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ALGAL GROWTH IN THE BIOLOGICAL TREATMENT OF CATTLE WASTE

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Abstract
The steady increase in contaminants and pollutants reaching our1akes and streams has caused the steady decline in the 1ife supporting and aesthetic qualities of our waters. This is caused by excessive fertilization from effluents high in phosphorus, nitrogen and organic growth substances. Algae and aquatic plants become excessive and when they decompose a sequence of objectionable features arise. The objective of this study is to investigate the influence of organic loading and concentration on algal growth and also see how algal growth is affected by the efficiency of treatment. The cattle waste was treated biologically in a stabilization pond. Two concentrations of 5g/l and 10g/l were used and a detention time of 30 days was used for the treatment. The rate of loading was 0.2L/s. The results showed an efficiency of 75% in terms of BOD removal and that algae grew abundantly during sunshine and at a temperature ranging between 30 - 32°C and pH values ranging from 7.4 to 8.1. The peak algal growth for both concentrations occurred between 14 – 18 days detention time. Also, the peak algal growth for the 5g/l concentration occurred at 45% BOD removal efficiency while that of the 10g/l concentration occurred at 48% BOD removal efficiency. It was also observed that turbidity determination could be used as an indirect method of confirming algal growth. This work reveals the influence of concentration, temperature, hydrogen ion concentration (pH), detention time and turbidity on algal growth and recommends ways of attaining safe standards of effluents before discharging into receiving streams.

Key Words: *Contaminants, Pollutants, Algal growth, Excessive fertilization*

Introduction

Eutrophication of our streams and lakes have often been 1inked to the increased contamination reaching these waters both from municipal sewers and through underground percolation from soil treatment systems. It appears that since the world population will continue to increase to the point of doubling in the next decade, contaminants reaching the water courses wil1l also increase Wickham *et al*. (2016). The problems this will create can only be surmised, but indications exist that all but the largest, swiftest and coldest bodies of water may be choked with algae within the next decade. Two schools of thought have emerged on ways to combat the problem Halfhide *et al*. (2015).

The first school has taken the defeatist attitude and concludes that algal growth presence is impractical. This decision is based partly on the present inadequacy of information on exact nutrient and environmental requirements for bloom development and partly on the feeling that nutrients are rather ubiquitous and that natural environmental factors tend to favour blooms (Qin *et al.*, 2015). This thinking sometimes suggests control of blooms by physical or chemical removal of the algal after they reach a detrimental level. The other school is more optimistic and proposes to control blooms by limiting nutrients essential for their growth. Members of this school do not agree on either the proper nutrient to remove or how to remove it practically from the wastewater effluent. Mathiot *et al*. (2019) reviewed the 1ife nature and concluded that the most frequently reported 1imiting nutrient was organic phosphate. This is repeatedly cited as the most critical growth factor for algae growth. The concentration of phosphates in municipal wastewaters is increasing and removal efficiencies of these contaminants is poor and variable.

The process of eutrophication is primarily caused by the supply of plant nutrients to the aquatic environment, even though other factors are involved, such as morphometric relations and the degree of biological utilization of the nutrient substances (Rizwan *et al.,* 2018). The manifestation of eutrophication is the increasing primary productivity; in extreme cases in the water-bloom phenomenon develops and in stagnant water oxygen supply becomes depleted. The consequence of eutrophication is reduced fitness for use of the water. The primary cost of industrial and domestic water supply is considerably increased. Damage is done to fisheries, the landscape is aesthetically deteriorated and the recreational value of the water for public health is adversely affected (Rizwan *et al.*, 2018).

Practical application of the knowledge gained about the process of eutrophication is still a problem. The state of eutrophication of inland waters is difficult to measure and evaluate and the conventional 1imnoligical methods only seldom give information that meet the requirements of designing engineers (Agre *et al*., 2017). As a supplement to chemical and physical methods of importance for the practical handling of eutrophication problems, bio-assay methods using algal as test organisms have been developed in several laboratories (Franchino *et al*., 2016).

The aim of this study is to investigate how algal growth is promoted in the biological treatment of wastewater, while the objectives are to study the effect of organic loading, concentration, temperature and pH on algal growth; how algal growth is affected by the degree of wastewater treatment using a stabilization pond and formulate standard curves showing the cattle waste (expressed in weight per volume) and strength of waste (expressed in mg/l).

Materials and Methods

The study was carried out on the Abattoir located along Ede road in the South western part of Ile-Ife,Osun State, Nigeria (007^o 29′ 58.21″ N and 04^o 30′ 48.68″ E) while that of Obafemi Awolowo Teaching/ Research farm is on (007^o 32′ 38.6″ N and 004^o 32′ 34.5″ E) which located within the premises of Obafemi Awolowo University, Ile-Ife in Osun State, Nigeria (Figures 1).

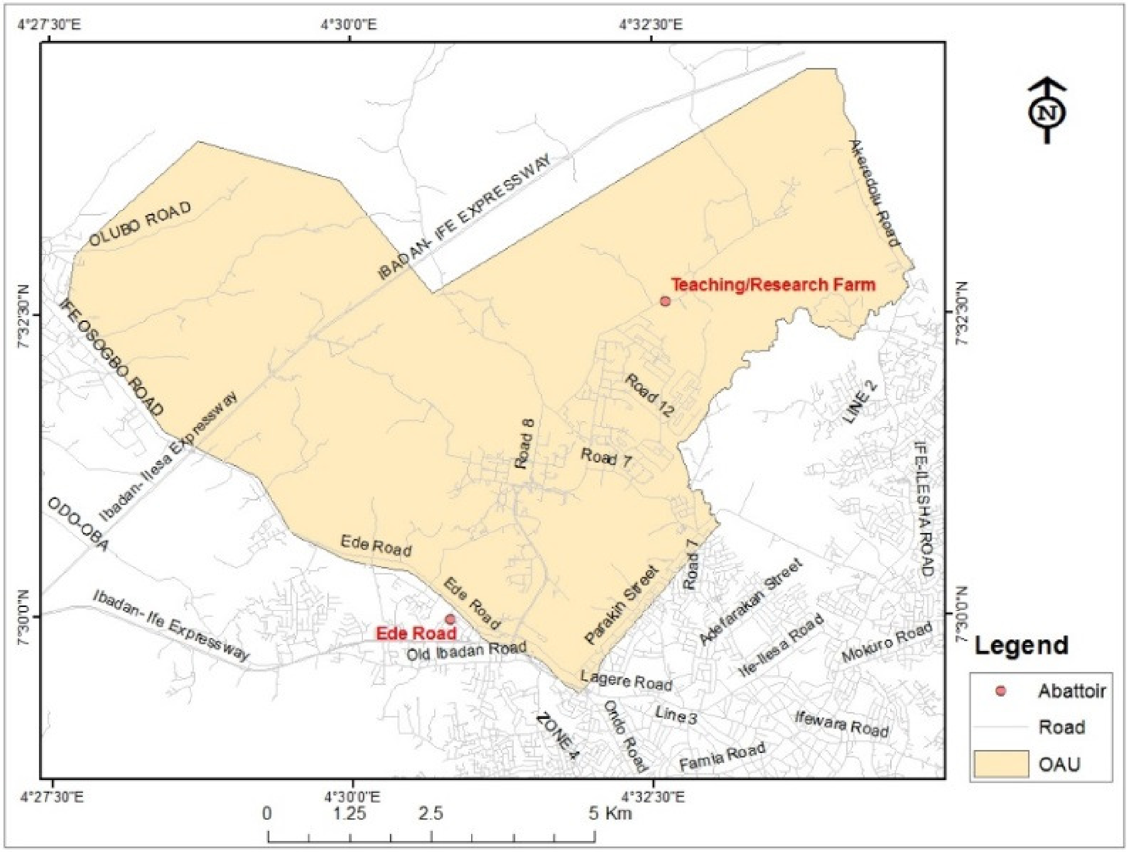

Fig. 1: Map of the Study Areas

The waste used for this work was cattle waste obtained from the two abattoirs (along old Ede Road and the Teaching and Research Farm). The waste was collected in buckets and transported to the laboratory.

An aerobic stabilization pond of dimension 4.57m x 1.52m x 1.22m was constructed for this study. The site was behind the Agricultural and Environmental Engineering Workshop, Obafemi Awolowo University. Baffles were constructed in the pond to ensure a reasonable dispersion of the wastewater.

In order to obtain a fairly constant rate of loading of the pond an 86cm x 46cm x 100cm rectangular tank was used as the mixing reservoir where the waste was mixed and flowed into the pond through a pipe by gravity.

A 6 bottle manometric apparatus, model 2173B was used to determine the strength of the waste (BOD). An electronic pH meter model 7010 was used to measure the hydrogen ion concentration (pH) of the waste samples while the Hf instruments Turbidimeter model PRT 200 was used to measure the turbidity of the waste samples. Temperatures were taken by using a standard thermometer in Fahrenheit and then converting to centigrade. A microscopic counting chamber was used to observe and identify the algae grown in the pond.

Methods

Preliminary Work

The aerobic pond was constructed by excavating the ground at a site behind the Department of Agricultural and Environmental Engineering Workshop, Obafemi Awolowo University, Ile-Ife. Since the soil was very dry and had a great affinity for water, the sides and bottom of the pond were plastered with cement mortar to reduce water seepage and percolation. Old unused concrete cubes 150mm x 150mm x 150mm were then collected and used to construct three baffles of a1mension 1.3m x 0.15m x 0.8m at 1.15m intervals. An outlet channel was constructed at the end of the pond.

The wet cattle waste was then spread in the sun to reduce its toxicity. The prepared waste was then diluted with water in varying concentrations of 5g/l, 10g/l, 15g/l, 20g/l, 25g/l and 30g/l. The concentrations were mixed manually very thoroughly for about 15 minutes. It was then allowed to settle for about 30 minutes. The supernatant of each dilution was then poured in the manometric BOD bottles in volumes of 160ml.

Procedure of Experiments

The cattle waste was mixed in the required concentrations of 5g/l and 10g/l in the mixing reservoir in order to establish the influence of organic loading on algae growth. The waste was mixed manually with a wooden rod for about 45 minutes. The waste was then discharged through a half-inch pipe at the bottom of the reservoir into the pond by gravity. The rate of loading of the pond was 0.2l/s.

The BOD, hydrogen ion concentration (pH), temperature and turbidity of the influent wastewater were determined for both concentration and repeated at intervals of 3, 7, 10, 14, 21 and 30 days.

The algae growth was monitored for the above day intervals and samples were taken on which microscopic algae counts were performed. The samples were taken with a measuring cylinder and poured into clean bottles. The samples were divided into 5 or 10ml samples which were then poured into the counting chamber and the algae present were counted. The average number of algae was then determined and expressed in number of algae per litre.

Results and Discussion

The BOD values at unsteady state for the various concentrations of the cattle waste are illustrated in Figure 1 through Figure 3. Table 1 shows the amount of BOD removed for the two concentrations used.

The variation of temperature and Hydrogen ion concentration (pH) with detention time is shown in Table 2 while Figure 4 shows the variation of turbidity of the wastewater with detention time for both concentrations. The number of algae produced at the various detention times and various efficiencies of treatment for both concentrations are also illustrated in Figure 5.

The curves shown in figure 1 through 3 show the BOD versus time relationships for various concentrations at the unsteady state. The unsteady state implies that the microbes are still exerting a considerable amount of BOD after each day (Praveen *et al*., 2018). The shape of the curves which are parabolic indicate higher BOD readings for each successive day and these values will eventually stabilize after some time. The values of the BOD after 5 days of incubation are called the 5-day BOD values. The 5-day BOD values for the different concentrations are illustrated in figure 4. It can be seen that the BOD of the wastewater varied linearly with the concentration, thus it can be seen that an increase in the concentration of the waste will cause a corresponding increase in the 5-day BOD value (Cho *et al*., 2013). From table 1, it can be seen that the efficiencies obtained for both concentrations after 30 days detention time were almost the same value of 75%, though the 5g/l concentration was slightly more efficient. Thus, it is apparent that if the treatment was prolonged for more than 30 days, the quality and standard of the effluent obtained would be even better (Muwafq and Bernd, 2006).

The data in Table 2 shows that the algal growth occurred at temperatures ranging between 29°C to 32°C and the hydrogen ion concentration (pH) ranging from 7.4 - 8.2. This implies that the algal growth took place under slightly alkaline condition and fairly warm temperature, which are really ideal conditions for algal growth (Fathi, 2002).

Table 1: Efficiencies of two concentrations used at various detention times

Concentration (g/l)	**Detention Time (Days)**	**Effluent BOD (mg/l)**	**BOD Removed (mg/l)**	**Efficiency (%)**
5	0	220		
	7	170	50	E1 = 22
	10	145	75	E2 = 34
	14	120	100	E3 = 45
	21	80	140	E4 = 64
	30	55	165	E5 = 75
10	0	295		
	7	220	75	E6 =25
	10	180	115	E7 = 39
	14	155	140	E8 = 48
	21	100	195	E9 = 66
	30	75	220	E10 = 74

Table 2: Variation of temperature and pH with detention time

Concentration (g/l)	**Detention Time (Days)**	**Temperature (°C)**	**pH**
5	7	32	7.4
	10	30	7.6
	14	31	8.1
	21	29	8.1
	30	32	7.9
10	7	31	7.9
	10	29	8.0
	14	30	8.1
	21	32	7.8
	30	32	7.6

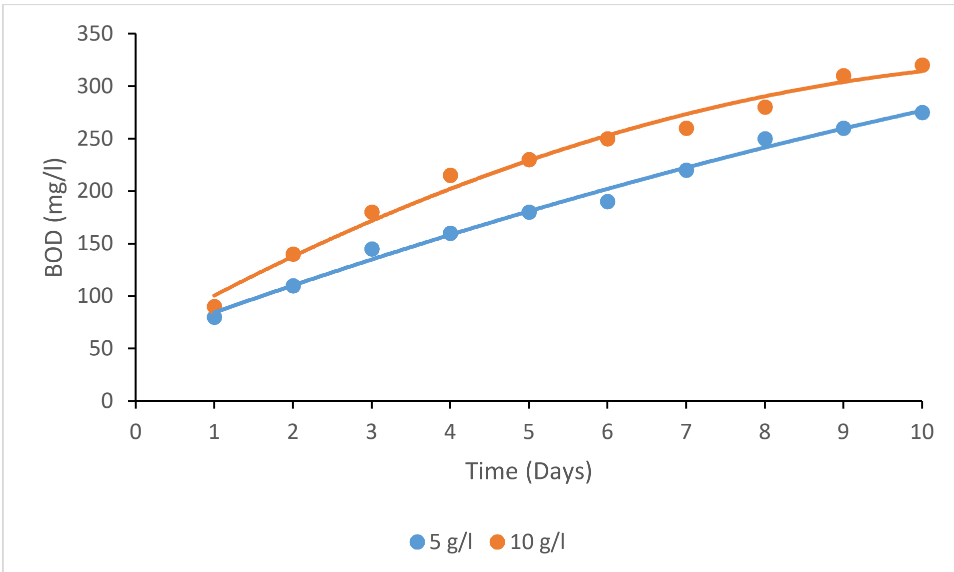

Fig. 2: BOD – Time Curve at unsteady state for 5 and 10 g/l concentrations

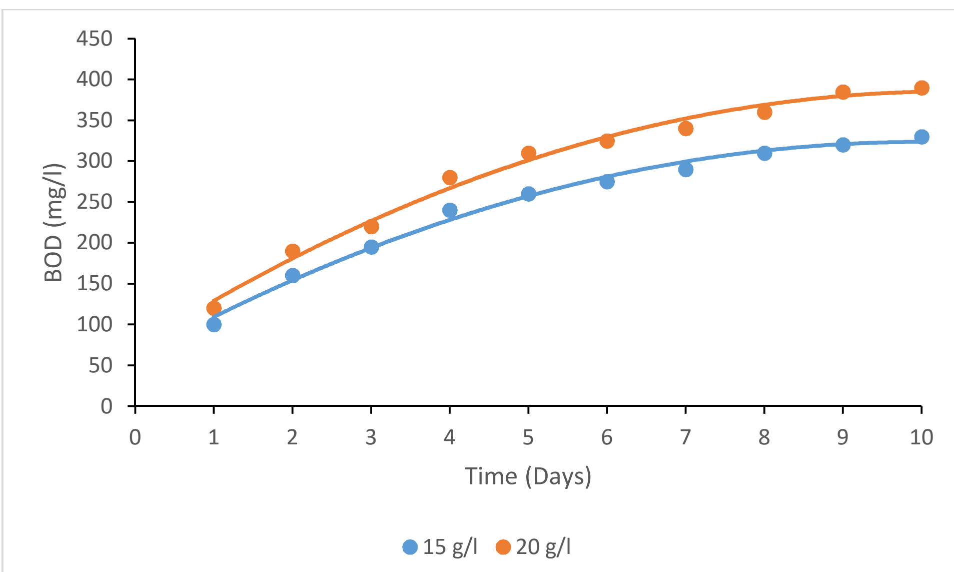

Fig. 3: BOD – Time Curve at unsteady state for 15 and 20 g/l concentrations

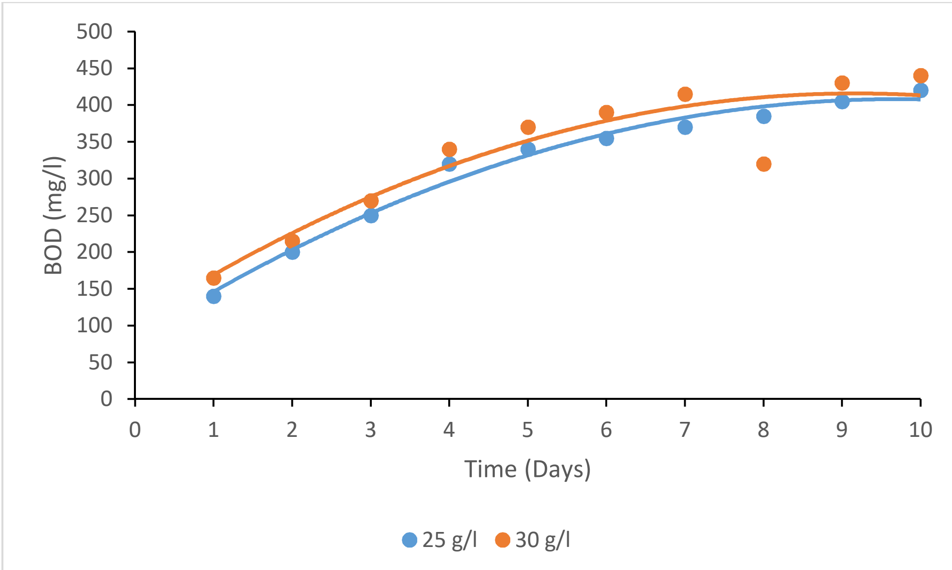

Fig. 4: BOD – Time Curve at unsteady state for 25 and 30 g/l concentrations

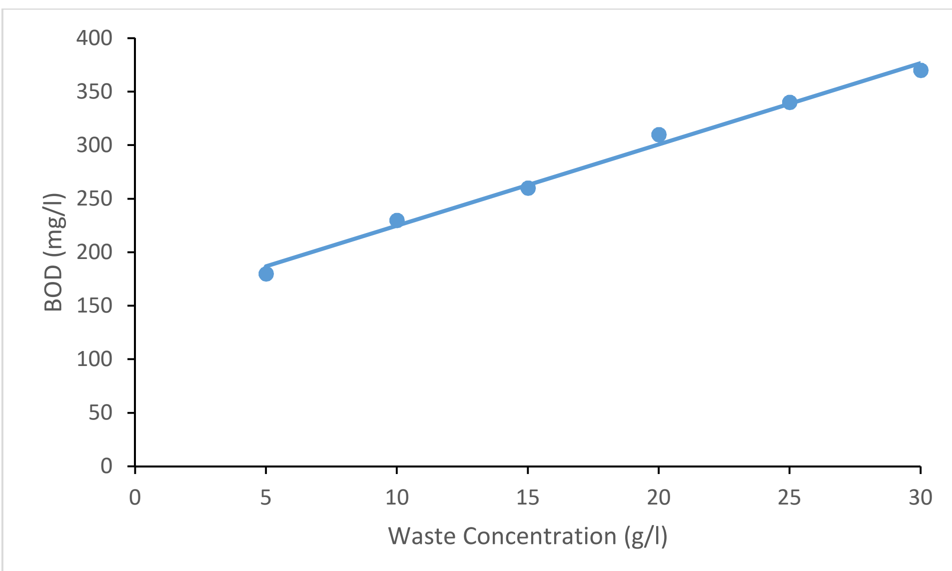

Fig. 5: BOD_5 Concentration relationship

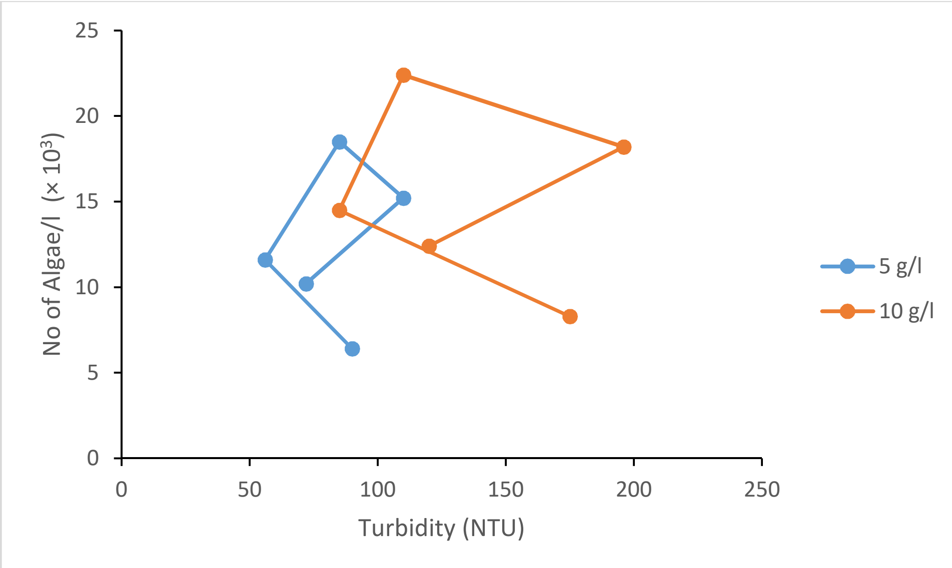

Fig. 6: Number of Algae – Turbidity relationship for the two concentrations used

Figure 5 illustrates the relationship between the Number of Algae and Turbidity for the 5g/l and 10g/l concentrations. For the 10g/l concentration the Number of Algae produced increases as the turbidity decreases. This continues up to a point when the turbidity now increases as algal growth increases. The initial decrease in turbidity was due to the treatment processes being undergone by the wastewater thus as the sludge in the wastewater settles it becomes less turbid. As more algae is produced, the effluent becomes more turbid due to the fact that it is algae laden. Eventually there comes a time when the algal growth decreases as the turbidity also decreases. The decrease in turbidity is due to the settlement as sludge of the decomposing algae which makes the effluent clearer. The drop in algae production is due to overloading of the system of higher BOD values.

The relationship between the algae produced and the detention time for both concentrations is illustrated in Figure 6. It can be observed that algal growth increases as detention time also increases until when a peak value is reached, then algal growth drops. It can be observed that the peak values for the two concentrations are different though they occur at almost the same time. The 10g/l concentration had a higher peak value of algal growth than 5g/l concentration. This may be due to the presence of more nutrients in the 10 g/l concentration than in the 5g/l one.

Figure 7 shows the relationship between the Number of Algae and BOD removal efficiency. It can be observed for both concentrations that algal growth increases as the efficiency of treatment increases. After the peak value of algal growth has been attained, algae production decreases with increase in BOD removal efficiency. This drop in algal growth may be attributed to the fact that as treatment efficiency increases, the effluent is rendered less stimulating to algal growth. It can also be observed from Figure 7 that the peak values of algal growth occurred at different efficiencies.

The peak value for the 10g/l concentration occurred at 48% BOD removal efficiency while that of the 5g/L concentration occurred at 45% BOD removal efficiency.

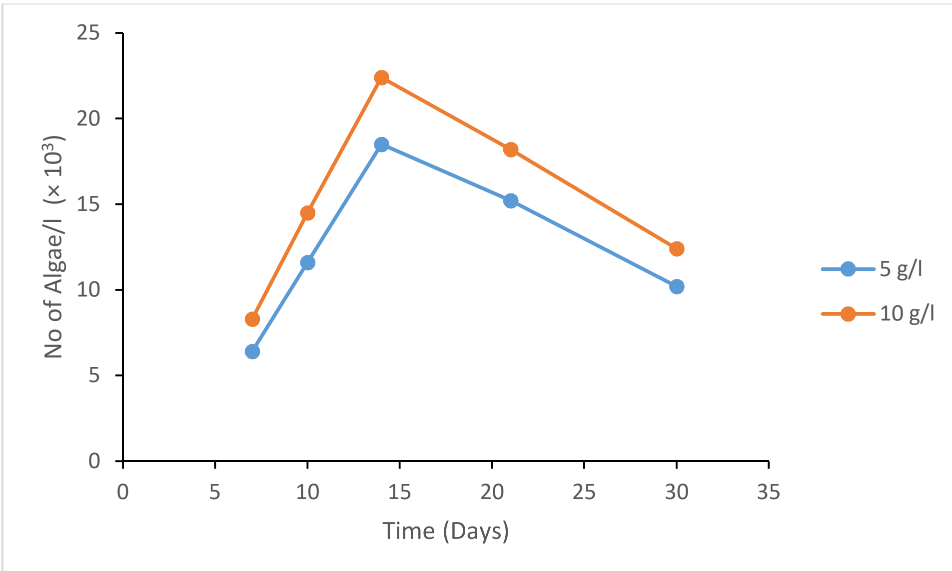

Fig. 7: Number of Algae – Detention Time relationship for the two concentrations used

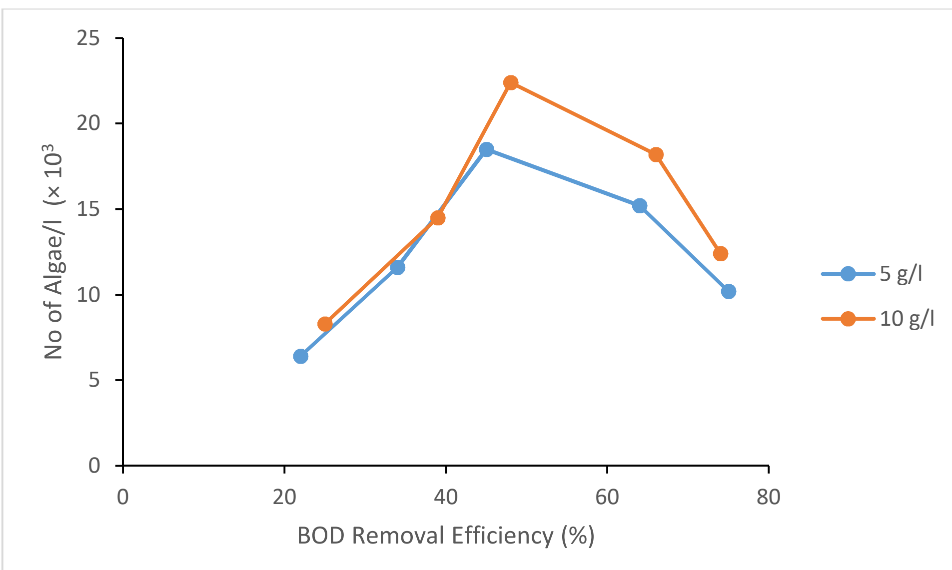

Fig. 8: Number of Algae – BOD Removal Efficiency relationship for the two concentrations used

Conclusion

The value of the 5-day BOD increases as the concentration of wastewater increases thus the more the dilution of the waste, the lower the 5-day BOD value. The BOD removal efficiency of 75 % for both concentrations was a fairly good value but this can be improved upon by further increasing the detention time of treatment.

Algal growth was abundant during sunshine and at temperatures ranging between 30 - 32°C and at hydrogen ion concentration within the range 7.4 - 8.1. This indicates warm and slightly alkaline conditions. Also, algal growth increases with concentration due to the availability of more nutrients.

Turbidity may be used as an indirect method of monitoring and confirming algal growth since effluents which are algae laden tend to be more turbid than those effluents which are free of algae.

Initially algal growth increases with increasing detention time and then after a peak has been reached falls for increasing detention time. Also, algal growth increases with increase in BOD removal efficiency and then drops after peak has been reached despite an increase in BOD removal efficiency.

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