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Microbial Quality and Assessment of Dynamism of Physiologic Factors on Selected Physicochemical Properties of Waste Water

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ABSTRACT

Physicochemical factors are important parameter widely used in assessing the quality/competence of surrounding ecosystem. Aquatic surrounding hold a vital point of every living system in the biosphere as compromised findings in the physicochemical properties of the aquatic system proves a point of danger to live progression. Cheap and effective way of waste treatment can be achieved easily when possible interactions and changes of responsible quality marking factors of a particular body is well understood. Waste water sample were collected from Rumuekini, Rivers state, Nigeria. Reference Sample was sited 0.5 km away from the waste water reservoir. Microbial analysis of the waste water sample in the presence of the control experiment after seven (7) days of incubation showed total viable count (TVC) of 5.4 x 10^3 and 4.6 x 10^3 CFU/ml respectively for day 0; 4.4 x 10^3 and 2.9 x 10^4 respectively for day 7. Total coliform counts of the waste water in the presence of the control experiment showed total coliform count (TCC) of: 1.3 x 10^2 and 8.0 x 10^2 CFU/ml respectively for day 0; 1.8 x 10^3 and 3.2 x 10^2 CFU/ml respectively for day 7. Physicochemical properties of waste water from a dairy industry surge tank located at Rumuekini, Portharcourt showed the following: pH (5.0), temperature (41°C), conductivity (610); water dissolved minerals such as Cl^-, K^+, PO_3, $Mg2^+$, Ca^{2+} were all determined. Initial dissolved oxygen concentration (mg/l) of the waste water was determined using a probe connected to a meter with initial value of 39.4 mg/l. Biochemical oxygen demand (BOD_5) was determined after five incubation days at room temperature in separate bottles optimized at varying pH levels of 4.0-9.0 in a range of 1.0 units. BOD_5 decreased with increased pH values the tested samples incubated for 5 days. pH 5.0 gave a significant reduction of the oxygen exertion (1400 mg/ml) while pH 4.0, 6.0, 7.0 showed an oxygen exertion (BOD_5) of 1978, 2778, and 2965 mg/ml respectively. Samples incubated at 8.0 and 9.0 showed oxygen exertion of 2945 and 2899 mg/ml respectively. Other contents

of the dairy waste water such as total organic carbon (TOC), total organic matter (TOM) contents were all determined respectively. Proceedings from this study showed the compromised statues of our aquatic environment and also in a wider look gave a great insight of effective modalities in water treatment; as increasing population of myriads industries in our country today pose great challenge to the competence of our aquatic body.

Key words: BOD_5, pH, aquatic bodies, physicochemical, oxygen exertion

INTRODUCTION

Ecosystem is a self-supporting unit with biotic and abiotic plausible (Igweze *et al.,* 2014). Organisms live in surface water, with aerobic species congregating near the water surface and anaerobic microbes increasing with depth of the water level due to decrease in oxygen concentrations and reduced water conditions (Ubalua *et al.,* 2007). Oxygen among other gases present in air is as important at water and soil interfaces as it is a vehicle for nutrients and contaminants delivered to the wetland as biochemodynamic principles depict (Valero, 2010).

The competence of every part (aquatic) of the ecosystem is revealing in its physicochemical features; in a wider sense, these physical and chemical properties defines healthiness of surrounding biosphere (Ron and George, 2008). Discharge of municipal and industrial wastewaters as well as agricultural drainage containing organic materials in water resources result in a reduction of dissolved oxygen (DO) concentration and compromising aquatic body's physicochemical properties (Yudianto and Yuebo, 2008). Biochemical oxygen demand (BOD) is an empirical parameter which refers to the amount of required oxygen (mg/l) for microorganisms living in aqueous environment to oxidize carbonaceous organic materials present in the wastewater, effluent, and polluted water samples (Penn *et al.*, 2009). Oxygen in the atmosphere when dissolved in aqueous surrounding (dissolved oxygen) is an important element for survival of inhabitant faunas and floras in the water body. Many biochemical activities of these cultural organisms revolve around dissolved oxygen because its presence in these water bodies is detrimental to aquatic organismal survival (Yudianto and Yuebo, 2008). However, BOD is often used ambiguously in relation to Carbonaceous Oxygen Demand (CBOD) which is the oxygen consumed during the oxidation of carbonaceous (carbon containing) compounds to carbon dioxide (CO_2) and other oxidized end product (water) (Joshi *et al.,* 2011). Dairy product production is a common bio-process and practice globally, including Nigeria. The production process results in an accumulation of a considerable amount of dairy whey, which poses serious environmental problems when disposed.

Whey is the aqueous fraction of milk generated as by-products of dairy industries during their bioprocessing (Sinnott and Withers, 2011). Whey contains approximately 0.4-0.5% butterfat, 0.6-0.8% soluble protein, 4.5 – 5% lactose, minerals, trace amount of vitamins and other organic matters (Bras *et al*., 2010).

Disposing of excess whey in the environment, especially in water bodies is problematic because of its high organic content (biodegradable matter) with high Biochemical Oxygen Demand (BOD) and high Chemical Oxygen Demand (COD) (ATSDR, 2009).

Implementation of stringent standards for the disposal of wastes in the environment has necessitated the need for the development of alternative waste treatment (especially water bodies) processes. Biochemical oxygen demand (BOD) is an effective standout parameter in monitoring water quality by eco-toxicologists. This study highlight the change associated with certain effluent's physicochemical features at given physiologic treatment. This went further to reveal the dependence of these physicochemical properties and at given physiologic condition. It is noteworthy that waste treatments is almost the difficult task for environmentalist and toxicologist; however understanding the relationship and dynamism of relevant water properties from studies empiricals will give a proper guide for experts in handling treatments especially involving water bodies.

MATERIALS AND METHODS

Site Description

Rumuekini field is in Obio/Akpor local government area of Rivers state; it is located between the Eastern coastline of the Alakahia and Choba, River. It is at the mangrove swamp forest of the Niger Delta, South-south Nigeria.

Sample collection

Waste water from the dairy industry was collected in a clean sterile container. The collection was made at three different points of the waste collection centre. This was done using sterile sampling bottles and a long rope tiedaround the neck of each bottle. It was allowed to gradually sink into the waste water to fill the bottles. The bottles were covered aseptically and transported to the laboratory where the analysis was done immediately.A geographically similar virgin area located fifty meters (50 m) adjacent to the effluent site was used as the standard control (reference) samples; they were labeled accordingly and taken to the laboratory for analyses.

METHODS

Research layout

Four distinct stages make up the experimental process:

- Collection of the waste water from Rumuekini, Rivers state, Nigeria.
- Determination of the waste water physicochemical properties.
- Incubation of the waste water whose initial physicochemical properties have being determined at different pH and temperature.
- Microbial analysis of the waste water
- Statistical analysis of the revealing results.

Physicochemical Analyses.

Conductivity, pH, Chloride, Sulphate, total solid (TS), total dissolved solid (TDS), total suspended solid (TSS), were determined using standard laboratory methods as reported by Onojake*et al*. (2011). Water hardness (Ca and Mg), turbidity were also determined as described by APHA (1992). Total Organic Carbon (TOC), Total organic matter (TOM)were determined in the laboratory using titrimetric method as described byWalkey and Black (1934).

Estimation of Total organic carbon (TOC) and Total organic matter (TOM)

This was done as described by Onojake *et al*. (2011), briefly ten ml (10 ml) of waste water samples was measured out and poured into 500ml volumetric flask. 10ml of$K_2Cr_2O_7$ and 20ml of conc. H_2SO_4were added. 100ml of distilled water (1:1), 10ml of $H_3PO_4$and five drops of diphenylamine indicator were added before titrating with 0.5N ferrous ammonium sulphate $(NH_4)_2SO_4Fe$.

Ablank titration was thereafter carried out and the % TOC was calculated as:
%TOC = TVB - TVS/ Weight of sample
TOM = TOC X 1.752

Where TVB and TVS are titre values of the blank and the test sample.

Water physicochemical properties such as dissolved oxygen concentration and biochemical oxygen demand exertion (BOD_5) were analyzed using the dissolved oxygen meter with a probe. BOD was determined from the dissolved oxygen concentration after five days of incubation as described in the protocol by APHA (1992).

BOD sample bottles were used during the study; pH of the waste water was varied using 1% HCl (v/v) (4.0- 6.0) and 0.1 mol. of NaOH (8.0-9.0) (w/v).
$BOD_5 = Do_1 - Do_5$
$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$
$6H^+ + O^-_2 = 2H_2O + 2H^+$
Where Do_1 is the initial dissolved oxygen concentration
Do_5 is the final dissolved oxygen concentration

Determination of TS, TDS and TSS

Total solids = $\frac{\text{mg. total solids} \times 1000}{\text{mL of sample}}$
TDS= conductivity * 0.65
TSS = TS - TDS

Microbial isolation:

Microbial analysis of the waste water was determined using standard microbiology and biochemical techniques as described by Ezeonu *et al*.(2013). Morphology identification, microscopic mounting and biochemical tests were carried out as well.

Coliform counting was determined after plating on a standard bacteria medium as follows:
TCFU/g = colony observed x dilution factor x volume used

RESULTS

Table one and two show the microbial populations of the dairy waste water at varying days of incubations

Heterotrophic Counts (CFU/ml)	**Control**	**Dairy waste water**
Total Viable Counts (TVC) (10^{-2})	4.6 X 10^3	5.4 X 10^3
Total Coliform Counts (TCC) (10^{-2})	8.0 x10^2	1.3x10^3
Day 0		

Heterotrophic Counts (CFU/ml)	**Control**	**Dairy waste water**
Total Viable Counts (10^{-2})	2.9 x 10^4	4.4 X 10^3
Total Coliform Counts (10^{-2})	3.2 x 10^2	1.8 x10^3
Day 7		

Table three: Physicochemical Properties of the Dairy Effluent against the Standard

Physiochemical parameters	**Control experiment**	**Water sample**
pH	7.2	5.02
Dissolved oxygen	46.98	39.4
BOD	8.22	14 (factor of 100 folds)
TDS	258.70	469.95
TSS	40.06	55.70
TS	298.76	525.65
Water Conductivity	398	723
Chloride ion (Mg/l)	393±0.18	1151.614±0.36
Phosphate (Mg/l)	1.86±0.02	1.53±0.02
Magnesium (Mg/l)	4.27±0.09	11.27±0.21
Potassium (Mg/l)	7.42±0.22	12.52±0.45
Calcium (Mg/g)	14.23±0.1	22.34±0.17
Turbidity (NTU)	28.77	53.50
Colour	Clear/transparent	Colloidal
Total Organic Carbon (TOC)	2.85±0.02	57.64±0.1
Total Organic Matter	4.99±0.01	100.99±0.12
Water temperature	24.5^{0}C	33.0^{0}C

Figure 1 below show the impact of temperature on dissolved oxygen concentration (DO) of the dairy waste water compared with the standard.

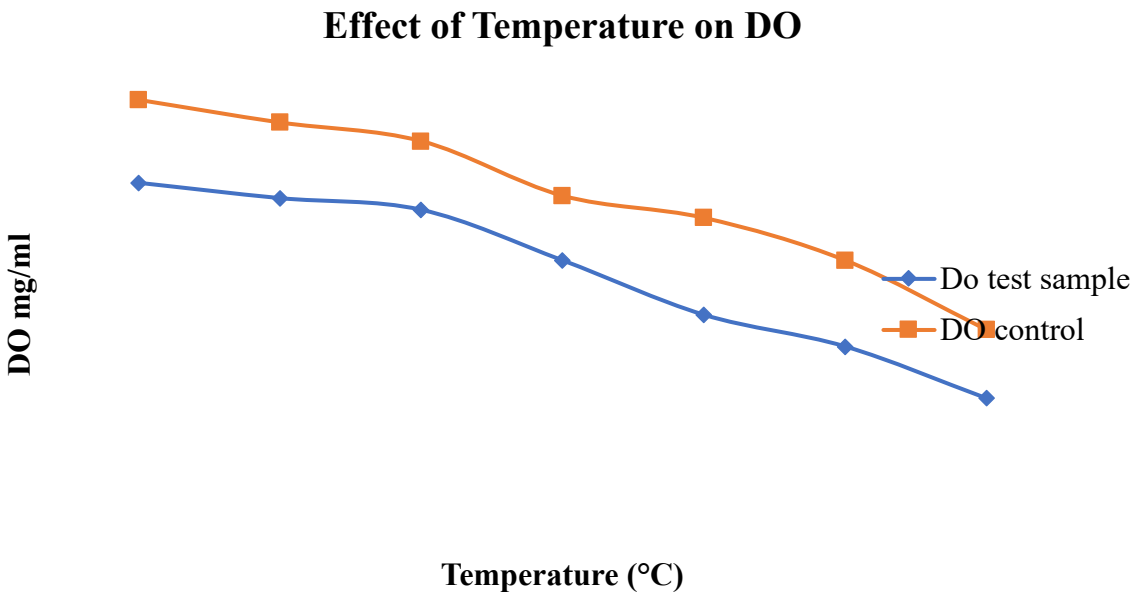

Fig 1. Effect of temperature on dissolved oxygen (DO) concentration in both the dairy waste water and the standard

Figure 2 shows the impact of pH ranging from 4.0-9.0 on biochemical oxygen demand (BOD_5) exertion of the dairy waste water modeled for five days.

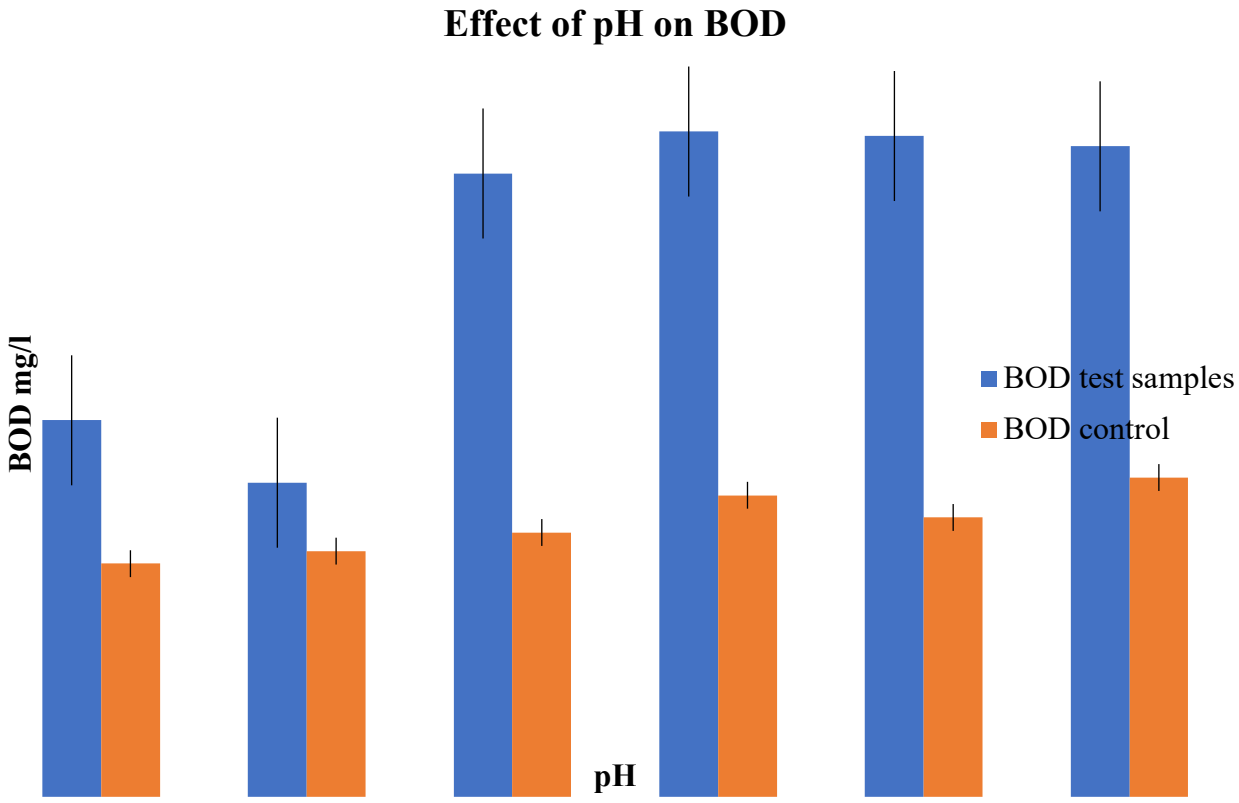

Fig.2 Fig .2 Changes in BOD level at various physiologic pH

Figure 3 shows the effect of temperature optimized from 20-70°C on total dissolved solid particles in the dairy waste water and that of the standard.

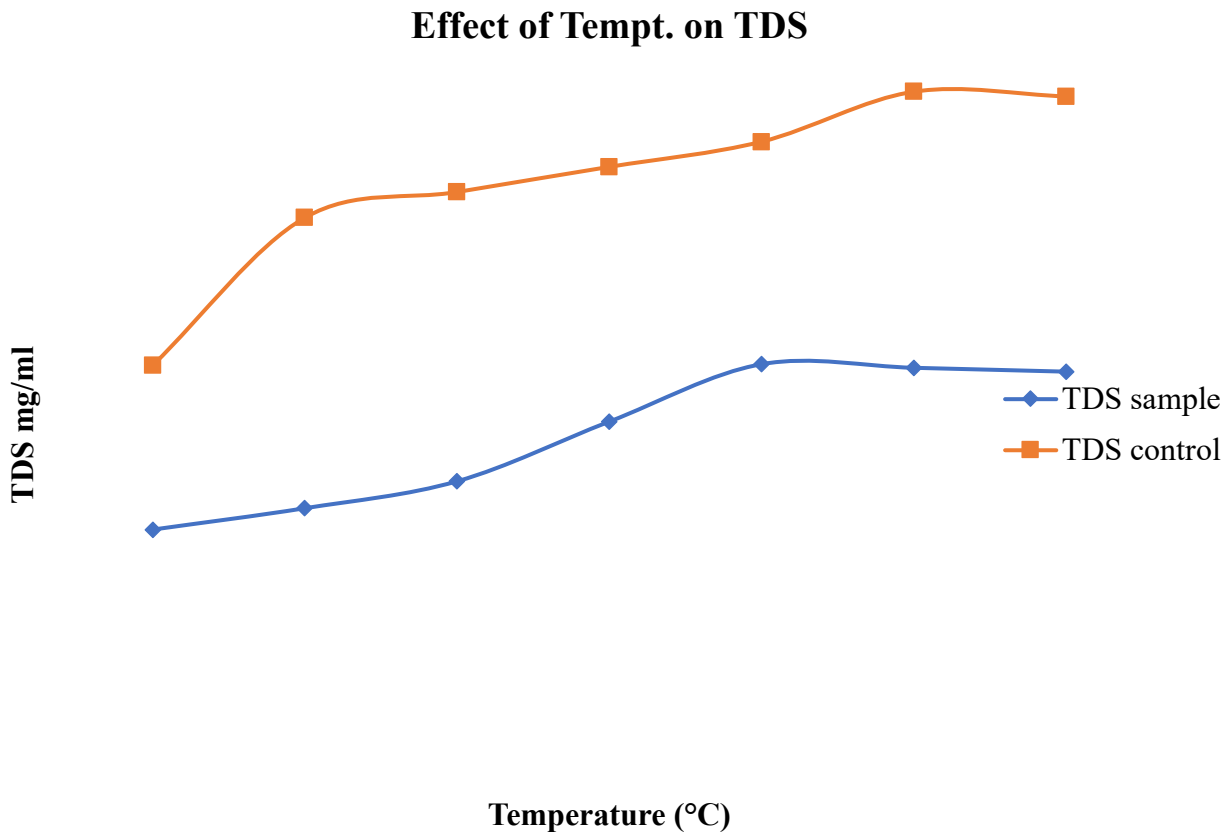

Fig.3 Effect of temperature (deg. Celsius) on total dissolved solids in both the dairy waste water and of the reference standard

DISCUSSION

Sustainability of the ecosystem, especially the water bodies is a collective approach of competent biotic and abiotic factors. Biochemical oxygen represents an important constitutive factor of the aquatic environment; compromising the standard of this factor could result in a lethal effect on inhabitants of the aquatic bodies. The present study undertakes the impact of physiologic pH on biochemical oxygen demand counts of dairy industrial waste water from Rumuekini, Portharcourt, Rivers state. Dairy effluent waste water from Rumuekini, Portharcourt, Rivers state showed high heterotrophic activity of microorganisms incubated for seven (7) days against the control experiment. Total viable counts of the organisms isolated from the waste water were 5.4 x 10^3CFU/ml and 4.4 x 10^3 CFU/ml at day 0 and day 7 of the incubation respectively. These observations showed a significant variation from the control experiment at these recorded days of incubations which shows total viable cell counts (TVC) of 4.6 x 10^3 and 2.9 x 10^4 CFU/ml respectively. Total coliform counts (TCC) of the organisms isolated from the dairy waste water were 1.3 x 10^3 and 1.8 x 10^3 CFU/ml for the day 0 and day 7 incubation periods respectively while the TCC from the control experiment were: 8.0 x 10^2 and 3.2 x 10^2 CFU/ml for day 0 and day 7 incubation periods respectively. Vallero (2010) suggested a seasonal fluctuation of organisms with respect to days and other impacted

physiologic factors. Increase in the coliform counts of the organisms from the waste water could be attributed to the nature of recalcitrantpresent in the surge tank of the dairy industry; also as suggested by center for disease control (2008)pathogenic organisms increase in any system due to favorable conditions for cross specie interactions and organismal budding from the inhabitant hosts.

Results obtained from the dairy waste water after physicochemical analysis showed that the waste water relatively contain higher hydrogen ion concentration (H^+) showing an acidic range profiling on pH scale. This can be attributed to the nature of the contaminant in the water such as oxidized sugars and metabolites of fermentation such as lactic acid, glycerol and gluconic acidwhich can lower the pH of the waste water as stated in the proceedings of the ATSDR (2005). Other components of the waste water upon analysis showed high concentrations of potassium (12.52 mg/l), Magnesium (11.27 mg/l) and chloride ions (1151.614mg/l). The components of the waste water showedrelatively lower PO_3 (1.53mg/l) ions compared to the control. The presence of Potassium, magnesium and chloride ions in higher concentrations (Mg/l) against the control revealed the level of influx of pollutantsfrom the dairy processing firm. Chikere *et al.*(2006) in their study at Eleme Rivers reported a similar correlation of ions in the Bonny river. Their resultrevealed a higher concentration of the mineral ions in the following order 2.28, 1.84, 5.22 and 1789.22 mg/g respectively for potassium, nitrate, magnesium and chloride ions.

Total organic carbon content and total organic matter (TOM) content of the waste water were observed at53.50 and 100.99 mg/l respectively in the tested sample. This showed a strong significant difference from the control experiment which showed TOC and TOM of 2.85 and 4.44 mg/l respectively .Mbachu *et al*.(2016) reported a sharp variation in their research on microbial diversities in a spent engine polluted site at Mgbuka, Onitsha Anambra state with Total organic carbon content and total organic matter contents showing the highest in concentrations of 116.06 and 203.34 mg/kg respectively.

Effect of temperature on dissolved oxygen (DO) concentration of the dairy waste water as shown in fig.1, depictstemperature dependent oxygen solvation in the dairy waste water. Gas availability in liquid medium is said to be dependent on the enthalpy state of the medium as most gases become kinetic competent at high temperature and such escape from the surface of the medium.From fig. 1, it can be observed that a lot of the oxygen quotient in mg/l was found at the lower temperature range of the waste water while the concentration of the oxygen decreased as the incubation temperature increased with 80^oC showing the least DO concentration (27.39 and 20.33)on both the control and test samples respectively.

Effect of pH on the biochemical oxygen demand counts (BOD_5) of the dairy waste water showed a pH dependent solvation of atmospheric oxygen in the water body. From fig.2, oxygen exertion was found more on the dairy waste water at the alkaline range while oxygen availability was highfor biochemical activities at the lower pH (acidic range). Co-existence of hydrogen ions and oxygen can be traced tomutual scrambling of ion pairs as reported by Price and stones.

Total dissolved solid (TDS) of the waste water revealed the physical conductivity of the aquatic body to the dissolved solid contents. Fig. 3 showed an increase of total dissolve solid (TDS)

particles in the dairy effluent as the temperature increased. This indicates a proportionate increase in conductivity of ions in the waste water sample. Temperature is said to have impact on the adiabatic state of matters, most feeble solid particles lose their basic crystalline shape when exerted upon by high energy inform of heat.

CONCLUSION

The study has shown the dynamism and interaction of physiologic factors on physicochemical properties and states of water bodies. The above results show how unhealthy the waste surges is to our environment as evident in the counts of proliferating organisms which maybe of medical important. The study has also shown the dynamisms of the aquatic factors at certain physiologic treatments: it was seen that dissolved oxygen level (as well BOD) decreases as pH and temperature increases respectively. Other physical properties such as total dissolved solids increases with temperature.

This presents an easier way by empirical of saving our ecosystem especially the aquatic environment through manipulation of certain physiologic factors for adequate sustainability of our environment.

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