Study of Synthetic Wastewater using Sequencing Batch Reactor in Anoxic/Aerobic Phase

A

PROJECT REPORT

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

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

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May 2020

STUDENT'S DECLARATION

I hereby declare that the work presented in the project report entitled **"Study of Synthetic Wastewater using Sequencing Batch Reactor in Anoxic/Aerobic phase"** submitted for partial fulfilment of the requirements for the degree of bachelor of technology in civil engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Amardeep and Mr. Anirban Dhulia.** 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.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled "**Study of Synthetic Wastewater using Sequencing Batch Reactor in Anoxic/Aerobic Phase**" in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Amber Soni(161605), Ambuj Awasthi (161611) and Prasanna Kumar(161670)** under the supervision of **Dr. Amardeep and Mr. Anirban Dhulia** 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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ABSTRACT

Discharge of industrial wastewater without treatment is very harmful to the environment. Because of the industrialization and urbanization water sources are getting polluted. Therefore, treatment of any kind of wastewater to produce effluent with good quality is necessary. Sequencing batch reactor is a modification of activated sludge process which has been successfully used to treat municipal and industrial wastewater. A small scale SBR fabricated from acrylic sheet was used in this particular study to treat synthetic wastewater. The ratio of wastewater to seed sludge was fixed at 1:5. The reactor was operated for two different cycle time (2 hour, 3 hour) for the treatment process. Peak removal efficiency for 2 hour cycle for TS, COD, and BOD were 59.1%, 62.2%, 48.9% respectively. Peak removal efficiency for 3 hour cycle for TS, COD, and BOD were 66.7%, 67.9%, and 56.2%.

Keywords- *Sequencing Batch Reactor, Anoxic, Aerobic, Activated-Sludge, Synthetic Wastewater, TDS, TS, COD.*

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CHAPTER 1

INTRODUCTION

1.1 General

Industrial effluent when disposed without any treatment is detrimental to the surroundings. The exponential growth of manufacturing sector in the past few decades has led to contamination of water sources. Industrial wastewater requires treatment for removal of chemical or biological impurities. Commercial as well as household wastewater can effectively be treated by use of sequencing batch reactor which is an improved version of activated sludge process. A small-scale sequencing batch reactor was used for treatment in this study.

1.2 Background

Rapid growth of city's and industries along with growth of urban population led to detrimental sanitary conditions .Thus Nineteenth century marked the construction of first urban sewage disposal systems. Environmental and aesthetics were primary concerns in the later part of twentieth century. Decreasing the amount of total suspended solids (Tss), Bio-chemical oxygen demand (BOD) and pathogenic organisms were of utmost priority at that time. Industrial wastewater when disposed into surrounding streams or ponds often lead to eutrophication and cause algal bloom. This severely damages the aquatic life often killing a large population of certain species due to which strict regulations over discharge of waste have been enforced by pollution control bodies such as National Green tribunal. Increased public awareness in recent times about the benefits of clean water bodies such as better public health, better sanitary conditions and aquatic life encouraged construction of treatment facilities on a large scale. Rivers and streams have self-cleansing capacity by which the discharged waste get's cleaned by natural process. Self-cleansing capacity depends on many factors such as presence of bacteria for decomposition and flow rate of river. Wastewater treatment plants are used to bring down concentration of pollutants to levels which can be handled by nature.
Various steps of wastewater treatment are as follows-

1. Wastewater Collection- Sewage is collected from commercial centers, industries and residential area by use of drains and directed towards a treatment facility.

2. Screening- This steps insures removal of large objects such as plastics, polythene, wood, gravel cloths etc. Screening involves use of coarse screen , fine screen and micro screen.

3. Primary treatment- In this step wastewater is poured into a large tank and left undisturbed so that heavier impurities can settle at the bottom.

4. Secondary Treatment- A seed sludge is introduced into the tank of wastewater in order to decompose the impurities into harmless substances. Air is pumped by using aerators along with mixing action to promote bacterial growth. These bacteria consume organic matter by using oxygen and convert various pollutants into harmless substance.

5. Tertiary Treatment- This step further improves the quality of effluent but is quite expensive and is used only when water is to be reused for irrigation or recreation purposes.

6. Disinfection- A mixture of sodium hypochlorite and chlorine is used for the purpose of disinfection. This mixture is added to a tank containing effluent and disinfected for 20-25 minutes.

1.3 Objectives

- Study of synthetic wastewater in anoxic/aerobic phases in sequential batch reactor (SBR).
- To study the performance of sequencing batch reactor for various parameters (COD, TS, BOD, DO).

1.4 Need for study

Disposal to industrial wastewater without treatment into the surrounding in highly detrimental to the environment. To bring effluent within the concentration limits of agencies an effective as well as cost efficient process is required. SBR offers various advantages such as single tank configuration, small footprint, easily expandable, simple operations, and low capital cost. In sequential batch reactor removal efficiencies of various parameters depends upon the cycle time. Cycle time can be adjusted to meet the standards of effluent required.

CHAPTER 2

LITERATURE REVIEW

2.1 General

In its most basic form, the SBR system is a collection of tanks that operate by filling and drawing. Each tank in the SBR system is refilled within a specified time and serves as a batch response. After receiving the treatment, you need, a mixed drink will be allowed to finish and a free agent will be taken out of the tank. Each tank cycle in a standard SBR is divided into five filling periods: Fill, React, Settle, Draw and Idle as shown in the figure. There are many types of fill time and React, which vary depending on the mixing and mixing processes. Sludge spills may have occurred near the end of React, or during Settle, Draw or Idle.

2.2 Sequencing Batch Reactor

In the early 1900s, basic principles of biodegradation processes using activated sludge were developed by Ardern, Lockett and Fowler among others. Further development took place in the 1970s especially in Australia and the United States, with the help of the EPA and the publication of EPA's SBR Design Manuals in 1986 and 1992, led to widespread use of technology worldwide.

Central to SBR design is the use of a single tank for multiple aspects of wastewater treatment as shown in figure 2.1-

1) **Fill:** The influence on the tank can be contaminated water (filtered and discarded) or primary effluent as shown in (fig. 2.1). It can be touched in or allowed to flow with gravity. Feed capacity is determined based on many factors including the desired loading and time of incarceration and expected biological settling characteristics.

2**) React:** The biological reaction, which was started during reproduction, is eliminated during React. As with Fill, alternating concentrations of low oxygen concentration (e.g., Mixed React) and high concentration of total oxygen (e.g. Aerated React) may be required.

3**) Settle:** In SBR, solids diffusion occurs under quiescent conditions (e.g., without evaporation or evaporation) in the tank as shown in (fig. 2.1). This major advantage in the clarification process stems from the fact that the entire aeration tank acts as a precision during a period when no flow into the tank is possible.

4) **Draw (Decant):** The retractor may take one of several directions, including a fixed pipe in a limited area controlled by a automatic flow or pump, or a fixed or floating service in or under the roof. The time at Drawing, however, should not be excessively increased due to potential problems with increased sludge.

5) **Idle:** The time between Draw and Fill is called idle as shown in (fig. 2.1). Without its name, this "idle" time can be successfully used to destroy the resolved slide. While sludge disposal can be as common as home every 2 to 3 months, more time-consuming systems are recommended to slow down process progress and slide resolution.

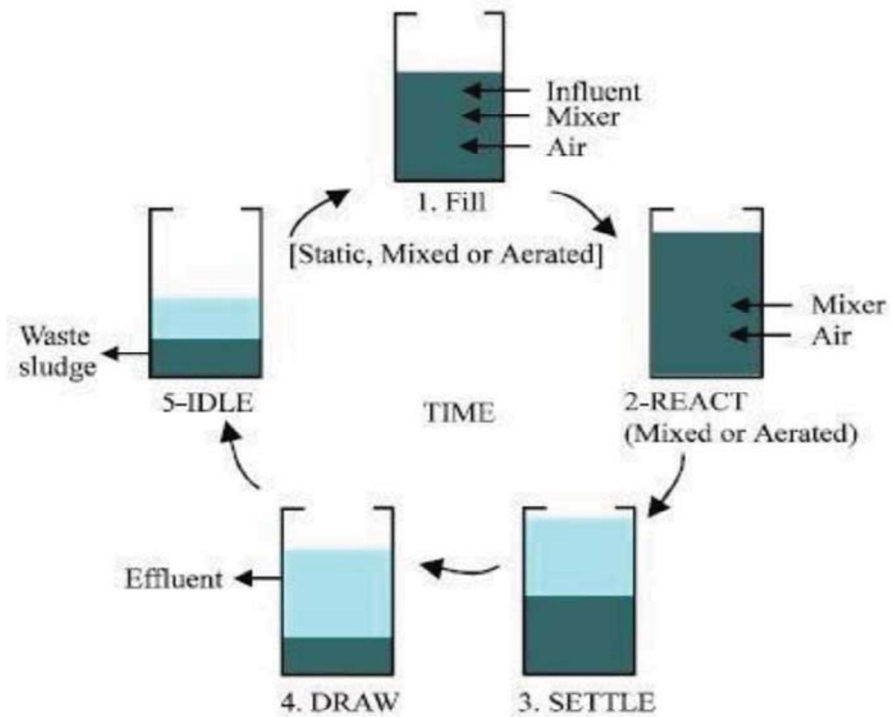

Figure 2.1 Cycles of SBR

2.3 Bacterial Growth in SBR

In the reaction batch when the accumulation of excess EPS (extracellular polymeric substances) is released into the system by microorganisms present in the system. EPS extracted from microorganisms in wastewater leads to a decrease in cell adhesion to the water and also alters the cost of cell surface leading to better germ cell growth and better adhesion of small cells and the cohesion where larger diameter machinery eventually leads to greater germ cell growth. Initially there are sludge sacs in the system but as the reactor is operating continuously these flocs are converted into large steel frames with a diameter of 0, mm. These granules are formed as a result of interactions in the shut-off process between the EPS, the microbial cell, and the ion. Viruses can be produced by binary fission, either in sexual mode or by germination. In a batch reactor the food comes depending on the organic matter when we feed it with the wastewater and the sludge is incurred with microorganisms in it. These microorganisms reproduce in binary outgrowth as most organisms survive and reproduce and become larger over time. These are microorganisms where the distribution of food exceeds these microorganisms that eat their own way and in the final stage of the treatment process the microorganism concentration decreases.

Bacteria growth in reactor takes place in 4 phases as shown in fig 2.2–

- The Lag Phase: With the addition of biomass, this underscores the need for biological time to adapt to new conditions prior to biomass generation and cell division.
- The Exponential Growth Phase: During this time the germ cell growth takes place at a tremendous rate, because there is no limit due to the elements of the world. Biomass growth curves increased during this period.
- The Stationary Phase: In this case the biomass accumulation remains stable over time and the rate of development decreases with the inactivation of cells.
- The Death (decline) Phase: At this stage, the substrate is removed. Significant decline observed.

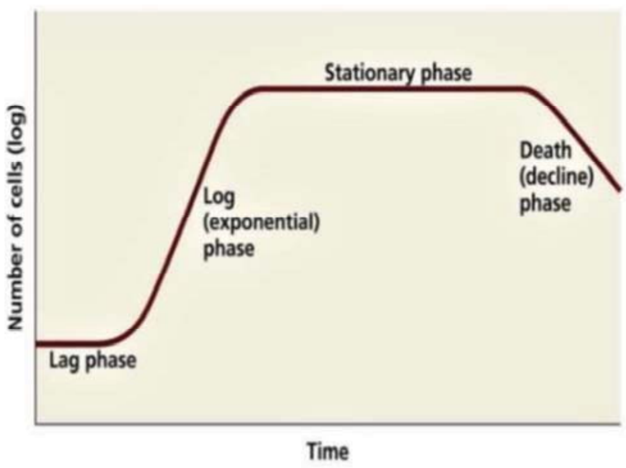

Figure 2.2 Bacterial Growth in SBR

2.4 Factors Affecting Performance of SBR

Temperature- Viral growth depends on temperature and very low temperatures will inhibit the growth of bacteria. Autotrophic bacteria are responsible for removing nitrogen and high temperatures stimulate their growth.

DO- Performance is one of the most important aspects of SBR operations. If DO concentration decreases, then the ammonia output also decreases and therefore we need to adjust the aeration rate and cycle time.

Cycle time-It is an important factor affecting the performance of the SBR. By changing the cycle time, we can conclude at what cycle time the removal efficiency is obtained. by changing the cycle time for example, the coupling and aeration increase nitration processes improve due to the presence of a good amount of DO of nitrogen-based autotrophs.

Mixing- Mixing improves biomass preparation and reactor performance by proper distribution of sludge to the reaction. A reactor is used to keep the sludge permanently suspended in the reactor.

Sludge Retention Time- The mean age of sludge resulting from high COD (94%), NH4-N (84%) and Po4-P (70%) of the six-day discharge was 10 days even though it resulted in 15 at slightly lower rates. The correct amount of SRT was found to be 10 days, resulting in the removal of the nutrients and the minimum SVI.

2.5 Uses of SBR

The batch reactor sequence is very useful for wastewater treatment. The SBR treats wastewater through the process discussed earlier with the help of sludge and provides aeration and proper mixing.

- For single batch reactor tank sequences are used we do not have a separate tank for solving and therefore solving, mixing and durability can be achieved in a single tank.
- Quality of outward water meets the need of BOD, COD, TS, TDS, TSS for on ground discharge.
- Power usage of SBR is lower in comparison to standard plant with finer power economy at lesser flows.
- Increased percent separation of all solids, BOD, COD and nitrogen which makes SBR very well ordered.

2.6 Literature Survey

Hamza et al. (2018) THIS reactor was read for 100 days, separated by two significant periods according to the OLR. In the first spraying phase, high-impact paintings were created and allowed to remain at an OLR of 10 ± 2.5 kg COD / m3 d for up to 41 days. In the second period of time (from 42 to day 100), the connected OLR was 27 ± 3.51 kg COD / m3 d. The COD output was 98% within 45 days of departure. However, as a result of increasing the OLR, the effective COD removal efficiency decreased positively by 64.77% from the daily average. Results from this demonstration of oxygen granulation can provide high-quality natural waste treatment technologies.

Zhang et al. (2018) Researched the effect of cadmium on nitration performance applied using SBR and noted that partial nitration is not affected when cadmium accumulation is less than 5mg / l but more than 10mg / l component nitration availability is affected by its removal rate decrease by 30%.

Abedinzadeh et al. (2018) From this observation, the COD removal efficiency of paper waste paper uses 10 SBR in combination with oxidation forms on the label scale. Reaction surface (RSM) strategy was used to monitor the SBR path. In the complete cases of COD initiation (1100 mg / l), MLSS (3100 mg / L) with a cycle length of 24 h, 75% COD, 58% exclusion concentration, and 85 mg / L SVI appear in pre-scheduling The use of Fenton oxidation after treatment improved the COD reduction once and for all while removing the shade.

Pulido et al. (2018) milk processing produces a large volume of wastewater that requires extensive reduction of nutrients before being released. Large business openings exist where cost effective technology is equipped to meet this need. In this case researchers have explored the use of SBR as a single tonnage management system for the removal of large amounts of parameters such as COD, nitrogen and phosphorus in the dairy industry. Changes in SBR aeration rates, (0.7, 0.5 and 0.3 L / min), affected the efficiency of nutrient removal. Aerationrateof0.6L / min wasbestandbroughtabout90% exclusionoforthophosphatesand ammonium, COD.

Neisi et al. (2018)the basic point of this study was to evaluate the biodegradation of Methyl Tertiary Butyl Ether using an aerobic sequential batch reactor (SBR). The conveyor is composed of a 3-mm room with a maximum size of 120 mm and a height of 600 mm. The SBR operates in five phases. The first stage was filling the reactor in 600 seconds. The second was the primary power source that planned the treatment of the wastewater for approximately 22 h. The third phase was a 60 minute breakdown / settlement. The fourth section was tapped on the reel for about 10min. The last section put inert for about 45 minutes. The precedents have shown that the synthetic microbial mixture can obtain high concentration of methanol 255 mg / l and, in addition, MTBE concentration up to 72 mg / l for a 24 h cycle.

Tang et al. (2018) It is being done to achieve the novel algal-bacterial beneficial co-creation benefit of removing nitrogen and phosphorus removal power. The effect of sexhibitedthattheTNandTPexpulsioninASBSBRwasexpandedto69.9% and 944.8% respectively. Experiments show that TN depletion essentially occurs in non-air circulation, in addition, TP outflow occurs in A-SBSBR. Occurred separately with respect to SBSBR administered, TN depletion by de-nitrization and anabolism in A-SBSBR increased from 12.7%, 7.7% and 50.13%.

Wang et al. (2018) research has been done on the important role of the charged slide at the beginning of the batch reaction sequence for the cultivation of granular sludge .In this case they took one inoculation sludge and stored in activated sludge. It was observed that granular sludge as inoculation sludge produces mature granule after desistingfor22daysandhasmorebacterialaccumulationandhasbetterefficiencythantheactivated sludge.

Wei et al (2018) research has been done on the removal of organic pollutants by batch reactionor followed by nano addition from municipal wastewater treatment and the results showed that99 (organicmicropollutants) showgoodorganicremovalwhichisover60%, six OMPs showed average removal from the most active compounds -30 (70 to 70%) and 10 OMPs rather than 40%.

Trelles et al. (2017) In this case, the settling jar test was performed on a 1 L cylindrical tube. The basic method that can be considered for solving fractions as part of the fabric is produced. In addition, a wide range of linkages between the sludge volume fraction and the half were found. This procedure yields good results for calibration of the volume sludge volume at a range of 30 and 240 mL / g.

Kargi and Uygur(2017) Research has been done on the effectiveness of batch reactor removal as a sludge age and the results show that the highest sludge ages maximum COD (94%) andPO4 (70%) removal efflux efficiencieswere10daysalthough15daysof SRT resulted in the lowest values. The correct amount of SRT was found to be 10 days leading to high doses and minimSV1.

Bakare et al. (2017) In this case they studied launch sequences supported under low air circulation and cyclic air circulation in the control of draw waterfrombottlingwork.Constantlow airdisseminationplotwasreliedupontochoose with the effect of making a reactor with a natural exhaust with a standard deviation of air flow. The output of the two-research facility is determined by the magnitude of the output of the reactive oxygen application and the bio oxygen application. These two components are selected as important toxins and environmental components in the wastewater treatment plant.Experimental results have shown that the decrease in oxygen demand and oxygen bio bioaccumulation application in the wastewater generated in the installation works can be successfully implemented using both air circulation systems. Besides, the success of the treatment up to the chase of oxygen application was maintained more than 91% and the biological interest was obviously 83% higher with a reactor operating under less flexible air circulation that was much more efficient than the terminal operating under the air circulation system. -cyclic.

Popple et al. (2016) This investigation provides an account of the improvement of the research facilities to redesign the SBR. Tools used for research with radioactive propranolol. An SBR with a 5-liter active volume was used in the 8-hour cycle for sewage. Propanol was extracted by single and continuous substitution reactions with more than 12 cycles of SBR. During regular dementia, 62% to 73% of propranolol was removed from the reported, yet less than 4% a fraction doubled as 14 CO2, suggesting that the biological process was minimal and that adsorbed from solids, which give rise to collections within the biomass for 17 days. duration of solids storage in SBR.

Mohan et al. (2016) In the SBR this was an open source granular sludge capable of producing high levels of nitrates. A significant accumulation of nitrite was observed in nitridations incomplete when SBR was supplied at 5425 mg / L with a C / N component of 2. The results indicate that substrate preparation plays a very important role in high nitrate recycling by affecting nitrite accumulation.

Muhamad et al (2015)research has been done on the comparative efficacy of the attached-enlarged- growth SBR systems in the treatment of recycled wastewater and the results show that the ratio of COD, turbidity, nitrogen, phosphorus, SS and color reduction rates in attachment growth of SBR in addition biomass was 95%, 95%, 86%, 60%, 92% and 82% respectively and operating systems using only GAC or biomass depending on the efficiency and stability of the process under load flexibility of biology.

Wang et al (2015) in this study two types of inoculation sludge are used namely activated sludge and granular sludge which is stored. Granular sludge is stored for a period of time. When granular sludge was used in Sequencing batch reactor a higher bacterial growth was observed compared to activated sludge reason being the growth of mature granules after 20 days of operation which help in increasing bacterial growth.

Rodríguez et al (2002) research has been done to monitor nitrogen removal through the nitrification- denitrification process in batch sequins and the results show that the batch reaction sequence in the treatment system is suitable to form a combined substance for removing organic and ammonia, nitrogen from the river water in the company's meat processing company.

2.7 Summary

If we use magnetic energy in a batch reaction sequence it will give us a higher ability to remove ammonia and oxygen requirements i.e. (7.76% and 4.76% higher) compared to standard SBR (excluding magnetic). The correct amount of SRT was found to be 10 days, resulting in the removal of the nutrients and the minimum SVI. High removal efficiency was achieved by removal of nitrogen and phosphorus at low temperatures. Better performance was observed when the reactor was operating under Continuous low action than that of the reactor operating under cyclic aeration.

CHAPTER 3

METHODOLOGY

3.1 General

This particular section deals with the methods involved in performing this experiment and the chemicals description and the seed sludge used from where and how much organic content it contains. The collected sludge is aerobic granular sludge, which has high speed and high bacterial abundance. The greatness of bacteria is the conversion of sludge into aerobic granules, which are spherical in shape and with larger diameter, increase the diameter of alveolar grains during granulation. Sludge plays an important role in the treatment process as it contains microorganisms for wastewater treatment.

3.2 Experimental Setup

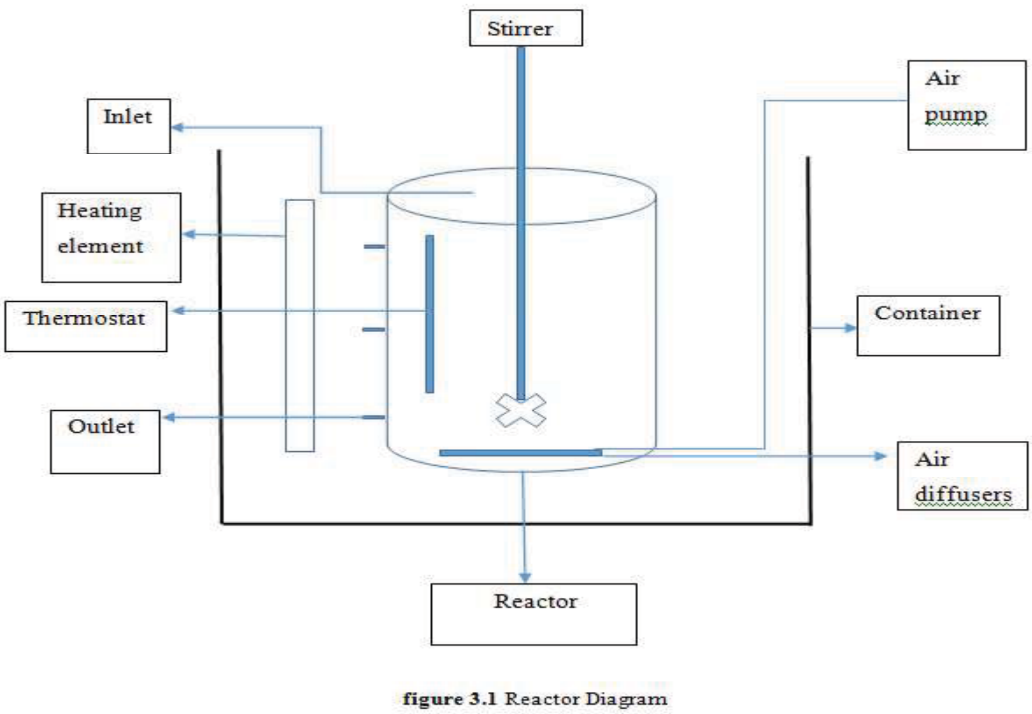

Figure 3.1 Reactor Design

Reactor- A reactor is built as shown in (fig. 3.1), It treats influent wastewater which have a working volume of 3.5 l and a total volume of 6 l with 3 openings.

Mixer- A stirrer is utilized as demonstrated in(fig 3.1) for legitimate scattering of sludge in the reactor and furthermore with the goal that sludge stays suspended in the reactor the mixing rate utilized is 300-400rpm and it mounted over the reactor..

3.3 Design of reactor

A lab scale circular SBR with working volume of 3 liters will be utilized as appeared in (fig 3.1) in the observation. Air circulation will be finished utilizing stone air diffusers. For blending in anoxic stage lab stirrer will be utilized. The material of round reactor is made by utilizing straightforward acrylic sheet. Reactors height is 210 mm and inner distance across is 190 mm in which the working stature is 110 mm and 50 mm is for freeboard and 50 mm from the base for sludge. The reactor is made temperature controlled utilizing a compartment loaded up with water and in this the water warming component is set up with the indoor regulator fixed at a temperature of (20º C ± 2º C). The proportion for seed sludge is 1:5

3.4 Composition of Wastewater

Composition	Concentration (mg/l)
SODIUM SULPHATE ($NaSO_4$)	100
SODIUM ACETATE (CH_3COONa)	500
POTASSIUM PHOSPHATE (K_3PO_4)	57
GLUCOSE ($C_6H_{12}O_6$)	200
AMMONIUM CHLORIDE (NH_4Cl)	85

Table 1 Composition of Waste water

3.5 Collection of Sludge

Sludge was sourced from JUIT Solan water treatment plant. Fresh sludge was used for treatment process as the sludge obtained from treatment plant was semi solid in nature.

Ratio of sludge to wastewater was one is to five. Sludge plays the most crucial role in treatment process as it contains the bacteria required for treatment of wastewater. The collected sludge was rich is bacteria and a high settling coefficient. Flocs of sludge get's converted to granules and with subsequent cycles these granules grow in size. Bigger granules provide larger surface area for bacteria to stick and thus improving the efficiency of removal.

3.6 Operation of Reactor

In reactor operation we utilize two SBR which was loaded up with 3.5 L (fig3.1) of influent wastewater. In which seed sludge in 1:5 is vaccinated. Both SBR's are loaded up with engineered wastewater. In this we perform two patterns of 5 stages having time length of 2h, 3h. At the point when the fill stage begins, the influent wastewater comes in the reactor body. After that respond stage comprises a high impact and anaerobic procedure. The wastewater in the reactor body was blended by a 4 bladed stirrer cutting edges having span of 2 cm and air was provided at the pace of 1.5l/min1with aerators fitted with air diffusers during the oxygen consuming stage in the reactor bowl and permeable diffusers are utilized for appropriate scattering of air. During settle period a layer of thick sludge was shaped at the base which was expelled during the inert stage. During draw stage clear water is gotten at the top as muck gets settled down the reasonable water at the top is known as which was then supernatant was evacuated. The profluent emptied was gathered and test investigation is finished.

3.7 Parameters to Be Analyzed

The influent and the effluent wastewater water are analyzed for various parameters listed below :

- Biochemical oxygen demand
- Chemical oxygen demand
- Total Solids
- Dissolved Oxygen

The BOD, COD, TS were estimated according to standard technique as indicated by (APHA, 2005). DO is estimated utilizing DO meter. Its essential to take note of that Suspended Solids were absent as the wastewater was prepared utilizing distilled water and by this Total Solids were equivalent dissolved solids.

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CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 General

This particular section deals with the results which we have collected from the experiments performed and discussion on that results. In the previous chapters we have discussed the methods and parameters which needs to be identified in this particular chapter. Later, in this chapter we have discussed the results based on seasonal variation and different hour's cycle. The discussion is done for both variations as well as removal efficiency and accordingly conclusion is drawn. In some cases temperature plays an important role and in some there is greater cycle time but generally it is said that greater cycle gives greater removal efficiency as temperature can be controlled manually.

4.2 Results for 2hr cycle

4.2.1 Variation for Total Solids removal

4.2.1.1 SUMMER VARIATION (PHASE 1)

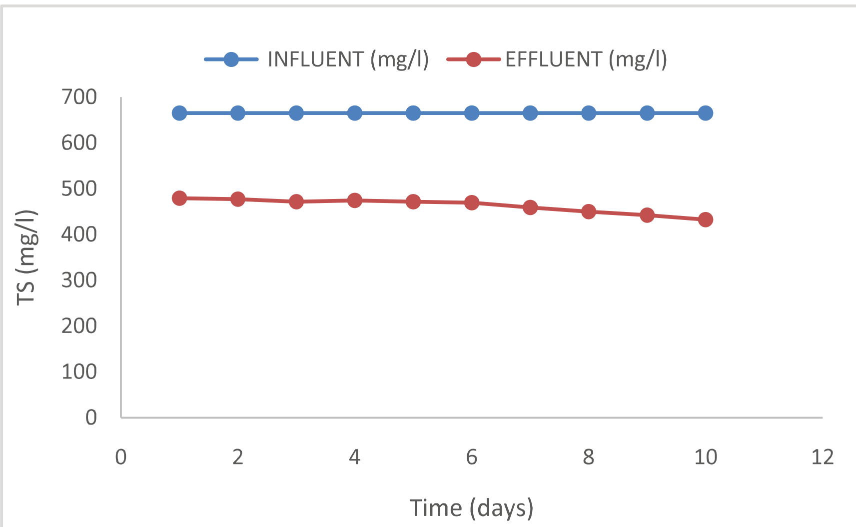

Figure 4.1 Variations for total solids (summer variation)

4.2.1.2 WINTER VARIATION (PHASE 2)

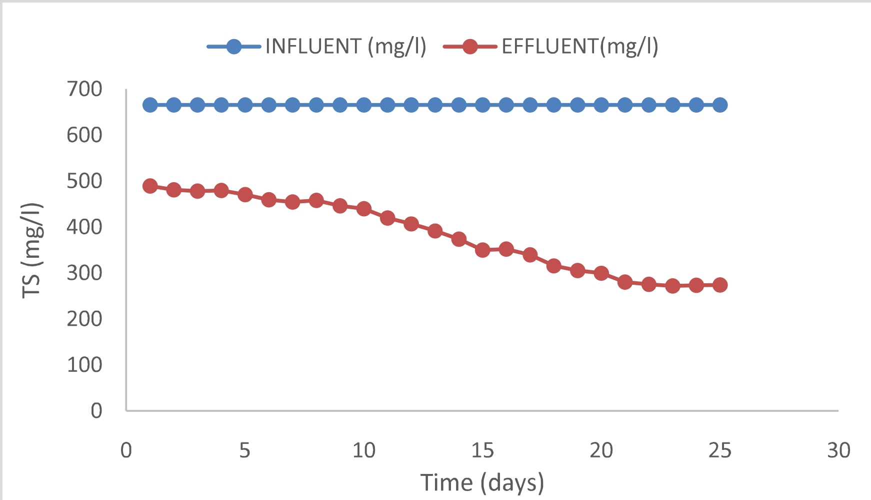

Figure 4.2 Variations for total solids (winter variation)

Waste water was synthetically prepared and influent concentration was known and constant i.e. 665 mg/l as shown in fig (4.1) and fig (4.2) respectively. In the commencing phase as expected lower removal was noticed but with subsequent cycles and acclimatization of bacteria with synthetic wastewater better efficiency was observed. In the intermediate phase a significant increase in removal efficiency was observed as seen from fig (4.3)and fig (4.4). This is attributed to granule formation in the reactor. Further gradual increase in TS removal takes place due to higher bacterial concentration in the bioreactor. Towards the terminal phase aging of sludge takes place and stable removal efficiency is observed as seen from fig (4.3) and fig (4.4).The removal efficiency for summer and winter initial were 28mg/l and 26.5 mg/l respectively which increased up to35 mg/l and 58.8 mg/l respectively.

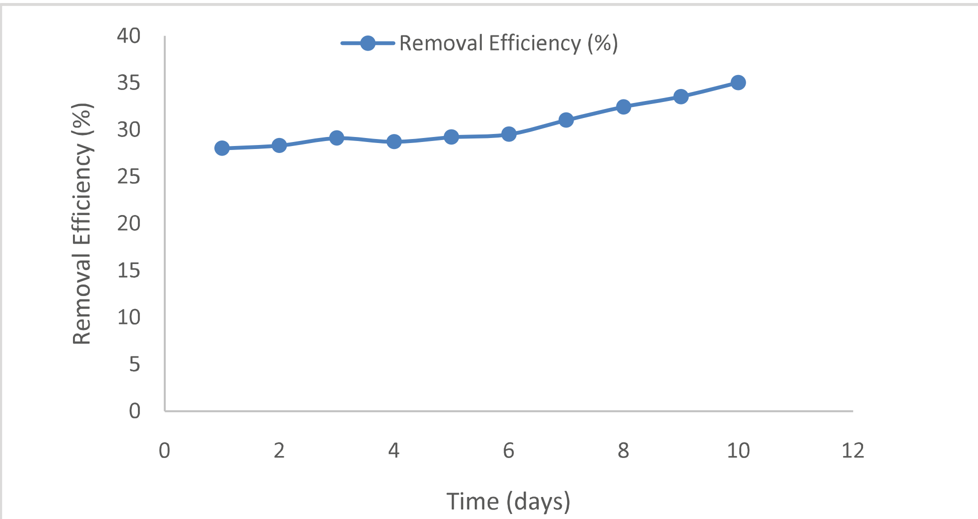

Figure4.3Removal Efficiency for total solids (summer variation)

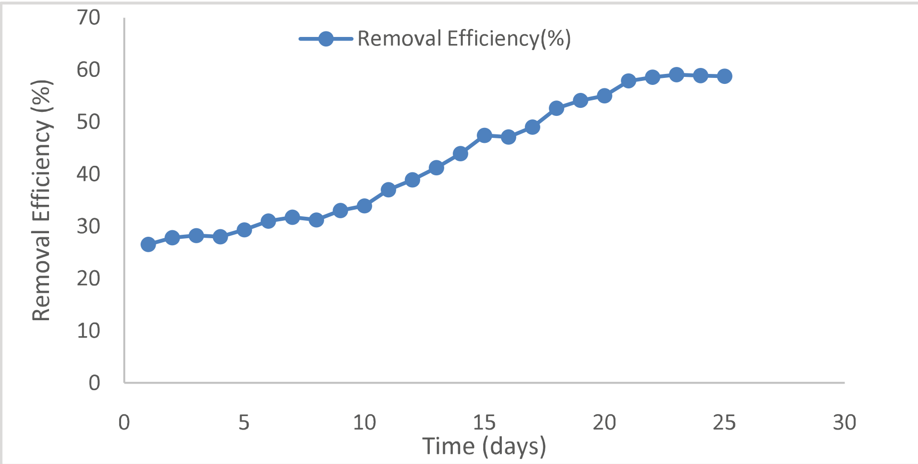

Figure 4.4Removal Efficiency for total solids (winter variation)

4.2.2 <u>Variation for COD removal</u>

4.2.2.1 SUMMER VARIATION (PHASE 1)

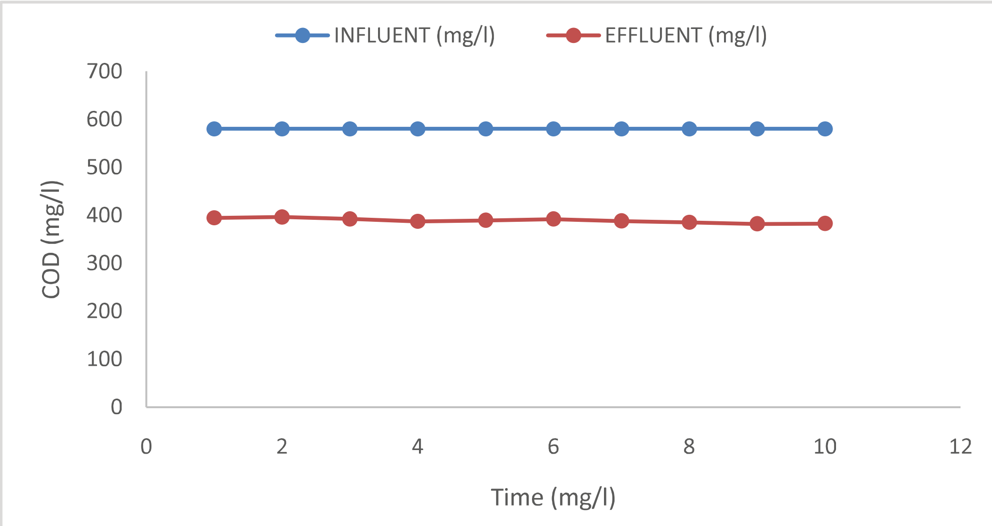

Figure 4.5Variation for COD (summer variation)

4.2.2.2 WINTER VARIATION (PHASE 2)

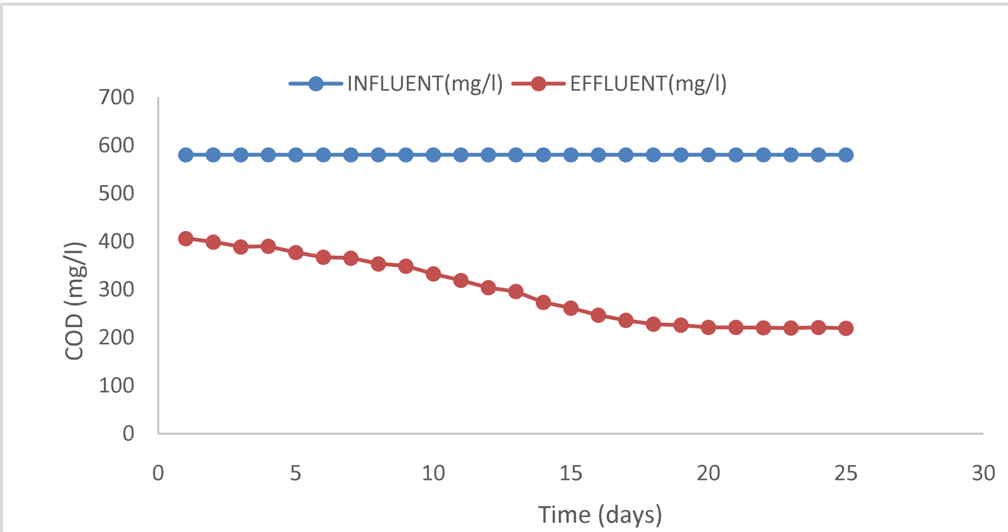

Figure 4.6Variation for COD (winter variation)

In the initial phase the COD concentration removal is low as shown in fig (4.5) and fig (4.6).But with passage to time due to acclimatization of bacteria with the synthetic wastewater an improvement in removal of COD is seen. A gradual increase in COD removal takes place due to rise in bacterial concentration. Further with the development of granules in the reactor a significant increase in removal efficiency is observed as seen from fig (4.7) and fig (4.8). In the last fue days of reactor operation along with aging of sludge it was observe that the removal efficiency for COD has stabilized as seen from fig (4.7) and fig (4.8). The removal efficiency for summer and winter initial were 32 mg/l and 28 mg/l respectively which increased up to 34 mg/l and 62.2 mg/l respectively.

While comparing the results of summer and winter months it is observed that better removal was observed in case of summer reason being a higher temperature favors' higher bacterial growth which in turn increase the removal efficiency of COD.

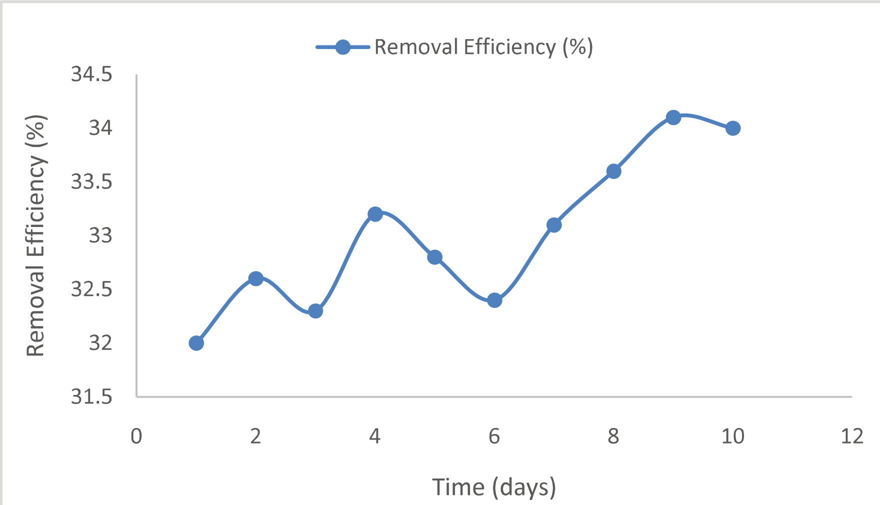

Figure 4.7 Removal Efficiency for COD (summer variation)

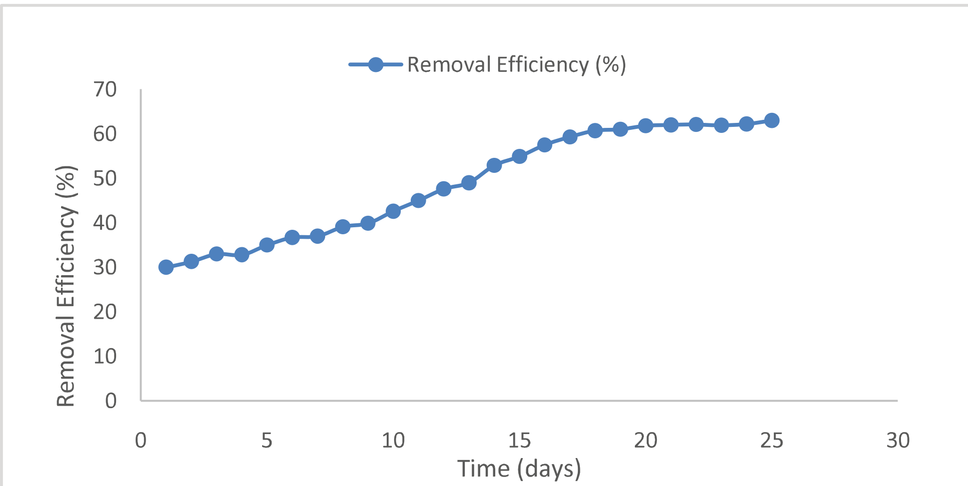

Figure 4.8Removal Efficiency for COD (winter variation)

4.2.3 Variation for DO removal

4.2.3.1 SUMMER VARIATION (PHASE 1)

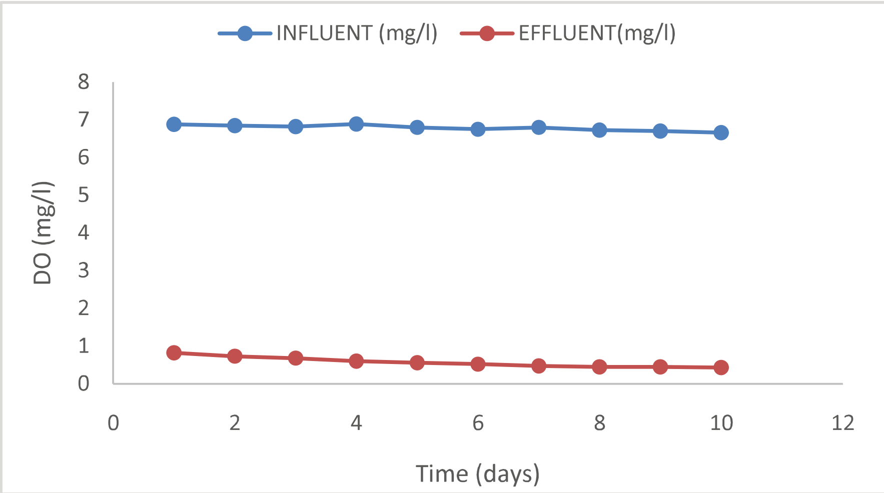

Figure 4.9 Variation for DO (summer variation)

4.2.3.2 WINTER VARIATION (PHASE 2)

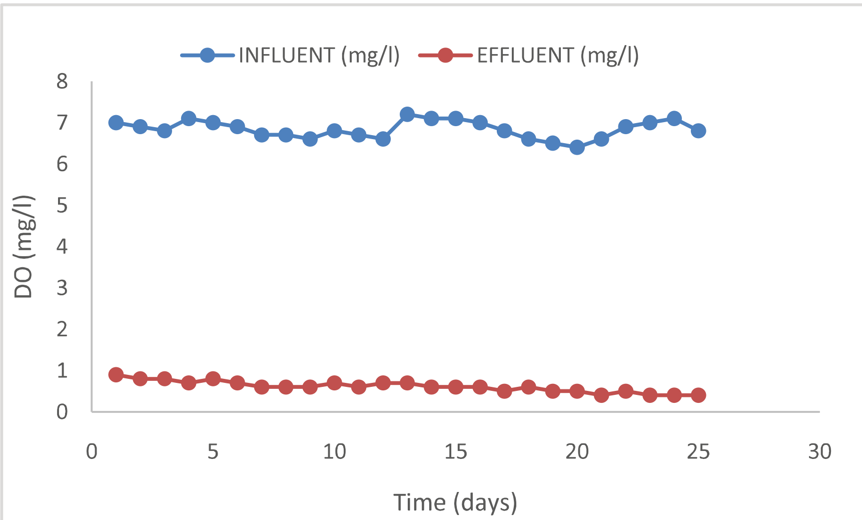

Figure 4.10 Variation for DO (winter variation)

Influent DO value varies between the range of 6.4 mg/l to 7.2 mg/l as seen from fig (4.9) and fig

(4.10). Synthetic wastewater when mixed with sludge activates the microorganism. These microorganism starts to replicate and increase their population significantly. The microorganisms present in bioreactor require oxygen to breakdown the organic content due to which a decreasing concentration of DO is observed during the cycle period. In the settle phase microorganism utilize the DO to breakdown organic matter hence decreasing DO concentration of the wastewater as seen from fig (4.9) and fig (4.10) respectively.

A decreasing trend in the effluent DO value was observed reason being the formation of bio film in the bioreactor.

Bio film restricts the mixing of oxygen from the atmosphere with the wastewater. With subsequent cycles an increase in thickness of bio film was observed which further restricted the mixing of atmospheric oxygen leading to lower DO concentration of effluent. The minimum effluent DO concentration in summer and winter were 0.43 mg/l and 0.4 mg/l respectively.

4.2.4 Variation for BOD removal

4.2.4.1 SUMMER VARIATION (PHASE 1)

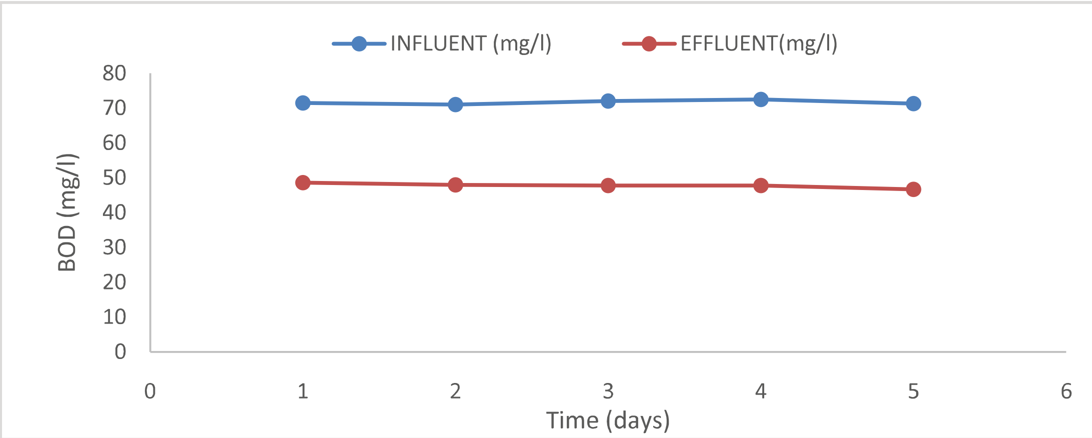

Figure 4.11Variation for BOD (summer variation)

4.2.4.2 WINTER VARIATION (PHASE 2)

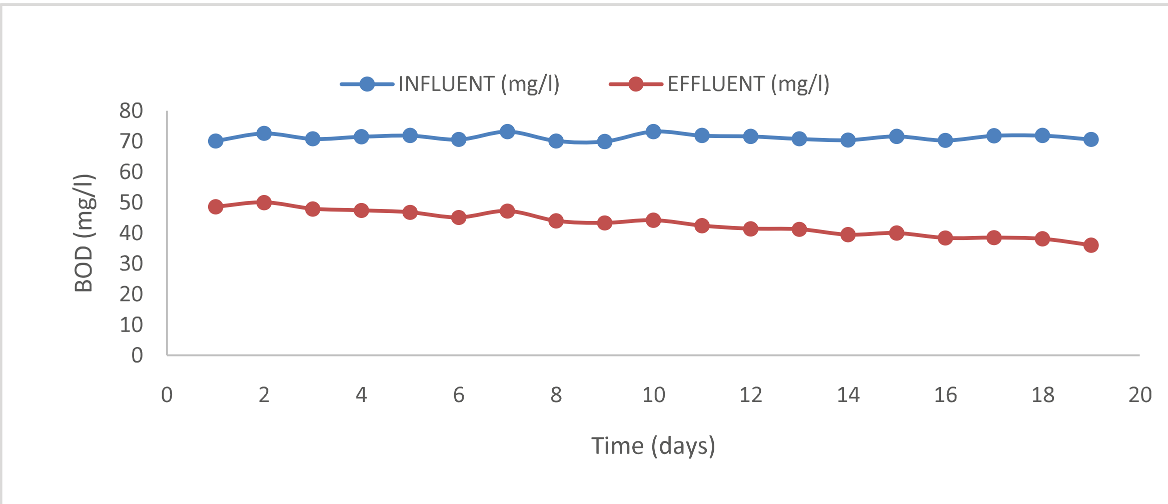

Figure 4.12 Variation for BOD (winter variation)

The influent biological oxygen demand value varies between the range of 69.9 mg/l and 72.3 mg/l as seen from fig (4.11) and fig (4.12). Initially the removal efficiency was found to on the lower end as observed from the fig (4.13) and fig (4.14). But with subsequent cycles and better bacterial concentration a gradual improvement in removal efficiency were observed. The bacteria get adapted to the synthetic waste water and replicate. Consumption of substrate starts as there population increases. An upwards trend or removal efficiency is observed in the intermediate phase reason being granular formation in the bioreactor as seen from fig (4.13) and fig (4.14) .

Peak efficiency achieved in case of summer and winter are 34.4 mg/l and 48.9 mg/l respectively.

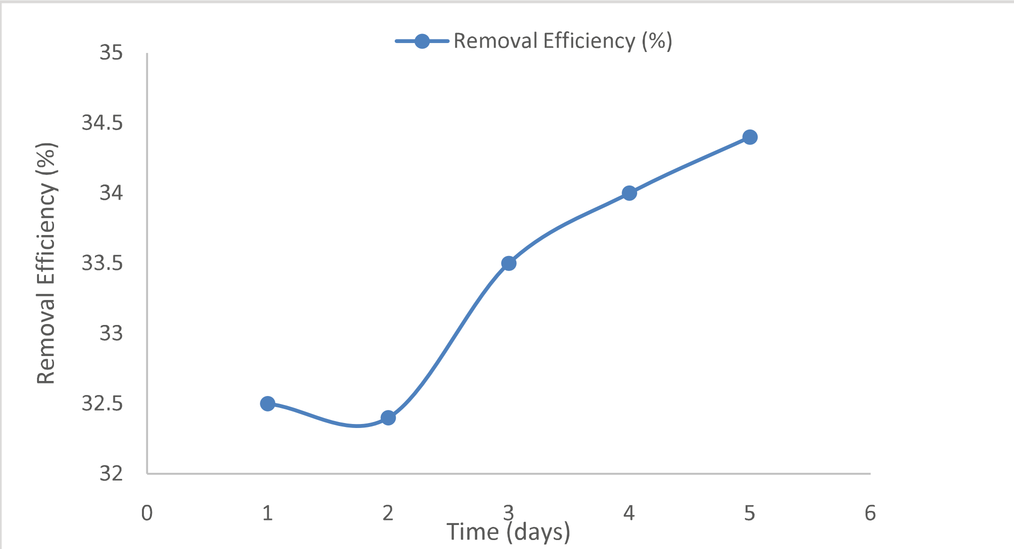

Figure 4.13 Removal Efficiency for BOD (summer variation)

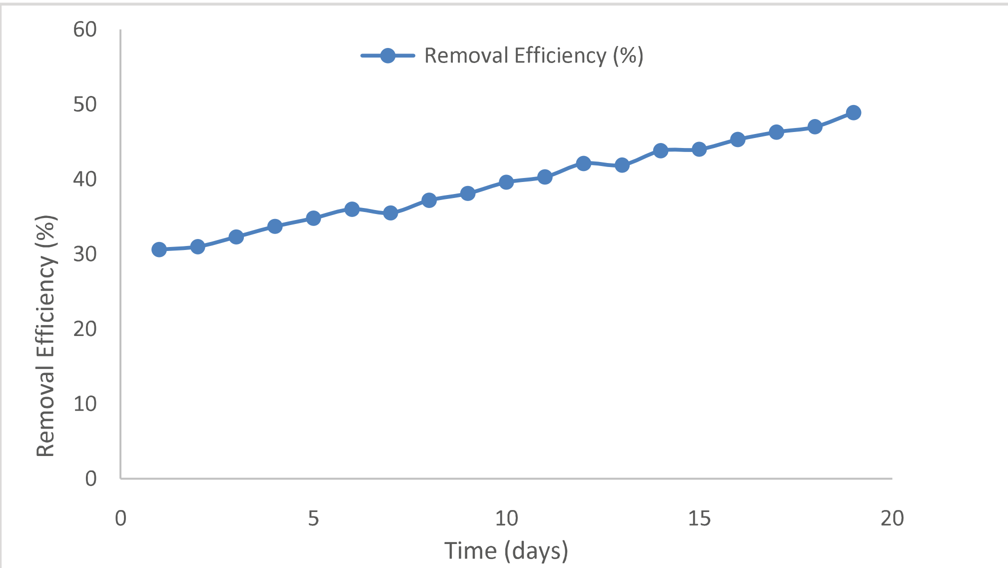

Figure 4.14 Removal Efficiency for BOD (winter variation)

4.3 Results for 3hr cycle

4.3.1 Variation for Total Solids removal

4.3.1.1 SUMMER VARIATION (PHASE 1)

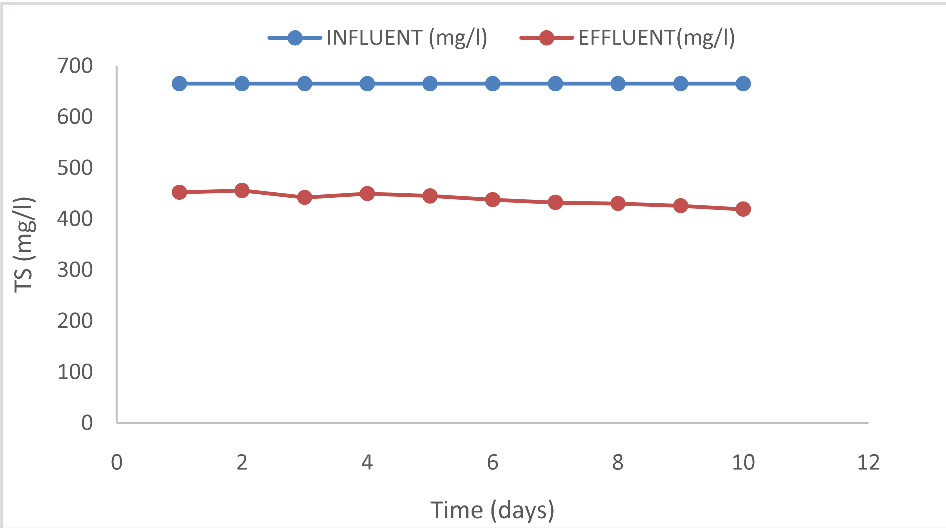

Figure 4.15 Variation for total solids (summer variation)

4.3.1.2 WINTER VARIATION (PHASE 2)

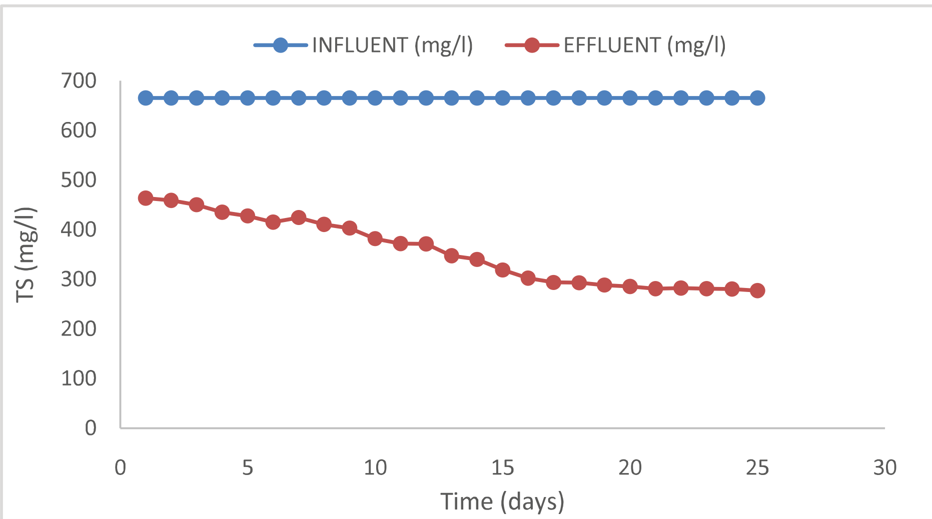

Figure 4.16 Variation for total solids (winter variation)

Waste water was synthetically prepared and influent concentration was known and constant i.e.

665mg/l as shown in fig (4.15) and fig (4.16) respectively. In the commencing phase as expected lower removal was noticed but with subsequent cycles and acclimatization of bacteria with synthetic wastewater better efficiency was observed. In the intermediate phase a significant increase in removal efficiency was observed as seen from above fig (4.17) and fig (4.18). This is attributed to granule formation in the reactor. Further gradual increase in TS removal takes place due to higher bacterial concentration in the bioreactor. Towards the terminal phase aging of sludge takes place and stable removal efficiency is observed as seen from above fig (4.17) and fig (4.18).The removal efficiency for summer and winter initial were 32 mg/l and 30.3 mg/l respectively which increased up to 37 mg/l and 66.7 mg/l respectively. Comparing the results it is observed that the overall removal rate of TS is lower in case of 2hr cycle compared to 3hr cycle reason being a lower cycle time leads to lesser bacteria concentration.

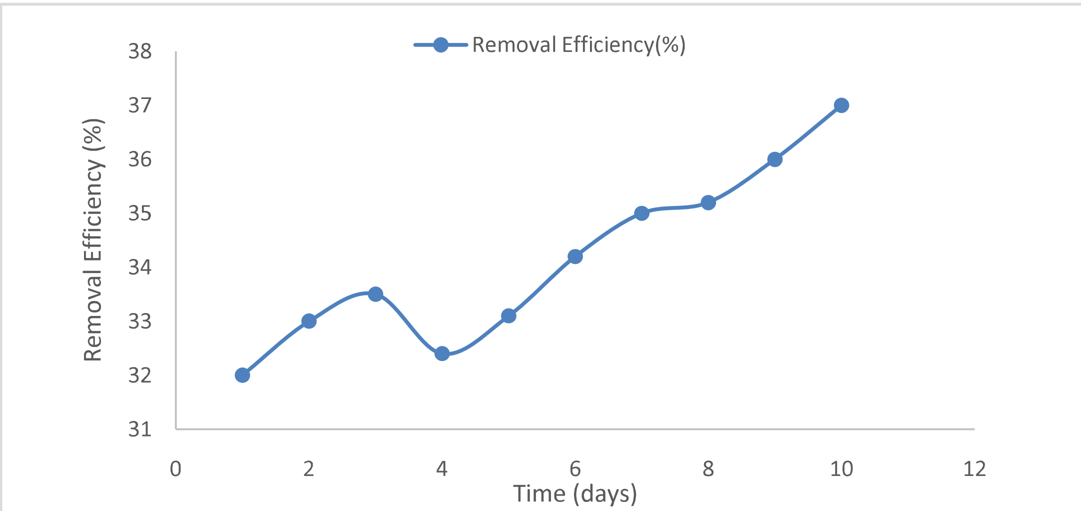

Figure 4.17 Removal Efficiency for total solids (summer variation)

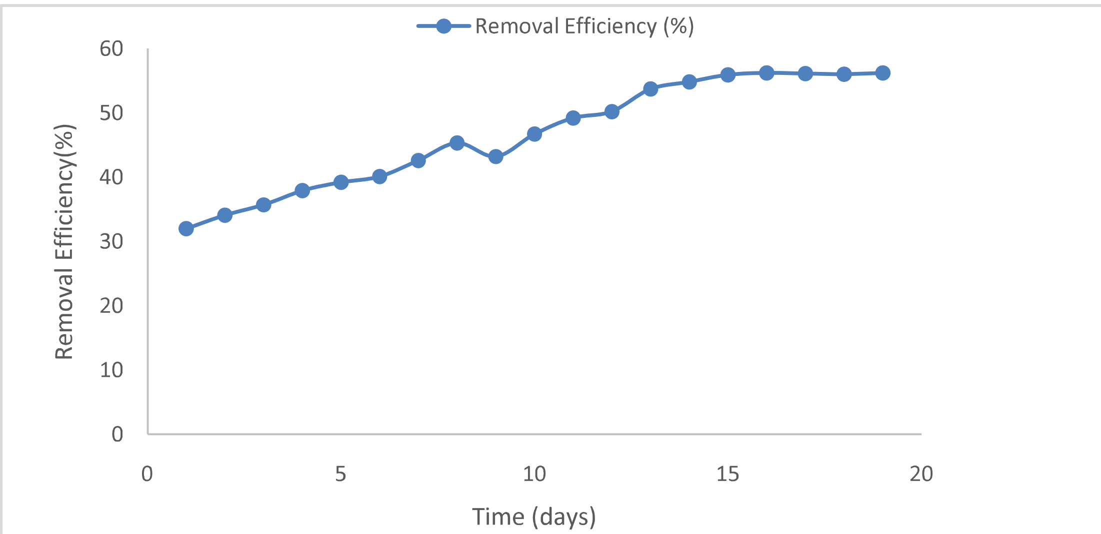

Figure 4.18 Removal Efficiency for total solids (winter variation)

4.3.2 Variation for COD removal

4.3.2.1 SUMMER VARIATION (PHASE 1)

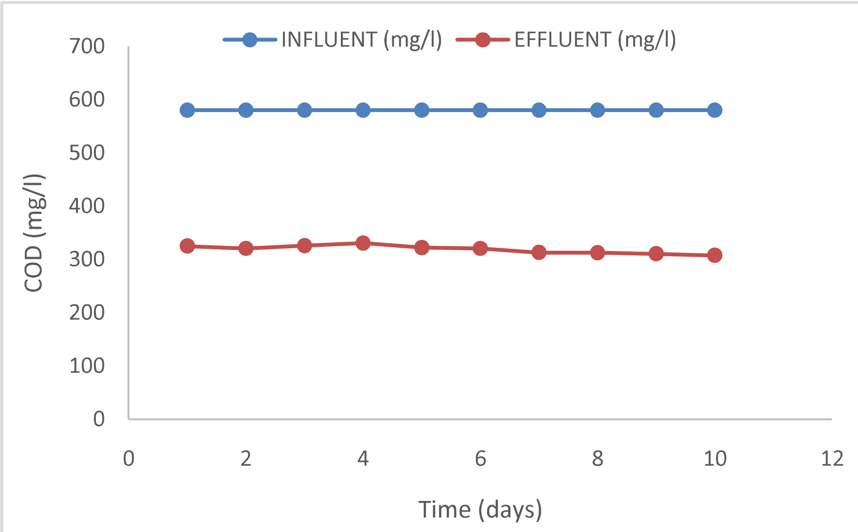

Figure 4.19 Variation for COD (summer variation)

4.3.2.2 WINTER VARIATION (PHASE)

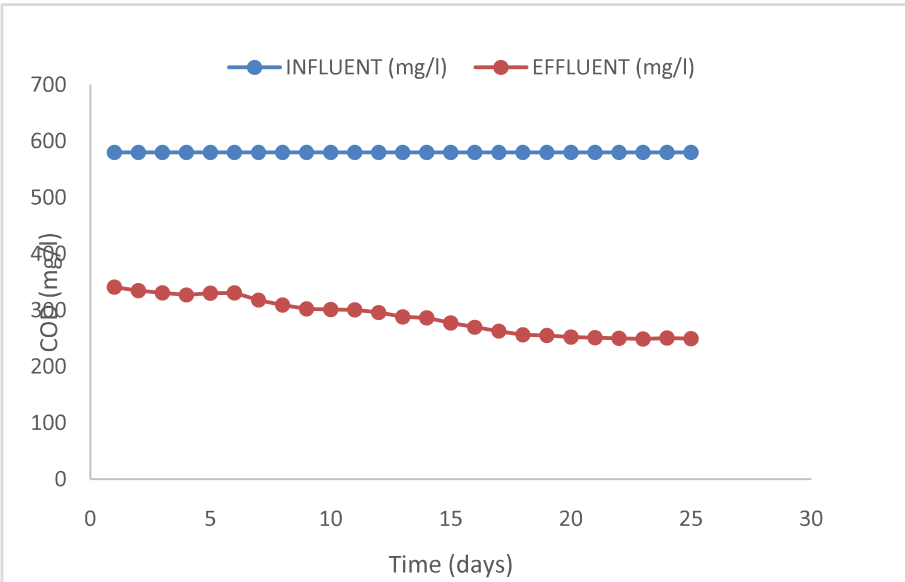

Figure 4.20 Variation for COD (winter variation)

In the initial phase the COD concentration removal is low as shown in fig (4.19) and fig (4.20).But with passage to time due to acclimatization of bacteria with the synthetic wastewater an improvement in removal of COD is seen. A gradual increase in COD removal takes place due to rise in bacterial concentration. Further with the development of granules in the reactor a significant increase in removal efficiency is observed as seen fig (4.21) and fig (4.22). In the last fue days of reactor operation along with aging of sludge it was observe that the removal efficiency for COD has stabilized as seen fig (4.21) fig (4.22). The removal efficiency for summer and winter initial were 44 mg/l and 35.4 mg/l respectively which increased up to 47 mg/l and 67.9 mg/l respectively. While comparing the results of summer and winter months it is observed that better removal was observed in case of summer reason being a higher temperature favors' higher bacterial growth which in turn increase the removal efficiency of COD.

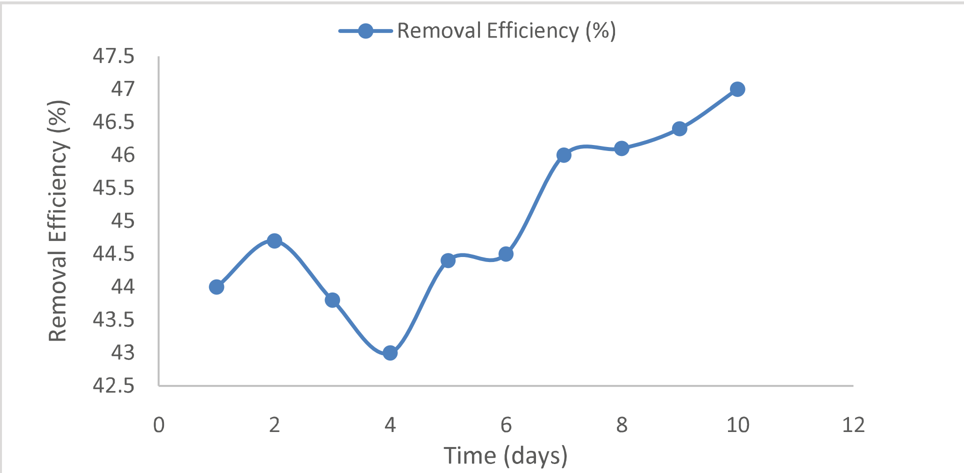

Figure 4.21 Removal Efficiency for COD (summer variation)

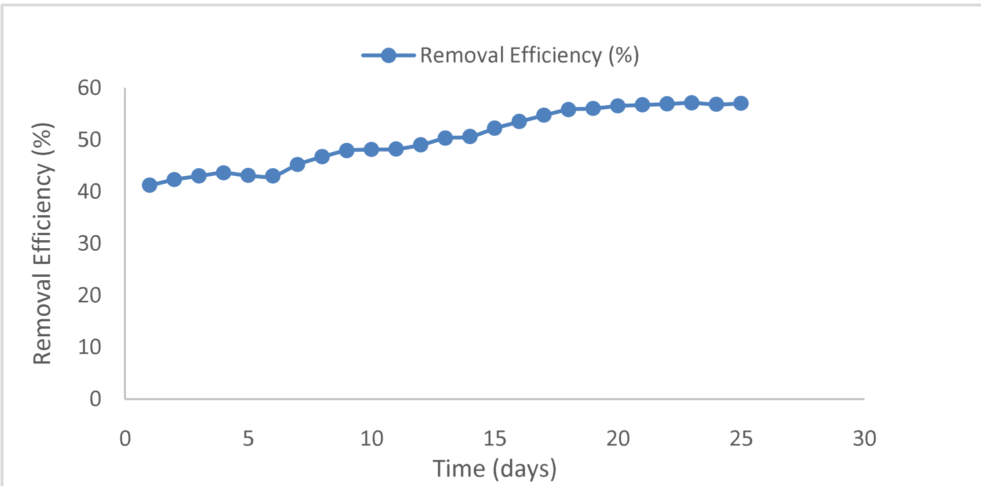

Figure 4.22 Removal Efficiency for COD (winter variation)

4.3.3 Variation for DO removal

4.3.3.1 SUMMER VARIATION (PHASE 1)

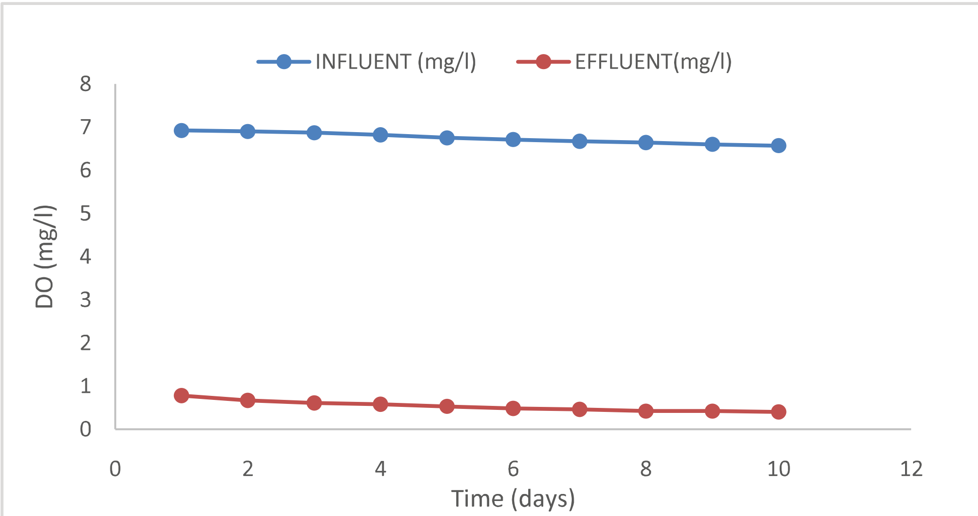

Figure 4.23 Variation for DO (summer variation)

4.3.3.2 WINTER VARIATION (PHASE 2)

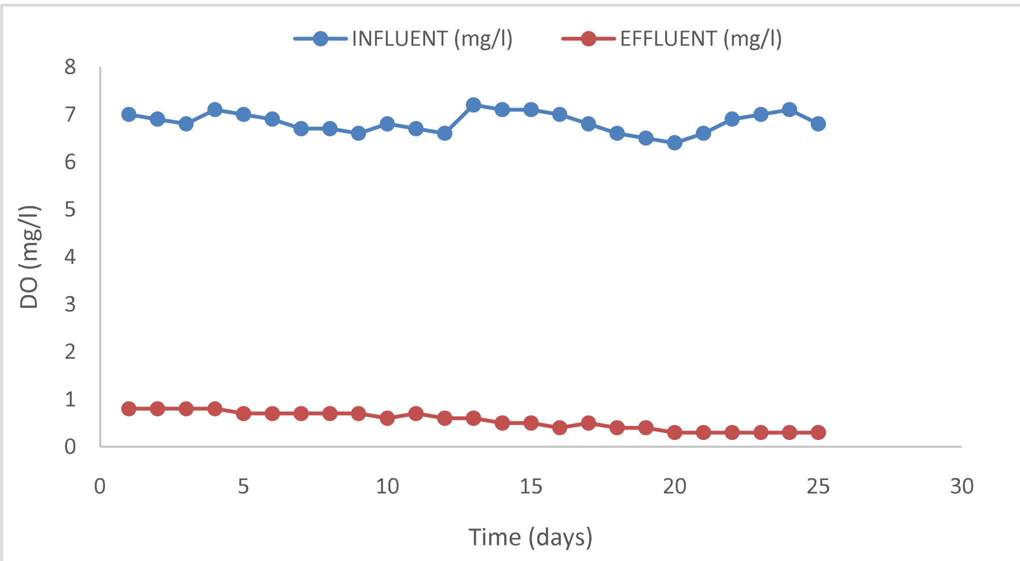

Figure 4.24 Variation for DO (winter variation)

Influent DO value varies between the range of 6.4 mg/l to 7.2 mg/l as seen from fig (4.23) and fig (4.24). Synthetic wastewater when mixed with sludge activates the microorganism. These microorganism starts to replicate and increase their population significantly. The microorganisms present in bioreactor require oxygen to breakdown the organic content due to which a decreasing concentration of DO is observed during the cycle period. In the settle phase microorganism utilize the DO to breakdown organic matter hence decreasing DO concentration of the wastewater as seen from fig (4.23) and fig (4.24) respectively.

A decreasing trend in the effluent DO value was observed reason being the formation of bio film in the bioreactor.

Bio film restricts the mixing of oxygen from the atmosphere with the wastewater. With subsequent cycles an increase in thickness of bio film was observed which further restricted the mixing of atmospheric oxygen leading to lower DO concentration of effluent. The minimum effluent DO concentration in summer and winter were 0.4 mg/l and 0.3 mg/l respectively.

4.3.4 Variation for BOD removal

4.3.4.1 SUMMER VARIATION (PHASE 1)

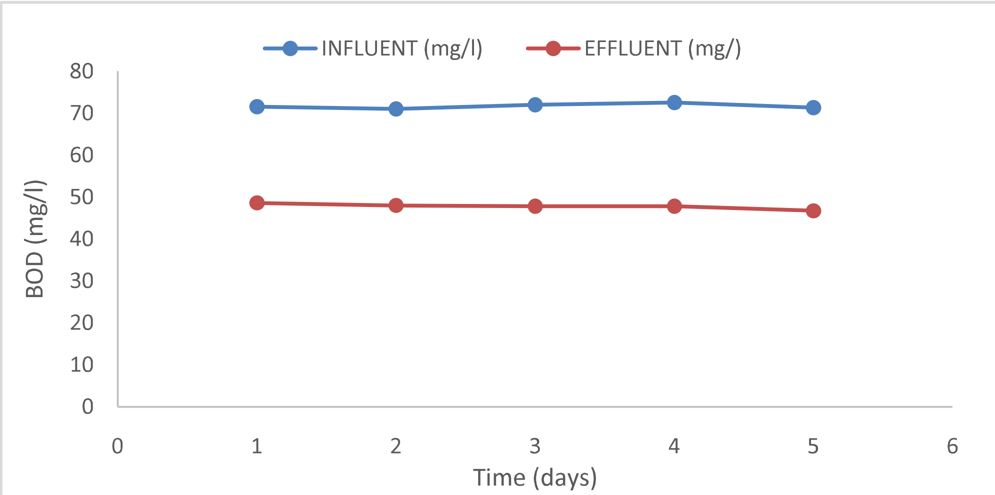

Figure 4.25 Variation for BOD (summer variation)

4.3.4.2 WINTER VARIATION (PHASE 2)

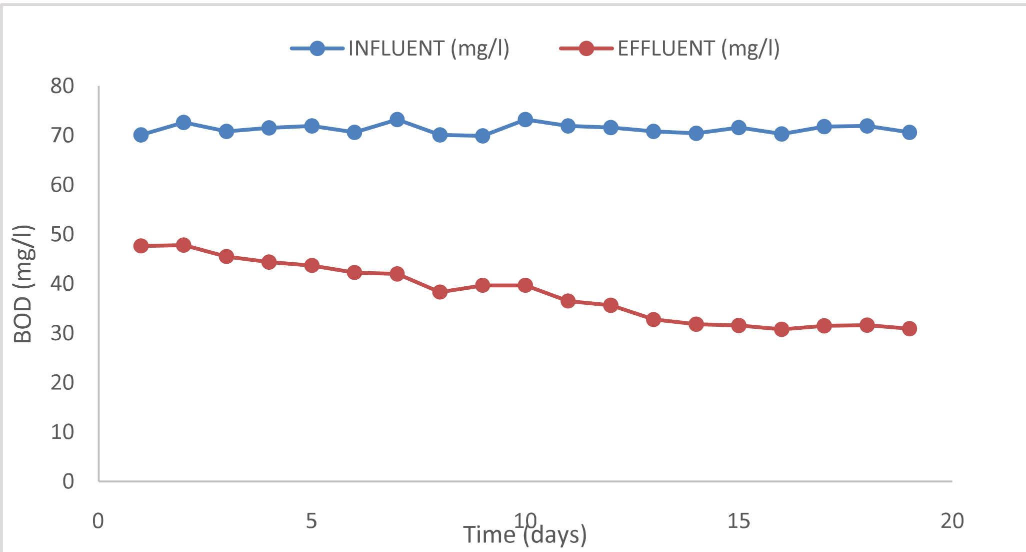

Figure 4.26 Variation for BOD (winter variation)

The influent biological oxygen demand value varies between the range of 69.9 mg/l and 72.3 mg/l as seen from fig (4.25) and fig (4.26). Initially the removal efficiency was found to on the lower end as observed from the fig (4.27) and fig (4.28). But with subsequent cycles and better bacterial concentration a gradual improvement in removal efficiency were observed. The bacteria get adapted to the synthetic waste water and replicate. Consumption of substrate starts as there population increases. An upwards trend or removal efficiency is observed in the intermediate phase reason being granular formation in the bioreactor as seen from fig (4.27) and fig (4.28).In the terminal phase a gradual growth was seen in case of 2 hr cycle and in case of 3 hr cycle removal efficiency stabilizes.

Comparing the results it is observed that the overall removal rate of BOD is lower in case of 2hr cycle compared to 3hr cycle reason being a lower cycle time leads to lesser bacteria concentration.

Peak efficiency achieved in case of summer and winter are 37 mg/l and 56.2 mg/l respectively.

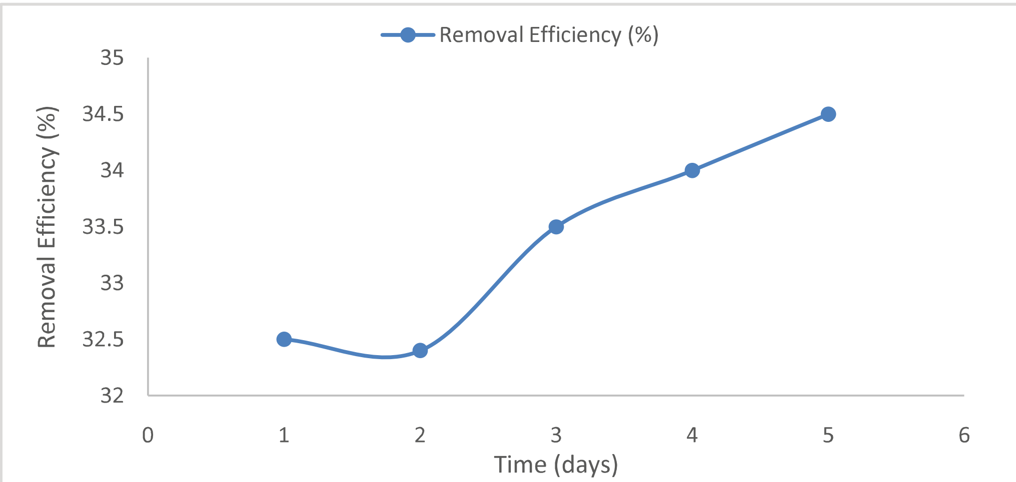

Figure 4.27 Removal Efficiency for BOD (summer variation)

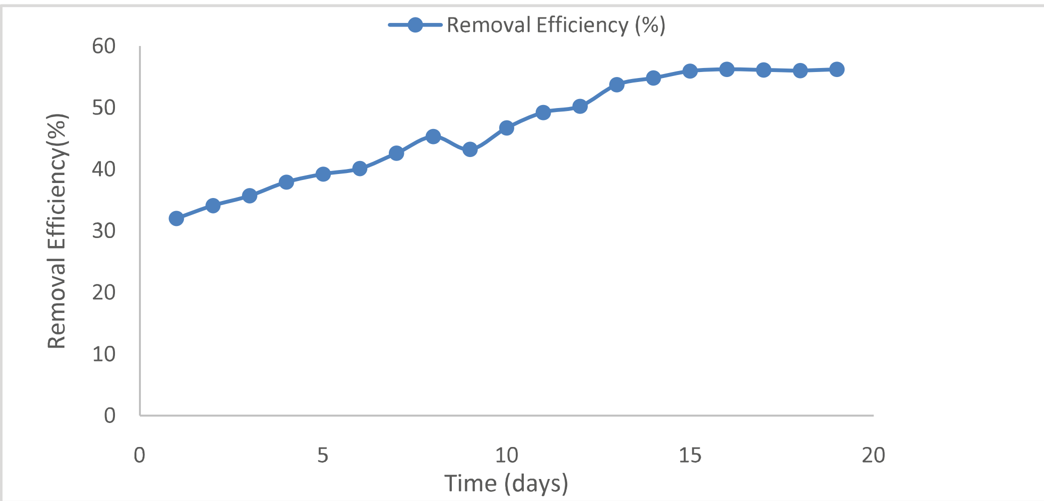

Figure 4.28 Removal Efficiency for BOD (winter variation)

CHAPTER 5

CONCLUSION

5.1 General

The objective of this project was to study the removal efficiency for different parameters in sequencing batch reactor. The variations in removal efficiency for Biological oxygen demand, Total solids, Chemical oxygen demand and Dissolved oxygen were studied for a cycle time of 2 hours and 3 hours. The following conclusions were drawn on the basis of results obtained.

In the initial phase of reactor operation lower removal efficiencies were obtained but with further cycles bacteria got acclimatized to the synthetic waste water and an improvement in removal efficiency was observed. In the intermediate phase a significant increase in removal efficiency was observed which can be attributed to granule formation in the reactor. Further gradual increase in removal takes place due to higher bacterial concentration in the bioreactor. Towards the terminal phase aging of sludge takes place and stable removal efficiency were observed.

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- .Initial removal efficiency were higher in cases of summer phase in comparison with winter phase reason being higher temperature increased bacterial growth in the reactor.

- Removal efficiency were found to be dependent on cycle time. As the cycle time for reactor operation was increased better removal efficiency were obtained for various parameters. Peak removal efficiency for 2 hour cycle for TS, COD, and BOD were 59.1%, 62.2%, 48.9% respectively.

5.2 Future Scope

Better method for mixing of wastewater and sludge may be used. Better results are expected if magnetic stirrer is used for mixing purposes. The bioreactor can be sealed and and a pump can be used to suck air out effectively creating a partial vacuum in order to better simulate anoxic condition. Peak removal efficiency for 3 hour cycle for TS, COD, and BOD were 66.7%, 67.9%, and 56.2%

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APPENDIX A

Figure A.1 Experimental Setup

Figure A.2 Filling of Wastewater

Figure A.3 Mixing (React Phase)

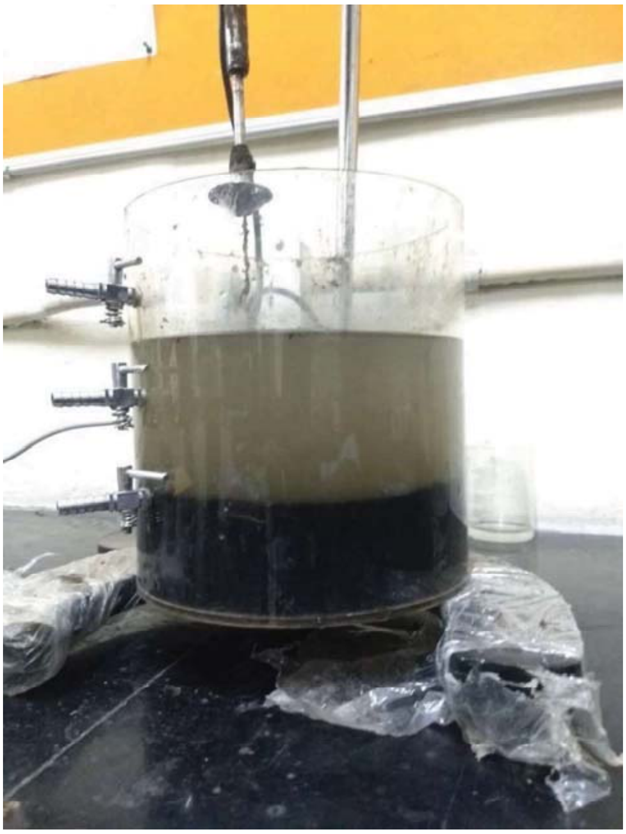

Figure A.4 Settling of Sludge

Figure A.5 Setup for Titration (COD)

Figure A.6 Bio-film Formation

APPENDIX B

2HR CALCULATIONS

TS Removal for Synthetic Wastewater having 2 hr cycle

PHASE 1 (SUMMER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	665	479	28
2	665	476.8	28.3
3	665	471.4	29.1
4	665	474	28.7
5	665	471	29.2
6	665	469	29.5
7	665	458.8	31
8	665	449.5	32.4
9	665	442.2	33.5
10	665	432.2	35

Table 2 TS Removal for 2hr (summer variation)

PHASE 2 (WINTER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	665	488.7	26.5
2	665	480.1	27.8
3	665	477.4	28.2
4	665	478.8	28
5	665	470.1	29.3
6	665	458.8	31
7	665	454.1	31.7
8	665	457.5	31.2
9	665	445.5	33

10	665	434.5	33.9
11	665	418.4	37
12	665	406.3	38.9
13	665	391.0	41.2
14	665	373	43.9
15	665	349.7	47.4
16	665	351.7	47.1
17	665	339.1	49
18	665	315.2	52.6
19	665	305.2	54.1
20	665	299.2	55
21	665	279.9	57.9
22	665	275.3	58.6
23	665	271.9	59.1
24	665	273.3	58.9
25	665	273.9	58.8

Table 3 TS Removal for 2hr (winter variation)

COD Removal for Synthetic Wastewater having 2 hr cycle

PHASE 1 (SUMMER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	580	394.4	32
2	580	396.2	32.6
3	580	392.2	32.3
4	580	387.2	33.2
5	580	389.4	32.8
6	580	392	32.4
7	580	388	33.1
8	580	385	33.6
9	580	382	34.1
10	580	382.8	34

Table 4 COD Removal for 2hr (summer variation)

PHASE 2 (WINTER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	580	406	28
2	580	398.4	30
3	580	388.6	31.3
4	580	389.7	33
5	580	377	32.8
6	580	367.1	35
7	580	366	36.7
8	580	365.4	37
9	580	353.2	39.1
10	580	348.5	39.9
11	580	332.9	42.6

12	580	319	45
13	580	303.9	47.6
14	580	295.8	49
15	580	273.8	52.9
16	580	261.5	54.9
17	580	246.5	57.5
18	580	235	59.8
19	580	277.9	60.7
20	580	226	61.0
21	580	221.5	61.8
22	580	220.4	62
23	580	219.8	62.1
24	580	220.9	61.9
25	580	219.2	62.2

Table 5 COD Removal for 2hr (winter variation)

DO Variation for Synthetic Wastewater having 2 hr cycle

PHASE 1 (SUMMER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)
1	6.88	0.82
2	6.85	0.73
3	6.82	0.68
4	6.89	0.6
5	6.80	0.56
6	6.75	0.52
7	6.80	0.47
8	6.73	0.45
9	6.70	0.45
10	6.66	0.43

Table 6 DO Removal for 2hr (summer variation)

PHASE 2 (WINTER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)
1	7.0	0.9
2	6.9	0.8
3	6.8	0.8
4	7.1	0.7
5	7.0	0.8
6	6.9	0.7
7	6.7	0.6
8	6.7	0.6
9	6.6	0.6

10	6.8	0.7
11	6.7	0.6
12	6.6	0.7
13	7.2	0.7
14	7.1	0.6
15	7.1	0.6
16	7.0	0.6
17	6.8	0.5
18	6.6	0.6
19	6.5	0.5
20	6.4	0.5
21	6.6	0.4
22	6.9	0.5
23	7.0	0.4
24	7.1	0.4
25	6.8	0.4

Table 7 DO Removal for 2hr (winter variation)

BOD Variation for Synthetic Wastewater having 2 hr cycle

PHASE 1 (SUMMER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	71.5	48.6	32.5
2	71	48	32.4
3	72	47.8	33.5
4	72.5	47.8	34
5	71.3	46.7	34.4

Table 8 BOD Removal for 2hr (summer variation)

PHASE 2 (WINTER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	70.1	48.6	30.6
2	72.6	50	31
3	70.8	47.9	32.3
4	71.5	47.4	33.7
5	71.9	46.8	34.8
6	70.6	45.1	36
7	73.2	47.2	35.5
8	70.1	44	37.2
9	69.9	43.33	38.1
10	70.1	44	37.2
11	73.2	44.2	39.6
12	71.9	42.4	40.3
13	71.6	41.4	42.1
14	70.8	41.2	41.9
15	70.4	39.5	43.8
16	71.6	40	44

17	70.3	38.4	45.3
18	71.8	38.5	46.3
19	71.9	38.1	47
20	70.6	36	48.9

Table 9 BOD Removal for 2hr (winter variation)

3 HR CALCULATIONS

TS Removal for Synthetic Wastewater having 3 hr cycle

PHASE 1 (SUMMER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	665	452	32
2	665	455.5	33
3	665	442	33.5
4	665	449.5	32.4
5	665	444.8	33.1
6	665	437.5	34.2
7	665	432.2	35
8	665	430	35.2
9	665	425.6	36
10	665	419	37

Table 10 TS Removal for 3hr (summer variation)

PHASE 2 (WINTER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	665	463.5	30.3
2	665	456.8	31.3
3	665	448.2	32.6
4	665	444.8	33.1
5	665	439.5	33.9
6	665	428.2	35.6
7	665	417.6	37.2
8	665	406.3	38.9

9	665	392.3	41
10	665	374.3	43.7
11	665	357.7	46.2
12	665	341.1	48.7
13	665	331.1	50.2
14	665	308.5	53.6
15	665	287.2	56.8
16	665	273.3	58.9
17	665	260.6	60.8
18	665	249.3	62.5
19	665	234.0	64.8
20	665	226.7	65.9
21	665	225.4	66.1
22	665	222.1	66.6
23	665	223.4	66.4
24	665	222.7	66.5
25	665	221.4	66.7

Table 11 TS Removal for 3hr (winter variation)

COD Removal for Synthetic Wastewater having 3 hr cycle

PHASE 1 (SUMMER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	580	324.8	44
2	580	320.4	44.7
3	580	325.5	43.8
4	580	330.5	43
5	580	322.10	44.4
6	580	320.5	44.5
7	580	313	46
8	580	312.5	46.1
9	580	310.5	46.4
10	580	307.4	47

Table 12 COD Removal for 3hr (summer variation)

PHASE 2 (WINTER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	580	374.6	35.4
2	580	368.8	36.4
3	580	360.7	36.5
4	580	354.9	37.8
5	580	350.3	38.8
6	580	341.0	39.6
7	580	324.8	41.2
8	580	313.7	44
9	580	297.5	45.9
10	580	288.2	48.7
11	580	274.9	50.3
12	580	262.1	52.6

13	580	248.8	54.8
14	580	234.9	57.1
15	580	226.7	59.5
16	580	213.4	60.9
17	580	206.4	63.2
18	580	203	64.4
19	580	198.36	65
20	580	193.1	65.8
21	580	190.8	66.7
22	580	189.0	67.1
23	580	188.5	67.4
24	580	187.0	67.5
25	580	186.1	67.9

Table 13 COD Removal for 3hr (winter variation)

DO Variation for Synthetic Wastewater having 3 hr cycle

PHASE 1 (SUMMER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)
1	6.92	0.78
2	6.90	0.67
3	6.87	0.61
4	6.82	0.58
5	6.75	0.53
6	6.71	0.48
7	6.67	0.46
8	6.64	0.42
9	6.60	0.42
10	6.57	0.4

Table 14 DO Removal for 3hr (summer variation)

PHASE 2 (WINTER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)
1	7	0.8
2	6.9	0.8
3	6.8	0.8
4	7.1	0.8
5	7	0.7
6	6.9	0.7
7	6.7	0.7
8	6.7	0.7
9	6.6	0.7
10	6.8	0.6
11	6.7	0.7

12	6.6	0.6
13	7.2	0.6
14	7.1	0.5
15	7.1	0.5
16	7.0	0.4
17	6.8	0.5
18	6.6	0.4
19	6.5	0.4
20	6.4	0.3
21	6.6	0.3
22	6.9	0.3
23	7.0	0.3
24	7.1	0.3
25	6.8	0.3

Table 15 DO Removal for 3hr (winter variation)

BOD Variation for Synthetic Wastewater having 3 hr cycle

PHASE 1 (SUMMER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	75	48.7	35
2	68	44	35.3
3	76	48.6	36
4	73	46.2	36.6
5	79	49.7	37

Table 16 BOD Removal for 3hr (summer variation)

PHASE 2 (WINTER VARIATION)

DAYS	INFLUENT(mg/l)	EFFLUENT(mg/l)	REMOVAL EFFICIENCY (%)
1	70.1	47.6	32
2	72.6	47.8	34.1
3	70.8	45.5	35.7
4	71.5	44.4	37.9
5	71.9	43.7	39.2
6	70.6	42.2	40.1
7	73.2	42.0	42.6
8	70.8	32.7	53.7
9	70.1	38.3	45.3
10	69.9	39.7	43.2
11	73.2	39.0	46.7
12	71.9	36.5	49.2
13	71.6	35.6	50.2
14	70.8	32.7	53.7
15	70.4	31.8	54.8
16	71.6	31.5	55.9
17	70.3	30.7	56.2
18	71.8	31.5	56.1
19	71.9	31.6	56
20	70.6	30.9	56.2

Table 17 BOD Removal for 3hr (winter variation)

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