Effect of Non-Continuous Aeration on Activated Sludge Process

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Abstract - *Most of the sewage treatment plants in India are based on activated sludge process (ASP). In the aerobic biological treatment, aeration accounts for a significant portion of total operating cost of the treatment process. The continuous supply of power to aeration unit of conventional ASP is not provided either unintentionally due to power cut-offs or intentionally to reduce the energy cost. This may affect effluent quality as well as aerobic biomass in reactor. Therefore, the present studying aims to evaluate the impact of non-continuous aeration on reactor performance and associated changes on aerobic biomass.*

Key Words: Sewage, Activated Sludge Process, Aerobic, Aeration, Effluent, Biomass, Reactor.

1. INTRODUCTION

Expansion of urban population and increased coverage of domestic water and sewerage create to greater quantities of wastewater. As per Central Public Health and Environmental Engineering Organization (1993) [3] estimates, about 70-80% of total water supplied for domestic use gets generated as wastewater. Domestic wastewater contains organic and inorganic matter in suspended, colloidal and dissolved form. The concentration of organic and inorganic matter within the wastewater depends on the initial concentration within the water and therefore, the uses to which the water has been put to. The climate, wealth and habits of the people has a marked effect on the wastewater characteristics. Thus, wastewater characteristics vary not only from city to city, but also from season to season and even hour to hour within a given city.

The sewage treatment consists of primary, secondary, and tertiary treatment depending upon the effluent quality required. Primary treatment designed for removal of settleable solids from the bottom and removal of oil and grease from top of the basin. The remaining liquid portion is a then sent to secondary treatment. Secondary treatment is designed for removal of dissolved and suspended organic matters with the help of indigenous, waterborne micro-organisms in a managed habitat. At the end of secondary treatment, the solid phase (i.e. biomass) and liquid phases are separated, and the liquid phase is then sent for tertiary treatment. Tertiary treatment is a final stage treatment to further improve the effluent quality before it is discharged to the receiving environment.

Aerobic heterotrophic bacteria are main activated organisms in activated sludge process. Heterotrophic bacteria obtain energy from carbonaceous organic matter in an influent wastewater for the synthesis of new cells. It is essential to maintain aerobic conditions in the system by using appropriate aeration devices. If the aeration is not carried around the clock (due to improper working of aeration devices during night time due to decrease flow rate to the treatment plant, outsourcing of routine operation and maintenance work to private enterprise lacking skilled manpower to undertake such works, etc.) in the conventional activated sludge systems, the characteristics of the aerobic biomass is likely to get disturbed which might have an adverse impact on the effluent quality.

Very few investigations are available to highlight the effect of non-continuous aeration on activated sludge, and the impact on the overall treatment imparted through activated sludge process as well as the impact on active biomass itself. Therefore, the main objective of this investigation is to study the impact on the performance as well as on the aerobic biomass of the conventional activated sludge systems when subjected to non-continuous aeration in batch and continuous mode of feeding. In this study, we select our college sewage treatment plant which is based on activated sludge process for our BE final year research program and all the test are performed in the environmental laboratory civil engineering department of VPM's Maharshi Parshuram College of Engineering Velneshwar Ratnagiri Maharashtra.

1.1 Literatures Review

Waste water, is any water that has been adversely affected in quality by anthropogenic influence. The sewage from colonies additionally effluent from industrial units has been identified as main cause for pollution across our country. Sewage may be water-carried waste, in solution or suspension that's intended to be aloof from a community. This is also called wastewater, it's over 99% water and is characterized by volume or rate of flow strength, chemical constituents, and therefore, the bacteriological organisms that it contains. During recent years, there has been an increasing awareness and concern about conservation everywhere on the planet. Hence, new approaches towards achieving sustainable development of water resources are developed internationally.

Chatterjee *et. al.* (2003), within the proceedings of 8th International conference on Water Conservation and Reuse of Waste Water held at Mumbai, in their paper Sewage Reuse – A Case Study has reported TSS removal from 150 mg/l to 10 mg/l by Dual Media filtration. Together with TSS removal, COD and BOD removal was also reported. The BOD, and COD reduction was achieved by Dual Media Filtration to the tune of 96.8 % & 92.5 %. This was mainly because of removal of TSS concentration which was otherwise contributing to total COD.

Jungle *et. al.* (2009), has studied the performance of activated sludge process in treating waste water from food industry. In their paper, "aerobic treatment of waste water generated from food industry by activated sludge process" they need to report BOD reduction of 82% and COD reduction of 72%. As a component of tertiary treatment, the biologically treated sewage has been further treated by chlorination. The pathogen removal achieved to the tune of 99%. The initial Coliform count was reported as 107 MPN/100 ml reduced to 104 MPN/100 ml. Chlorination also reported slight reduction in BOD from 18 to 8 mg/L and COD from 65 mg/L to 35 mg/L.

Shrirang Vrushali and Chatterjee Kaustav*et et. al.* (2014). With rapid development of cities and domestic water system, quantity of sewage generation is increasing within the same proportion. Treatment of sewage and its reuse is the need of the hour. One among the most reasons of pollution of surface water in our country is discharge of untreated sewage. Thus, during this research paper, a trial has been made to treat sewage and put it back for reuse. The sewage has been treated by activated sludge process, and there the results are very encouraging. In 96, Hours, BOD and COD reduction achieved were 90.5% & 79.6 % respectively. The ultimate BOD has been reported as 18 mg/L and COD as 65 mg/L. [8]

1.2 Problem Definition

Review of the literature shows that the activated sludge process has experienced operational problems since its inception. However, improved process control can be obtained by systematically staring at the issues and their potential causes. Once the cause is defined, control actions are initiated to eliminate the matter. Problems related to the activated sludge process can usually be associated with three conditions.

1. The primary is foam. Such a lot of foam can accumulate that it becomes a security problem by spilling out onto walkways.
2. The second, high effluent suspended solids, can be caused by many things. It's the foremost common problem found in activated sludge systems.
3. The third is high concentrations of soluble materials travel through the system and not being properly treated.

2. THEORATICAL ANALYSIS

The activated sludge process is now used routinely for biological treatments of municipal and industrial wastewater. The schematic of conventional activated sludge process is illustrated in Fig-1, which consists of following three basic components:

1. A reactor in which the microorganisms responsible for the treatment are kept in suspension and aerated.
2. Liquid-solid separation, usually in a sedimentation tank.
3. A recycle system for returning solids removed from the liquid-solids separation unit back to the reactor.

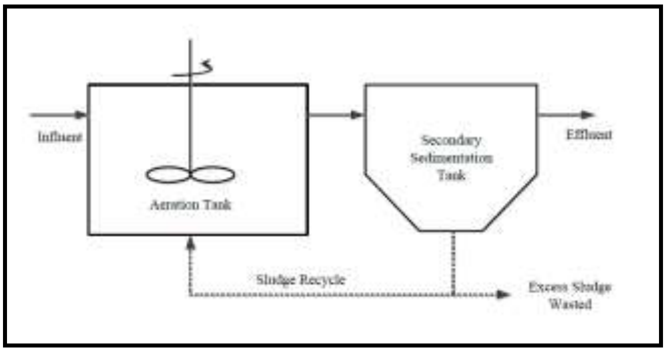

Fig-1: Schematic representation of domestic wastewater treatment using conventional activated sludge process

The conventional activated sludge process consists of a set of two basins. First is the aeration basin where air is pumped through perforated pipes at the bottom of the basin, air rises through the water in the form of fine bubbles. These bubbles accomplish two functions: they provide oxygen from the air to the wastewater and create highly turbulent conditions that favours intimate contact between microbial cells, the organic material in the wastewater and oxygen. This unit consists of mixed culture of microorganisms which feed on the wide variety of organics present in the domestic wastewater. Since the contents of the aeration basin is in suspension, and the flow through the aeration basin is continuous, the concentration of mixed culture of microorganisms (present in the aeration unit plus the growth of newer microorganisms) is likely to decrease steadily. To ensure adequate concentration of mixed culture of microorganisms all the time in the aeration unit, the microorganisms escaping the aeration unit is captured in the secondary sedimentation basin and the part of it is then returned to the aeration unit and the remaining part wasted.

The secondary sedimentation basin also accomplishes two tasks simultaneously: it captures most of the microorganisms coming out of the aeration basin thereby reducing the content of the organic matter in the treated effluent as well as it help in concentrating the captured microorganisms so as to return a part of the concentrated microorganisms to the aeration basin to maintain a optimum level of mixed cultures for effective treatment. Therefore, the secondary sedimentation basin is considered an integral part of the conventional activated sludge processes. The continuous around the clock operation of activated sludge process (comprising aeration tank and secondary sedimentation tank) are critical to impart requisite treatment to the wastewater. However, any break in around the clock operation of activated sludge process may cause disturbance to the biomass present in the aeration unit. Depending upon the duration of the break, the physiological condition of the biomass present in the aeration basin may change and the system may become unstable.[9]

2.1 Effect of Non-Continuous Aeration on Aerobic Sludge

The conventional activated sludge process is designed to provide around the clock aeration to the sludge biomass retained in the aeration unit and also to keep the biomass and substrate in contact with each other with simultaneous mixing. If the aeration is not carried out on continuous basis intentionally or unintentionally, it puts a big question mark on the quality of the effluent as well as the quality of aerobic biomass present in the reactor. A conventional activated sludge system can be converted in to an intermittently aerated activated sludge process, when the aeration in the aeration tank is getting on and off periodically. It can be assumed that the main portion of the microbial population that develops under such conditions will be facultative heterotrophic organisms, which have a capacity for substrate utilization under both aerated and unaerated conditions. When the flow rate of influent wastewater and the concentration of activated sludge are low, a problem of excessive aeration is encountered if the aeration is carried out at a constant rate leading to deteriorate quality of the treated wastewater as well as notably high wasteful operating energy in operating the aeration devices. On the other hand, if the flow rate of influent wastewater and the concentration of activated sludge are high, the aeration becomes insufficient if carried out at the constant rate leading to production of deteriorated quality of the treated wastewater. In a well operated aeration unit of activated sludge process, the biomass grows in the presence of oxygen by using organic matter as food. The overall oxygen consumption rates depend upon the substrate removal mechanisms. However, if the aeration is inadequate or stopped for a longer duration of time, the active aerobic biomass may decrease in concentration or even die out in large numbers. Since the activated sludge process uses mixed culture of microorganisms, some of them could still carry out metabolic activities (on a limited scale) in the absence of oxygen by using the dead microorganisms as their food source. However, these metabolic activities of organisms in the absence of oxygen may not be able to provide the intended treatment to the wastewater as is expected from a well-functioning activated sludge system of wastewater treatment.[13]

3. EXPERIMENTAL ANALYSIS

To attain the objectives of this investigation, experiments were planned to be conducted in laboratory. This section deals with the event of suspended aerobic biomass, monitoring of S.T.P, procedure for estimation of activity of aerobic biomass, etc. We've performed the subsequent experiments to understand the sewage characteristics:

1. Biochemical Oxygen Demand (BOD)
2. Chemical Oxygen Demand (COD)
3. Dissolved Oxygen (DO)
4. pH
5. Alkalinity

3.1 Biochemical Oxygen Demand (BOD)

The biochemical oxygen demand determination could be a chemical procedure for determining the number of oxygens needed by aerobic organisms in a very water body to break the organic materials present within the given water sample at a certain temperature over a particular period of your time. BOD of sewage is an amount of oxygen required for biological decomposition of dissolved organic come to occur under standard condition at standardized time and temperature. Usually, the time is taken as 3 days and temperature is 27 °C.

3.2 Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) test is usually accustomed indirectly measure the number of organic compounds in water. It's expressed in mg/L, which indicates the mass of oxygen consumed per liter of solution. COD determines the amount of oxygen required to oxidize the organic matter in waste water sample, under specific conditions of oxidizing agent, temperature & time. The applicable range of COD is 3-900 mg/L.

3.3 Dissolved Oxygen (DO)

The term Dissolved Oxygen is employed to explain the number of oxygens dissolved in a very unit volume of water. Dissolved oxygen (DO) is important for the upkeep of healthy lakes and rivers. It's a measure of the flexibility of water to sustain aquatic life. The dissolved oxygen content of water is influenced by the source, raw water temperature, treatment and chemical, or biological processes go down within distribution system. The presence of oxygen in water could be a good sign. Depletion of dissolved oxygen in water supplies can encourage the microbial reduction of nitrate to nitrite and sulphate to sulphide. There are various methods available to live Dissolved Oxygen, which we are going to discuss well. In a very healthy body of water like a lake, river, or stream, the dissolved oxygen is about 8 parts per million. The minimum DO level of 4 to 5 mg/L or ppm is desirable for survival of aquatic life. The wastes function the food certainly aerobic bacteria. Because it moves downstream, the conc. of bacteria increases. Because these bacteria remove oxygen from water, their population increase causes a decline within the amount of DO. Beyond certain point, most of the wastes break down. The conc. of DO rises because the river recovers oxygen from the atmosphere and aquatic plants. Thus, DO test is the basis for BOD test which is a very important parameter to judge organic pollution potential of a waste. It's necessary for all aerobic biological wastewater treatment processes to manage the speed of aeration.

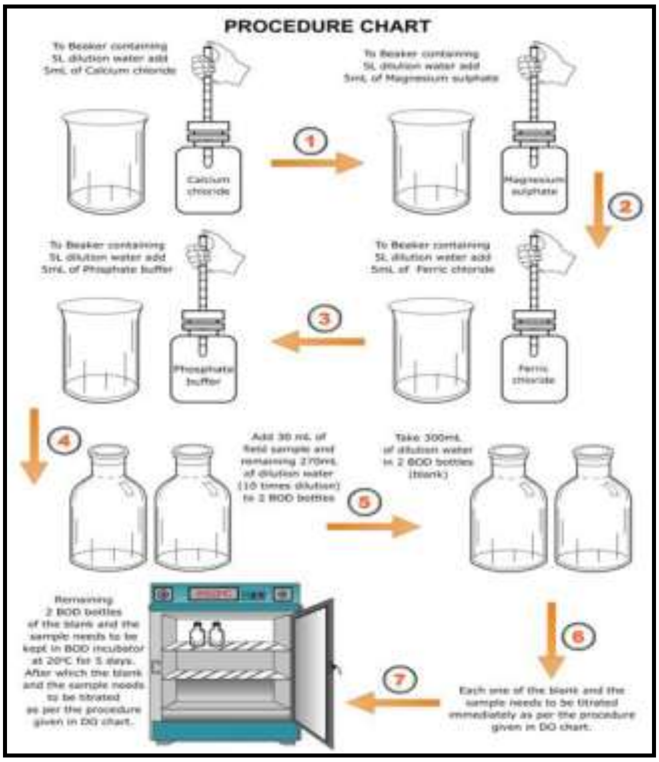

Fig.2: Procedure chart of BOD test

3.4 pH

The term pH refers to the measure of hydrogen ion concentration in a solution and defined as the negative log of H^+ ions concentration in water and wastewater. The values of pH 0 to a bit but 7 are termed as acidic and also the values of pH a bit above 7 to 14 are termed as basic. When the concentration of H^+ and OH^- ions are equal then it's termed as neutral pH.

3.5 Alkalinity

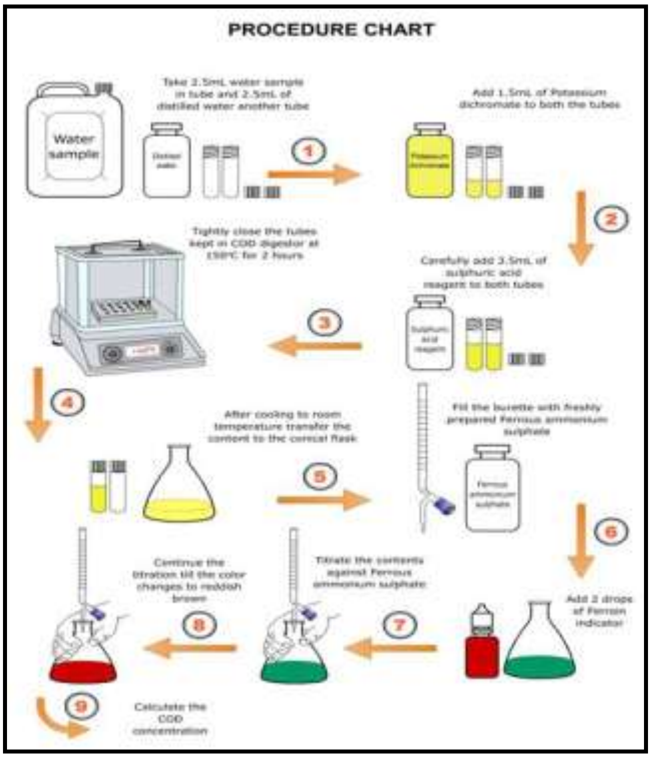

Fig.3: Procedure chart of COD test

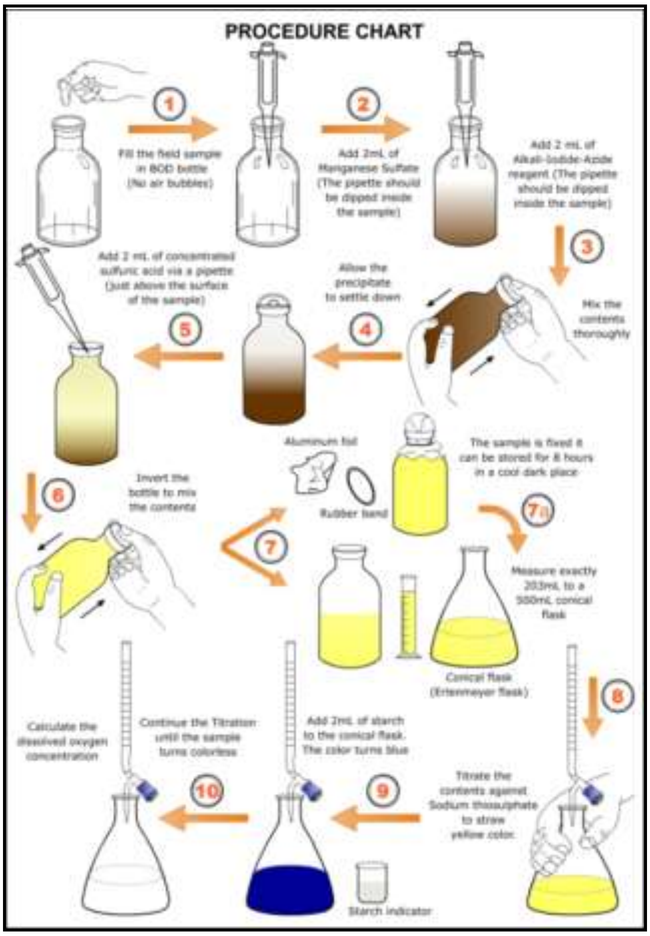

Fig.4: Procedure chart of DO test

Alkalinity is primarily some way of measuring the acid neutralizing capacity of water. In other words, its ability to keep up a comparatively constant pH. The possibility to keep up constant pH is due to the hydroxyl, carbonate and bicarbonate ions present in water. The flexibility of natural water to act as a buffer is controlled in partially by the quantity of calcium and carbonate ions in solution. Carbonate ion and calcium ion both come from calcium carbonate or limestone. So, water that comes in contact with limestone will contain high levels of both Ca^{++} and $CO3^{2-}$ ions and have elevated hardness and alkalinity.

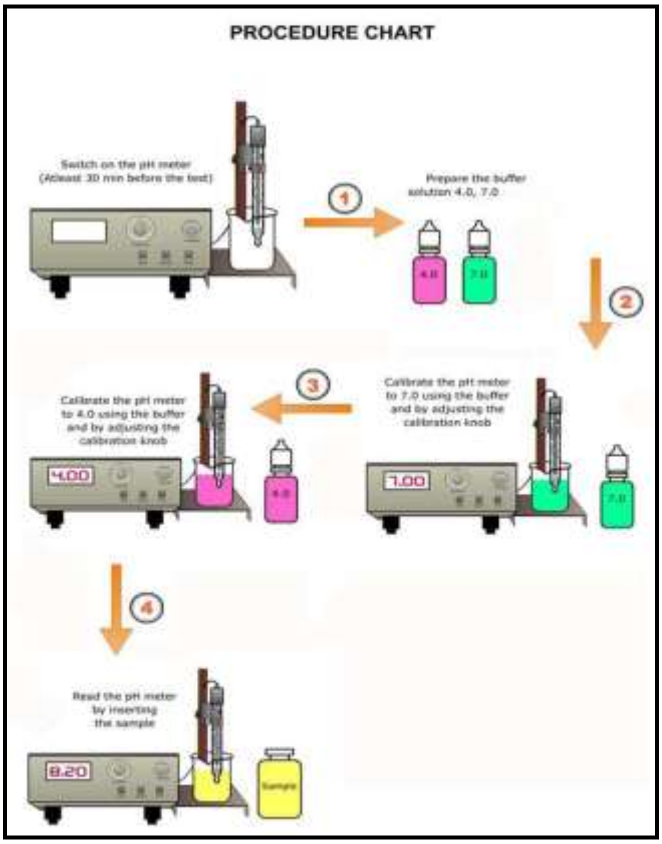

Fig.5: Procedure chart of pH test

4. RESULTS AND DISCUSSION

4.1 Influent characteristics of STP

In this project a lab scales study was conducted to gauge the inlet characteristics of raw sewage of biological treatment (Activated Sludge Process followed by Filtration) in treating sewage. The dissolved oxygen of inlet sewage was found as '0 'mg/l throughout the cycle of 24 hours. The raw sewage was collected, and various parameters were analyzed as shown in Table-1. From the table data we came to grasp that , the initial characteristics of influent of raw sewage having ranges of temperature (27.5-32 ℃), pH (7.14 -7.85), dissolved oxygen (0 mg/l), biochemical oxygen demand (190-213 mg/l), chemical oxygen demand (320-391 mg/l), and alkalinity (190-220 mg/l). It implies that raw sewage is extremely polluted and unsafe for Agricultural purpose. If this raw sewage is directly discharged into water bodies without treatment then water body will get polluted. So, it becomes necessary to a supply proper treatment thereto raw sewage to attain higher efficiency of effluent.

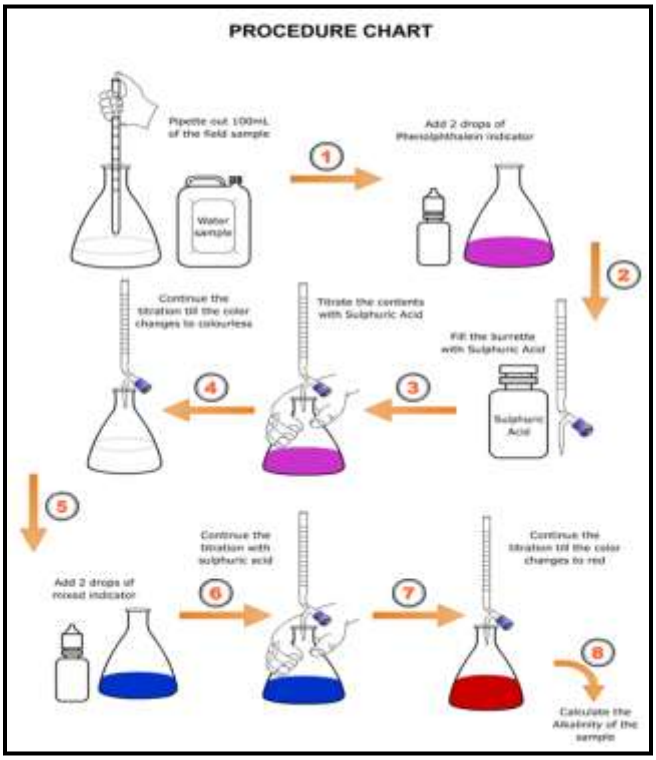

Fig.6: Procedure chart of Alkalinity test

Table-1: Inlet characteristic of raw Sewage of the whole one day

Time	Temp. (℃)	pH	COD (mg/l)	BOD (mg/l)	Alkalinity (mg/l)
8 am	28	7.85	383	211	220
10 am	29	7.44	356	197	205
12 am	30.5	7.28	368	205	195
2 pm	32	7.24	352	203	190
4 pm	31	7.23	334	196	190
6 pm	30	7.39	362	204	200
8 pm	29	7.27	391	213	195
10 pm	28	7.25	321	191	195
2 am	27.5	7.14	320	190	185
6 am	27	7.26	357	201	195
8 am	28	7.78	372	209	210

4.2 Effluent characteristics of STP

In this project a lab scales study was conducted to evaluate the outlet characteristics of raw sewage of biological treatment (Activated Sludge Process followed by Filtration) in treating sewage. To evaluate the effect of non-continuous aeration, provided 6 hours ,12 hours and 24 hours aeration in raw sewage for 1-1-month duration each. All samples were collected at 10 am on every 2nd day for 3 months duration.

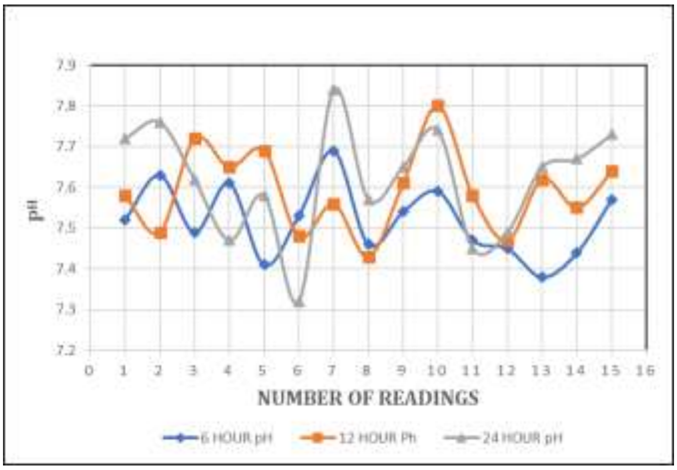

Chart-1: Effect on pH value of 6 hours aeration, 12 hours aeration, and 24 hours aeration.

From chart-1, it can be observed that the pH values of effluent are not showing so much variation due to change in aeration cycle. It means the variation of aeration period does not affect the pH values of effluent so much and showing similar results, so far.

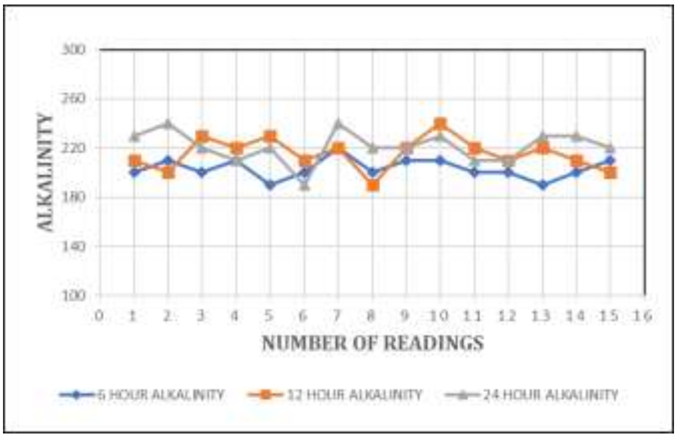

Chart-2: Effect on Alkalinity of 6 hours aeration, 12 hours aeration, and 24 hours aeration.

From chart-2, it can be observed that the alkalinity of effluent sewage is showing little variation due to change in aeration cycle. The alkalinity values for 24 hours aeration cycle is giving little higher values as compared to 12 hours aeration and 6 hours aeration which means 24 hours aeration cycle shows promising result for conventional activated sludge process.

From chart-3, it can be observed that the dissolved oxygen content in effluent sewage are increasing as well as we are increasing aeration period from 6 hours cycle to 24 hours cycle. The 24 hours aeration cycle shows higher values of dissolved oxygen because we are providing continuous aeration in aeration tank and dissolved oxygen is none other than the amount of oxygen dissolved in a unit volume of sewage. But the difference in the values of dissolved oxygen content for 12 hours aeration cycle and 24 hours aeration cycle is less so, we can provide aeration of 12 hours cycle in the small scale activated sludge process, and we can use the effluent for agriculture purpose also.

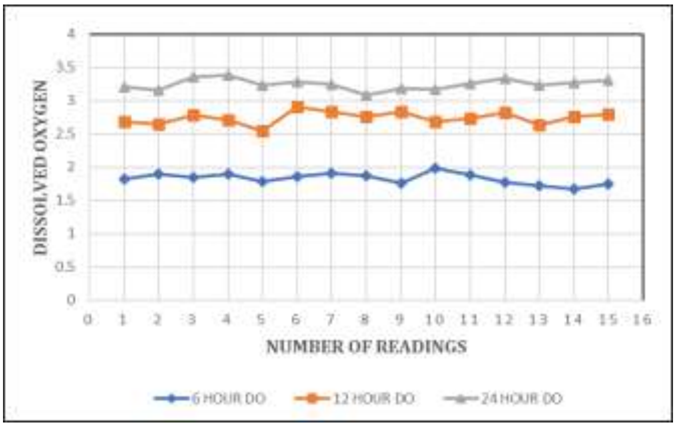

Chart-3: Effect on Dissolved Oxygen value of 6 hours aeration, 12 hours aeration, and 24 hours aeration.

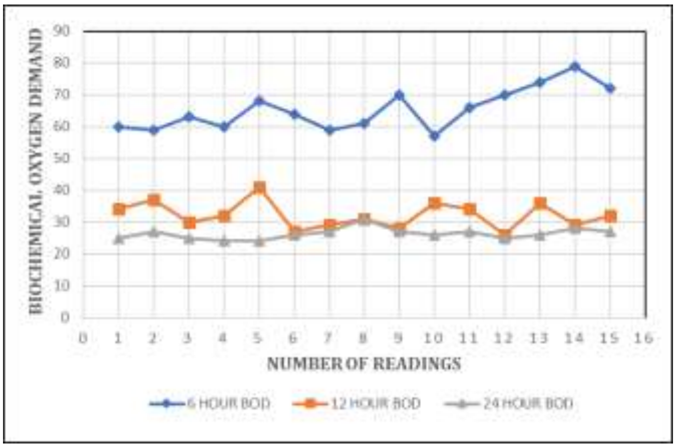

Chart-4: Effect on Biochemical Oxygen Demand value of 6 hours aeration, 12 hours aeration, and 24 hours aeration.

From chart-4, it can be observed that the biochemical oxygen demand of effluent sewage are goes on decreasing as well as we are increasing aeration cycle from 6 hours cycle to 24 hours cycle because BOD means the amount of oxygen required for biological decomposition of dissolved organic matter in the sewage. The 24 hours aeration cycle is showing lower values of BOD and the difference in the values of BOD, s of 12 hours aeration cycle and 24 hours aeration cycle is less so one can provide 12 hours aeration cycle also instead of providing 24 hours aeration cycle for the treatment of sewage on small scale.

From chart-5, it can be observed that the chemical oxygen demand of effluent sewage are goes on decreasing as well as we increase the aeration cycle from 6 hours to 24 hours because COD means amount of oxygen required to oxidize the organic matter in sewage. The difference between the COD values of 12 hours aeration cycle and 24 hours aeration cycle is less so, we can provide 12 hours aeration cycle also for sewage treatment in small scale activated sludge process instead of 24 hours aeration cycle.

Table -2 are showing the ranges of effluent characteristics of different aeration cycle as the permissible limit of BOD of treated sewage for agriculture purpose is up to 500 mg/l and here we get the values of BOD is 26-41 mg/l which is favorable for situation. Initially the dissolved oxygen content in untreated sewage was found to be zero and after treatment of sewage we get the DO content of treated sewage is 1.69-3.39 mg/l which is good for agriculture purpose.

Chart-5: Effect on Chemical Oxygen Demand value of 6 hours aeration, 12 hours aeration, and 24 hours aeration.

Table-2: Ranges of Effluent characteristics of different aeration condition

SR NO.	CHARACTERISTICS	PERIOD OF AERATION		
		6 HOURS	12 HOURS	24 HOURS
1.	Temperature (?)	28.5-32	28.5-33	29.5-34
2.	pH	7.38-7.69	7.43-7.80	7.32-7.84
3.	Alkalinity (mg/l)	190-210	190-240	190-240
4.	DO (mg/l)	1.67-1.98	2.55-2.91	3.09-3.39
5.	BOD (mg/l)	57-79	26-41	25-39
6.	COD (mg/l)	93-135	49-70	43-55

5. CONCLUSIONS

1. It is concluded that 12 hr aeration is suitable for sewage treatment plant. 12 hr non-continuous aeration saves 50% of power consumption by overall process. (previously it was 24 hr) 12 hr aeration is sufficient for small scale load. It gives favourable results which are required.
2. As this effluent water is used for agriculture purpose, the parameters which we get are favourable.
3. This effluent water can also be used for flushing purpose, as it is odourless.
4. Foaming is not forming on the surface of aeration tank chocking of pipe and pumps are comparatively less.

6. FUTURE SCOPE

1. The study can be modified to improve the STP performance using different cycles of aeration and no aeration period for different target parameter removal.
2. The aerobic biomass activity during the investigation the DO, BOD, pH, Alkalinity, COD of effluent was estimated for samples collected at 48 h from effluents of all the reactors, which has not given the clear idea about reactor performance. Hence, it is advised to estimate the performance related parameters at 24 h/12 h/6 h intervals which will give the more accurate idea of the reactor performance.

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