ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

Waste Water Characterization of Alfred Akawe Torkula Hostel, University of Agriculture, Makurdi, Benue State, Nigeria

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ABSTRACT. This research was based on the characterization of wastewater of Alfred Akawe Torkula Hostel, University of Agriculture, Makurdi. Composite samples of the wastewater were analyzed for the physical, chemical and biological characteristics. Total hardness and Total dissolved Solids were found to be appreciably significant at the regression coefficients of 0.9622 and 0.8376 respectively. For a student population of 474, 256.5m^3/day flow rate was determined at an area loading of 500kgBOD_5/ha/day. A series arrangement of one facultative pond (with an area of 1593m^2, dimensions of 67.95m by 22.65m and a retention time of 9 days) and two maturation ponds (with an area of874.07m^2 dimension of 51.21m by 17.07m and a retention time of 7days each was designed for treatment plant based on preliminary investigation. The effluent quality at the two maturation ponds at the end of the waste water stabilization pond system is 22.5mg / l BODs and 73FC /100ml which meet the standard for domestic and irrigation water needs for the College of Engineering and its environs.

KEYWORDS*:* Characterization; Composite samples Wastewater; Stabilization pond; Alfred Akawe Torkula hostel

I. INTRODUCTION

Most developing countries lack adequate wastewater collection systems for domestic, agro-industrial wastes and sewage systems. Surface water and groundwater have often been studied and managed as separate resources although they are interrelated [1]. A 2007 study found that discharge of untreated sewage is the single most important source of pollution in surface and ground water in India. There is a large gap between generation and treatment of domestic waste water in India. The problem is not only that India lacks sufficient treatment capacity but also that the sewage treatment plants that exist do not operate and are not maintained CPCB [2]. Sources of surface water pollution are generally grouped into two categories based on their origin. Point source water pollution refers to contaminants that enter a waterway from a single identifiable source, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain. The U.S. Clean Water Act (CWA) defines point source for regulatory enforcement purposes. The CWA definition of point source was amended in 1987 to include municipal storm sewer systems, as well as industrial storm water, such as from construction sites.

There is need for adequate wastewater collection systems and its disposal in order to reduce the spread of communicable diseases caused by pathogenic organisms in the sewage and also to prevent the pollution of surface and ground water [3]. These two reasons are interdependent to the extent that a polluted body of water is a potential and frequently an actual source of infection, particularly in the hot climates (Nigeria inclusive). There is now an increasing awareness that pollution and contamination of the environment are most undesirable in themselves and, therefore, measures to abate pollution should be judged from an ecological stand point rather than merely the improvement they may make to the human condition [4]

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Domestic sewage is typically 99.9 percent water with 0.1 percent pollutants. Although found in low concentrations, these pollutants pose risk on a large scale [5], [6] . In urban areas, domestic sewage is typically treated by centralized sewage treatment plants. Well-designed and operated systems (i.e., secondary treatment or better) can remove 90 percent or more of these pollutants. Some plants have additional systems to remove nutrients and pathogens. Most municipal plants are not specifically designed to treat toxic pollutants found in industrial waste water [7]. Cities with sanitary sewer overflows or combined sewer overflows employ one or more engineering approaches to reduce discharges of untreated sewage, including: utilizing a green infrastructure approach to improve storm water management capacity throughout the system, and reduce the hydraulic overloading of the treatment plant [8], repair and replacement of leaking and malfunctioning equipment increasing overall hydraulic capacity of the sewage collection system (often a very expensive option).A household or business not served by a municipal treatment plant may have an individual septic tank, which treats the waste water on site and discharges into the soil. Alternatively, domestic waste water may be sent to a nearby privately owned treatment system (e.g. in a rural community).

Wastewater collected from municipalities and communities must ultimately be returned to received water or to the land. It is however unfortunate that Nigeria has no clearly established effluent standards to ensure that the streams and watercourses do not become unsuitable for their present uses. In recent times, industrial development and the growth of cities in the country has led to increased rate of pollutant discharges into our water courses [9], [10]. At present, according to an unpublished report from the Lagos State Ministry of Environment, it is estimated that 128 million litres of raw sewage are being dumped into the lagoon annually. The reason for the rapid growth in the population was due to increased urbanization and unplanned settlements [11]. This dramatic increase resulted from the uses of these watercourses (rivers and streams) include fishing, irrigation, cattle grazing, laundry and recreation. These watercourses are usually polluted in the dry seasons when flows are minimal.

Most towns, communities or industries in Nigeria and other developing countries consider treating their wastewater as a wasteful venture. Hence it is very convenient to dispose its wastewater from communal premises without paying attention to its toxicity or level of pollution. However, some institutions in Nigeria have over the years being involved in the treatment of wastewater and have succeeded in establishing or constructing wastewater treatment plants which have, at present, improved the well being of the occupants of the hostels. These institutions are: Ahmadu Bello University (A.B.U.) Zaria, Kaduna State, University of Nigeria, Nsukka (U.N.N), Enugu State, and Obafemi Awolowo University Ife (OAU), in Osun State,

This research was aimed to characterize a wastewater stabilization pond system to help improve the well being of the occupants of the hostels through water supply, mosquitoes control and proper sewage disposal. The specific objectives of this work include:

1. To evaluate the constituent composition of wastewater within the area of study
2. To characterize the wastewater for the Alfred Akawe Torkula Hostel, University of Agriculture, Makurdi for sewage treatment and recycling.
3. To make recommendations for the construction of sewage treatment plant for the Alfred Akawe Torkula Hostel.

II. MATERIALS AND METHODS

A. Materials

Materials used in the experiments include plastic containers, conical flasks, clinical thermometer, beaker, Hach Test Kit (for measurement of Total hardness, calcium and magnesium), conductivity and TDS meter, lovibond comparator, and spectrophotometer.

B. Sampling

Due to the variable nature of the flow of wastewater "Time-interval composite" were taken and analyzed on a six day over

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a six week period for six months. The sample collection time was between 10:00 am and 4:00pm so as to ensure that the wastewater was not fresh. This is the time when most students must have left the hostels for their lectures. These samples were taken and mixed together in proportion at the time of collection. This is because grab samples do not provide much information. This wastewater samples were collected in 2 litre plastic containers.

C. Analysis

The temperature and the pH of the wastewater were measured using the clinical thermometer and the lovibond comparator. The lovibond comparator was used in measuring the pH, instead of the pH meter because of the reading taken by the pH meter is affected by the source of power (battery) and hence does not last. The laboratory analyses were carried out at the Water Board, Makurdi. The parameters determined includes temperature, pH, electrical conductivity total dissolved solids(TDS) suspended solids (SS), odour, total hardness, calcium hardness, magnesium hardness, nitrate-nitrogen, total phosphorous, total organic matter, turbidity, BOD_5 & COD The bacteriological analysis (coliform count) was also carried out. Apart from the pH, temperature, odour total hardness, calcium hardness, magnesium, electrical conductivity, total dissolved solids (TDS) all other parameters were measured or determined spectrophotometrically. In spectrophotometric analysis light of a definite wavelength of 1-10 Angstrom units in bandwidths that extend to UV region of the spectrum constitutes the source of light.

This necessitates the use of more complicated instrument known as the direct spectrophotometer. The analyses were carried out in four phases and the procedures used for the determination of these parameters are described below:

1. *Physical Parameters*

a). Turbidity:

This is a measure of the light transmitting property of the wastewater. The turbidity of the wastewater was measured using the spectrophotometer. The wavelengthwas adjusted to 450nm. A sample cell was filled with 25ml of clear colourless, turbidity free-water (distilled water) and placed into the reference position followed by entering the stored program value of 355. The light beam in the sample position was blocked and adjusted to Zero (0.00mg/l). Another sample cell filled with the test sample was placed in the sample position and the transmittance values measured in FTU (Formazin Turbidity Units) were recorded. All the six samples of wastewater were similarly measured.

b). Total Dissolved Solids.

This was measured using the conductivity meter. By pressing the mode key to move between conductivity, salinity and TDS, any of the measurements can be taken. The probe of the meter was inserted into the sample solution. By immersing the tip to or beyond the vent holes, agitating the probe vertically and making sure air bubbles were not entrapped near the temperature, the reading were allowed to stabilize before recording.

c). Suspended Solids

This was determined by filling the sample cell with 25ml of the sample to be tested. The stored program number for the suspended solids (630) was entered on the device and the wavelength was set at 810nm. The Enter key button was pressed to display mg/l susp.solids. 25ml of deionized water was poured into another sample cell (the blank). The blank was placed into the cell holder and the light shield was closed after the removal of the blank from the cell holder. This displayed the value of the suspended solids of the sample under test.

d). Electrical Conductivity.

This is the measure of the ability of a conductor to convey electricity [12], [13]. This was measured with a mains operated conductivity meter. The mode key on the meter was pressed to display the conductivity mode with the units of mS (micro Siemens) displayed. The probe of the meter was inserted into the sample solution. By immersing the tip to or beyond the vent holes, agitating the probe vertically and making sure air bubbles are not entrapped near the temperature, the reading were allowed to stabilize and then recorded [14].

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2. Chemical Parameter.

a). Hardness

Hardness of water is understood to be a measure of the water required to precipitate soap. The precipitation of soap is due to the presence of calcium and magnesium.

i). Total Hardness

The plastic measuring tube was filled with the wastewater sample to be tested and the contents were then poured into a mixing bottle. Three drops of Buffer solution hardness were added into the mixing bottle and was swirled followed by addition of a drop of Manver hardness indicator solution. EDTA (ethylene-diamine-tetra-acetic acid) titrant was then added to the solution in the mixing bottle drop by drop; swirling the mixture on addition of each drop of the EDTA titrant added into the mixing bottle, each drop of EDTA titrant added to the mixture was recorded.. The addition continued until a colour change from pink to blue was seen / noticed. The hardness in mg/l as calcium carbonate ($CaCO_3$) is equal to the number of drops of EDTA titrant required to bring about colour change multiplied by 20.

ii). Calcium Hardness.

The plastic measuring tube was filled with the wastewater sample to be tested and the contents of the tube were then poured into a mixing bottle followed by the addition of three drops of 8N potassium hydroxide. A clipper was used to open Calver Calcium indicator powder pillow which was added into the solution in the mixing bottle. EDTA (ethylene-diamine-tetra-acetic acid) titrant was then added to the solution in the mixing bottle drop wisely with swirling at each drop addition and each drop of the EDTA titrant added into the mixing bottle was counted. The addition continued until a colour change from pink to blue was noticed. The hardness in mg/l calcium carbonate ($CaCO_3$) is equal to the number of drops of EDTA titrants required to bring about colour change multiplied by 20. The calcium hardness value was subtracted from that of the total hardness to obtain the magnesium hardness.

b). Nitrate-Nitrogen.

This is one of the four inorganic forms of nitrogen compounds that is of sanitary significance. This is measured using the spectrophotometer. The stored program number for nitrate-nitrogen 355 was entered by pressing the respective buttons and the wave-length was set at 500nm. By pressing the enter button on the device, mg/l N NO_3^- H is displayed. A sample cell was filled with 25ml of the sample to be tested followed by the addition of the contents of one nitraver 5 nitrate reagent powder pillows to the cell (prepared sample). The shift timer buttons on the device was pressed and the cell was vigorously shaken until the timer beeped in one minute. The contents of the sample were allowed to stand for 5 minutes. Another sample cell filled with 25ml of distilled water was placed into the cell holder and closed until the timer beeped, 0.00mg/l N NO_3^- H was displayed. By removing the blank and placing the prepared sample in the cell holder the value of the nitrate-nitrogen was displayed and it was recorded.

c). Total Phosphorus.

This was also measured by the use of the spectrophotometer. The stored program for phosphorus was entered by pressing 494 and the wave length was set at 890nm. By pressing the enter button mg/l P was displayed. A sample cell filled with 25ml of the sample to be tested was added with the contents of phosphate Accuvac Ampulus reagent (prepared sample). The cell was vigorously shaken for approximately 30 seconds and was allowed to stand for 2 minutes. The shift timer buttons were pressed and when the timer beeped, 0.00mg/l P was displayed. Another sample cell filled with 25mg/l of distilled water (the blank) was placed into the cell holder and closed when the timer beeped and 0.00mg/l was displayed. By removing the blank and placing the prepared sample in the cell holder and closing the light shield, the value of phosphorus in the sample in the sample was displayed.

d). Biochemical Oxygen Demand.

This represents the amount of oxygen required by bacteria to decompose aerobically the organic matter present under

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standard conditions of time and temperature. A suitable volume of dilution water (well oxygenated water free from bacteria inhibitors) was prepared. The required amount of distilled water, transferred to another container and 1ml of each of the calcium chloride, magnesium sulphate, ferric chloride and phosphate buffer solution per liter of water were added. A sample was placed in a full air tight bottle and incubated under specified conditions for a specified time (5 days chosen). Dissolved oxygen concentration was measured initially after incubation. The difference between the initial and final dissolved oxygen gave the required BOD after 5 days of incubation. The BOD after 5 days of incubation was determined from the formula

$$BOD_5(mg/l) = \frac{D_1 - D_2}{P}$$

Where, D_1 and D_2 are the dissolved oxygen of the diluted ample immediately after preparation and after 5 days of incubation respectively.

$$P = \frac{ml\ of\ sample}{volume\ of\ BOD\ bottle}$$

e). Chemical Oxygen Demand.

This is a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. A suitable volume of samples and reagents were measured and sealed. Each was vetted several times for complete mixing. These tubes were placed in block digest pretreated at 150^{o}C and refluxed for 2 hours. The mixture was now cooled to test tubes of racks. The degree of dichromate reduction was measured, cooled, samples inverted, blanked and standardized several times and solids were allowed to settle before measurement of absorbency.

Also according to [4], for untreated domestic sewage, a large number of measurements have indicated the following ratio for BOD_5 to COD.

BOD_5 / COD = 0.5 , Therefore, COD = 2 X BOD_5

3. *Bacteriological Analysis*

This is the determination of the indicator organism in a sample of wastewater or water. This is also referred to as coliform count. The 14th Edition of *Standard Methods* [15] defines total coliform as a group of bacteria which is aerobic and facultative anaerobic, gram-negative, nonspore-foaming, rod shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C. This definition includes the following bacteria: Escherichia coli, E. Aurescens, E. Freundii, E. Intermedia; Aerobacter, Aerogenes, A. Cloacae. The test was carried out using the most probable number (MPN).

An indicator, bromoresol purple indicator was added into a series of sterilized culture bottles. A change of colour from pink to yellow after 48 hours indicated the presence of coliform. The number of coliform present was estimated by the use of MPN Table. The culture media was prepared by dissolving approximately 1g of beef boullion and 4g of powdered milk in 250ml of distilled water. 15ml of media was then introduced into each 15 clean screw-capped sterilized bottles followed by the addition of 5 drops of bromoresol purple indicator solution.

10ml of wastewater sample was introduced in the first group of five sterilized culture bottles which contained the media and indicator solution. The second group of five sterilized bottles was introduced with 1ml of wastewater sample and the third group of five sterilized bottles was introduced with 0.1ml of wastewater sample by means of a sterilized syringe. The bottles were then incubated at about 35^{o}C for two days. After two days, the bottles were observed for colour change, Positive test- bottles that have colour change from pink were obtained. A MPN table was used to estimate the number of coliform present in the wastewater. MPN values per 100ml of sample and % confidence limit for various combinations of positive and negative results when (five 10ml, five 1ml and five 0.1ml) test portions are used

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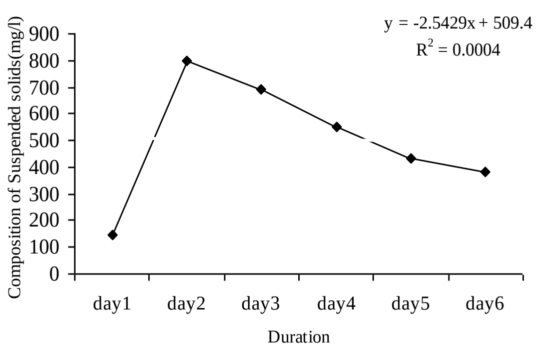
Table 1: Most Probable Number of Coliform Organisms.

Sample No.	Concentration			MPN (per 100ml)	95% confidence limit	
	10ml	1ml	0.1ml		Upper	Lower
1	5	5	5	>1800	-	-
2	5	5	5	>1800	-	-
3	5	5	5	>1800	-	-
4	5	5	5	>1800	-	-
5	5	5	5	>1800	-	-
6	5	5	5	>1800	-	-

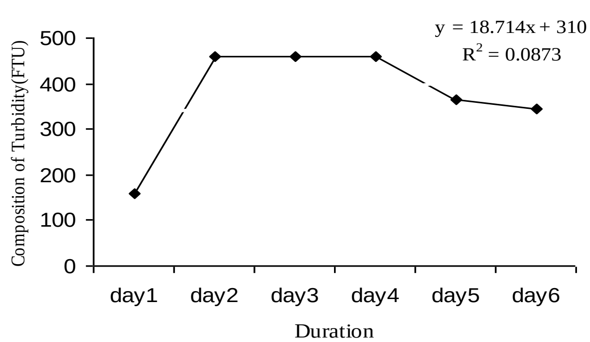
Source: Field survey (2007)

III. CHARACTERIZATION OF RESULTS

Wastewater samples were collected for six weeks and their physical, chemical and biological parameters analyzed. The results of these analyses are shown in table six (6) below . The results of the analyses showed that the wastewater of the Alfred Akawe Torkula Hostel is generally strong in terms of electrical conductivity, total dissolved solids, hardness, and pH, but is low in values of phosphorus, BOD_5 and COD. This means that after the stabilization of this wastewater has taken place to meet the expected effluent quality at the end of the design period, another treatment will be required for the effluent so as to remove the hardness and reduce the electrical conductivity. Physical appreciations of the plot of the respective constituents are presented below:



(a)



(b)

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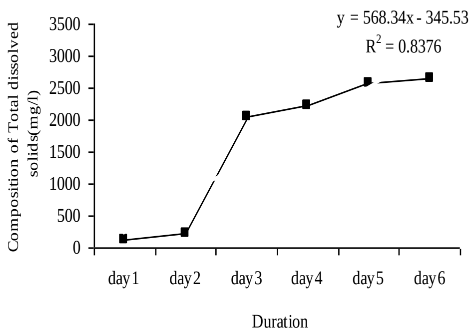
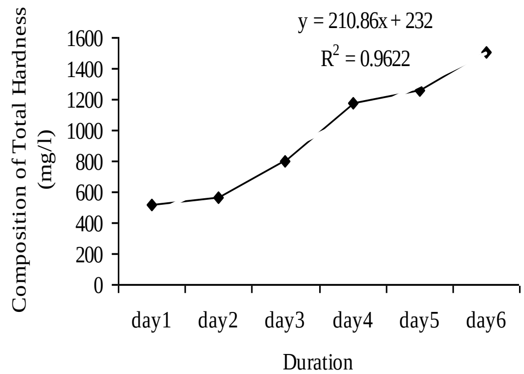
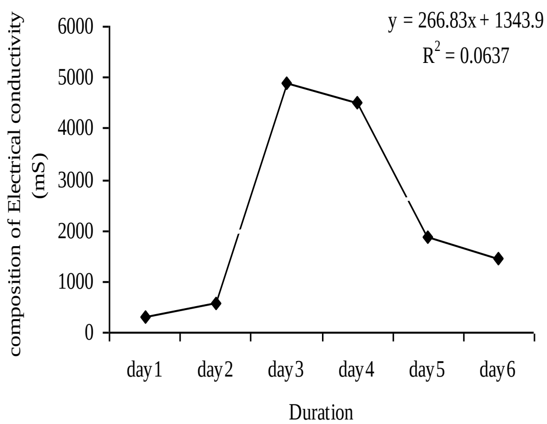


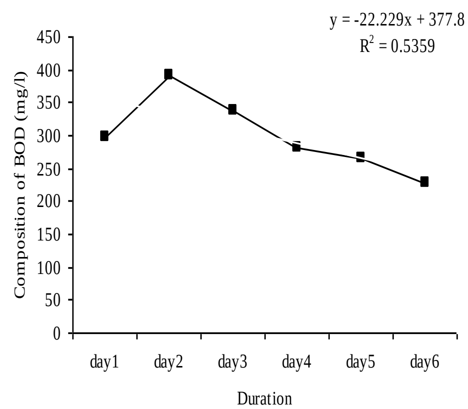
(c)



(d)



(e)



(f)

Fig 1. Physical appreciations of the plot of constituents (a) Suspended solids (b)Turbidity (c) Total dissolved Solids (d) Total Hardness (e) Electrical conductivity (f) Biochemical oxygen demand

Possible relationship were also carried out between the constituents and the period of survey. The relationship and the regression coefficient (R^2) values are presented in the table below.

Table 2: Relationship between constituents and duration of survey.

Constituents	Equation of best fit	R^2
Suspended solids	$y = -2.5429x + 509.4$	0.0004
Total Dissolved solids	$y = 568.34x - 345.53$	0.8376
Turbidity	$y = 18.714x = 310$	0.0873
Total Hardness	$y = 210.86x + 232$	0.9622
BOD_5	$y = -22.229x + 377.8$	0.5359
Electrical conductivity	$y = 266.83x + 1343.9$	0.0637

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The temperature of the wastewater was usually high and hence the thermal energy of the wastewater, which facilitates bacterial oxidation of the oxidation of the organics in the wastewater.

On the other hand, the high nitrate-nitrogen content of the wastewater shows that the total nitrogen content of the wastewater will be high and as such enhance dense algal blows in waste stabilization ponds which provided oxygen for bacterial oxidation of the wastewater and are also a valuable food source.

There was however a great variation in the composition of wastewater anytime flows. This was as a result of the very low levels of suspended solids and BOD_5 in the mornings when the residents of the hostel prepare for lecture (i.e. the time when most of the students are having their bath) but the wastewater was highly acidic.

In addition to the results of the laboratory analysis of the wastewater of the Alfred Akawe Torkula hostel, [16] gave the levels of the major constituents of strong, medium and domestic wastewater as shown in and since the strength of wastewater is judged by its BOD_5 or COD, the strength of the wastewater for the block is that of a strong domestic wastewater. This in essence signifies that the BOD_5 is high and as such has a high level of organic pollution is a basis for the treatment of wastewater, a system of treatment should be suggested. And in this perspective, the suggested treatment should be one which is capable of minimizing the extremes. Hence, wastewater stabilization pond system should be designed for the hostel. This is due to its low capital cost, high temperature and high sludge removal and its design will be highly imperative.

Table 3: Major constituent of Typical Domestic Wastewater

*Con*stituent	Constituent concentration in mg/l		
	Strong	Medium	Weak
Total solids	1200	700	350
Dissolved solids (TDS)	850	500	250
Suspended solids	350	200	100
Nitrogen (as N)	85	40	20
Phosphorus (as P)	20	10	6
Chloride	100	50	30
Alkalinity (as $CaCO_3$)	200	100	50
Grease	150	100	50
BOD_5	300	200	100

Source: UN Department of Technical Cooperation for Development (1985)

IV. CONCLUSION AND ECOMMENDATION

A. Conclusion

From the study undertaken, it can be concluded that wastewater from the Alfred Akawe Torkula hostel is generally strong in terms of BOD_5, COD, total dissolved solids (TDS) and suspended solids. Besides the high concentration of BOD_5, COD, total dissolved solids and suspended solids, the wastewater has a high nitrate-nitrogen concentration which implies that the total nitrogen content of the wastewater is high. This will enhance algal blooms in wastewater stabilization pond. The algae in the cause of photosynthesis provide oxygen for bacterial oxidation of the wastewater and also a valuable source of protein. The appropriate treatment method for treating wastewater from the Alfred Akawe Torkula hostel is the wastewater stabilization pond system. It has least cost of construction and maintenance compared to other treatment methods with BOD5 removals of greater than 90%. This choice is greatly influenced by the resources needed for its implementation and the feasibility reuse schemes associated with waste stabilization pond systems.

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B. Recommendation

From the above, it is recommended that;

1. The wastewater stabilization pond system should be located at the lowest elevation of the block. This is to enhance gravity flows.
2. Since the wastewater stabilization pond system cost is less and is more efficient than the most conventional treatment works, it is that more stabilization ponds should be built where necessary and it should be ensured that all requirements are met.
3. The university authority should consider the proposed wastewater stabilization pond system as long term investment with a certain reasonable "growth" in revenue generation over a short period. With all these in mind, it is recommended that the university authority should consider constructing the wastewater stabilization pond system as it will improve the well being of the occupants of the hostels.
4. Further research should be carried out in evaluating the cost of constructing the pond.

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