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STUDY ON THE BALANCE OF PHOSPHATE AND NITRATE CONCENTRATIONS IN THE LAGOS LAGOON'S WATER SYSTEM

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ABSTRACT: *The effect of nutrient enrichment on surface water has continued to be a major environmental problem. The balance of nitrogen to phosphorus in water often determines the productivity of the water. This study was carried out to determine the nitrogen to phosphorus ratio in the Lagos lagoon, hence the nutrient availability in the water. Water samples were obtained at six different locations in the Lagos lagoon at different months; March, June and August 2015. The physico-chemical properties were determined in the laboratory by titrimetry. Phosphates and nitrates were determined spectrophotometrically; pH, 7.09-8.37 (7.704±0.18); alkalinity, 50-180 (93.89±0.2.45mgL^{-1}); dissolved oxygen, 3.38-5.31 (4.65±0.53 mgL^{-1}); biochemical oxygen demand, 75.3-233 (151.65±6.49 mgL^{-1}); Phosphates, 0-0.892 (0.285±0.13mgL^{-1}) Nitrates, 0.149-0.312 (0.198±0.01mgL^{-1}). High concentrations of Nitrates and Phosphates in the water samples from the Lagoon indicated that the waters flowing into the Lagoon were highly polluted, is highly contaminated and therefore not suitable for drinking purposes by man. In conclusion, this study is baseline data toward future ecological study, conservation and management of the resources of this economically important wetland in Nigeria.*

KEYWORDS: Phosphate, Nitrate, Lagos Lagoon, Water System, Environmental Problem.

INTRODUCTION

Nutrients

Phosphorus and Nitrogen are the basic macro nutrients that when present in excessive amounts pollute lakes, rivers, wetlands and surface water in general. Runoff from our farms and cities is a major source of phosphorus and nitrogen entering rivers, lakes and coastal waters. Acid rain coupled with airborne pollutants generated by human activities also supply nitrogen to surface waters. In aquatic ecosystems, over enrichment with phosphorus and nitrogen causes a wide range of problems, including toxic algal blooms, loss of oxygen, fish kills, loss of seagrass beds and other aquatic vegetation, degradation of coral reefs, and loss of biodiversity including species important to commercial and sport fisheries and shellfish industries. Thus, nutrient fouling seriously degrades our marine and freshwater resources and impairs their use for industry, agriculture, recreation, drinking water and other purposes (ESA, 1998).

Nitrogen is essential to the production of plant and animal tissue. It is used primarily by plants and animals to synthesize protein. Nitrogen enters the ecosystem in several chemical forms and also occurs in other dissolved or particulate forms, such as tissues of living and dead organisms. Nitrate, a compound containing nitrogen can exist in the atmosphere or as a dissolved gas in water, and at elevated levels can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. Common sources of excess nitrate

reaching lakes and streams include septic systems, animal feedlots, agricultural fertilizers, manure, industrial wastewaters, sanitary landfills and garbage dumps (Smith *et al.*, 2003).

Phosphorus is a vital nutrient for converting sunlight into usable energy, and essential to cellular growth and reproduction. It is one of the twenty most abundant elements in the solar system, and the 11th most abundant in the earth's crust. Under natural conditions. phosphorus is typically scarce in water. In the late 1960, scientists discovered phosphorus contributed by human activity to be a major cause of excessive algae growth and degraded lake water quality. Phosphorus occurs in dissolved organic and inorganic forms or attached to sediment particles. Phosphates, the inorganic form, are preferred for plant growth, but other forms can be used when phosphates are unavailable. Phosphorus builds up in the sediments of a lake. When it remains in the sediments, it is generally not available for use by algae; however, various chemical and biological processes can allow sediment phosphorus to be released back into the water (Smith *et al.*, 2003).

Sources of Nutrient Pollution in the Environment

The geology and land use within a lake's watershed determine the amount of nutrients that enter the lake via surface water runoff. These nutrient sources are called nonpoint because they involve widely dispersed activities. Nonpoint inputs are difficult to measure and regulate because of their dispersed origins and because they vary with the seasons and the weather. Yet, nonpoint inputs are the major source of water pollution today. These human sources could be divided into the following categories;

i. **Industrial Sources:** These are discharges to surface water or groundwater from food processing industries, sewage treatment plants, leachate from garbage of intensive livestock industries for example, feedlots or large poultry operations.

ii. **Agricultural Sources**: The organic nitrogen and phosphorus contents are derived from the soil, plant and animal material associated with agricultural land uses, fertilizers (e.g ammonium nitrate) and manures, urban runoff (e.g drone fertilizers) are all sources of nitrogen and phosphorus into the waters.

iii. **Natural Sources:** The organic nitrogen and phosphorus components are typically derived from soil, plant and animal material which are all natural sources.

iv. **Transport Sources:** Exhaust- emissions from automobiles usually contain oxides of nitrogen which will be dissolved by rain, and thereby enter streams, lakes and other water bodies.

v. **Consumer Products:** These are also a very good source of nitrogen and phosphorus in various organic and inorganic forms, ranging from fertilizers to floor polish and household cleaners.

Species of Nitrogen and Phosphorus in Water

The species of nitrogen and phosphorus are of different forms and can be illustrated using nitrogen and phosphorus cycles.

Forms of Nitrogen

Almost all the nitrogen in the atmosphere is present as the inert nitrogen molecule. The cycling of Nitrogen is well illustrated in Figure 1.1. Because of the high energy cost of N_2 fixation, comparatively little nitrogen is liberated from the nitrogen pool and into biological cycles. Nitrogen is also present in the atmosphere as nitrogen oxides (mainly nitric oxide, NO and nitrogen dioxide, NO_2) and ammonia (NH_3). Although present in minuscule amounts relative to nitrogen, these gases can combine with water and enter biological cycles via rainfall which can be significant where human activities such as the burning of fossil fuels have greatly increased the abundance of these gases, such as in areas of the Niger Delta.

In water, nitrogen is also present as inorganic ammonium ions (NH_4^+) and nitrate (NO_3^-), with smaller amounts of nitrite (NO_2^-). These forms of nitrogen are readily available to plants and algae (*bioavailable*). Water quality reporting often refers to Dissolved Inorganic Nitrogen (DIN), which represents the total amount of nitrogen present as ammonium, nitrate and nitrite. Nitrogen is also present as soluble, carbon-containing molecules such as urea and amino acids, collectively known as Dissolved Organic Nitrogen (DON). Finally, it is found in particulate organic form as phytoplankton and organic detritus (Particulate Organic Nitrogen, or PON). The total nitrogen concentration in water (TN) includes all these forms (Naiman *et al.,* 1995).

Nitrogen Cycle

Aquatic plants and algae take up simple inorganic nitrogen (ammonia, nitrate) and assimilate it into complex organic molecules such as proteins. Organic nitrogen is then transported through estuary food chains as plants are eaten by herbivores, herbivores by carnivores and so on. Nitrogen is released from this organic component through excretion of metabolic waste products and decomposition of dead organisms. When organic matter decomposes, what is not consumed by detritivores is broken down by bacterial and fungal action into simple compounds, including ammonia. Ammonia is also an unwanted by-product of many metabolic processes in animals and is either excreted directly or is first converted to simple organic compounds (e.g. urea, uric acid). In the presence of oxygen, bacterial action can convert ammonia to nitrate, a process known as nitrification. These processes occur in water and sediments. The repeated movement of nitrogen through these pathways within the estuary (recycling) can sustain biological activity even when external nitrogen concentrations are low. Nitrogen can be removed from the biological cycle in an estuary in a number of ways. Firstly, it can be flushed out to sea as a result of freshwater flows and/or ocean exchange (Smith *et al.* 2003).

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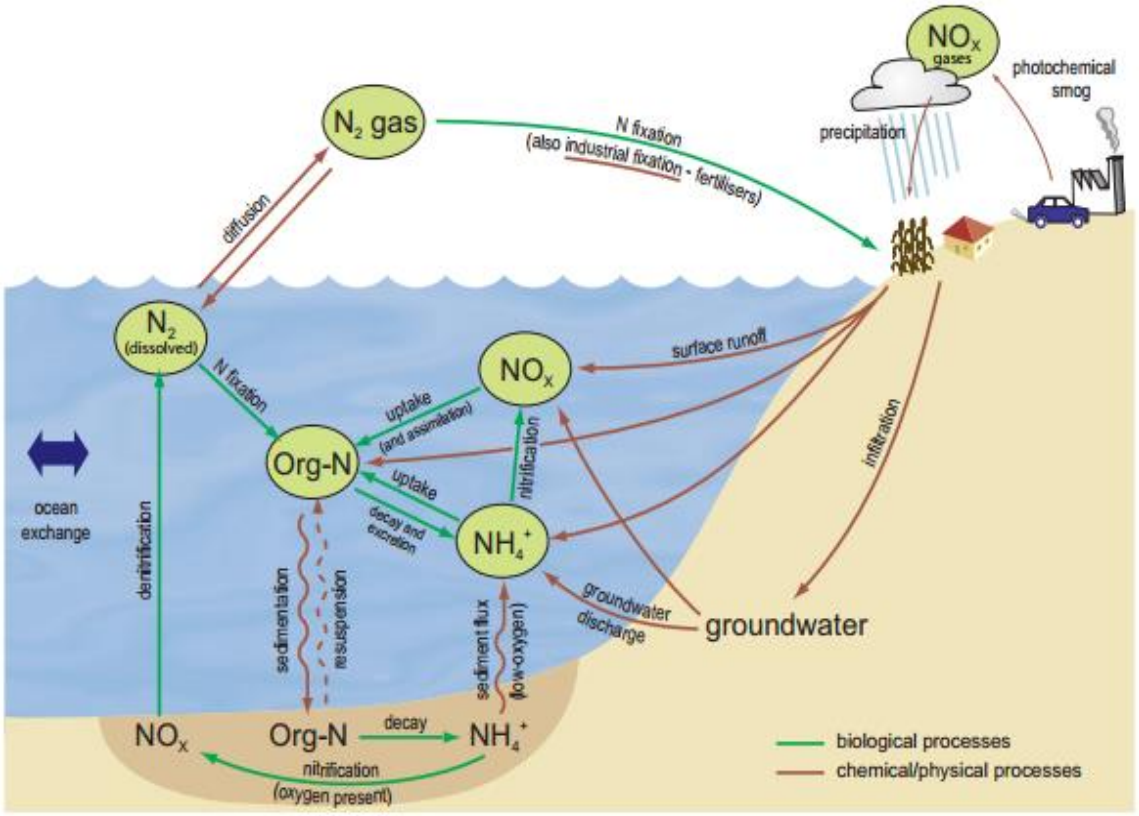

Figure 1.1. Nitrogen cycle as it relates to Estuarine Environment

Source: www.swanrivertrust.wa.gov.au

Many estuaries in temperate West Africa are poorly flushed as a result of the small tidal range, barred or narrow entrances and sporadic rainfall. Over time, estuaries gradually accumulate sediment, and the deposition of particulate nitrogen onto the sediments also provides a major nitrogen sink. The removal of organisms from an estuary e.g. through fish harvests, can also constitute a significant loss of nitrogen. Nitrogen can also be removed from an estuary by denitrification – the bacterial conversion of nitrate to gaseous nitrogen. Denitrification has been shown to be an important mechanism for nitrogen removal in estuaries (Galloway, 2004).

Nutrient enrichment can lead to a build-up of organic matter on the estuary floor where it is broken down by aerobic (oxygen-consuming) bacteria, leading to declining oxygen concentrations at the sediment surface. This blocks nitrification (an aerobic process) which in turn blocks denitrification by preventing the production of nitrate. Instead, ammonium builds up and is released from the sediments, which can exacerbate nutrient enrichment problems (Moir 2011).

Forms of Phosphorus

Orthophosphate is the major form of biologically available phosphorus found in water. It is usually present as a combination of hydrogen phosphate (HPO_4^{2-}) and dihydrogen phosphate

($H_2PO_4^{-}$), depending on pH, but for simplicity will be referred to here as phosphate (PO_4^{3-}). In water quality reporting, it is usually referred to as dissolved inorganic phosphorus (DIP) or by the technical term filterable reactive phosphorus (FRP). There is usually a balance in water between free PO_4^{3-} and PO_4^{3-} which is loosely bound (adsorbed) to the surface of sediment particles (Enger *et al.*, 2002).

Phosphorus is also found as soluble organic compounds such as DNA and RNA (collectively known as Dissolved Organic Phosphorus – DOP), and in a number of insoluble (particulate) forms. The sum of all forms of phosphorus in water is Total Phosphorus (TP). In waterways, the majority of phosphorus is usually in particulate form readily available through mineralisation or desorption. However, most of the sediment phosphorus pool remains unavailable most of the time. This component includes inorganic phosphate compounds that are highly insoluble and organic phosphate compounds resistant to mineralization (Kanan *et al.* 2008).

Most of the phosphorus on Earth is tied up in rocks, from which it is released very slowly by weathering and erosion. Almost all the phosphorus released from rock breakdown is carried in inert mineral form to permanent sinks, mainly in the deep ocean. Some, through chemical weathering, is released as soluble phosphate. As phosphate is made available in soils and waterways, it is incorporated by plants and then animals, thereby forming the basis of the biological phosphorus cycle. Phosphate is also released as microbes break down organic material in the soil. Phosphorus can cycle many times through ecosystems, passing up food chains before being recycled through death and decay. However, there is a slow but steady loss via waterways to the deep ocean. Mining of phosphate-rich rock and guano deposits for fertilizer has greatly increased the rate at which bioavailable phosphorus is released into the environment on a global scale. Because plants require large amounts of phosphorus, it is added to soils to maintain or increase fertility and agricultural productivity. While this can produce benefits – such as an increase in fish catches – it is often manifested by a dominance of certain organisms in 'boom and bust' cycles. This can contribute to numerous problems such as nuisance algal blooms, anoxia, fish deaths, and seagrass loss (Miller *et al*,. 2001).

Phosphorus Cycling

Most of the phosphorus entering waterways from the catchment is attached to soil particles, the phosphorus cycle is best illustrated by figure 1.2. Increases in soil erosion can result from clearing and ploughing of agricultural land, or soil disturbance due to forestry, urban development, stock tracks and watering areas, and gravel roads. The use of phosphate fertilisers can greatly increase the phosphorus content of soil eroded from cropland as phosphorus applied to soils as fertiliser is generally soluble. In most soils, PO4 rapidly binds to soil minerals and organic matter, becoming highly resistant to leaching through the soil profile. As plants take up PO_4^{3-} from the soil, it is replenished from the pool of soil-bound phosphate. If soils contain few binding metals and little clay, silt or organic matter, very little phosphate will be bound within the soil. In this case PO_4^{3-} can be mobile, and a relatively high percentage may be leached into ground and surface waters (Busman *et al.*, 2002).

Very high concentrations of PO_4^{3-} are also present in sewage effluent. Sewage treatment plants and other point source discharges away from the metropolitan area. Other sources of PO_4^{3-}

include septic systems, animal and plant wastes, and detergents. Soluble phosphate (PO_4^{3-}) in the estuary can feed the growth of phytoplankton and other plants. Animals obtain their phosphorus compounds by eating plants, other animals or detritus. Death and decay of organisms (e.g. during a collapsing phytoplankton bloom) leads to the breakdown of organic phosphates by micro-organisms and the release of PO_4^{3-}, making it available once more for growth. Thus, phosphate is readily and rapidly recycled through bioavailable, organic and adsorbed forms in estuary waters. In estuary sediments, most of the phosphorus is bound (adsorbed) to clay and silt particles or is precipitated as mineral phosphorus (Nebel *et al.*, 1998).

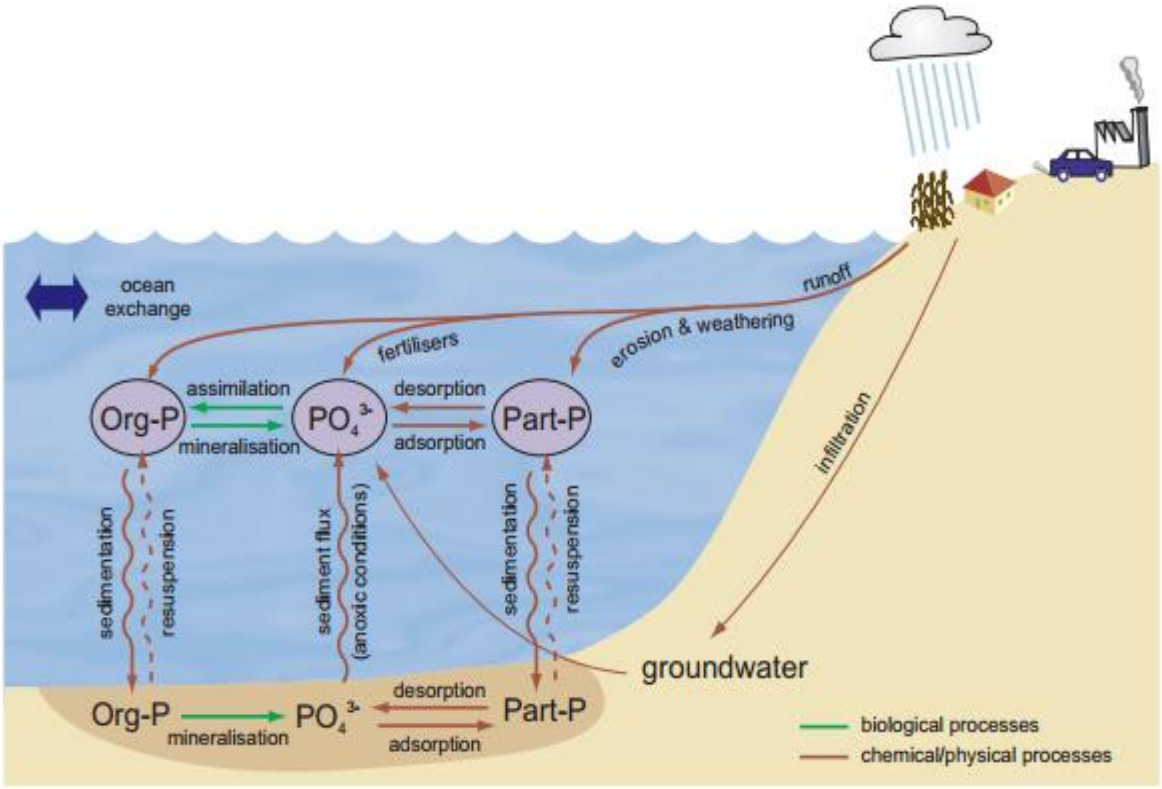

Figure 1.2: Cycling of Phosphorus in estuary

Source: www.swanrivertrust.wa.gov.au

As a result, a large amount of phosphorus tends to remain 'locked' in bottom sediments, where it is normally unavailable for growth. Changes in physical conditions such as oxygen concentration, salinity or pH can alter this balance. For example, PO_4^{3-} is often adsorbed onto sediment particles containing iron or aluminum in oxygenated water. If the water becomes anoxic, PO_4^{3-} becomes more soluble, and can be released into the water. Alternatively, if the pH is high, PO_4^{3-} in the water can bind with calcium, forming insoluble calcium phosphate, which settles out in the sediments. Numerous reactions of this sort govern the ratio of soluble to particulate phosphate in the sediments and the movement of PO_4^{3-} from the sediments into the overlying water. Because phosphorus does not exist as a gas, most of it remains within the estuary apart from what is lost to the ocean through tidal exchange and freshwater flows. Over time, phosphorus (as organic matter and particulates) tends to settle out on the estuary floor as part of the permanent accumulation of sediments, with very little being flushed to the ocean.

In some estuaries, flood events can periodically scour large amounts of sediment, including phosphorus, from the estuary floor and wash it out to sea. However, due to frequent anoxic events, phosphate is also released from the sediments throughout the year (Harper, 2001).

Common Uses of Nitrogen and Phosphorus

Total Nitrogen and phosphorus have no use and this is attributed to the fact that they are not products. Nevertheless, the major use of phosphates and nitrates as inorganic forms of fertilizers is predominant e.g. N.P.K fertilizers. They are also used as oxidizing agents in the production of explosives, while purified potassium nitrate is used for glass making. Hence, storage of samples for nitrates and phosphates (or total nitrogen and total phosphorus) must be stored in plastic bottles and not glass bottles. Sodium Nitrite is used as a food preservative while sodium nitrate is added to such to provide a reservoir for the nitrite.

Environmental Impacts of Nutrient Enrichment

Eutrophication

The word eutrophication is now being used in a perspective of preserving the ecological quality of waters, e.g. in the Directives of the European Union and various international treaties. Eutrophication is an accelerated growth of algae or higher forms of plant life caused by the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus and inducing an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned. Thus, today, eutrophication is more of a status than a trend and the term describes the qualitative conditions of an aquatic environment that has been disrupted, more than its quantitative (biomass) productivity (WHO 2003).

Eutrophication is the slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. Some of the nutrients come from natural processes, such as decomposition of plant and animal material. During the later stages of eutrophication, the water body is choked by abundant plant life due to higher levels of nutrients such as nitrogen and phosphorus. Human activities can accelerate the process with urban construction, sewage discharges, agricultural practices, and residential development (Vollenweider, 1996).

Aquatic plants need two essential nutrients for growth: phosphorus and nitrogen. They receive these nutrients through a process known as *eutrophication*, in which water bodies accumulate plant nutrients, typically from nutrient-rich land drainage. In a healthy lake, both nutrients occur in limiting amounts, restricting plant growth. However, anthropogenic (human) factors can dramatically increase the concentration of plant nutrients in water bodies, a phenomenon known as "*cultural eutrophication*". Human-induced pollution through the impacts of excessive fertilizer use, untreated wastewater effluents, and detergents significantly increases nutrient loading into lakes, accelerating eutrophication beyond natural levels and generating deleterious changes to the natural ecosystem (Litke, 1999).

Over the past 50 years, a large body of literature has been developed to identify the principal impacts and sources of increased nutrient levels on the quality of receiving waters (Smith, 2003). It is now generally accepted that cultural eutrophication can stimulate the rapid growth of plants and algae, clogging waterways and potentially creating toxic algae blooms.

As discussed earlier, eutrophication occurs as an effect of excessive nitrogen and phosphorus in water bodies which allows the unhealthy elevation in the rate of the growth of phytoplankton. Eutrophication has few benefits but is detrimental to the environment in a lot of ways:

i. **Algae Blooms cloud the Water and Prevent Light from reaching Submerged Vegetation:** Various submerged aquatic vegetation such as sea grasses depend upon sunlight for photosynthesis to occur and hence to survive. Water containing a dense algal bloom allows less light penetration and can result in damage to seagrass beds (ESA 1998).

ii. **Low Oxygen:** This results from the severe algae blooms, since oxygen is used in the decomposition of algae. High decomposition rates would result in a decrease in the concentration of the dissolved oxygen even up to the point of affecting the ability of other oxygen-dependent organisms to survive. Dissolved oxygen less than 2mg is considered hypoxic. In some cases, the water may lose all of its oxygen and become anoxic. This low oxygen level would also cause the water to stink due to stagnancy and lack of air (Mandaville 2000).

iii. **Changes in Species Composition:** Dramatic changes in ecological communities can occur in the environment when species that die are replaced by species that can tolerate eutrophic conditions.

Hypoxic Conditions

Very low oxygen conditions may result when plants and algae die and decompose thus stripping water of dissolved oxygen, leading to fish kills and degrading the aesthetic and recreational value of the lake (ESA, 2008). Cultural eutrophication is an increasingly global problem as the deterioration of water quality and excessive biological productivity in lakes inflicts significant environmental and societal damage. In identifying sources of eutrophication, studies have observed a strong relationship between algal biomass and nutrient loading, with phosphorus being the primary limiting nutrient in freshwater bodies. Therefore, most efforts to control algal biomass in lakes concentrate on reducing phosphorus levels in water (Smith, 1999). Among the strategies developed to mitigate eutrophication, an integrated approach focusing on nutrient loading restrictions serves as the essential cornerstone of effective management in lakes. This approach would incorporate nutrient loading restrictions with biomanipulation to limit the levels of phosphorus and nitrogen in lakes as well as to alter the food web to control phytoplankton populations- the major contributor to eutrophication.

Natural eutrophication is a slow and gradual process, typically occurring over a period of many centuries as nutrient-rich soil washes into lakes. In contrast, human-induced eutrophication can occur over time frames as short as a decade.

The accelerated input of these two nutrients into aquatic ecosystems due to human activities, is the primary cause of most algal bloom problems. Understanding nutrient cycles, i.e. the ways in which these elements are transported and transformed within the environment, is therefore essential to understanding and effectively managing algal blooms (Diersing, 2009).

The cycling of nitrogen – the most common element in the atmosphere – is mostly mediated by living organisms. Phosphorus cycling, on the other hand is primarily a chemically mediated process that originates with the weathering of rocks. These differences have important

implications for management efforts to reduce the prevalence of nitrogen and phosphorus in our waterways (Sharpley *et al.*, 1994).

Impact of Nutrients on Human and its Health Effects

High nitrate levels in water can cause methemoglobinemia or blue baby syndrome, a condition found especially in infants less than six months. Their stomach acid is weaker than is found in older children and adults, which can cause an increase in bacteria that can readily convert nitrate to nitrite (NO_2). Nitrite is absorbed in the blood and the hemoglobin (oxygen-borne components of blood) is converted to methaemoglobin. Methaemoglobin does not carry oxygen efficiently. This results in a reduced oxygen supply to vital tissues such as the brain. Severe methaemoglobin can result in brain damage and death. Pregnant women, adults with reduced stomach acidity and people deficient in the enzyme that changes methaemoglobin back to normal are all susceptible nitrite-induced methemoglobinemia (Ajayi, 2006).

Abnormally high serum phosphate levels cause a condition known as Hyperphosphatemia which can result from increased phosphate intake, decreased phosphate excretion, or a disorder that shifts intracellular phosphates to extracellular space. However, even severe hyperphosphatemia is for the most part clinically asymptomatic. Morbidity in patients with this condition is more commonly associated with an underlying disease than with increased phosphate values.

Phosphate or phosphorus, is similar to calcium as is found in bones and teeth. Like calcium, vitamin D is needed to absorb phosphate properly. The kidneys excrete phosphate. Therefore, the most common cause of increased phosphate levels (or hyperphosphatemia) is the kidney's inability to get rid of phosphate (Diersing, 2009).

Effect of Excessive Nutrients on Animals

Drinking of water with excessive nitrate-nitrogen affects young animals the same way as human babies. Older animals may tolerate higher levels. Ruminant animals (cattle, sheep) are susceptible to nitrate poisoning because bacteria present in the human convert nitrate to nitrite. Non-ruminant animals (swine, chicken) rapidly eliminate nitrate in their urine (Ajayi, 2006)

Nitrogen to Phosphorus (N: P) Ratio in Water and its Implications

Water bodies exhibit a huge range of total nutrient concentrations and a great variability in relationships between nitrogen (N) and phosphorus (P). The empirically developed stoichiometric ratio is found to be 16:1. Phosphorus originates primarily from soil minerals and can accumulate to a substantial degree at sediments of lakes and oceans. On the other hand, nitrogen is unique among lake nutrients. It originates from the atmosphere as an inert gas, is closely tied to organic matter, exceptionally accumulates to a significant degree in river sediments, and has a cycle more complex than Phosphorus. Very often Nitrogen concentration increases less than Phosphorus concentration during eutrophication (Quiros, 2003).

Plants compete exploitatively for nutrients. For example, algae should respond to variations in environmental nutrient ratios and concentrations. For example, at high environmental N: P ratios, algae species with high affinity for phosphorus may be able to grow faster and monopolize space better than a species that is less efficient at phosphorus uptake. The N: P ratio limits the growth of phytoplankton in water bodies, a high N: P ratio would ensure the

growth of more phytoplankton and in turn would cause the lowering of the Dissolved Oxygen in the water as the plants would use up the available dissolved oxygen. Also, chemical composition in phytoplankton cultures vary as a function of the degree of nitrogen to phosphorus ratio (Leonardos *et al.,* 2004).

Physico-Chemical Parameters in Water

pH

The pH is the most important in determining the corrosive nature of water. The lower the pH value, the higher the corrosive nature of water. The reduced rate of photosynthetic activity in the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month. Various factors bring about changes in pH of water. High pH values suggest that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physicochemical condition (Karanth, 1987).

Conductivity

Conductivity is an indicator of salinity. Salinity (or salts) often originate from the earth's crust, although the additions of fertilizers and organic matter may also contribute salts. Through weathering, small amounts of rock and other deposits are dissolved and carried away by water. This slow weathering may cause an accumulation of salts in both surface and subsurface waters. Surface runoff of these dissolved salts has caused the salt concentrations in oceans and lakes (Provin *et al.,* 2002).

Alkalinity

Alkalinity (expressed as CaCO3) is a buffering property caused by the presence of bicarbonates and carbonates, but calculated based on the concentration of calcium and magnesium. Alkalinity is an estimate of the ability of water to resist change in pH upon addition of acid (Patil *et al*., 2012).

Suspended Solids

Solids present in water can be divided into three types according to size; suspended, colloidal and dissolved The suspended solids include sand silt etc, and are an indicator of possible bacterial or hazardous concentration. Total suspended solids is the mass that can be separated from the water by filtration. Total suspended solids is an indication of the amount of erosion that took place nearby or upstream (Provin *et al.,* 2002).

Dissolved Oxygen (DO)

DO is one of the most important parameters here. Its correlation with water body gives direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc. In the progress of summer, dissolved oxygen decreased due to increase in temperature and also due to increased microbial activity. The high DO in summer is due to increase in temperature and duration of bright sunlight has influence on the % of soluble (Moss, 1972).

Biochemical Oxygen Demand (BOD)

BOD is a measure of organic material contamination in water, specified in mg/L. BOD is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials (e.g., iron, sulfites). Typically, the test for BOD is conducted over a five-day period (Patil *et al.*, 2012).

Nitrate (NO_3-N)

Decaying organic matter, sewage, fertilizers, manures, and nitrates in the soil results in soluble nitrates. Water with high nitrate content may cause methemoglobinemia (blue-baby syndrome) and should not be used by pregnant women or for infant feeding. High concentrations of nitrate in rivers, streams, and lakes encourage the growth of algae and other organisms that may produce undesirable tastes and odors in water (Provin *et al.,* 2002).

Phosphates

Phosphorus may be found naturally in ground water and in surface water from landscape runoff or discharges from sewage treatment facilities. Elevated phosphorus in surface water can lead to algal blooms and lower dissolved oxygen content, thereby reducing desired aquatic life and creating water taste issues (Provin *et al.,* 2002).

Effects of Nutrients Enrichment on Physicochemical Parameters of Water

Some physicochemical parameters of water can be affected by the enrichment of nutrients in the water bodies. Dissolved oxygen for example is greatly reduced by the presence of excessive nutrients, this is because when nutrients are in excess in water bodies, it encourages the growth of phytoplankton and algae. When this happens, the plants use up the dissolved oxygen available in the water and hence deplete the quantity of dissolved oxygen in the water.

When dissolved oxygen is used up, it leads to an increase in the quantity of the Biochemical Oxygen in the water. The effect of nutrient enrichment also affects the level of the Chemical Oxygen Demand (COD) since the level of the dissolved oxygen determines both the level of the BOD and COD.

Lagos Lagoon

The Lagos Lagoon covers about 700km^2, is a brackish coastal lagoon, located on the Western part of Nigeria (6º 26'-37ºN; 3º 23'- 4º 20'E) and is the largest along the West African Coast. The lagoon is separated from the Ocean by the narrow strip of barrier bar complex and opens to the sea through the Commodore Channel. Some of the Rivers flowing into the Lagoon are: Ogudu, Odo Iya Alaro among many others. The Lagoon is drained by four major Rivers: Ogun, Agboyi, Majidun and Aye. The lagoon is shallow with an average depth of about 1.5m. Shoals of sand are scattered in the lagoon and are usually exposed during low tides with many small islands within the lagoon (Obafemi, 2008).

The population of the city of Lagos is about 5 million people, with many industries and untreated sewage dumped directly into the Lagoon. The environmental pollutants such as the discharge of raw sewage or primary treated sewage are on the increase and the initial use of the lagoon which was for fishing became obsolete and almost a history. Other sources of

pollution are contamination from sawmills, heavy metal load coupled with contaminants from domestic and industrial waste (Nnamdi *et al*., 2015).

Effects of Nutrient Enrichment on the Lagos Lagoon

Nutrient enrichment on the Lagos lagoon has certain effects which include an increase in the growth of certain species of plants, reduction in oxygen as result of the presence of these plants. As a result of the low DO, certain areas of the Lagos Lagoon are brackish, malodorous and are filled at the surface with plants and phytoplankton. Nutrient levels are significantly higher during the wet season than in dry season. The vegetation around the lagoon is basically fringed by the red mangrove; *Rhizophora mangle*, *Rhizophora harrisonii* and the grass; *Paspalum veginatum*, water hyacinth in the dry season; *Eichorna crassipes.*

The fauna is composed of fresh, marine and brackish water species e.g prawns, shrimps, crabs, oysters, pelagic and demersal fishes depending on the season.

Phosphates and nitrates are the most important in limiting primary productivity and algae growth. Some algae growth potential studies have shown correlations between orthophosphate and algae growth, while correlations are also likely for different nutrients in other aquatic environments.

Spectrophotometry

Spectrophotometry is a method to measure how much a chemical substance absorbs light by measuring the intensity of light as a beam of light passes through sample solution. The basic principle is that each compound absorbs or transmits light over a certain range of wavelengths. This measurement can also be used to measure the amount of a known chemical substance. Spectrophotometry is one of the most useful methods of quantitative analysis in various fields such as chemistry, physics, biochemistry, material and chemical engineering and clinical applications.

The instrument that measures the amount of photons (the intensity of light) absorbed after it passes through sample solution is known as the spectrophotometer. With the spectrophotometer, the amount of a known chemical substance (concentrations) can also be determined by measuring the intensity of light detected. Depending on the range of wavelength of light source, it can be classified into two different types:

i. UV-visible spectrophotometer: uses light over the ultraviolet range (185 - 400 nm) and visible range (400 - 700 nm) of electromagnetic radiation spectrum.

ii. IR spectrophotometer**:** uses light over the infrared range (700 - 15000 nm) of electromagnetic radiation spectrum.

In visible spectrophotometry, absorption of a certain substance can be determined by the observed colour. Visible spectrophotometers use a prism to narrow down a certain range of wavelength so that the particular beam of light is passed through a solution sample.

Devices and Mechanism

Spectrophotometer consists of a light source, a collimator, a monochromator, a wavelength selector, a cuvette for sample solution, a photoelectric detector, and a digital display or a meter

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as shown in figure 1.3. A spectrophotometer, in general, consists of two devices; a spectrometer and a photometer.

i Spectrometer: It produces a desired range of wavelength of light. First a lens transmits a straight beam of light that passes through a monochromator to split it into several component wavelengths. Then a wavelength selector transmits only the desired wavelengths.

ii Photometer: After the desired range of wavelength of light passes through the solution of a sample in cuvette, the photometer detects the amount of photons that is absorbed and then sends a signal to a galvanometer or a digital display.

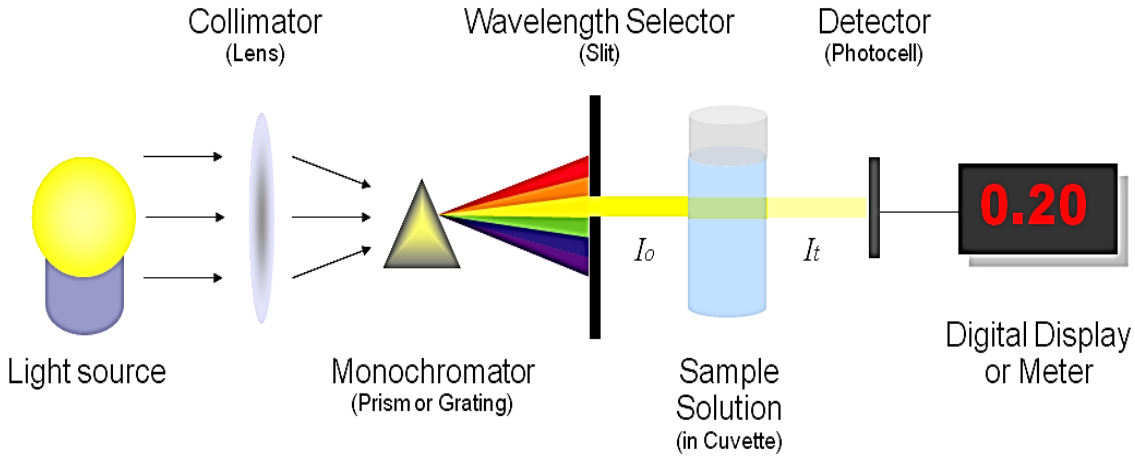

Figure 1.3: Schematic diagram of a spectrophotometer

Transmittance is the fraction of light that passes through the sample as shown in figure. This can be calculated using the equation:

$$\text{Transmittance (T)} = I_t/I_o \qquad (1.1)$$

Where I_t is the light intensity after the beam of light passes through the cuvette and I_o is the light intensity before the beam of light passes through the cuvette.

$$\text{Absorbance (A)} = -\log (T) = -\log (It/Io) \qquad (1.2)$$

Where absorbance stands for the amount of photons that is absorbed. With the amount of absorbance known from the above equation, the unknown concentration of the sample can be determined by using Beer-Lambert Law.

Beer – Lambert Law

Beer-Lambert Law states that there is a linear relationship between the absorbance and the concentration of a sample. For this reason, Beer's Law can only be applied when there is a linear relationship. Beer's Law is written as:

$$A = \epsilon lc \qquad (1.3)$$

A is the measure of absorbance,

ϵ is the molar extinction coefficient or molar absorptivity,

l is the path length,

c is the concentration.

LITERATURE REVIEW

Tiseer *et al.* (2008) reported that the seasonal occurrence of algae and physicochemical parameters of Samaru stream, Zaria (11°3`N; 7°42`E) Nigeria, was investigated between the dry season (November/December 2003) and rainy season (May/June 2003). Five sampling stations were chosen along the stream length (within the university community) at approximately the same distance from one station to the other and physicochemical parameters such as temperature, pH, conductivity, dissolved oxygen, nitrate, phosphates, biochemical oxygen demand were tested for. Results from ANOVA showed significant differences in all the parameters observed except the pH between seasons.

Further report by Obire *et al.* (2007) showed the impact of the national fertilizer company of Nigeria outfall effluent on the physicochemistry and bacteriology of Okrika creek during the sampling period from May to December, 1998. The physico-chemical parameters analyzed for all the samples included temperature, pH, total chloride, total dissolved solids, dissolved oxygen, conductivity, free ammonia, total phosphate, urea, zinc and iron, while the bacteriological determinations were total culturable aerobic heterotrophic bacteria count and identification of representative isolates. The Okrika creek recorded higher concentrations for all the physico-chemical parameters and bacteria load than the control creek. The higher values of pH, free NH3, urea, TDS and the conductivity were above the FEPA standards. This reflects the poor effluent quality generated by the National Fertilizer Company of Nigeria. The investigation revealed that there was an extremely adverse impact on the physico-chemical and bacteriological water qualities of the Okrika creek as a result of the discharge of poor quality effluent from National Fertilizer Company of Nigeria operations.

According to Omaka *et al.* (2013), physicochemical parameters and nutrient loads of major rivers and streams in Abakaliki, Ebonyi State were studied for a period of seven (7) months from May to November, 2011. Regular and constant monitoring of water bodies is vital to ensure that water quality characteristics are maintained. The results obtained were: temperature (28.60–30.00°C), pH (6.80–7.93), DO (1.40–3.53 mg/l), turbidity (41.33–97.67 NTU), conductivity (19.00–613.30 µS cm^{-1}), total acidity (9.17–17.23 mg/l), total alkalinity (6.43–10.97 mg/l), BOD (1.20–7.03 mg/l), COD (16.200–53.533 mg/l), phosphate (0.11–1.17 mg/l) and nitrate (0.12–1.45 mg/l). The results suggested that refuse disposal, fertilizer use, and natural phenomena (soil erosion; flooding) may have contributed in various ways to the impairment of the water quality of the studied sites. Although the results did not indicate adverse pollution status of any of the sites, they provided the need for further investigations and monitoring.

The report of Onyema (2013) contained the impact of primary production with regard to chlorophyll *a* concentration, nutrient (Nitrate-nitrogen, phosphate-phosphorus, sulphate and

silicate), rainfall and salinity were investigated at twelve stations for two years for the Iyagbe lagoon, Lagos. The parameters reflected seasonal changes related to the inflow of nutrient rich water, especially during the rains and tidal seawater incursion, which occurs mostly during the dry season. The sulphate (20.8 -114.0 mg/l), silica (0.9 - 6.0 mg/l) and salinity (0.06 - 35.1%) recorded increased values in the dry season than wet season. Nitrate (3.3 - 59.8 mg/l) and phosphate (0.01 - 1.68 mg/l) recorded higher values during the wet season than the dry season. The values for chlorophyll *a* were higher in the dry than wet season. Positive spearman rank correlation coefficient was recorded between chlorophyll *a* concentrations and salinity, nitrate and sulphate. Recorded chlorophyll *a* values places the Iyagbe lagoon between the mesotrophic and eutrophic status. It is suggested that increasing tidal influence associated with reduced rain may have encouraged elevated salinities and created conditions for the development of more algal cells, hence higher chlorophyll *a* estimates. Furthermore, the higher levels of nutrients recorded from the wet season were from Land-based sources.

Popoola *et al.* (2012) reported that the physico-chemical characteristics, phytoplankton composition and distribution at the East mole area of the Lagos harbour were investigated between January and June, 2012. The results of the investigation were: air temperature (26 - 33ºC) and water temperatures (28 - 31ºC), salinity (19.40 - 30.72%), nutrients (nitrate ≥ 3.11 mg/l, phosphate ≥ 0.65 mg/l, sulphate ≥ 878.6mg/l, alkaline pH (7.75 – 8.48), transparency (141.2 - 236.5cm), alkalinity (33.0 - 85.2 mg/l), conductivity (32700 – 49,600 µs/cm), dissolved oxygen (4.8 - 5.4 mg/l) and Chlorophyll *a* (8.5 - 10.1 mg/l). The results showed a positive correlation between the parameters.

A study conducted by Lawson *et al.* (2011) on the physico-chemical parameters and heavy metal content of water from the mangrove swamps of Lagos lagoon, Nigeria. The study was aimed at assessing its suitability for fish production and its safety for drinking purpose by man. Results of the temperature and pH tests were obtained from the field using a mercury-in-glass thermometer and a pH meter. Salinity, dissolved oxygen and carbon dioxide, total alkalinity and acidity, total suspended and dissolved solids were determined in the laboratory by titrimetric method. The concentrations of Fe, Zn, Mn, Cd, Cr and Pb in water were determined by atomic absorption spectrophotometer (AAS). The results were: air temperature (26.00-31.75) , water temperature (20.0-30.50); pH (1.89-8.50), salinity (0.2-16.75%) ,dissolved oxygen (0.58-10 mg/l), dissolved carbon dioxide (9-29-25.97 mg/l), total alkalinity (20.5-90.0 mg/l), total acidity (11.0-22.5 mg/l). The concentrations of the heavy metals were above maximum contaminant level (MCL) recommended by USEPA. The water parameters favoured the production of brackish water fish. However, it is highly contaminated and therefore not suitable for drinking.

Study Aim and Objectives

Aim

The aim of the research work is to determine the nitrogen to phosphorus ratio (N:P) of selected points along the coast of the Lagos Lagoon.

Objectives

Some of the research objectives are:

i. To determine the pH values of selected points along the coast of the Lagos lagoon.

ii. To determine the dissolved oxygen levels and biochemical oxygen demand of selected points along the lagoon.

iii. To determine the Alkalinity of the lagoon.

iv. To determine the amount of suspended solids in the lagoon.

MATERIALS AND METHODOLOGY

Sampling Locations

Six different sampling points (Ogudu, Oworo, University of Lagos axis, Makoko, the Iddo axis and CMS) along the coast of Lagos Lagoon were established for the study. Lagos Island axis. The choice of the six sampling points was based on their accessibility, nearness to urban settlement and their sustainability for future surveys and these stations are accessible through navigation by boats.

Sampling

Water samples at different locations collected for laboratory analyses were taken at recorded depths during the humid period with a washed and acid-rinsed 2-litre polyethylene plastic container and labelled immediately on the field. The samples were transported to the laboratory where they were analysed immediately or stored at 4ºC to maintain the present status of the indicated parameters. The sampling process was carried out thrice (March, June and August 2015) for comparison and seasonal environmental variations.

Physicochemical Analysis

pH Determination

The pH of the sample was determined electrometrically with the use of a Mettler Toledo pH meter. The pH meter was calibrated using Buffer 4.0, 7.0 and 9.0. Thereafter, the pH meter was used to determine the pH of the water sample.

Alkalinity Determination

Accurately, 50ml of water sample was measured in 250 ml conical flask and two drops of mixed indicator was added and the mixture was titrated with 0.1 M HCl solution to a pink endpoint. The HCl solution was standardized using 0.05 M sodium tetraborate decahydrate.

$$\text{Alkalinity } \{(\text{mg } CaCO_3)/L\} = \frac{\text{titre value} \times \text{molarity} \times 50000}{\text{Volume of sample}}$$

Acidity Determination

Accurately, 50 ml of water sample was measured and transferred into a 250 ml conical flask. To this, 2 drops of phenolphthalein indicator was added and titrated with 0.02 N NaOH solution to a light pink endpoint.

$$\text{Acidity (mg CaCO3/L)} = \frac{\text{titre value x molarity x 50000}}{\text{Volume of sample}}$$

Total Solids Determination

A clean Petri-dish was dried at 100^0C in an oven for 30 min. It was cooled in a desiccator and then weighed. Accurately, 10 ml of the sample was measured and transferred into the evaporating dish at 105^0C. The sample was dried and then cooled in the desiccator. The residue was weighed to a constant weight.

$$Total\ solids\ \left(\frac{mg}{L}\right) = \frac{weight\ of\ residue\ \times\ 10^6}{volume\ of\ sample}$$

Total Dissolved Solids Determination

The sample was filtered into a clean conical flask. A clean Petri dish was dried at 100^0C in an oven, cooled in a desiccator and then weighed to a constant weight. 10 ml of the filtrate was put in the petri-dish and this was evaporated to a constant weight in the oven at 180^0C. The residue was cooled in the desiccator and weighed to a constant weight.

$$Dissolved\ Solids\ \left(\frac{mg}{L}\right) = \frac{weight\ of\ residue\ \times\ 10^6}{volume\ of\ sample}$$

Suspended Solids Determination

This was obtained by subtracting the value of dissolved solids from total solids.

SS = $Total\ solids - Dissolved\ Solids$

Dissolved Oxygen Determination

The sample was poured into a 300 ml bottle until the bottle was filled to the brim. 1 ml of $MnSO_4$ solution and 1 ml of alkali-iodide-azide reagent were added well below the surface of the sample. The bottle was stoppered and its content was mixed by inverting it several times. The solution was allowed to settle for 2 min and 2 ml of concentrated H_2SO_4 was added. The solution was mixed very well.

Accurately, 50 ml aliquot of the solution was taken for titration. This was titrated with sodium thiosulphate until a straw colour was reached. Two drops of starch solution were added. The blue solution was titrated with standard sodium thiosulphate solution to a colourless endpoint.

$$\text{DO (mg/L)} = \frac{16{,}000\ x\ M\ x\ V}{\frac{V_2}{V_1}(V_1 - 2)}$$

M = molarity of the thiosulphate solution

V = titre of thiosulphate solution (Blank minus sample)

V_1 = volume of the bottle used for fixing oxygen

V_2 = aliquot of sample taken for titration

Biochemical Oxygen Demand Determination

10 mL each of phosphate buffer, magnesium sulphate, calcium chloride, ferric chloride, sodium sulphite and ammonium chloride was added to 10 l of tap water in a polyethylene bucket to make dilution water. The dilution water was agitated by shaking it for three minutes to permit the dissolution of atmospheric oxygen into it.

A clean standard flask was filled half-way with dilution water and 15 ml of the sample was added to it. The standard flask was then filled with more dilution water to the 1l-mark. This diluted sample was poured into a 300 ml amber-coloured bottle until it was fIlled to the brim. The bottle was stoppered and incubated at 20^0C for 5 days. Another transparent 300 ml bottle was filled to the brim with the diluted sample. 1 ml of $MnSO_4$ solution and 1 ml of alkali-iodide-azide reagent were added below the surface of the diluted sample in the transparent bottle. The bottle was stoppered, shaken by inverting it a number of times and allowed to settle for two minutes. 2 ml of concentrated sulphuric acid was added and the solution was mixed by inverting the bottle a number of times. A 50 ml aliquot of the solution was taken for titration. Two drops of starch solution were added. The blue solution was titrated with standard sodium thiosulphate solution to a colorless endpoint to determine DO_0 at the beginning of the 5 days.

At the end of the 5 days, the sample in the incubator was brought out and opened. 1 ml of $MnSO_4$ solution and 1 ml of alkali iodide-azide reagent were added well below the surface of the sample in the amber-coloured bottle. The bottle was stoppered and allowed to settle for 2 min. 2 ml of concentrated sulfuric acid was added and the solution was mixed by inverting the bottle several times.

A 50 ml aliquot of the solution was taken for titration. This was titrated with sodium thiosulphate until a straw colour was reached. Two drops of starch solution were added. The blue solution was titrated with standard sodium thiosulphate solution to a colorless endpoint to determine DO_5. A blank was prepared in a transparent bottle for DO_0. Another blank was prepared in an amber-coloured bottle and incubated with the sample for DO_5.

Calculation

$$BOD_5\,(mg/L) = \frac{DO_0 - DO_5}{Dilution\ factor}$$

Hardness

Accurately, 25 ml of water sample was measured into 250 ml conical flask. 4 ml of a buffer solution and two drops of the Eriochrome black T indicator are added in turn and then shaken. This was titrated with 0.01 M EDTA solution.

$$Hardness\ \left(mg\frac{CaCO3}{L}\right) = \frac{molarity\ of\ EDTA\ \times\ volume\ of\ EDTA\ \times\ 100{,}000}{Volume\ of\ sample}$$

Nitrate Determination

Nitrate standards were prepared in the range 0.1–1.0 mg/l by diluting 1.00, 2.00, 4.00, 7.00 and 10.0 ml standard nitrate solution to 10 ml with distilled water. A series of reaction tubes in the

test tube stand was set up. Accurately, 10 ml of sample was measured and transferred into the reaction tubes and placed in a cool water bath and 2 ml of NaCl solution was added and mixed.

Thereafter, 10 ml H_2SO_4 solution was added and mixed well and allowed to cool. The stand was then placed in a cool water bath and 0.5 ml brucine-sulphanilic acid reagent was added. The tubes were swirled and mixed well and placed in a boiling water bath at temperature 95°C. After 20 minutes, the tubes were removed and immersed in a cool water bath. They were then poured into the dry tubes of the spectrophotometer and the standards and sample were read against reagent blank at 410 nm.

Phosphate Determination

Accurately, 50.0 ml sample was measured into a clean 100 ml Erlenmeyer flask. A 0.05 ml (1 drop) phenolphthalein indicator was added and 5 *N* H_2SO_4 solution was also added. 8.0 ml combined reagent was added and mixed thoroughly. The mixture was allowed to develop color and the absorbance for each sample at 880 nm, using reagent blank as the reference solution was calibrated. A calibration curve was plotted from the result of the standard solution.

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RESULTS AND DISCUSSION

Table 4.1: Results of Physiochemical Parameters of the analyses of water samples collected in Lagos Lagoon (March, June and August 2015)

						MARCH ANALYSIS					
		COND.(us/cm)	DO(mg/L)	BOD(mg/L)	TS(mg/L)	TDS(mg/L)	SS(mg/L)	Hardness(mg/L)	Alkalinity(mg/L)	Phosphate(mg/L)	Nitrate(mg/L)
OGUDU	7.31	1,072	ND	182.3	870	310	660	112	140	0.892	0.21
OWORO	7.36	16,340	3.87	158	9,930	9,520	900	7,600	80	0.878	0.195
AKOKA	7.52	13,010	4.99	226.3	9,560	8,660	650	7,200	60	0.305	0.2
MAKOKO	7.61	9,670	4.19	95.3	14,760	14,110	1,910	7,520	50	0.332	0.213
IDDO	7.63	16,320	4.03	183	20,850	18,940	3,140	10,800	80	0.283	0.156
CMS	8.02	14,970	4.03	156	26,860	23,720	660	11,600	130	0.262	0.193
AVERAGE	7.575	11,897	4.222	166.81667	13805	12543.3333	1320	7472	90	0.492	0.1945
ST. DEV.	0.21439	4958.764679	0.3625098	39.474186	7758.1934	6991.47372	858.3206	3430.498506	31.1677489	0.258054811	0.018697148
						JUNE ANALYSIS					
	pH	COND.(us/cm)	DO(mg/L)	BOD(mg/L)	TS(mg/L)	TDS(mg/L)	SS(mg/L)	Hardness(mg/L)	Alkalinity(mg/L)	Phosphate(mg/L)	Nitrate(mg/L)
OGUDU	7.79	972	ND	150.7	920	280	640	68	180	0.662	0.149
OWORO	7.92	15,010	4.51	153	10,149	9,870	270	8,400	90	0.152	0.195
AKOKA	7.96	12,280	4.83	214.7	9,410	8,600	810	16,400	50	0.153	0.205
MAKOKO	7.74	10,570	4.67	96.7	14,970	14,200	770	9,600	50	0.091	0.236
IDDO	7.96	18,110	4.35	172	21,870	20,920	950	14,000	80	0.116	0.169
CMS	8.37	18,010	4.19	75.3	30,830	25,750	5,080	20,400	120	0.109	0.149
AVERAGE	7.95667	12,492	4.51	143.73333	14691.5	13270	1420	11478	95	0.213833333	0.183833333
ST. DEV.	0.18782	5408.98723	0.2065591	42.870125	8866.0054	7720.53662	1527.93	6016.379072	41.66190449	0.186710943	0.029132293
						AUGUST ANALYSIS					
	pH	COND.(us/cm)	DO(mg/L)	BOD(mg/L)	TS(mg/L)	TDS(mg/L)	SS(mg/L)	Hardness(mg/L)	Alkalinity(mg/L)	Phosphate(mg/L)	Nitrate(mg/L)
OGUDU	7.09	508	ND	170	1600	1030	570	32	160	0.522	0.231
OWORO	7.61	14,010	5.31	138	7,100	6,870	230	8,400	80	0.047	0.21
AKOKA	7.64	11,280	4.51	233	9,950	8,880	1,070	11,600	60	NIL	0.19
MAKOKO	7.52	12,440	3.86	124	15,540	14,710	830	9,600	60	0.050	0.159
IDDO	7.59	17,860	4.03	196	21,900	21,030	870	12,000	80	0.091	0.169
CMS	8.03	19950	3.38	96.7	26000	21880	4120	24600	140	0.028	0.312
AVERAGE	7.58	12,675	4.218	159.61667	13681.667	12400	1281.667	11038.66667	96.66666667	0.1476	0.211833333
ST. DEV.	0.25377	5752.381039	0.5977012	42.276316	7800.6051	6989.08946	1200.41	6711.696117	36.12148813	0.045529853	0.047066569

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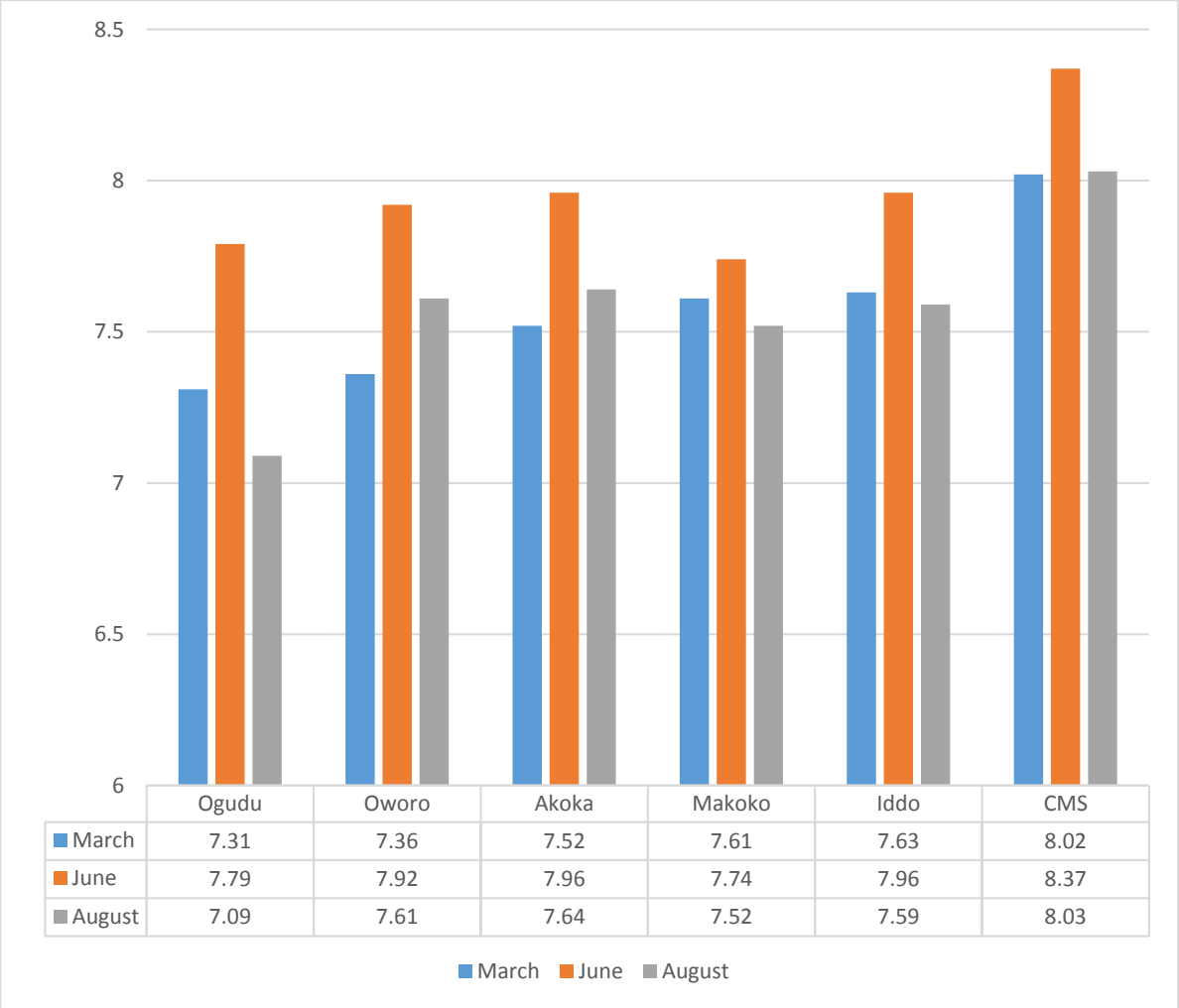
DISCUSSION

pH



	Ogudu	Oworo	Akoka	Makoko	Iddo	CMS
March	7.31	7.36	7.52	7.61	7.63	8.02
June	7.79	7.92	7.96	7.74	7.96	8.37
August	7.09	7.61	7.64	7.52	7.59	8.03

Fig 4.1. pH values of the sampling locations

The pH value of water samples for the sampling locations ranged from 7.31 - 8.02 for the first sampling, 7.74 - 8.37 for the second sampling and 7.09 – 8.03 for the third sampling. The first and third samplings had averagely the same pH values for the locations which could be attributed to the almost equal amount of rainfall.

Generally, high pH values were observed in June. This could be attributed to the consistent heavy rainfall during that period, which in turn led to the increasing pH of the water. Ogudu was observed to have the lowest pH values generally while CMS was observed to have the highest pH values. The sampling point at CMS is very busy. Unlike the Ogudu point, a lot of commercial and transport activities take place around the area. This could be the reason for the observed difference in the pH of both points.

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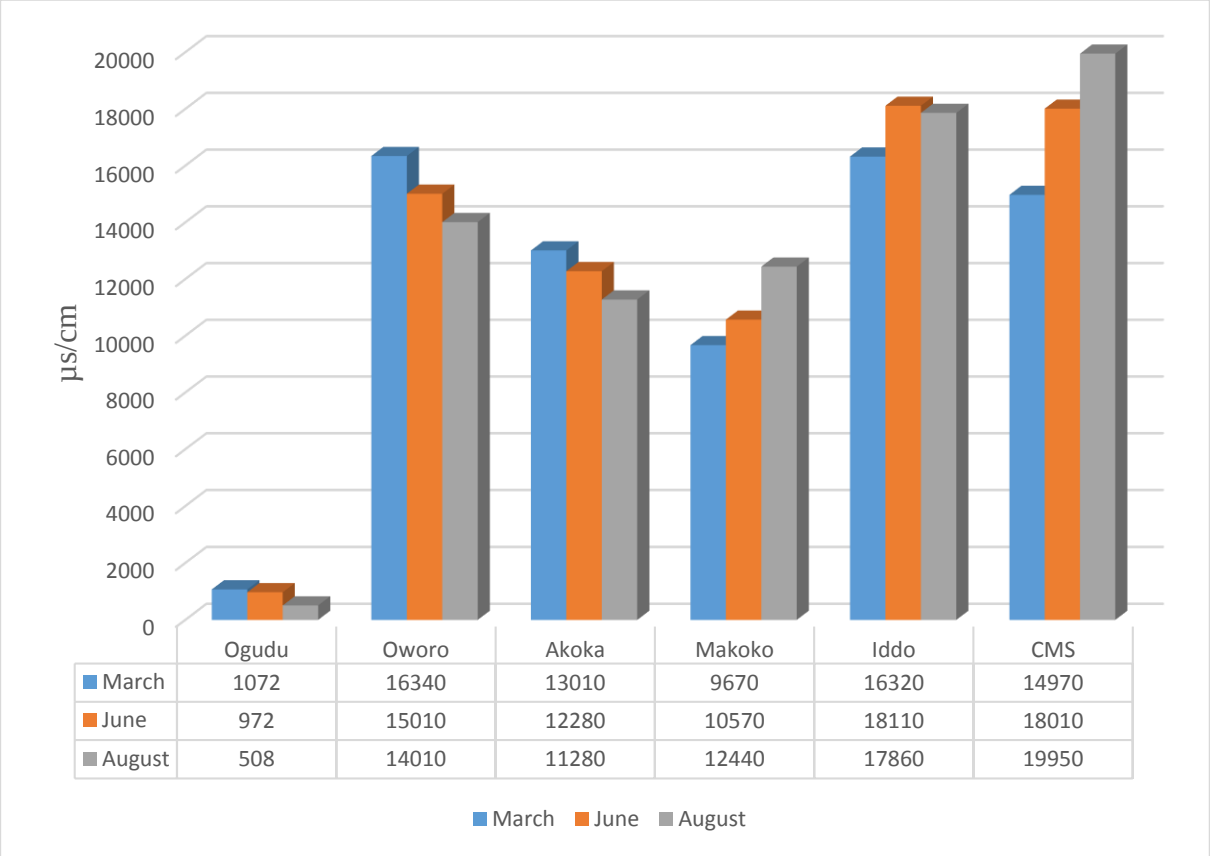
Conductivity



	Ogudu	Oworo	Akoka	Makoko	Iddo	CMS
March	1072	16340	13010	9670	16320	14970
June	972	15010	12280	10570	18110	18010
August	508	14010	11280	12440	17860	19950

Figure 4.2. Conductivity values of the sampling points

The conductivity values for the samples ranged from (1,072-16,340) µs/cm for the first sampling, (972-18,110) µs/cm for the second sampling and (508-19,950) µs/cm for the third sampling.

The conductivity values shown in fig 4.2 for the water samples show that the water was polluted. Ogudu had very low conductivity values for all the sampling period, thus pollution could be as a result of the effluent release of very toxic chemicals into the water by the industry in that area. The highest recorded conductivity was recorded in August at the CMS sampling point with a value of 19,950μs/cm while the lowest was found in August.

Alkalinity

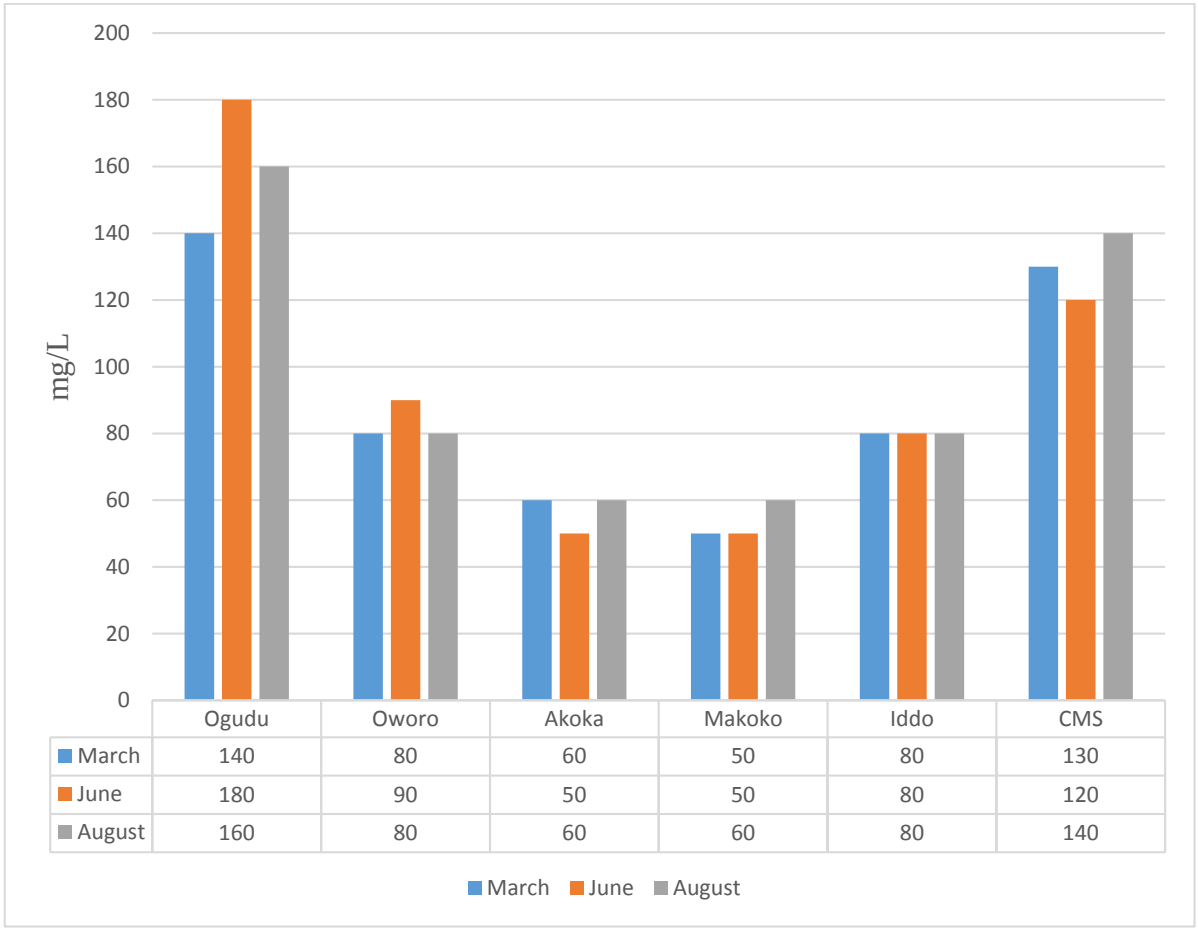


Fig 4.3. Alkalinity values of the sampling points

Alkalinity values for the first month ranged from (50-140) mg/l, (50-180) mg/l for the second month and (60-160) mg/l for the third month. Ogudu had the highest alkalinity values while Akoka and Makoko had the lowest overall alkalinity values.

Alkalinity values from the water also suggest that the water was polluted. This may be due to the presence of salts of weak acids such as ethanoic, formic, carbonic acid and or the presence of ammonia and hydroxides in industrial effluents. Total alkalinity of the samples gotten from the Lagos lagoon ranges from about 50- 180 mg/l.

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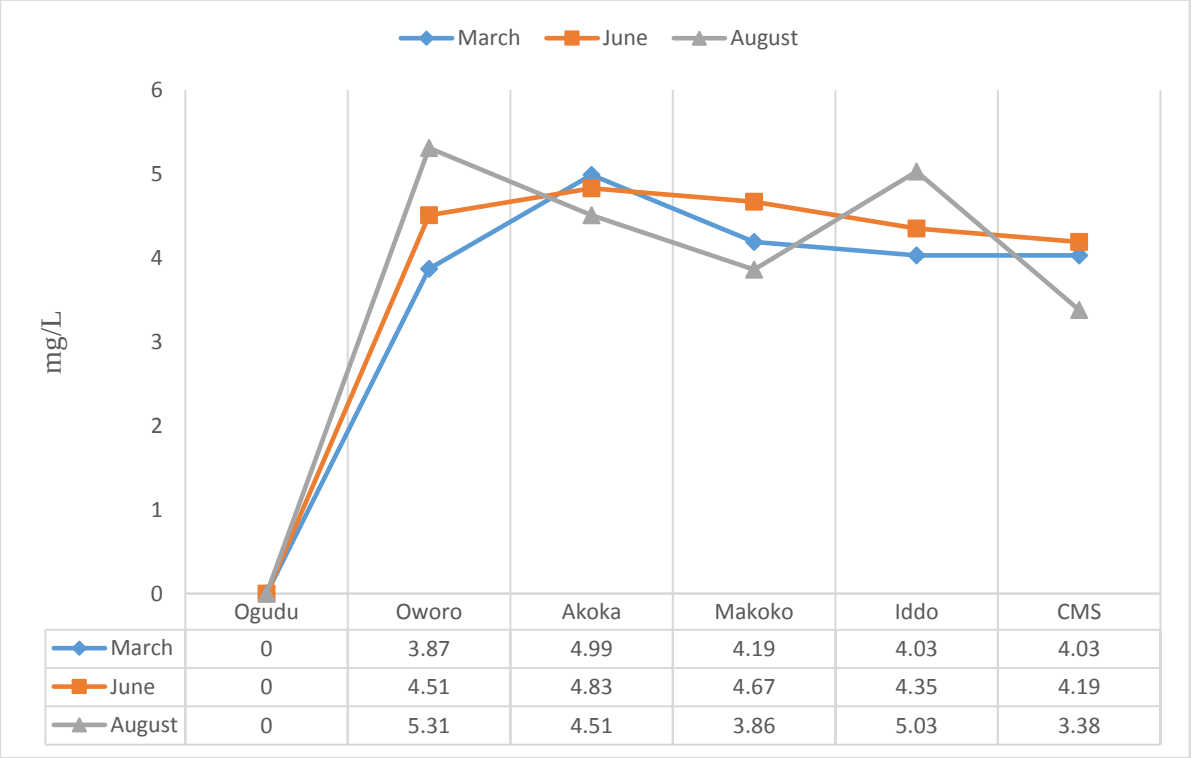
Dissolved Oxygen



	Ogudu	Oworo	Akoka	Makoko	Iddo	CMS
March	0	3.87	4.99	4.19	4.03	4.03
June	0	4.51	4.83	4.67	4.35	4.19
August	0	5.31	4.51	3.86	5.03	3.38

Fig 4.4. DO values of the sampling points

The DO for the first sampling ranged between 3.87-4.99 mg/l, 4.19-4.83 mg/l for the second sampling and 3.38-5.31 mg/l for the third sampling.

The sampling point in Ogudu for all three times had no dissolved oxygen value. This is evident that there was no aquatic life present and hence could not be used for domestic activities. The other sampling points along the Lagos lagoon have dissolved oxygen levels however low which fall within the Federal Environmental Protection Agency (FEPA) limits for natural water and hence could support aquatic life.

However, the range of the dissolved oxygen (3.38 mg/l – 5.31 mg/l) provided information about the level of pollution of the water which is significant. Many of the values have shown the water to be hypoxic as they have values below 4.8 ml. The absence of Dissolved oxygen is also shown by the presence of excessive plant life on the water surface which made navigation by boats even quite difficult. These recorded DO values are in line with the work conducted by Popoola *et al.* (2012) where the recorded DO of the water ranged similarly.

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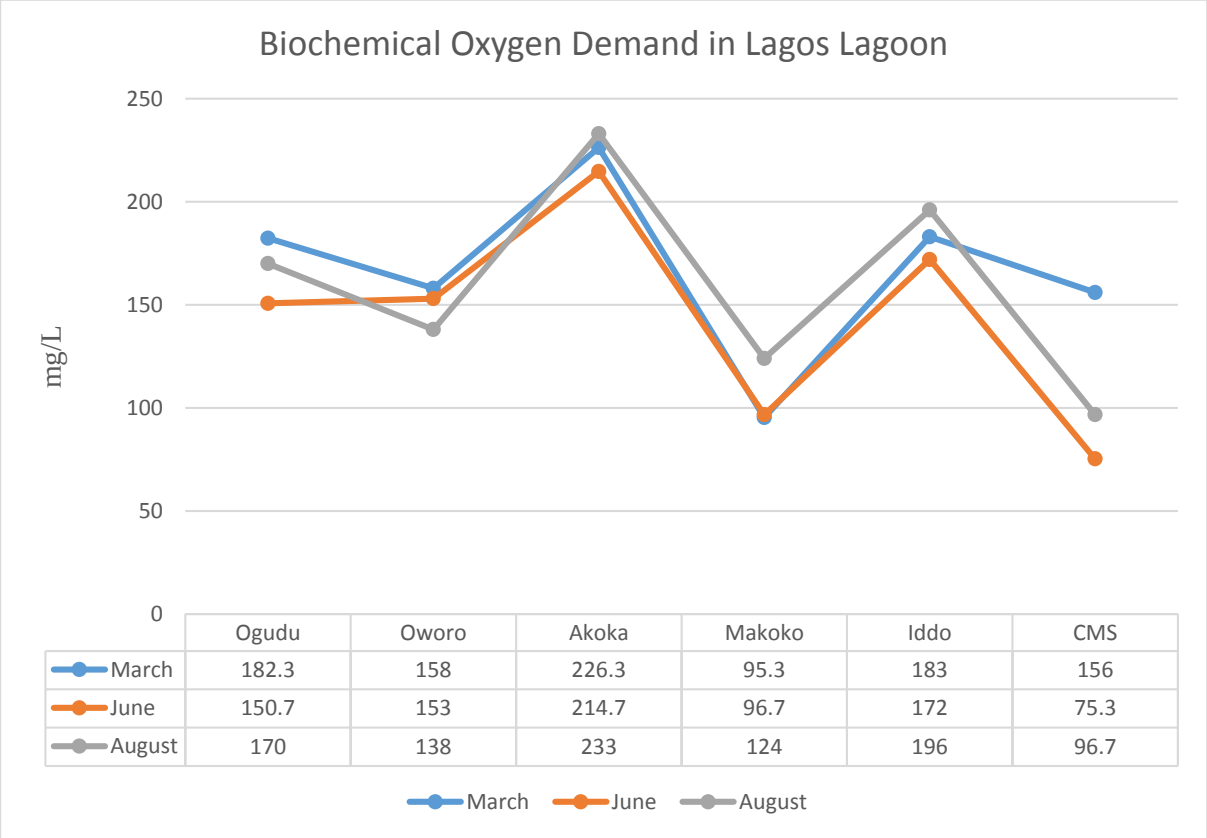
Biochemical Oxygen Demand



	Ogudu	Oworo	Akoka	Makoko	Iddo	CMS
March	182.3	158	226.3	95.3	183	156
June	150.7	153	214.7	96.7	172	75.3
August	170	138	233	124	196	96.7

Fig 4.5. BOD values of the sampling points

The BOD values obtained in all the sampling points were very high and this shows high microbial activities and population of the whole river. This is supported by the results of the low DO as microorganisms had used up most of the available oxygen present in the water and hence higher microbial activities. The higher the biochemical oxygen demand, the lower the dissolved oxygen and the lower the biochemical oxygen demand, the higher the dissolved oxygen.

The high BOD values also indicate why the banks of the river are closing up and eutrophication signs were observed (as seen by the growth of phytoplankton and algae).

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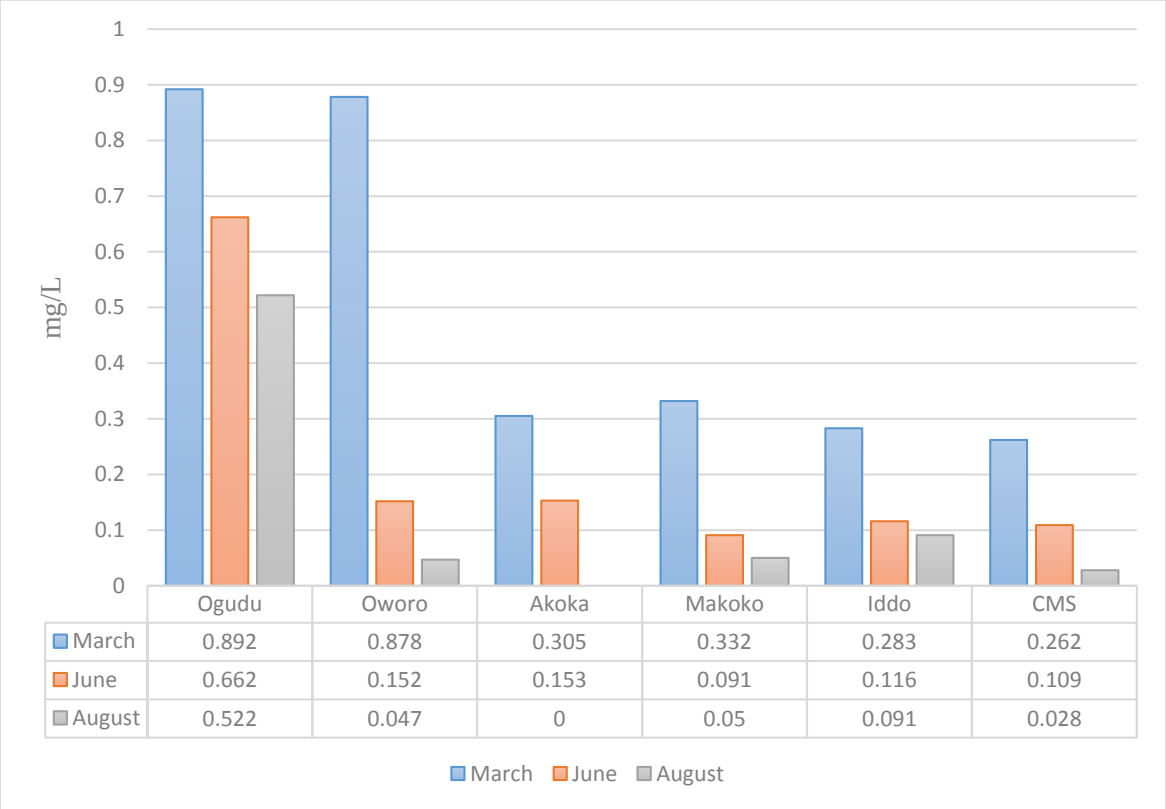
Phosphates



	Ogudu	Oworo	Akoka	Makoko	Iddo	CMS
March	0.892	0.878	0.305	0.332	0.283	0.262
June	0.662	0.152	0.153	0.091	0.116	0.109
August	0.522	0.047	0	0.05	0.091	0.028

Fig 4.6. Phosphate values of the sampling locations

The phosphate values for the samples ranged between 0.262-0.892 mg/l for the first month, (0.091-0.662) mg/l for the second month and (0.028-0.522) mg/l for the third month. The month of March was also recorded to have the highest phosphate levels and this is attributed to the heavy rainfall that was recorded in that month. Ogudu sampling point shows the highest phosphate values as seen in fig 4.6. The sampling location was seen to have a high population of water hyacinth. Ogudu showed characteristics of adverse eutrophic effects and the recorded phosphate values highlight the presence of excess nutrients in the water body. Other sampling points did not contain as much phosphate in the water as Ogudu and were mostly devoid of plants on the water surface during the sampling process. High phosphate in the sampling location could come from industrial effluents, effluents from laundry wastewater and others.

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Nitrates

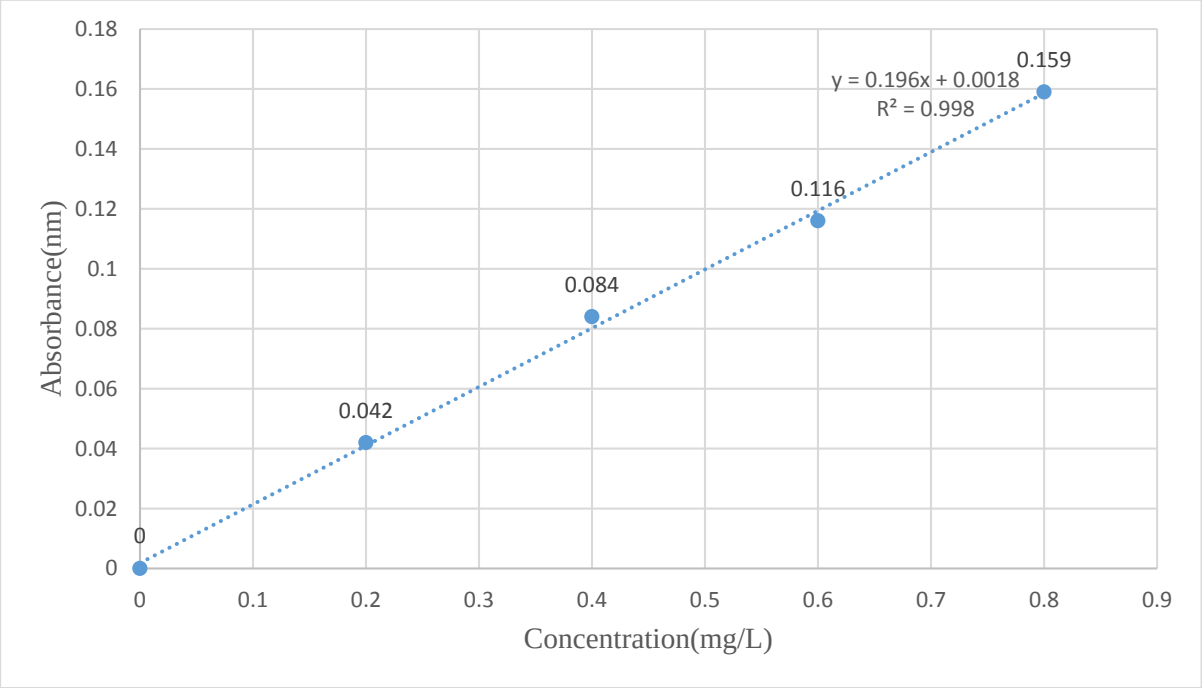
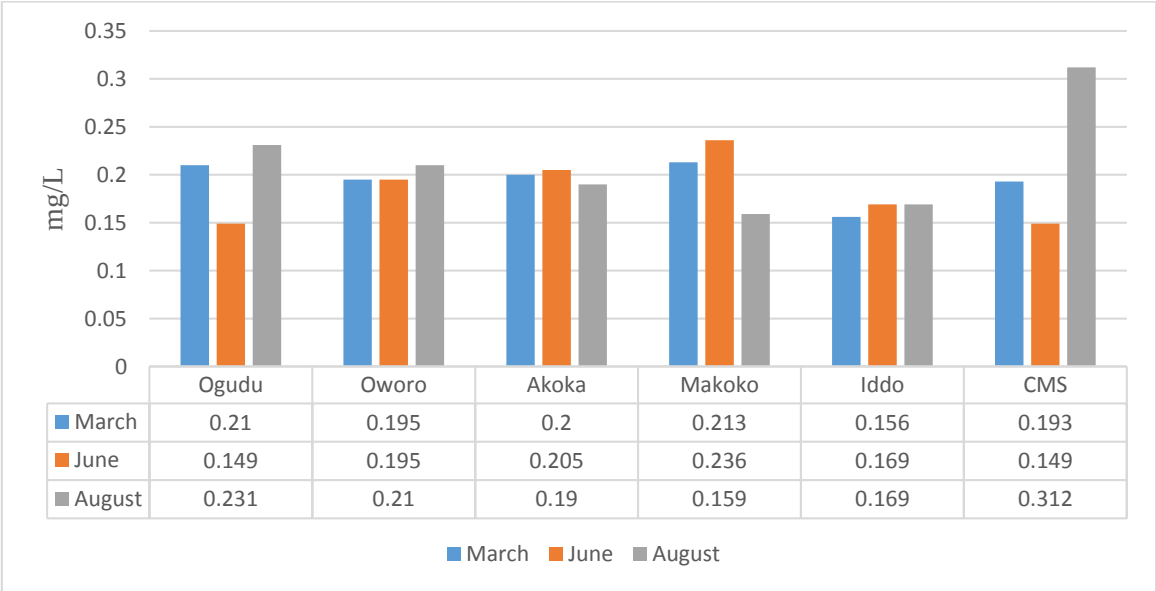


Fig 4.7. Calibration Standard Curve used in the determination of Nitrates

From the graph shown in Fig 4.7, the equation of the graph was deduced (y = 0.196x + 0.0018) with which the concentration of the samples nitrate absorbance was extrapolated. The correlation coefficient (R^2) value for the graph was $R^2 = 0.998$. This shows a good linearity and that it could be used to extrapolate the concentration of the samples.



	Ogudu	Oworo	Akoka	Makoko	Iddo	CMS
March	0.21	0.195	0.2	0.213	0.156	0.193
June	0.149	0.195	0.205	0.236	0.169	0.149
August	0.231	0.21	0.19	0.159	0.169	0.312

Fig 4.8. Nitrate values for the sampling locations

The Nitrate values of the samples were reasonably high and also responsible for eutrophication. The high nitrate values could be attributed to runoff from dumpsites and agricultural farmland containing fertilizer compounds. It can also be from the exhaust emissions of industries around the area which usually contain oxides of nitrogen which when dissolved by rain would enter the rivers and the lagoon. Other sources include nitrogenous materials carried by overland flow or soil erosion into streams flowing into the lagoon. About eight times more nitrogen is required than phosphorus for eutrophication to occur. Phosphorus thus limits eutrophication if nitrogen is more than eight times as abundant as phosphorus, while nitrogen limits eutrophication if its concentration is less than eight times as abundant as phosphorus.

CONCLUSION

The Redfield ratio (N:P ratio = 16:1) is not detected as the level of phosphates in the water is higher than the nitrates and this is because phosphorus is not exchanging between the ocean and an atmospheric reservoir as nitrogen does, the delivery of phosphorus, not nitrogen, limits net production of organic material in the water.

High concentrations of nitrates and phosphates in the water samples from the lagoon indicated that the waters flowing into the lagoon were highly polluted, as seen in the water samples collected in Ogudu. It is a likely source of pollution to the lagoon. Ogudu river clearly carries a large load of nutrients and around these sampling locations are farmlands and industries which could be the main contributing sources of pollution in the water body. The fertilizers used by farmers are leached directly into the river, and the effluents from the industries also heighten the nutrient level in the water.

The extremely low and in some cases absent dissolved oxygen (DO) make the water brackish. The banks were covered with water weeds in some of the sampling points and were getting shallow. If uncurbed, many of the rivers leading to the lagoon could be lost.

RECOMMENDATIONS

Government authorities are advised to enforce laws on environmental pollution to discourage the discharge of effluents into water bodies by industries and communities. Awareness should be made to educate people on the hazards of environmental pollution. The concept of reducing waste, recycling waste and reusing should be encouraged to help curb the effects of pollution. This will enable the conservation of the valuable resources such that fishing as well as fisheries can thrive in the Lagos lagoon and banks.

REFERENCES

Abara P. N., Obiekezie S. O., Onyeagba R. A. and Nwaugo V. O. (2005): Physicochemical Characteristics of Ivo River, Ebonyi State Nigeria, *International Journal of Natural Sciences*, 1(2), 145-149.

Addy K and Green L. (1996): Phosphorus and Lake Aging. University of Rhode Island: Natural Resources Facts; Report nr 96-2.

Adebisi S. A. and Fayemiwo K. A. (2010): Physicochemical Properties of Industrial Effluents in Ibadan, Nigeria, *Nature and Science* 8(12), 234-238.

Adefemi S. O. and E. E. Awokunmi, (2010): Determination of physico-chemical parameters and heavy metals in water samples from Itaogbolu area of Ondo-State, Nigeria, African Journal of Environmental Science and Technology, 4(3), pp 145-148.

Adeyemo O. K., Adedokun O. A., Yusuf R. K. and Adeleye E. A. (2008): Seasonal Changes in Physicochemical Parameters and Nutrient Load of River Sediments in Ibadan city, Nigeria, *Global NEST Journal*, 10(3), 326-336.

Ajao, E. A. (1996): Review of the state of pollution of the Lagos lagoon. NIOMR Tech. Paper No. 106. 19pp.

Ajayi J. T.,(2006): Analysis of Nitrogen Fractions in Odo Iyaalaro and Lagos Lagoon.

Anderson D. M, Gilbert P. M and Burkholder J. M. (2002): Harmful Algal Blooms and Eutrophication: Nutrient Sources, Composition, and Consequences. Estuaries 25:704-726.

Bartram, J., Wayne W. Carmichael, Ingrid Chorus, Gary Jones, and Olav M. Skulberg (1999): Chapter 1. Introduction, in: *Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management*.

Carpenter S. R. (2008): Phosphorus control is critical to mitigating eutrophication. Proceedings of the National Academy of Science 105:11039-11040.

Carpenter, S. R., N. F. Caraco, and V. H. Smith. (1998): Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecological Applications 8:559–568.

Correll, D., 1998. The role of phosphorus in the eutrophication of receiving waters: A review, J. Environ. Qual. 27, 261-266.

Cultural eutrophication (2010): *Encyclopædia Britannica*. Retrieved April 26, 2010, from Encyclopædia Britannica Online:

De Jonge, V. N.; Elliot, M.; Orive, E. (2002): Causes, historical development, effects and future challenges of a common environmental problem: eutrophication. *Hydrobiologia 475-476*:1-19.

Diersing, N., 2009. Phytoplankton Blooms the Basics, Florida Keys National Marine Sanctuary.

Ecological Society of America. (ESA) (1998): Washington DC: Ecological Society of America; 1 p.

Edmondson W. T. (1970): Phosphorus, Nitrogen, and Algae in Lake Washington after diversion of Sewage. Science 169:690-691.

Enger, Elton D. and Bradley Smith (2002): Environmental Science. A Study of Interrelationships. McGraw Hill:2002.

ESA-Ecological Society of America. (2008): Hypoxia. Washington DC: Ecological Society of America; 1 p.

European Environment Agency (2005): *EEA Report*, 7 Office for Official Publications of the European Communities: Luxembourg. ISBN 92-9167-777-9.48 pp.

Eutrophication and health. European Commission (2002): Office for Official Publications of the European Communities: Luxembourg. ISBN 92-894-4413-4.28 pp.

Galloway, J. N.; (2004): "Nitrogen cycles: past, present, and future". *Biogeochemistry* 70: 153-226.

Harper D. (1992): Eutrophication of Freshwaters: Principles, Problems, and Restoration. New York: Chapman & Hall.

Kanan, Matthew W., and Daniel G. Nocera, (2008) "In situ formation of an oxygen-evolving catalyst in neutral water containing phosphate and Co2+." *Science* 321.5892 (2008): 1072-1075.

Karanth, H., & Murthy, R. S. R. (2007). pH-sensitive liposomes-principle and application in cancer therapy. *Journal of pharmacy and pharmacology*, *59*(4), 469-483.

Lawson, O. E., & Lawson, E. O. (2011). Physico-chemical parameters and heavy metal contents of water from the Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria.

Leonardos, N., & Geider, R. J. (2004). Effects of nitrate: phosphate supply ratio and irradiance on the C: N: P stoichiometry of Chaetoceros muelleri. *European Journal of Phycology*, *39*(2), 173-180.

Litke D. W. (1999): Review of phosphorus control measures in the US and their effects on water quality. National Water Quality Assessment Program: Water-Resources Investigations Report. Report nr 99-4007.

M. Nasir Khan and F. Mohammad, (2014): "Eutrophication: Challenges and Solutions" in A. A. Ansari, S. S. Gill (eds.), Eutrophication: Causes, Consequences and Control, Springer Science+Business Media Dordrecht 2014doi: 10.1007/978-94-007-7814-6_5.

Mandaville S. M. (2000): Limnology- Eutrophication and Chemistry, Carrying Capacities, Loadings, Benthic Ecology, and Comparative Data. Project F-1, Soil & Water Conservation Society of Metro Halifax. xviii, Synopses 1, 2, 3, 13, and 14.

Miller, G. Tyler Jr. (2001): Environmental Science. Brooks/Cole Thomson Learning: (2001).

Moir, James WB, ed. *Nitrogen cycling in bacteria: molecular analysis*. Horizon Scientific Press, 2011.

Moss, B., (1972): Studies on Gull Lake, Michigan II. Eutrophication evidence and prognosis, Freshwater Biology, 2, pp 309-320.

Naiman, R. J., Magnuson J. J, McKnight D. M., and Stanford J.A,. (1995): The Freshwater imperative. Island Press, Washington D.C.

National Research Council. (1992): Restoration of Aquatic Ecosystems: Science, Technology and Public Policy. National Academy Press, Washington D.C.

Nebel Richard J. and Richard T. Wright,(1998): Environmental Science. Patience Hall: 1998.

Nnamdi H. Amaeze, Sabine Osman Sozeri, Adebayo A. Otitoloju, Rosemary I. Egonmwan, Volker M. Arlt and Nic R. Bury. Mutagenesis (2015) 30 (1): 117-127.

Obafemi, M. O. (2008). Lagos lagoon coastal profile: Information database for planning theory. *Department of Urban and Regional Planning, University of Lagos-Accessed September*, *22*, 2008.

Obire, O., Ogan, A., & Okigbo, R. N. (2008). Impact of fertilizer plant effluent on water quality. *International Journal of Environmental Science & Technology*, *5*(1), 107-118.

Odum, E. P., (1971): Fundamentals of Ecology. 3 Edn., rd W.B. Saunders. Philadelphia, pp: 574.

Omaka O. N. (2007): Phosphorus in the Environment, Effects of Eutrophication, Cycle, Fractionation, Determination and Procedures for Sampling and Storage – A Review, *Journal of Applied and Natural Sciences*, 1(1), 27-36.

Omaka, O. N., Nwabue, F., Itumoh, E. J., Oroke, E. C., & Igwe, D. O. (2014). Physicochemical parameters and nutrients variations of streams and rivers in Abakaliki, Ebonyi State, Nigeria. *Global NEST Journal*, *16*(1), 114-123.

Onyema, I. C. (2008): A checklist of phytoplankton species of the Iyagbe lagoon, Lagos. *Journal of Fisheries and Aquatic Sciences*. 3(3): 167 – 175.

Onyema, I. C., Popoola, R. T. (2013). The Physico-Chemical Characteristics, Chlorophyll A Levels and Phytoplankton Dynamics of the East Mole Area of the Lagos Harbour, Lagos. *Journal of Asian Scientific Research*, *3*(10), 995-1010.
Patil. P. N, Sawant. D. V, Deshmukh. R. N (2012): International journal of environmental sciences volume 3, no 3, 2012.
Provin, T. L., & Pitt, J. L. (2002). Description of Water Analysis Parameters. *Texas A&M Agrilife Extension. Texas*.
Quirós, R. (2003). The relationship between nitrate and ammonia concentrations in the pelagic zone of lakes. *Limnetica*, *22*(1-2), 37-50.
Rowe, D. R. and I. M. Abdel-Mazid. (1995): Handbook of Wastewater Reclamation and Reuse. CRC Press, Inc. 550 pp.
Schindler D. W. (2006): Recent Advances in the Understanding and Management of Eutrophication. Limnology and Oceanography 5:356-363.
Schindler, David and Vallentyne, John R. (2004): *Over fertilization of the World's Freshwaters and Estuaries*, University of Alberta Press, p. 1, ISBN 0-88864-484-1.
Schindler, David W., Vallentyne, John R. (2008): *The Algal Bowl: Overfertilization of the World's Freshwaters and Estuaries*, University of Alberta Press, ISBN 0-88864-484-1.
Schindler, David William (2009): "A personal history of the Experimental Lakes Project". *Canadian Journal of Fisheries and Aquatic Sciences* 66 (11): 1837–1847. doi:10.1139/f09-134.
Sharpley A. N, Chapra S. C, Wedepohl R, (1994): Managing Agricultural Phosphorus for Protection of Surface Waters: Issues and Options. Journal of Environmental Quality 23:437-451.
Smaya T. J. (2008): Complexity in the eutrophication— harmful algal bloom relationship, with comment on the importance of grazing. Harmful Algae 8:140-151.
Smith VH. (2003). Eutrophication of freshwater and coastal marine ecosystems: a global problem. Environmental Science and Pollution Research 10:126-139.
Smith, F. W., Cybinski, D. H., & Rae, A. L. (1999). Regulation of expression of genes encoding phosphate transporters in barley roots. In *Plant Nutrition—Molecular Biology and Genetics* (pp. 145-150). Springer Netherlands.
Smith, R. L., & Thomas M. Smith., (2003): Elements of Ecology. Source apportionment of nitrogen and phosphorus inputs into the aquatic environment, Pearson Education, CA. p 438-439.
Tiseer, F. A., Tanimu, Y., & Chia, A. M. (2008). Seasonal occurrence of algae and physico-chemical parameters of Samaru stream, Zaria, Nigeria. *Asian journal of Earth Science*, *1*(1), 31-37.
Vollenweider, R. A (1996). Assessment of the state of eutrophication in the Mediterranean Sea, MAP Technical Report series no106, UNEP, Athens.
WHO Geneva, (2008): Guidelines for drinking-water quality (electronic resource), 3rd edition incorporating 1st and 2nd addenda, Volume 1, Recommendations.
World Health Organization-(WHO). (2003): Emerging Issues in Water and Infectious Disease. World Health Organization. Report no 2.