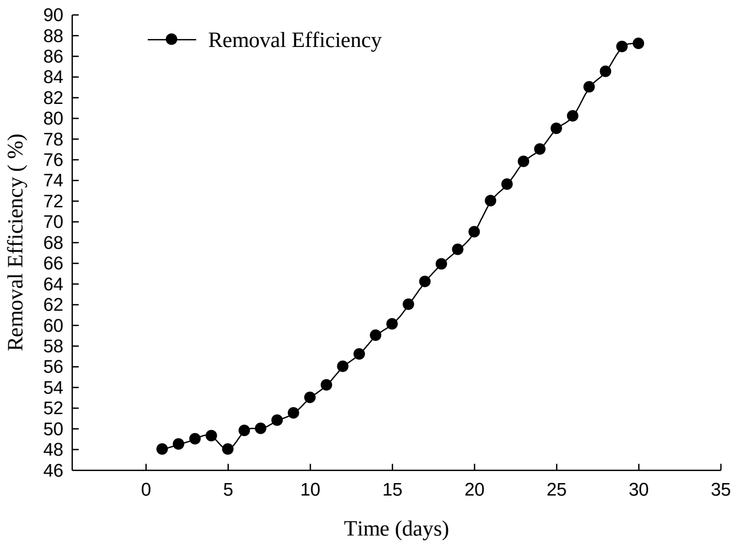

Figure 4.28 Removal efficiency for COD

4.5.2 Variation for BOD removal

Here the BOD removal efficiency curve started from 51 % as during the initial days the bacteria replicate itself and starts consuming the substrate as its strength increases as here the react time is more than previous cycle. As the aerobic granulation started to form the removal efficiency started to increase and gone maximum to 90 % as shown in (fig 4.30).

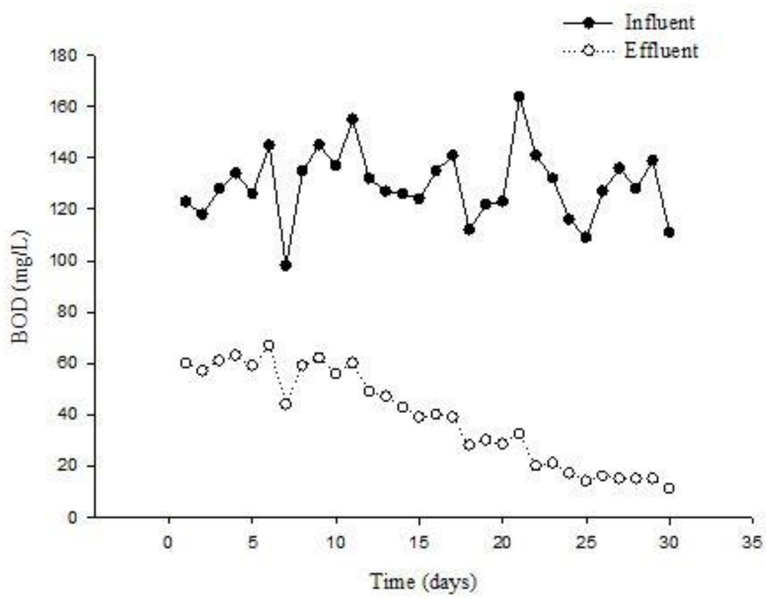

Figure 4.29 Variation for BOD

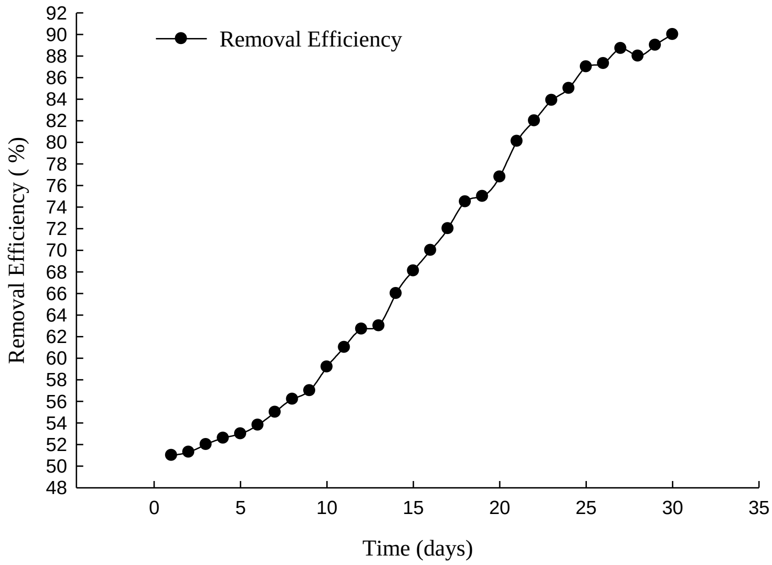

Figure 4.30 Removal efficiency for BOD

4.5.3 Variation for TDS removal

During the first few days of the reactor operation removal efficiency was low but as the time progresses the removal efficiency started to increase from 56 % to 87.7 %. This is due to the biomass growth and bacterial growth in the reactor as shown in (fig 4.32).

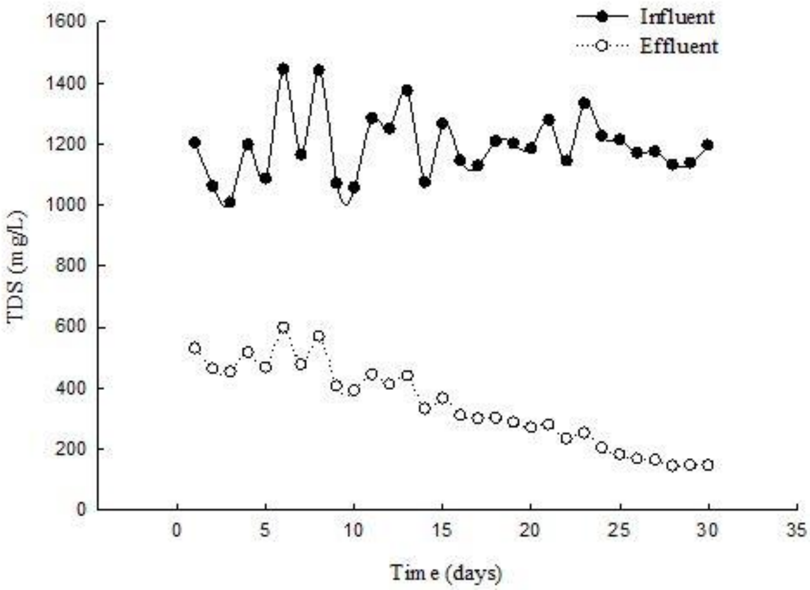

Figure 4.31 Variation for TDS removal

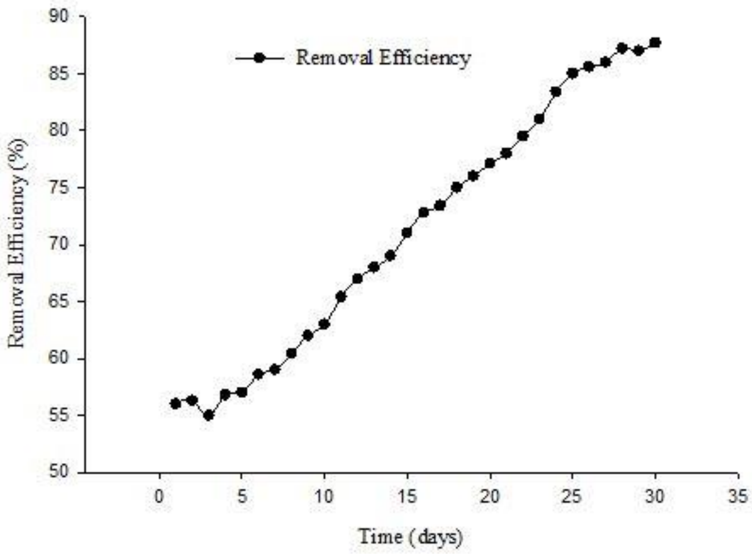

Figure 4.32 Removal efficiency for TDS

4.5.4 Variation for TSS removal

TSS vary from the removal efficiency of (fig-4.34) 54 % to range of (fig-4.34) 89 %. In first few days the removal efficiency was low but after increase of bacteria and with the increase of bacteria concentration, the settling of granules with wastewater improved so the efficiency increases and resulted in aerobic granule with good settling.

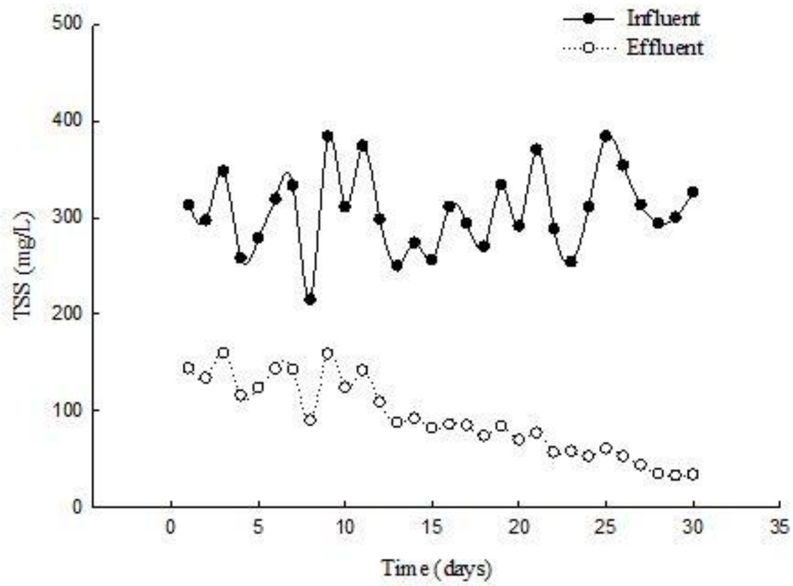

Figure 4.33 Variation for TSS

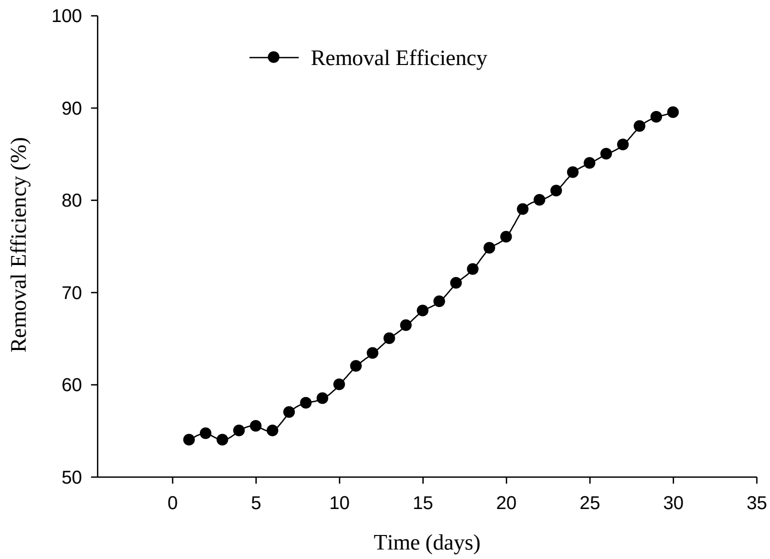

Figure 4.34 Removal efficiency for TSS

4.5.5 Variation for TS

TS removal efficiency started from the initial range of (fig-4.36) 52 % to 86 %.When the reactor was started the SRT and HRT were less so bacterial population was also less, but after few days the aerobic granules started to show up and then the bacterial population increases thus efficiency also increases.

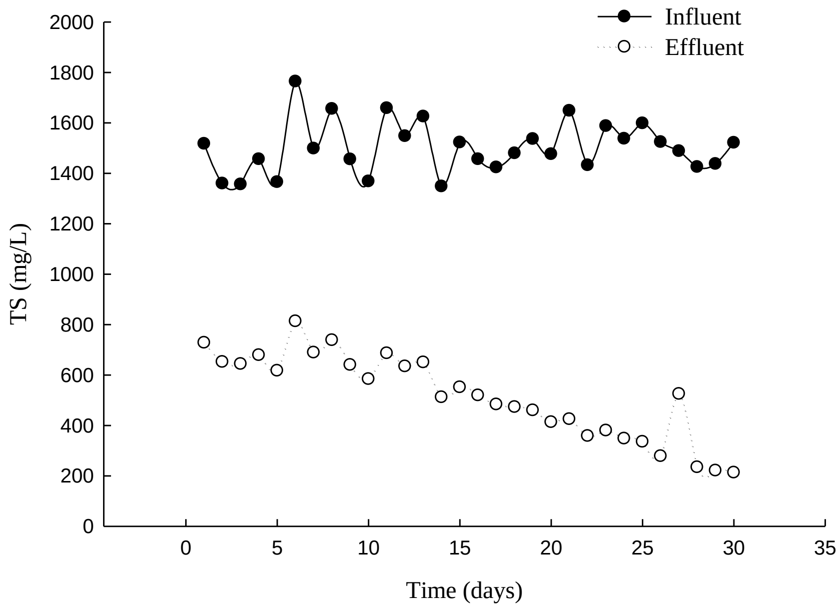

Figure 4.35 Variation for TS

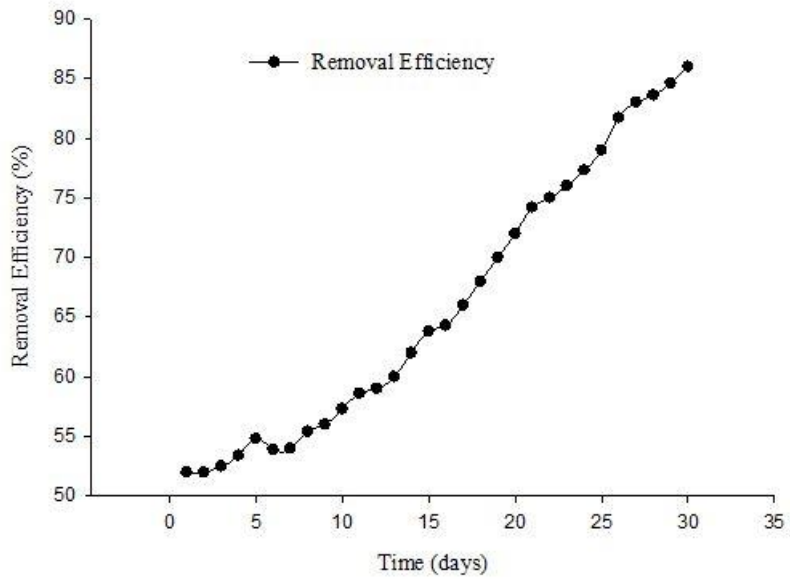

Figure 4.35 Removal efficiency for TS

4.5.6 Variation for DO

As dissolved oxygen is very necessary for the bacteria for its growth here the reaction time was 240 minutes. As the mixing takes place bacteria starts to consume the oxygen gradually and the DO concentration in the reactor decrease (fig 4.36).

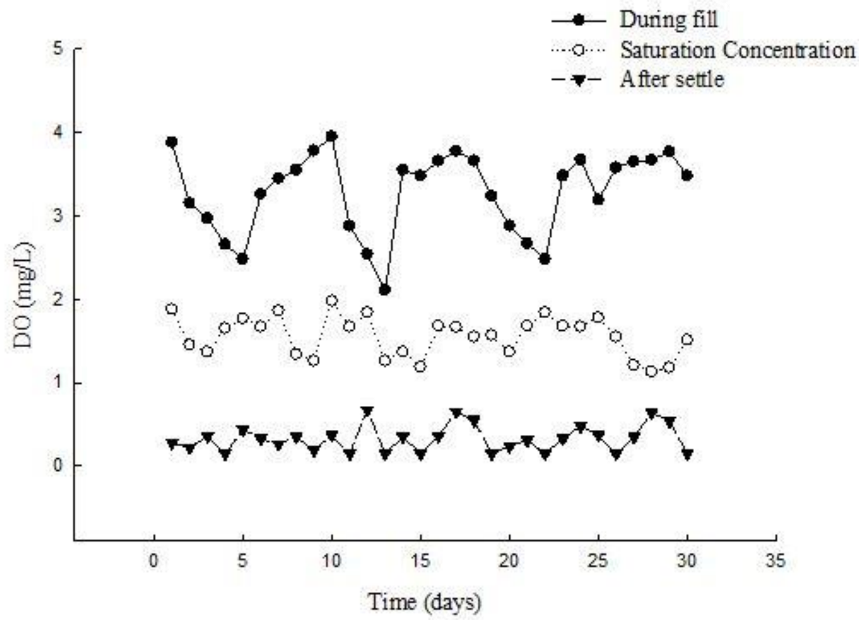

Figure 4.35 Variation for DO

4.6 RESULTS FOR DOMESTIC WASTEWATER FOR 8 H CYCLE

4.6.1 Variation for COD removal

Basically COD is the measurement of the non-biodegradable organics which is present in the wastewater. In this case the wastewater used is domestic as sludge affinity towards domestic wastewater is more compared to the synthetic wastewater. Here the removal efficiency started from 50 % in the first few days and maximum was 90 % as the reaction time was 320 minutes as in (fig 4.37).

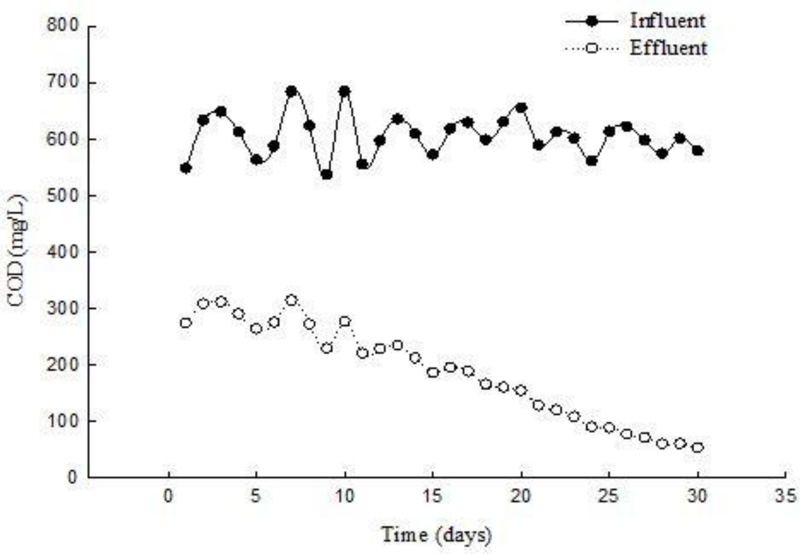

Figure 4.36 Variation for COD Removal

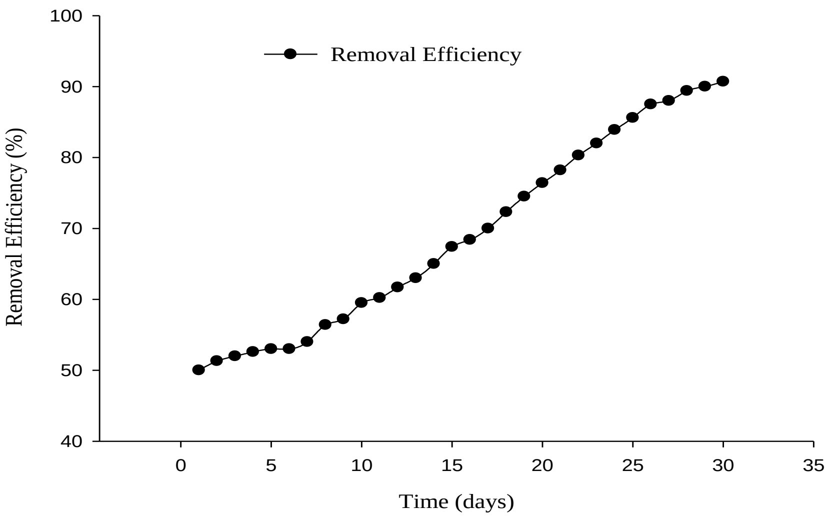

Figure 4.37 Removal Efficiency for COD

4.6.2 Variation for BOD

Here the BOD removal efficiency curve started from 53 % as during the initial days the bacteria replicate itself and starts consuming the substrate as its strength increases as here the react time is more than previous cycle i.e. 240 minutes. As the aerobic granulation started to form the removal efficiency started to increase and gone maximum to 93 % as shown in (fig 4.39).

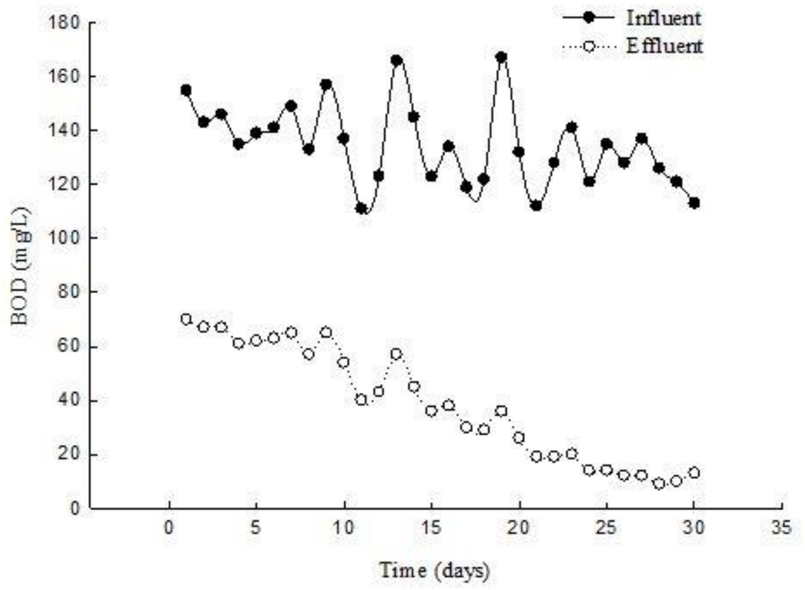

Figure 4.38 Variation for BOD

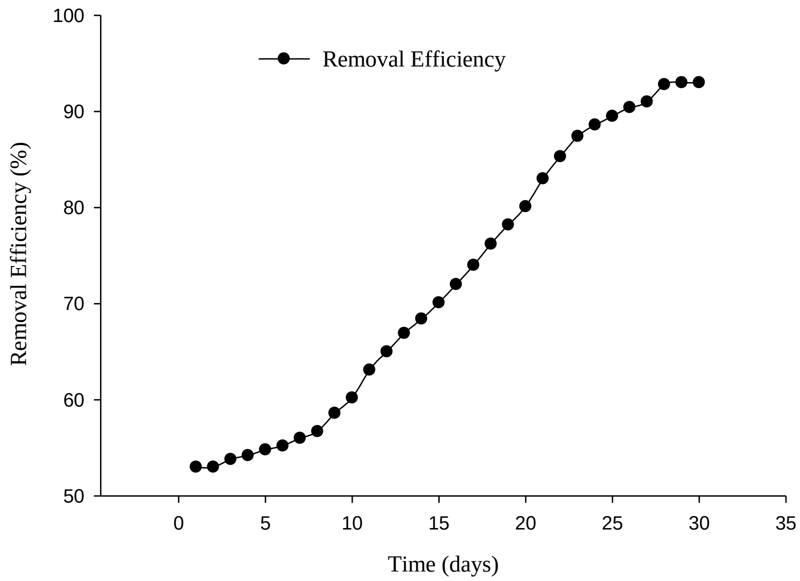

Figure 4.39 Removal efficiency for BOD

4.6.3 Variation for TDS removal

During the first few days of the reactor operation the removal efficiency was low but as the time progresses the removal efficiency started to increase from 58 % to 92 %. This is due to the biomass growth and bacterial growth in the reactor as shown in (fig 4.41).

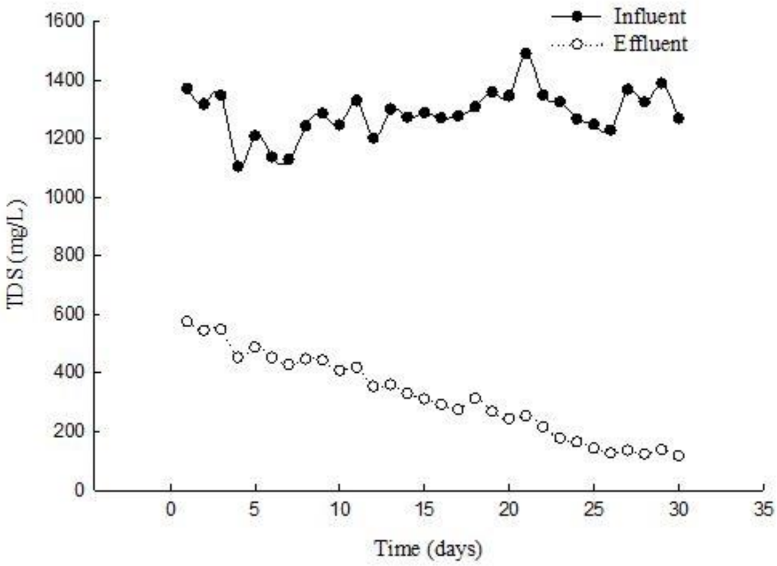

Figure 4.40 Variation for TDS

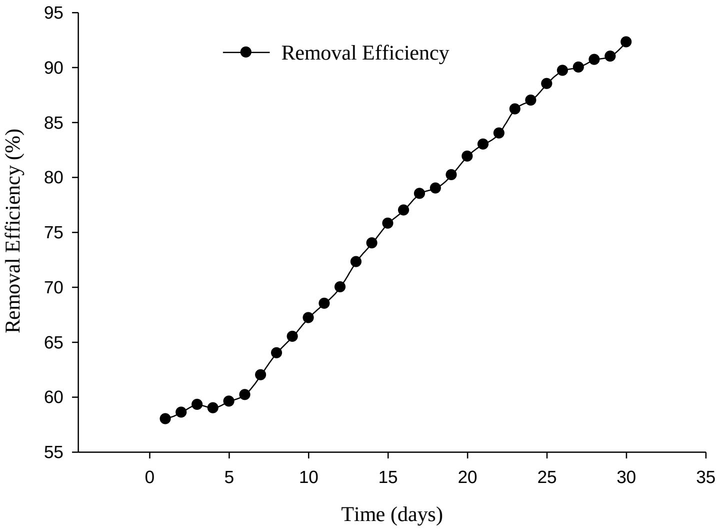

Figure 4.41 Removal efficiency for TDS

4.6.4 Variation for TSS

TSS vary from the removal efficiency of (fig-4.43) 56 % to range of (fig-4.43) 92.8 %. In first few days the removal efficiency was low but after increase of bacteria and with the increase of bacteria concentration, as sludge in the reactor settles and forms a distinctive layer with the treated effluent.

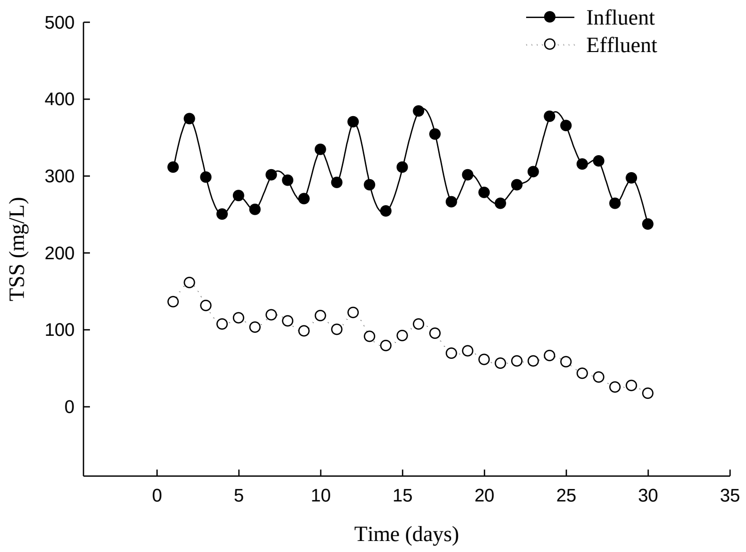

Figure 4.42 Variation for TSS

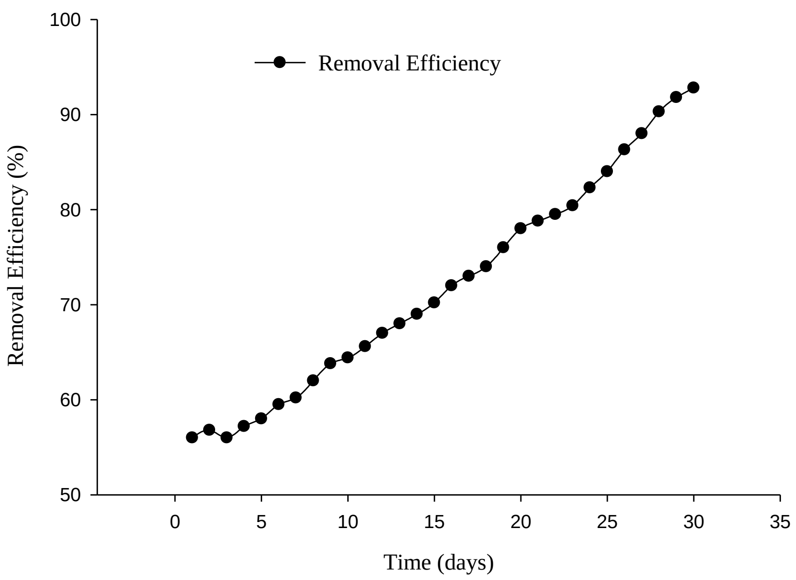

Figure 4.43 Removal efficiency for TSS

4.6.5 Variation for TS

TS removal efficiency started from the initial range of (fig-4.44) 54 % to 80 %. When the reactor was started the SRT and HRT were less so bacterial population was also less, but after few days the aerobic granules started to show up and then the bacterial population started to increase thus efficiency also increases.

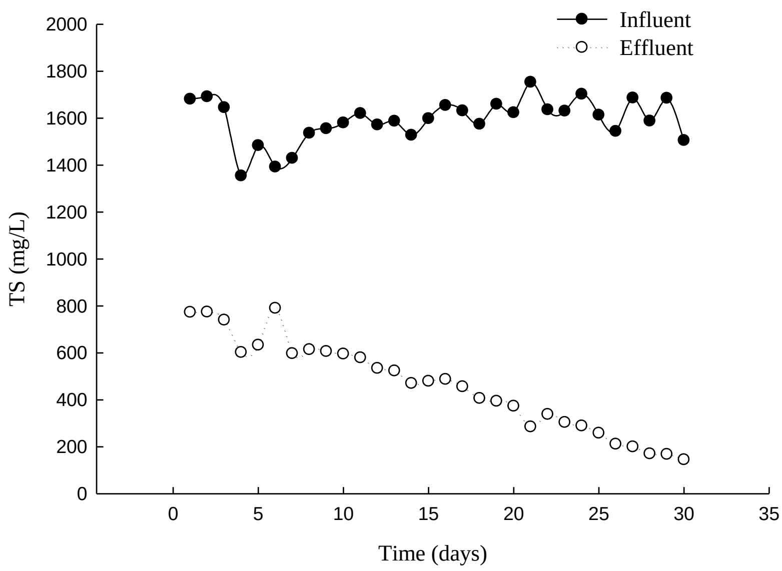

Figure 4.44 Variation for TS

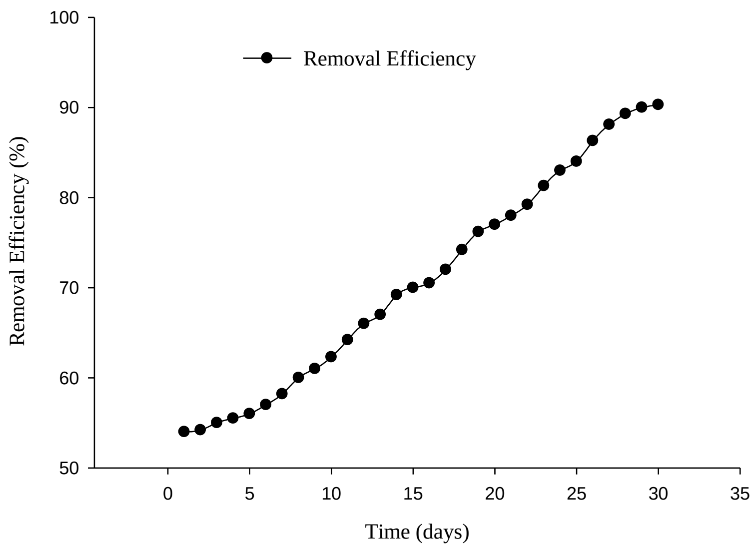

Figure 4.45 Removal efficiency for TS

4.6.6 Variation for DO

As dissolved oxygen is very necessary for the bacteria for its growth here the reaction time was 320 minutes. Initially the DO level was 4.22 mg/L and after the settle it was .15 mg/L. As the mixing takes place bacteria starts to consume the oxygen gradually and the DO concentration in the reactor decrease (fig 4.46).

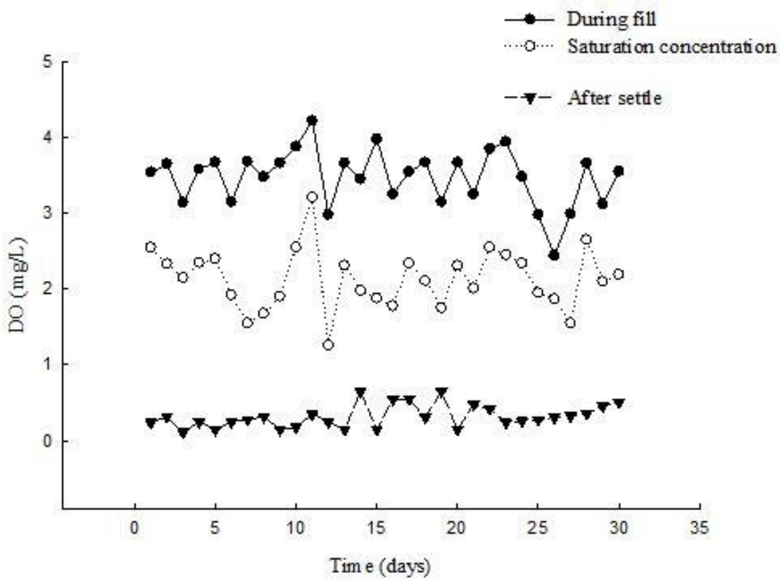

Figure 4.46 Variation for DO

CHAPTER 5

CONCLUSION

5.1 GENERAL

Now a day's water contamination is mainly one of serious problems due to lack of area for building STPs, lack of technology, overpopulation and industrialization. Sequencing batch reactor was built for the present study. Several parameters of the wastewater were tested and its variation of its characteristics.

5.2 CONCLUSIONS

In the present study we used SBR (Sequencing batch reactor) as an approach to treat wastewater (synthetic and domestic).

- In the present study we treated synthetically prepared wastewater and domestic wastewater taken from the JUIT treatment plant by the SBR.
- In the first phase of study we treated synthetic wastewater. The maximum removal efficiency for COD and TDS observed for 6h, 8h and 12h cycle times were 86.6 %, 88 %, 90 % and 82 %, 84 %, 88 %. The removal efficiency decreases with cycle time. The SBR was operated in aerobic phase in the study.
- In the second phase we treated domestic wastewater and maximum removal efficiencies for COD, BOD, TDS, TSS, TS for cycle time 4h is 84 %, 87%, 85 %, 86.9 % and 84.5% for 6h is 87.2 %,90 %, 87.7 %, 89.5 %, 86 % and for 8h is 90.7 %, 93% ,92.3 %, 92.8%, 90.3 % respectively.
- It is concluded that SBR is efficient for treatment of domestic wastewater as it gives maximum removal efficiency and can replace the conventional activated sludge process.

5.3 SCOPE FOR FUTURE WORK

As SBR is updated version of the conventional activated sludge process it is seen that it requires less area and basins as in ASP. Areas were the land requirement is less the SBR is feasible technology for the wastewater treatment. In SBR the returned activated sludge is not required as in ASP. In SBR we can modify the cycles times which makes it flexible to adapt to the effluent standards given by the board authorities. The SBR is very economical as compared to the conventional ASP. So we can say that the SBR can be used as an alternative technology for the wastewater treatment.

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ANNEXURE A

A1 REACTOR DIAGRAMS

Fig. A.1 Experimental setup

Fig. A.2 During treatment of wastewater

Fig. A.3 Supernatant formed

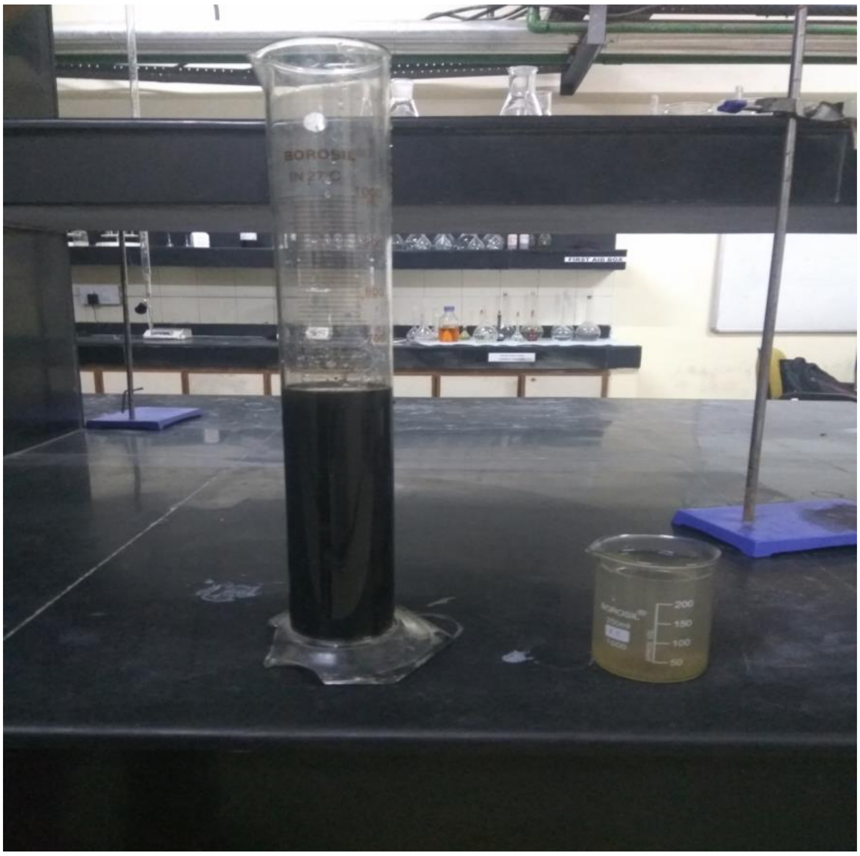

Fig. A.4 Sludge sample taken from JUIT plant

ANNEXURE B

B1 RESULTS FOR SYNTHETIC WASTEWATER FOR 6 H CYCLE

Table B.1 Results for COD for 6h

Days	Inlet (mg L)	Outlet (mg/L)	Overall Efficiency (%)
1	747	405	45.7
2	747	415	44.4
3	747	408	45
4	747	402	46
5	747	395	47
6	747	388	48
7	747	380	49
8	747	371	50
9	747	362	51.5
10	747	355	52
11	747	340	54
12	747	327	56
13	747	313	58
14	747	300	59.8
15	747	290	61
16	747	274	63
17	747	255	65
18	747	241	67
19	747	228	69
20	747	200	73
21	747	176	76
22	747	158	78.8
23	747	141	81
24	747	133	82
25	747	128	82.8
26	747	112	85
27	747	108	85.5
28	747	102	86
29	747	103	86
30	747	100	86.6

Table B.2 Results for TDS for 6h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	830	470	43
2	830	473	43
3	830	469	43.4
4	830	465	43.9
5	830	460	44.5
6	830	457	44.9
7	830	450	45.7
8	830	438	47
9	830	420	49
10	830	401	51
11	830	388	53
12	830	375	54
13	830	366	55
14	830	359	56.7
15	830	348	58
16	830	339	59
17	830	330	60
18	830	318	61.6
19	830	310	62.6
20	830	298	64
21	830	287	65
22	830	272	67
23	830	258	70
24	830	234	72
25	830	214	74
26	830	201	75
27	830	188	77
28	830	169	79
29	830	154	81
30	830	147	82

Table B.3 Results for DO for 6h

Days	During fill	Saturation Concentration	After settle
1	7.7	2.44	0.44
2	7.4	2.12	0.23
3	8.11	2.89	0.72
4	8.13	3.08	0.53
5	7.69	2.5	0.78

6	7.48	2.76	0.44
7	7.96	2.51	0.38
8	8.88	2.53	0.47
9	8.65	2.84	0.95
10	8.87	2.36	0.26
11	8.11	2.22	0.77
12	7.99	2.47	0.84
13	7.72	2.19	0.76
14	7.59	1.87	0.89
15	8.3	1.33	0.67
16	8.21	2.51	0.89
17	8.4	2.84	1.1
18	7.58	2.13	0.78
19	7.77	2.8	0.66
20	6.78	1.99	0.87
21	7.41	1.78	0.9
22	7.54	1.62	1.47
23	8	2.48	0.82
24	7.32	2.69	0.49
25	7.98	2.73	0.55
26	7.84	2.47	0.39
27	7.22	2.99	0.61
28	7.65	2.23	0.49
29	7.84	2.1	0.37
30	7.53	1.49	0.83

B2 RESULTS FOR SYNTHETIC WASTEWATER FOR 8 H CYCLE

Table B.4 Results for COD for 8h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	747	381	48.9
2	747	383	48.7
3	747	379	49.2
4	747	380	49.1
5	747	376	49.6
6	747	360	51.8
7	747	345	53.8
8	747	340	54
9	747	335	55
10	747	328	56
11	747	310	58

12	747	301	59.7
13	747	292	60.9
14	747	276	63
15	747	259	65.3
16	747	248	66
17	747	225	69
18	747	219	70
19	747	192	74
20	747	180	75
21	747	168	77
22	747	154	79
23	747	141	81
24	747	138	81
25	747	129	82
26	747	118	84
27	747	108	85
28	747	99	86
29	747	90	88
30	747	95	87

Table B.5 Results for TDS for 8h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	830	451	45.6
2	830	447	46
3	830	435	47
4	830	418	49
5	830	398	52
6	830	381	54
7	830	362	56.3
8	830	357	56.9
9	830	340	59
10	830	336	59.5
11	830	330	60
12	830	328	60
13	830	320	61
14	830	310	63
15	830	301	64
16	830	288	65
17	830	268	68
18	830	255	69

19	830	223	73
20	830	211	74
21	830	216	74
22	830	198	76
23	830	188	77
24	830	175	79
25	830	160	80
26	830	157	81
27	830	151	82
28	830	147	82
29	830	140	83.1
30	830	132	84

Table B.6 Results for DO for 8h

Days	During fill	Saturation concentration	After 2h	After settle
1	7.64	4.12	2.56	0.55
2	8.1	4.6	2.34	0.32
3	8.11	3.84	2.98	0.78
4	8.13	3.47	3.12	0.35
5	7.96	3.78	2.5	0.87
6	7.84	3.95	2.67	0.86
7	7.96	3.47	2.15	0.38
8	8.88	4.11	2.35	0.74
9	8.54	4.85	2.48	0.59
10	8.78	4.2	2.63	0.62
11	8.11	4.5	2.22	0.77
12	7.99	3.84	2.74	0.84
13	7.27	3.59	2.91	0.67
14	7.59	4.26	1.87	0.98
15	8.03	3.35	1.33	0.57
16	8.12	3.37	2.15	0.98
17	8.4	4.2	2.84	1.1
18	7.85	3.88	2.31	0.78
19	7.77	3.58	2.8	1.21
20	6.87	3.9	1.99	0.87
21	7.14	4.1	1.87	0.9
22	7.54	3.5	1.26	1.47
23	8	3.78	2.84	0.82
24	7.23	3.65	2.96	0.94
25	7.89	3.3	2.37	1.2

26	7.48	3.4	2.47	0.93
27	7.22	3.7	2.99	0.99
28	7.65	4.2	2.6	0.94
29	7.84	3.9	2.1	0.92
30	7.35	3.87	1.94	0.57

B3 RESULTS FOR SYNTHETIC WASTEWATER FOR 12 H CYCLE

Table B.7 Results for COD for 12 h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	747	370	50
2	747	371	50
3	747	367	51
4	747	361	51.6
5	747	354	52.6
6	747	341	54
7	747	327	56
8	747	309	58
9	747	292	60
10	747	280	62
11	747	263	64.7
12	747	251	66
13	747	233	68
14	747	221	70
15	747	201	73
16	747	188	74
17	747	169	77
18	747	151	79
19	747	138	81
20	747	121	83
21	747	113	84
22	747	99	86
23	747	91	87
24	747	85	88
25	747	82	89
26	747	80	89
27	747	78	89.5

28	747	71	90
29	747	70	90
30	747	68	90

Table B.8 Results for TDS for 12h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	830	442	46.7
2	830	439	47
3	830	440	46
4	830	437	47
5	830	435	47.5
6	830	430	48
7	830	419	49
8	830	405	51
9	830	397	52
10	830	385	53.6
11	830	374	55
12	830	359	56
13	830	341	58
14	830	322	61
15	830	308	62
16	830	298	64
17	830	286	65
18	830	266	67
19	830	251	69
20	830	237	72
21	830	221	73
22	830	211	74
23	830	193	76
24	830	178	78
25	830	159	80
26	830	141	83
27	830	129	85
28	830	111	86
29	830	102	87
30	830	97	88

Table B.9 Results for DO for 12h

Days	During fill	Saturation concentration	After 2h	After 2h	After settle
1	7.22	4.21	2.47	1.77	0.25
2	7.9	4.6	2.24	1.37	0.44
3	7.68	3.65	2.34	1.3	0.18
4	8.4	3.57	3.1	2.11	0.97
5	7.69	3.78	2.6	1.2	0.47
6	7.55	3.57	3.4	2.8	0.99
7	7.64	3.45	3.6	2.34	1.11
8	8.13	4.21	2.45	1.57	0.33
9	8.54	4.56	2.54	1.35	0.77
10	8.1	4.2	2.67	1.97	0.34
11	7.24	4.5	2.34	1.34	0.17
12	7.99	3.58	2.75	1.99	0.78
13	7.27	3.67	2.36	1.34	0.37
14	7.59	4.21	3.21	2.3	1.1
15	7.56	3.7	3.7	2.4	0.87
16	8.12	3.21	2.67	1.99	0.37
17	8.4	4.2	2.35	1.57	0.38
18	7.24	3.24	2.7	1.84	0.47
19	7.77	3.37	2.45	1.34	0.26
20	6.67	3.1	2.01	1.21	0.31
21	7.41	4.21	2.37	1.34	0.56
22	7.54	3	2.76	1.37	0.48
23	7.29	3.67	2.66	1.88	0.37
24	7.23	3.65	2.18	1.17	0.32
25	7.9	3.27	2.34	1.37	0.67
26	7.48	3.61	2.18	1.67	0.36
27	7.22	3.7	2.67	1.78	0.45
28	7.28	4.3	2.37	1.78	0.58
29	7.84	3.9	2.98	1.55	0.76
30	7.35	3.87	2.13	1.22	0.53

B4 RESULTS FOR DOMESTIC WASTEWATER FOR 4 H CYCLE

Table B.10 Results for COD for 4h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	628	333	46.9
2	612	321	47.5
3	594	310	47.8

4	645	394	48
5	675	375	48
6	615	313	49
7	630	308	51
8	580	270	53
9	600	275	54
10	618	265	55
11	594	250	57.9
12	672	280	58.3
13	635	250	60
14	609	133	61.7
15	572	210	63.2
16	618	220	64.4
17	629	221	65.7
18	598	200	66.55
19	630	201	68.1
20	655	205	69.2
21	589	175	70
22	612	173	71.4
23	601	165	72.5
24	561	148	73.6
25	613	153	75
26	581	139	76
27	588	129	78
28	609	121.8	80
29	617	111	82
30	630	100	84

Table B.10 Results for BOD for 4 h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	128	65	49
2	120	61	49
3	150	75	50
4	175	85	51
5	148	70	52.4
6	121	56	53
7	154	71	55
8	184	80.9	56
9	151	64.9	57
10	148	62	58
11	132	54	59

12	112	46.3	61
13	128	47.3	63
14	141	50.7	64
15	121	41	66
16	181	60	67
17	154	49	68
18	131	39	70
19	142	39.7	72
20	128	34	73
21	131	33	74
22	139	28	76
23	126	28.6	77
24	130	21	78
25	118	51.2	81
26	111	17.76	82
27	119	17.85	84
28	130	18.2	85.6
29	126	16.38	86.2
30	139	18	87

Table B.11 Results for TDS for 4h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	1273	585	54
2	1145	526	54
3	1092	499	54.3
4	1209	535	55.7
5	1043	456	56.2
6	1361	586	56.9
7	1294	556	57
8	1045	436	58.2
9	1306	525	59.8
10	998	391	60.8
11	1370	520	62
12	1317	480	63.5
13	1347	470	65.1
14	1104	366	66.8
15	1209	751	67.8
16	1136	325	69
17	1128	338	70
18	1242	356	71.3
19	1285	349	72.8

20	1246	323	74
21	1329	318	76
22	1201	278	76.8
23	1299	289	77
24	1273	268	78.9
25	1287	270	79
26	1270	228	82
27	1218	200	83.8
28	1215	184	84.8
29	1219	182	85
30	1233	184	85

Table B.12 Results for TSS for 4h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	298	146	51
2	250	122	51.2
3	274	134	51
4	256	122	52
5	311	148	52.3
6	294	139	52.7
7	270	126	53
8	334	151	54.6
9	291	129	55.8
10	370	162	56
11	288	121.5	57.8
12	267	108.9	59.2
13	277	108.8	60.7
14	237	92	61
15	315	116	63
16	301	108	64
17	295	100	65.8
18	237	79	66.7
19	247	79	68
20	216	64	70
21	294	81	72.3
22	231	59	74.3
23	288	69	76
24	264	57.5	78.2
25	311	65	79
26	272	53	80.5
27	248	41.6	83.2

28	237	36	84.5
29	218	30.5	86
30	299	39	86.9

Table B.13 Results for TS for 4h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	1571	801	49
2	1395	711	49
3	1366	681	50.1
4	1465	720	50.8
5	1354	663	51
6	1655	797	51.8
7	1564	735	53
8	1379	624	54.7
9	1597	707	55.7
10	1368	588	57
11	1658	696	58.2
12	1584	638	59.7
13	1624	628	61.3
14	1341	496	63
15	1524	542	64.4
16	1437	478	66.7
17	1423	455	68
18	1479	446	69.8
19	1532	427	72.1
20	1462	383	73.8
21	1623	405	75
22	1432	323	77.4
23	1587	341	78.5
24	1537	310	79.8
25	1598	306	80.8
26	1542	282	81.7
27	1466	252	82.8
28	1452	235	83.8
29	1437	230	84
30	1532	237	84.5

Table B.14 Results for DO for 4h

During fill	Saturation	After settle
1	3.28	0.33
2	3.77	0.25
3	2.94	0.64
4	3.78	0.11
5	3.67	0.23
6	3.95	0.34
7	3.48	0.12
8	3.78	0.15
9	3.24	0.7
10	3.68	0.45
11	3.28	0.32
12	3.77	0.16
13	3.88	0.24
14	3.67	0.08
15	3.64	0.11
16	2.94	0.26
17	2.66	0.48
18	3.8	0.64
19	2.67	0.25
20	2.59	0.13
21	2.84	0.14
22	3.55	0.26
23	3.6	0.19
24	3.9	0.26
25	3.4	0.24
26	3.33	0.31
27	3.67	0.36
28	2.97	0.28
29	2.65	0.15
30	2.88	0.19

B5 RESULTS FOR DOMESTIC WASTEWATER FOR 6 H CYCLE

Table B.15 Results for COD for 6h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	598	310	48
2	632	325	48.5
3	577	294	49
4	625	316	49.3

5	684	355	48
6	634	318	49.8
7	557	278	50
8	598	294	50.8
9	567	274	51.5
10	548	257	53
11	633	289	54.2
12	648	258	56
13	612	261	57.2
14	563	230	59
15	587	234	60.1
16	684	260	62
17	624	223	64.2
18	537	183	65.9
19	684	223	67.3
20	555	172	69
21	597	167	72
22	523	138	73.6
23	546	132	75.8
24	597	137	77
25	648	136	79
26	638	126	80.2
27	599	101	83
28	634	98	84.5
29	588	77	86.9
30	511	65	87.2

Table B.16 Results for BOD for 6h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	123	60	51
2	118	57	51.3
3	128	61	52
4	134	63	52.6
5	126	59	53
6	145	66.9	53.8
7	98	44	55
8	135	59	56.2
9	145	62	57
10	137	55.8	59.2
11	155	60	61
12	132	49	62.7

13	127	47	63
14	126	42.8	66
15	124	39	68.1
16	135	40	70
17	141	39	72
18	112	28	74.5
19	122	30	75
20	123	28.5	76.8
21	164	32.6	80.1
22	141	20	82
23	132	21	83.9
24	116	17	85
25	109	14	87
26	127	161	87.3
27	136	15	88.7
28	128	15	88
29	139	15	89
30	111	11	90

Table B.17 Results for TDS for 6h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	1204	530	56
2	1062	464	56.3
3	1008	453	55
4	1198	517	56.8
5	1086	467	57
6	1445	598	58.6
7	1165	477	59
8	1440	570	60.4
9	1071	407	62
10	1057	391	63
11	1284	444	65.4
12	1249	412	67
13	1375	440	68
14	1074	332	69
15	1266	367	71
16	1145	311	72.8
17	1129	300	73.4
18	1209	302	75
19	1202	288	76
20	1185	271	77.1

21	1278	281	78
22	1144	234	79.5
23	1333	253	81
24	1226	203.5	83.4
25	1214	182	85
26	1170	168	85.6
27	1175	164.5	86
28	1131	144.7	87.2
29	1137	147.8	87
30	1195	146.9	87.7

Table B.18 Results for TSS for 6h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	313	143.9	54
2	297	134	54.7
3	348	160	54
4	258	116	55
5	279	124	55.5
6	319	143.5	55
7	333	143	57
8	215	90	58
9	384	159	58.5
10	311	124	60
11	374	142	62
12	298	109	63.4
13	250	87.5	65
14	274	92	66.4
15	256	81.9	68
16	311	376	69
17	294	85	71
18	270	74	72.5
19	334	84	74.8
20	291	69.8	76
21	370	77	79
22	288	57	80
23	254	233	81
24	311	52.8	83
25	384	61	84
26	354	53	85
27	313	44	86
28	294	35	88

29	300	33	89
30	326	34	89.5

Table B.19 Results for TS for 6h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	1517	728	52
2	1359	652	52
3	1356	644	52.5
4	1456	678.4	53.4
5	1365	616.9	54.8
6	1764	813	53.9
7	1498	689	54
8	1655	738	55.4
9	1455	640	56
10	1368	584	57.3
11	1658	686	58.6
12	1547	634	59
13	1625	650	60
14	1348	512	62
15	1522	551	63.8
16	1456	519	64.3
17	1423	483	66
18	1479	473	68
19	1536	460	70
20	1476	413	72
21	1648	425	74.2
22	1432	358	75
23	1587	380	76
24	1537	348	77.3
25	1598	335	79
26	1524	278	81.7
27	1488	525	83
28	1425	234	83.6
29	1437	221	84.6
30	1521	213	86

Table B.20 Results for DO for 6h

During fill	Saturation concentration	After 2h	After settle
1	3.88	1.88	0.28
2	3.15	1.45	0.22
3	2.97	1.37	0.36
4	2.66	1.65	0.15
5	2.48	1.77	0.44
6	3.26	1.67	2.47
7	3.45	1.86	0.26
8	3.55	1.34	0.35
9	3.78	1.26	0.19
10	3.95	1.98	0.37
11	2.88	1.67	0.15
12	2.54	1.84	0.67
13	2.11	1.26	0.15
14	3.55	1.37	0.35
15	3.48	1.19	0.15
16	3.66	1.68	0.36
17	3.78	1.67	0.65
18	3.66	1.55	0.55
19	3.24	1.57	0.15
20	2.88	1.37	0.24
21	2.67	1.68	0.31
22	2.48	1.84	0.15
23	3.48	1.68	0.67
24	3.67	1.67	0.48
25	3.19	1.78	0.37
26	3.58	1.55	0.15
27	3.65	1.21	0.35
28	3.67	1.13	0.64
29	3.77	1.18	0.54
30	3.48	1.51	0.15

B6 RESULTS FOR DOMESTIC WASTEWATER FOR 8 H CYCLE

Table B.21 Results for COD for 8h

Days	Inlet (mg/L)	Outlet (mg/L)	Overall Efficiency (%)
1	548	274	50
2	633	308	51.3

3	648	311	52
4	612	290	52.6
5	563	264	53
6	587	275	53
7	684	314	54
8	624	272	56.4
9	537	229	57.2
10	684	277	59.5
11	555	220	60.2
12	597	228	61.7
13	635	234	63
14	609	212	65
15	572	186	67.4
16	618	195	68.4
17	629	188	70
18	598	165	72.3
19	630	160	74.5
20	655	154	76.4
21	589	128	78.2
22	612	120	80.3
23	601	108	82
24	561	90	83.9
25	613	88	85.6
26	622	77	87.5
27	598	71	88
28	574	60	89.4
29	601	60	90
30	579	53	90.7

Table B.21 Results for 8h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	155	70	53
2	143	67	53
3	146	67	53.8
4	135	61	54.2
5	139	62	54.8
6	141	63	55.2

7	149	65	56
8	133	57	56.7
9	157	65	58.6
10	137	54	60.2
11	111	40	63.1
12	123	43	65
13	166	57	66.9
14	145	45	68.4
15	123	36	70.1
16	134	38	72
17	119	30	74
18	122	29	76.2
19	167	36	78.2
20	132	26	80.1
21	112	19	83
22	128	19	85.3
23	141	20	87.4
24	121	14	88.6
25	135	14	89.5
26	128	12	90.4
27	137	12	91
28	126	9	92.8
29	121	10	93
30	113	13	93

Table B.22 Results for TDS for 8h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	1370	575	58
2	1317	545	58.6
3	1347	548	59.3
4	1104	452	59
5	1209	488	59.6
6	1136	452	60.2
7	1128	428	62
8	1242	447	64
9	1285	443	65.5
10	1246	408	67.2
11	1329	418	68.5
12	1201	354	70
13	1299	359	72.3
14	1273	330	74

15	1287	311	75.8
16	1270	292	77
17	1277	274	78.5
18	1308	313	79
19	1358	268	80.2
20	1345	243	81.9
21	1489	253	83
22	1348	215	84
23	1325	177	86.2
24	1266	164	87
25	1248	143	88.5
26	1229	126	89.7
27	1367	136	90
28	1324	123	90.7
29	1388	138	91
30	1268	117	92.3

Table B.23 Results for TSS for 8h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	311	136	56
2	374	161	56.8
3	298	131	56
4	250	107	57.2
5	274	115	58
6	256	103	59.5
7	301	119	60.2
8	294	111	62
9	270	98	63.8
10	334	118	64.4
11	291	100	65.6
12	370	122	67
13	288	91	68
14	254	79	69
15	311	92	70.2
16	384	107	72
17	354	95	73
18	266	69	74
19	301	72	76
20	278	61	78

21	264	56	78.8
22	288	59	79.5
23	305	59	80.4
24	377	66	82.3
25	365	58	84
26	315	43	86.3
27	319	38	88
28	264	25	90.3
29	297	27	91.8
30	237	17	92.8

Table B.24 Results for TS for 8h

Days	**Inlet (mg/L)**	**Outlet (mg/L)**	**Overall Efficiency (%)**
1	1681	773	54
2	1691	774	54.2
3	1645	740	55
4	1354	602	55.5
5	1483	633	56
6	1392	790	57
7	1429	597	58.2
8	1536	614	60
9	1555	606	61
10	1580	595	62.3
11	1620	579	64.2
12	1571	534	66
13	1587	523	67
14	1527	470	69.2
15	1598	479	70
16	1654	487	70.5
17	1631	456	72
18	1574	406	74.2
19	1659	394	76.2
20	1623	373	77
21	1753	285	78
22	1636	338	79.2
23	1630	304	81.3
24	1702	289	83
25	1613	258	84
26	1544	211	86.3
27	1686	200	88.1
28	1588	170	89.3

29	1685	168	90
30	1505	145	90.3

Table B.25 Results for DO for 8h

During fill	**Saturation concentration**	**After 2h**	**After settle**
1	3.54	2.55	0.24
2	3.65	2.33	0.32
3	3.14	2.15	0.11
4	3.58	2.35	0.25
5	3.67	2.4	0.15
6	3.15	1.92	0.25
7	3.68	1.55	0.28
8	3.48	1.68	0.32
9	3.66	1.9	0.15
10	3.88	2.55	0.18
11	4.22	3.21	0.35
12	2.98	1.26	0.25
13	3.66	2.31	0.15
14	3.45	1.98	0.65
15	3.98	1.88	0.15
16	3.25	1.78	0.545
17	3.55	2.34	0.55
18	3.67	2.11	0.31
19	3.15	1.75	0.65
20	3.67	2.31	0.15
21	3.25	2.01	0.48
22	3.85	2.55	0.42
23	3.94	2.45	0.24
24	3.48	2.34	0.26
25	2.98	1.95	0.28
26	2.44	1.87	0.31
27	2.99	1.55	0.33
28	3.66	2.65	0.36
29	3.12	2.1	0.46
30	3.55	2.19	0.51

B7 PUBLICATIONS

Vishv Kumar, Anirban Dhulia (2019). Review on SBR (Sequencing Batch Reactor) for Various Wastewater Treatment. Proceedings of the Indian Conference on Geotechnical and Geo-Environmental Engineering (ICGGE-2019) [MNNIT Allahabad: March 01-02, 2019], pp.58-70.