ASSESSMENT OF PHYSICO-CHEMICAL CHARACTERISTICS IN RELATION TO ZOOPLANKTON COMMUNITIES IN PONDS IN OGHARA, DELTA STATE.

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE, B.SC (HONS) IN ANIMAL AND ENVIRONMENTAL BIOLOGY, FACULTY OF LIFE SCIENCES.

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CERTIFICATION

This is to certify that this project work was carried out by AIDEYAN Idemudia GEORGE in the Department of Animal and Environmental Biology, University of Benin, Benin City, Nigeria.

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External Examiner Date

DEDICATION

To Almighty God, for his never ending love, grace and favor he has showered on my life. This work is also dedicated to myself, for always believing in me ad mist Shortcomings.

ACKNOWLEDGEMENTS

No one ever achieved much without the contributions of others, and writing this project thesis was no exception. There are innumerable people to thank for helping shape the blueprint of this work. I am indeed grateful to God Almighty, who has been with me from the onset of my academic journey up to this point in my life.

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To my course adviser, Dr. S. Ekaye, I am blessed to have you, not only as a teacher but as a Student Guide. To all other lecturers and lab technologists, and all my friends, I say a big thank you.

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ABSTRACT

Zooplankton constitute a diverse assemblage in most freshwater habitats. A study on the assessment of physico-chemical Characteristics in relation to zooplankton communities in fresh water habitats in Oghara, Delta State was conducted from January – March 2021. Water and Zooplankton samples were collected at monthly and fortnightly respectively at three different sampling stations. Physicochemical parameter were determined using standard methods while Zooplankton Samples were preserved with 4% formaldehyde solution. Mean temperature ranged from (26.00 ±0.577 - 28.83 ± 1.589). Mean Value of Ph was slightly acidic to neutral, ranging from (6.76 – 6.05). Dissolved Oxygen was quite low typical of most eutrophic water bodies. BOD mean value was relatively high (5.80 – 8.40) owing to increased organic decomposition by organisms during the study period. Nitrate ranged from (0.57 to 5.27) during the study period. The result of zooplankton composition indicated the presence of 33 species of Zooplanktons belonging to three major classes; Cladocera 1108 individual taxa (93.5%), Rotifera 5 individual taxa (0.43%) and Copepoda 72 individual taxa (6.07%). Cladocera were more diverse with 21 representative species, followed by Copepods and Rotifers with 9 and 3 species respectively. Indices of general diversity (H) and evenness (E) were in the following order station 3 > station 2 > station 1 respectively. Margalef's index for richness shown that station 2 had the highest species richness and indicated the following trend station 2 > station 3 > station 1. Families Daphnidae, Macrothricidae and Sididae dominated the Cladoceran group while copepods was singly represented by family Cyclopidae. Rotifers were represented by families, Lecanidae, Asplanchidae and Proalidae. Zooplankton taxa generally showed negative correlation with nutrients and positive correlation with dissolved oxygen. Presence of tolerant and dominance groups such as Cladocera, Copepods and Rotifers that survive under higher organic conditions indicate the eutrophic status of the ponds.

CHAPTER ONE

1.0 INTRODUCTION

Aquatic ecosystem is the most diverse ecosystem in the world. Life originated first in water bringing about the first aquatic organisms (Kabra *et al*., 2016). Almost every animal phylum, is represented at least at some life stage in the plankton. Since the onset of time immemorial, Ponds have played unique significant role in the life (Pattnaik, 2014) of aquatic organisms with respect to zooplanktons. Fresh water bodies notably ponds, rivers, streams play a very important role, acting as transitional system between land and water, hereby creating an interface between the terrestrial and the aquatic environments (Kuczynska-Kippen, 2020).

Fresh water habitats have been known to support wide range of organism. Among these, Zooplanktons are considered free floating and microscopic organisms found in water bodies. According to Odum (1996), zooplanktons are organisms that are unable to navigate and move against appreciable current. They can also exhibit active swimming movements to slight degree and can maintain vertical position in water. Fernando (2002), recognised zooplanktons in tropical freshwater as predominantly made of Rotifers, Cladocerans and Copepods, and on rare occasion are ostracods and insects found in such water bodies.

Zooplankton communities constitute a diverse framework in most fresh water bodies and are represented by a sundry of diverse assemblages of the invertebrate phyla (Imoobe, 2011). In nature, zooplanktons are heterotrophic, having a rich biodiversity (Kangasabapathi and Rajan, 2010), and aid in transferring energy from the lower trophic levels to higher trophic levels (Lampert & Somer, 1997; Levinsen & Nielsen, 2002)

Zooplanktons are quite important for fishes as they are used as source of food.They plays specific roles in the ecosystem (Anita *et al.*, 2019) including: recycling of nutrients, maintaining soil fertility and acting as food for other larger organisms. Zooplankton also play an important role in remineralisation of organic matter and top-down grazing on primary producers (Banse, 1995).

Zooplanktons are also generally influenced by feeding ecology, predation and even seasonal variations of water quality parameters. Zooplanktons are also very sensitive to environmental changes and react to a wide variety of environmental stresses and gradients (Harris *et al.* 2000; Jeppesen *et al.* 2000), and these changes influences the structure, abundance and zooplankton diversity.

Zooplanktons community fluctuates according to physicochemical parameter of the environment, especially Rotifer species which changes with biotic factors (Karuthapandi *et al.,* 2013). Brooks & Dodson (1965), laid emphasis on food, predation and temperature as the most important factors that exert control over the dynamics of cladocerans. The relative low density of rotifers in some water bodies may be attributed to predation and competition, as copepods are larger and better swimmers than rotifers. Rotifers are also weak in competing for limited food in comparison to both cladocerans and copepods, hence they have a narrow range of food they can consume and are usually prone to starvation (Thorp and Rogers, 2015). These generally have attributed to the abundance of copepods and cladocerans found in most freshwater bodies.

Zooplankton community structure acts as indicators responding sensitively to changes in environmental conditions and nutrient enrichment (Sarkar & Choudhury, 1999; Taylor *et al.* 2000). Nutrition enrichment commonly caused by increased algae blooms coupled with acidification of water, and agricultural effluents (Sachidanandamurthy and Yajurvedi, 2006; Parashar *et al.,* 2008) are some of the major physico-chemical factors that dictate zoological community structure. Zooplankton also stands out for being able to quickly react to environmental and toxicological changes (Moreira *et al*., 2014; Vieira *et al*., 2011)

Water quality influences the abundance, clustering and biomass of zooplanktons (Adelayo & Ifeanyi, 2018). Zooplankton is a good indicator of the changes in water quality because they are strongly affected by environmental conditions and respond quickly to changes in water quality. Therefore, zooplankton has been used recently as an indicator to monitor and realize changes in the ecosystem and are valuable tool in the assessment of water quality in generally almost all aquatic ecosystems.

Zooplanktons also play a huge role in nutritive level and pollution. They are an essential component of most freshwater and marine food webs, often serving as biotic indicators of ecosystem health (Purushothama *et al.,* 2011; Conroy *et al*., 2008). Studies have shown that these water drifters (zooplanktons) also play an important role in bio-monitoring of water pollution (Tyor *et al.,* 2014).

From earlier work on zooplanktons, it appears that negligible work has been carried out on the physico-chemical characteristics of water in ponds and how they affect zooplanktons communities, notably permanent ponds in Oghara, Delta State.

Aim of Study

The aim of this present study hence, is to determine how physico-chemical parameters of water affect zooplankton community structure and dynamics of Freshwater habitats (ponds) in Oghara, Delta State.

Specific Objectives

The objective of the investigation is to:

- Determine the physico-chemical conditions prevailing in these ponds.
- Investigate the composition and abundance of zooplankton selected ponds at Oghara, Delta State.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

A Considerable amount of researchers which include Imoobe (2011), Imoobe and Adeyinka, (2009), Ogbeibu *et al.* (2013), Omoigberale and Oronsaye (2011), Arazu and Ogbeibu (2017), Ogbeibu and Edutie (2002), Oboh (2017), have made significant studies and researches on the zooplankton dynamics (diversity, composition, abundance), physico-chemical properties and characteristics of water bodies in Nigeria (both lotic and lentic).

However only few hydrobiological studies focus on temporary and permanent ponds and their communities. This is found within the context of Nigeria inland waters to be true as the taxonomy of most Nigeria ponds are rarely and poorly known and this may be attributed to the hesitation to carry out limnological researches in these areas.

Otene *et al.* (2019) conducted a study on Okamini stream and recorded temperature ranging between 28.60 to 30.50°C with overall mean value of 29.53 ± 0.67°C. BOD and DO ranged between the values of 1.6 – 2.90mg/l and 5.50 and 6.50mg/l respectively, generally ascertaining that the knowledge of the physico-chemical conditions that directly or indirectly affect the inhabitants of an aquatic ecosystem are essential for a proper appraisal of the ecology of the aquatic animal species. Ph values also ranged between 5.1 and 6.4 with the overall mean value of 5.89 ± 0.40 indicative of an acidic condition, which was attributed to high rate of degradation in the area thereby leading to an increasing hydrogen ion concentration.

Dirisu *et al.* (2019), conducted a study on Plankton Diversity and Community Structure in Relation to Physico-Chemistry at Asarama Estuary, River State. Members of the rotifer group were reported to display positive correlation between BOD and DO. This was attributed to their affinity for environment rich in dissolved oxygen as well as requiring low biological oxygen demand for decomposition activity.

Omoregie (2017), study on heavy metals and total hydrocarbon of Osse river, reported a significant high concentration of iron (fe), manganese and lead, attributing the periodical variability in the levels of manganese to varying anthropogenic activities. A high concentration of nickel and total hydrocarbon owing to severe crude oil activities and illegal operations was also reported at station two.

Wan Maznah *et al.* (2017), conducted a study on zooplankton assemblages in relation to water quality parameters from May 2006 to February 2007 at both lentic and lotic habitats of Air Itam Reservoir, Penang, Malaysia. Water quality in relation to community structure of zooplankton was assessed. Station E recorded a low Water quality index (WQI) showing relatively pollution. This pollution was attributed to discharges from domestic waste water and farming through runoff during the rainy season and this led to an increase in zooplankton diversity around the station. High velocity in the upstream and downstream sampling stations, recorded in this study lead to a low density of rotifers in station E and complete absence of Cladocera in Station D. This was attributed to the fact that these rotifers may not have been able to resist the fast flowing water and the weak swimming abilities of these cladocerans.

Similarly, Ismail and Zaidin (2015), conducted a comparative study of zooplankton diversity and abundance from three different types of water body, in Balik Pulau, Penang, Malaysia from October 2013 until February 2014 and recorded high zooplankton abundance (182ind/L) in the month of November while the low abundance (19ind/L)) was noticed in the month of February. Zooplankton abundance showed strong positive correlation with water transparency ($r = 0.547$), increase in the water transparency lead to an increase in the zooplankton communities. High number of rotifers was also recorded owing prominently to their less specialized feeding habits, high fecundity and short developmental rates. Cladocera and Copepoda exhibited lower species richness and abundance in comparison to Rotifera, and this was attributed to the effects of size selective predation by fish.

Elsewhere, Ogbeibu and Oribhabor (2011), investigation on Buguma creek, River States, reported high abundance of Arthropods amongst all stations contributing to more than 95% of the entire fauna. The Arthropod phyla was represented by Copepoda and Decapoda. Higher densities and abundance were recorded during the dry months. This seasonal fluctuations in abundance was related to rainfall and alterations in salinity. Consequently during the dry seasons, more stability, concentration of nutrients and low current velocity lead to the increase in phytoplankton blood which inadvertently increased the abundance of the zooplanktons.

Imoobe and Adeyinka (2009), sampled zooplanktons from Ovia River, Edo state located in Southern Nigeria for a period of one year and three months between April, 2005 to June, 2006 with the densities of zooplankton ranging from 18 to 55 individuals/l with higher densities occurring from December to February deducing that the river is oligotrophic in nature due to very little primary production and low densities of zooplankton. Low level of nutrients (Primarily nitrate, sulphate and phosphate) was also recorded, as the main reason behind the oligotrophic nature of the river. The river was also dominated by small organisms like nauplii and small forms of rotifers and cladocerans. This high diversity of this smaller forms of zooplankton was attributed to predation pressure from planktivorous fishes. Another factor which contributed to this low densities in zooplankton was due to low nutrients input which consequently led to a decline in primary production and subsequent reduction in zooplankton abundance. *Conochilus dossuarius* and *Synchaeta longipes* species, which are typical of oligotrophic to mesotrophic ecosystems were reported in this study as potential indicators of environmental change, concluding that these species can be used to infer the apparent quality of such ecosystems.

Langer *et al.* (2007), conducted a study on the effect of some abiotic factors on zooplankton productivity in a subtropical pond in Jammu, India. Maximum abundance and biomass of zooplankton was recorded between the month of January-March when temperature was low (24ºC) and pH slightly alkaline or neutral (7.0-7.7) while high temperature in the month of May, August, and September lead to a decline in abundance of zooplankton. Maximum diversity of these planktons was due to the cumulative effect of high transparency, low temperature and high dissolved oxygen. Higher densities of cladocera was also recorded when DO concentration was highest (9.2 mg/l) while only *Brachionus* spp. exhibited its presence when DO level was recorded to be lowest (3.6 mg/l) in the pond indicative of high tolerance and resistance in the species to huge fluctuations in DO.

Ogbeibu and Edutie (2002) reported that water quality parameters singly or synergistically influenced cumulative changes in a biotic community. Brewery effluent according to this study was observed to not only influence rotifer community but also lead to significant differences in color, turbidity and transparency among different stations.

Fahd *et al.* (2000), in his research at Donana National Park, Spain, argued that the importance of physico-chemical parameters characteristic of small ponds and their consequences on the development, seasonal evolution and predictability of their communities, are often neglected, in spite of the large number of taxa surviving and flourishing in these fluctuating environments(ponds) and concluded that these parameters play a huge role in contributing to the biodiversity of ponds and even larger aquatic ecosystems. Hutchinson (1967) reported several factors like dissolved oxygen, pH, alkalinity, and temperature stating that zooplankton species are limited by these and other physico-chemical factors.

Adeniyi *et al.* (2020) investigation of the lower River Niger, recorded higher zooplankton abundance in the wet season as opposed to the dry season. Twenty (20) species of individual taxa was recorded with Copepod dominating with abundance of 55.40%. Family Cyclopidae was most (55.06%) abundant while the Family Chydoridae recorded the least (0.17%) abundance. The rotifer *Brachionus falcatus falcatus* was the most abundant with 635 individuals representing 33.33% of the total while *Alona eximia, Moina reticulate, Diaphanosoma sp, Thermocyclops hyalinus,* and *Thermocyclops taihokuensis* were least with 5 species each in abundance. The abundance Rotifera species (*Brachionus falcatus falcatus)* over other zooplankton was attributed to the capacity of rotifers to survive and thrive in the environments predominant with seasonal variations and environmental changes.

Bonjoru *et al.* (2020) conducted a preliminary study on zooplanktons and macroinvertebrates of River Kashimbila, Taraba State, Nigeria from August 2016 to March 2017 and recorded twenty one (21) species belonging to twelve (12) taxonomic groups.

However, this result was in contrast to findings by Adelayo and Ifeanyi (2019) at Erinle Lake who reported comparatively low abundance of zooplanktons during the rainy and early dry season with species relative abundance of 7.33% and 11.58% with a high species relative abundance of 31.33% recorded in the month of June (early rain) and peak abundance in zooplanktons in March (dry season). The low species richness observed during the rainy season was attributed to the release of water to the lake from very high water level coupled with the effect of highest turbidity experienced in the lake during the rainy season.

Nwinyimagu *et al.* (2018) investigation on seasonal variation in physicochemical parameters and its relationship with zooplankton abundance in River Asu, recorded dominance of Rotifers. Rotifera 54.17% to the total zooplankton abundance, while copepoda and cladoceran accounted for 18.75% and 27.08% respectively during the wet season. This trend of rotifer domination also continued in the dry season, as rotifers were seen to account for 48.39% while 19.35% and 32.26% percent of the total zooplankton abundance were recorded for copepoda and cladoceran respectively in the dry season. The dominance of rotifera was attributed to pressure from planktivorous fishes which preferentially prey on micro-crustaceans while the relative increase in abundance of cladoceran between the months of January and May was attributed to have been prompted by an increase in Ph.

Usman and Yerima (2017) conducted an ecological investigation of zooplanktons abundance on Ajiwa Reservoir, Katsina state from September 2014 to August 2015 and recorded Thirty one (31) species (1528 individual taxa) of zooplanktons belonging to four major classes viz Protozoa, Copepoda, Cladocera and Rotifera. Protozoa made up 27.1% of the total zooplanktons count with Cladocera, Copepoda accounting for 36.9%, 15.1%, and 21% respectively of the total zooplankton population. Rotifer had maximum species diversity with 12 species mainly dominated by Kellicottia longispina, Branchionus angularis, Rotaria neptunia, Euchlanis dilatata and Lecane lunaris while Cladoceran were dominated by Daphnia magna, Simocephalus vetulus, Ceriodaphnia dubia. Copepoda was mainly represented by Diaptomus africanus, Cyclops caudatus, Nauplius sp, Paracyclops fimbriatus and Temora longisornis.

Prashanthakumara & Venkateshwarlu (2016) conducted a study Zooplankton population and physico-chemical characteristics of a perennial pond of Tarikere city, India between January 2014 to December 2014 with the total zooplankton number fluctuating from 43 to 192 N/ml. Zooplanktons abundance of (192 No/L) was reported in the month of January, this was due to the high amount of DO and pH of the water body influencing the zooplankton population. These populations were found to slightly decrease by increasing water temperature and least (43 No/L) population of Zooplankton were recorded in the month of June 2010.

In a similar study, Pattnaik (2014), opined that monostyla, Asplanchna, Euchlanis and Keratella indicated comparatively better water quality as opposed to *Euglina vulgaris*, *Paramoecium caudatus*, Fillinia, Rotatoria, Polyarthra and Epiphanes which were obtained from ponds with heavy pollution and indicated poor water quality.

Dimowo (2013) Investigation on the Species composition and abundance of zooplankton in Ogun River, Abeokuta, Ogun State, Southwestern Nigeria recorded sixteen species belonging to five taxonomic groups (Cladocera, Protozoa, Rotifera, Copepoda and Ostracoda). Low zooplankton abundance and diversity observed in this study was largely attributed to anthropogenic activities which resulted in massive pollution nature around the shores of the water body.

Ibemenuga *et al.* (2013*)* Investigations on the zooplankton characteristics of a Southern Nigerian stream recorded more zooplanktons in the rainy months than in the dry months. The highest plankton abundance (29.11%) occurred in August while November witnessed the least zooplankton abundance (5.06%). Cladocera was represented by *Ceriodaphnia* and *Macrothrix* with *Ceriodaphni*a being the most prominent. The rotifer's order Ploima was represented by *Asplanchna, Brachionus* and *Lecane spp* with *Brachionus* being the dominant species.

Elsewhere Imoobe (2011), who studied the diversity and seasonal variation of Okhuo River between January and December 2006, recorded significantly higher ($p < 0.05$) numbers of zooplankton species and abundance in the wet season as opposed to dry season. Maximum Zooplankton abundance was recorded during the rainy season and minimum values during the dry season with zooplankton peaking in the wet season month of June (with average abundance of 172 individuals/l).

Omoigberale and Oronsaye (2011), recorded seventeen taxa which include Copepoda represented by seven taxa from the family Cyclopidae (*Thermocyclops negletus, mesocyclops* sp and *Cryptocyclops* being the most important) and a single taxa from the family Diatomidae (*Tropodiaptomus* sp). Copepoda dominated (53.98%) of the samples followed by cladocera (44.29%) and then rotifer (1.75%). Cladocera was represented by seven taxa from four families with *Pleuroxus similis, Alona exima* and *Moina micrura* being the dominant taxa and Rotifera represented by two families (Brachionidae and Colurellidae), each represented by a single species Brachionus and Colurella. Abundance was highest at station 3 (with low flow rate) contributing 32.62% and lowest at station 1 (with fast flowing) which accounted for 8.16% of total individuals, supporting the facts that high current velocity rarely afford (or allow) stable zooplankton community. Such flowing water was concluded to be poor habitat for zooplankton.

Arimoro and Oganah (2010), sampled zooplankton from Orogodo River, Delta state located in Southern Nigeria for a period of six months between January, 2008 to June, 2008. 79 species of zooplankton was recorded from the Orogodo River. Zooplankton fauna was dominated by rotifers followed by cladocerans, copepods, and ostracods. The rotifer fauna consisted of 49 species belonging to the orders, Plioma, Bdelloidea, and Flosculariacea. Rotifers of the order Bdelloidea dominated all the stations indicating their tolerance to a wide range of impact. The rotifer, *Rotaria tridens* contributed 9% to the total zooplankton abundance and was the most abundant and preponderant species recorded. The bdelloid rotifers was found to be the dominating zooplankton group with *Rotaria tridens* being the most abundant species. However, *Lecane unqulata*, *L. papuana* and *Trichocerca elongata* were only recorded in the dry season months. Cladocerans *Moina micrura* and *Daphnanosoma excisum* were also ubiquitous at all stations with *Chydorus* being the dominant cladoceran. Only two genera of Ostracods, *Eucypris and Nebalia* were recorded indicating poor representation of the group in terms of diversity and abundance. Zooplankton species were recorded in the rainy season months (April- June) as compared to the dry season months (January – March). The minimum values were recorded in the dry season month of January while maximum values were recorded in the peak of the raining season (June) suggesting a progressive increase of abundance from January to June.

CHAPTER THREE

MATERIALS AND METHODS

3.1 DESCRIPTION OF STUDY AREA

3.1.1 GEOGRAPHIC LOCATION

The study was carried out at two different ponds located at Ogharaefe Junction along the Benin-Delta Expressway, and Ogharaeki Community in Delta state, Nigeria. The map of the study area highlighting the sampling station is shown in (Fig. 1). The ponds has an average depth of 2.5m for the three stations. (Latitudes 5°40'E and 5°39'E and longitudes 5°57'N and 5° 56'N). It has an abundance of aquatic vegetation prominently found around pond's littoral zone. Water Samples were collected at monthly interval for Three (3) months from January, 2021 to March, 2021 covering dry season, while zooplanktons Samples were collected fortnightly (Once every two weeks). Sampling was carried out between the hours of 9am and 11:30am on each sampling day. Static flow rate, low transparency, high turbidity and almost uniform depth were characteristics of sampling stations during the course of the study.

3.1.2 CLIMATE

Oghara, Delta State is situated in the tropics and therefore experiences a fluctuating climate, ranging from the humid tropical in the south, to the sub-humid in the northeast. The lessening of humidity towards the north is accompanied by an increasingly marked dry season. The average rainfall is about 266.5mm in the coastal areas and 1905mm in the extreme north.

Rainfall is heaviest in July. Temperature increases from the south to the north. In the southern part, the average daily temperature is 30°C while the temperature in the northern part of Delta State areas is 44°C.

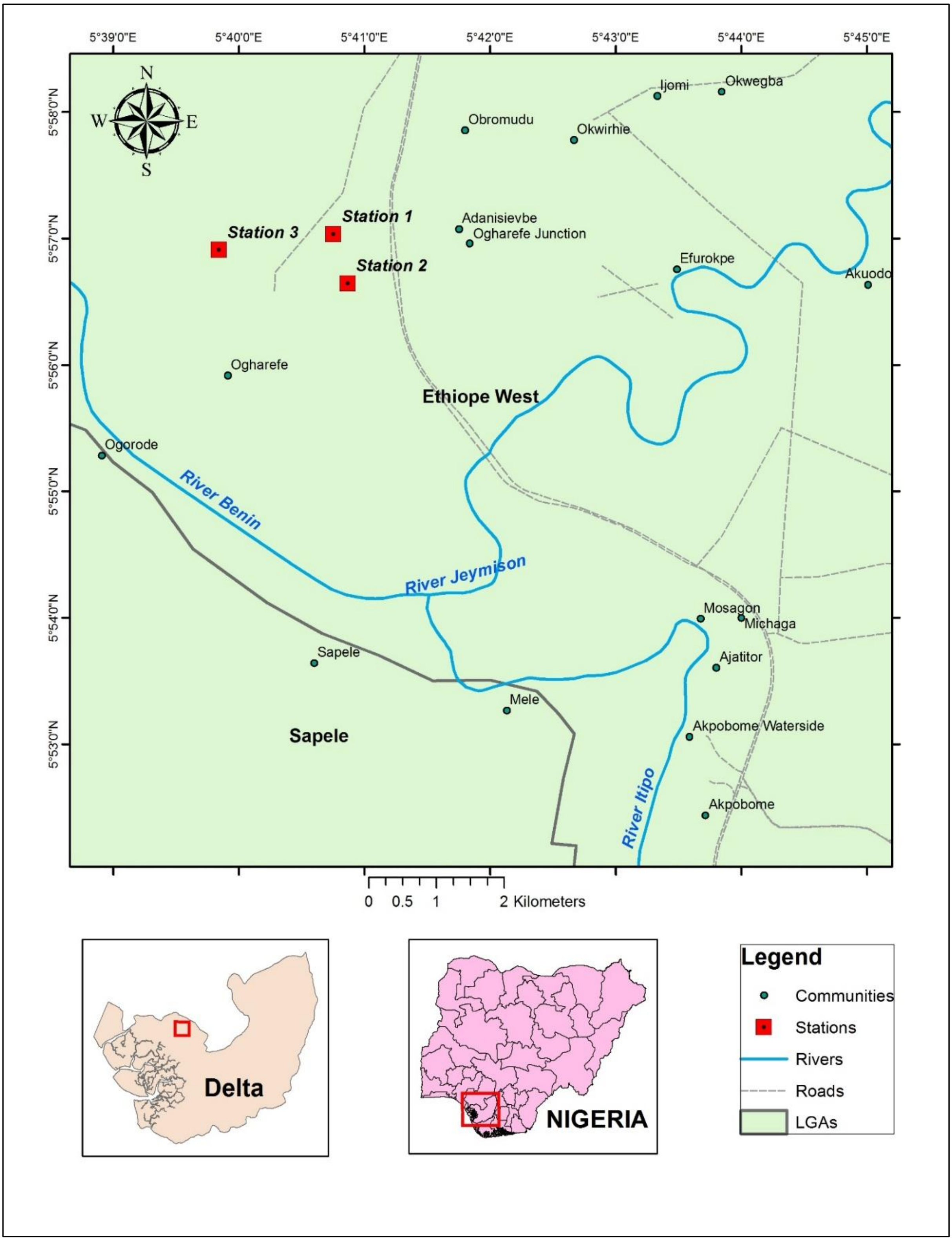

Fig. 1: Map of Study Area Showing the Sampled Locations

3.1.3 VEGETATION

Visibly present plants around the ponds are few trees and grasses like *Elaeis guineensis* (palm tree), *Axonopus compressus* (carpet grass), ferns, and enormous floating aquatic plants such as *Nymphaea lotus* (water lily) and *Eichornia sp*. (water hyacinth).

3.1.4 GEOLOGY

Delta State is a part of the Niger Delta Structural Basin in which three major sedimentary cycles have occurred since the early Cretaceous. The sub-surface stratigraphic units associated with the cycles are, the Benin, the Agbada and the Akata Formations (Kogbe, 1976). The surface rock throughout the state consists of the Ogwashi Uku formation. The Benn Formation is about 1800m and consists of loose and unconsolidated sands. There is little hydrocarbon associated with it. The underlying Agbada Formation which consists of sandstone and shales is, however, rich in hydrocarbons. It is up to 3000m and is underlain by the Akata Formation. The Ogwashi Asaba Formation that underlies the northeast consists of an alternation of lignite seams and clay.

3.1.5 HUMAN ACTIVITIES

The major occupation of people living around the study area is farming and fishing. Fish traps are set in place during the beginning of the wet season. The Ponds are also seen as sacred traditional grounds for worship. Other activities include grazing by cattle herds.

3.2 DESCRIPTION OF STUDY STATIONS

Three sampling stations were established at both ponds during the study period

STATION 1 (Latitude 5º40'44.974 E and Longitude 5º57'2.332 N") is very close to the Benin-Delta Expressway (Plate 1). Dominant plant species are Fern, *Eleais guineesis* (Palm tree) and some grasses. It is continuously inundated with anthropogenic activities such as waste dumping by surrounding households living in close proximity with the pond and also by cattle grazing during the day.

STATION 2 (Latitude 5º40'52.007 E and Longitude 5º56'38.582 N") is a few kilometers away from station 1 (Plate 2). It is located at Ogharaeki Community. It is subjected to human activities such as traditional worship and occasionally fishing during the wet seasons. Dominant plant there was Dominant plant species include *Nymhaea lotus* (waterlily) and *Ludwigia decurrens* (water primrose).

STATION 3 (Latitude 5º39'50.531 E" and Longitude 5º56'54.602 N") is 16m away from station 2 (Plate 3). The soil is marshy and is seldom disturbed by anthropogenic activities.

Plate 1: Showing the Location of Station 1, Oghara Ponds.

Plate 2: Showing location of Station 2, Oghara Ponds.


Plate 3: Showing location of Station 3, Oghara Ponds.

3.3 SAMPLING PERIODICITY

The sampling period was for duration of three months (January – March, 2021). Sampling was carried out on a bi-weekly basis. Samples were taken from three different stations located at three different ponds at Oghara. Sampling was carried out between the hours of 10:00am and 11:30am, parameters such as water depth, flow rate, temperature, were determined and the values were recorded. A total of six samples per site were collected for laboratory analysis throughout the sampling period. A total of eighteen samples were collected throughout the sampling period.

3.4 DETERMINATION OF PHYSICAL AND CHEMICAL CHARACTERISTICS

3.4.1 ANALYSIS OF PHYSICAL AND CHEMICAL CHARACTERISTICS

The physico-chemical characteristics analysed were Water and Air Temperature, Turbidity, Ph, Suspended Solid, Conductivity, Biochemical Oxygen Demand, Dissolved Oxygen, Alkalinity, Salinity, Phosphate, Sulphate, Nitrate, Calcium, Potassium, Sodium, Total Hardness, Chloride, Iron, Lead, Copper, Cadmium, Zinc, Chromium and Magnesium.

3.4.2 WATER AND AIR TEMPERATURE

Water and Air temperature were measured using a mercury in glass thermometer. The temperature of air was measured by suspending the thermometer in air for about 3-5 minutes and the values were recorded in ^{o}C. In measuring the water temperature, the thermometer was placed in the water but prevented from coming in contact with the bottom of water body for about 2-5 minutes and the value was recorded in ^{o}C.

3.4.3 DEPTH

The depth of the water body was measured in metre using a long pole and a measuring tape graduated in metre.

3.4.4 HYDROGEN IRON CONCENTRATION

The water samples were taken to the laboratory for the Ph to be analysed. The pH was determined using the pH digital meter standardized with appropriate buffer solution.

3.4.5 TURBIDITY

This was determined in the laboratory using a HACH turbidimeter in Nephelometric turbidity unit (NTU).

3.4.6 CONDUCTIVITY

The water conductivity was measured using the HACH Conductivity meter in uS/cm. A certain volume of water sample was poured into a beaker and the probe of the conductivity meter was put into it and the reading was taken.

3.4.7 ALKALINITY

4 drops of phenolphthalein was added to 100ml of water sample. If the colour changes to red, the sample is titrated against 0.01 H_2SO_4. The value of the end point is recorded when the red colour disappears. If there is no colour changes after the addition of phenolphthalein, alkalinity sis zero. Then, proceed to test for total alkalinity by adding 3 drops of methyl orange indicator to the water sample and titrating it against 0.05m of H_2SO_4 from a burette until the colour changes from yellow to orange. The value of the end point is recorded in mg/l. Alkalinity (mg $CaCO_3$ L^{-1}) is derived from the formula;

$$TA = \frac{1000 \times VA \times M}{100}$$

Where VA = volume of acid used

M = Mass of $CaCO_3$ equivalent to 1ml of titrant (5.00mgL^{-1} for 0.05m H_2SO_4) (Apha, 2012)

3.4.8 DISSOLVED OXYGEN (DO)

This refer to the amount of oxygen available to aquatic organisms for them to carry out their various metabolic activities. The dissolved oxygen was determined using the Winkler's method. Water sample was taken using a 250ml reagent glass bottle under water and replacing the stopper when it was filled under water. This is to ensure that no bubble is formed in the bottle and no atmospheric oxygen enters the sample.

The sample was fixed with 1.5ml each of Winker's solution A (Manganous Sulphate) and B (Potassium iodide in phosphate hydroxide). A brown precipitate was formed indicating the amount of oxygen trapped.

In the laboratory, the precipitate was dissolved using 2ml of concentrated H2SO4 and a golden yellow coloured solution was produced, 2 drops of starch indicator was added to 100ml of the sample in a conical flask and the sample turned blue black. The sample was titrated against 0.0125m of $Na_2S_2O_3$ (Sodium thiosulphate) until the solution turned colourless and the volume of the titrant was recorded. The procedure was repeated for replicate samples and the average ml of titrant was taken. The volume of $Na_2S_2O_3$ used gave the equivalent dissolved oxygen value in mg/l. (Apha, 2012)

3.4.9 BIOCHEMICAL OXYGEN DEMAND (BOD)

The biochemical oxygen demand of the water was determined in the laboratory. Water samples were taken from under the water with 250ml reagent glass bottles and the stoppers were replaced under water. The bottles were tied in black polythene bags. Biochemical Oxygen Demand is an empirical determination of the amount of oxygen required to oxidize the organic matter present in the sample during an incubation period of 5 days at 20^{o}C. The dissolved oxygen is measured at the beginning and at the end of the incubation period and BOD was calculated by subtracting the final DO from the initial DO. (Apha, 2012)

BOD_5 (mg/l) = $DO_0 - DO_5$

Where DO_0 = Dissolved oxygen at the beginning of the incubation period (initial DO)

DO_5 = Dissolved oxygen at the end of the incubation period (final DO)

3.4.10 NITRATE

Nitrate can be determined calometrically using the Metton Roy spectronic 21D spectrometer. The estimation of the unknown samples were determined from the standard curve and recorded in mg/l. Nitrate was determined using the Brucine method. 10ml of the water sample was measured into a Nessler tube and 10ml of distilled water into another Nessler tube. The tube with distilled water is the sample or blank treatment. 10ml each of Brucine was added to both the water sample and distilled water. 20ml H_2SO4 was added to the water sample. The water sample was then titrated against KNO_3 until the colour of the sample matches that of the water sample. The concentration of nitrate in mg/l was then calculated using the formula; (Apha, 2012)

$$NO_3 \text{ (mg/l)} = \frac{\text{Volume of } KNO_3 \times 1000}{\text{Volume of sample}}$$

3.4.11 PHOSPHATE

Phosphate was determined by H_2SO_4-HNO_3 digestion method described by Ademoroti (1996) 10ml of the sample was measured into a micro-kjeldahl flask, 1ml of concentrated H2SO4 was added and then 5ml of conc. HNO_3 was also added. The sample was then digested in the digester until the volume was reduced to 1-2ml. The digestion continued until the solution became colourless. This was to ensure that all HNO_3 had been removed.

On cooling, 15-20ml of distilled water was added and swirled gently. 1 drop of phenolphthalein indicator was then added and 1m of NaOH (Sodium Hydroxide) was also added in drops until a faint pink tinge was produced in the solution. The solution was then transferred to a 100ml volumetric flask and the solution was diluted with distilled water. This phase is the orthophosphate form.

25ml of the solution was placed in a 50ml volumetric flask. 10ml of vanadate-molybate reagent was added and diluted with distilled water. 25ml distilled water was used to substitute for the sample solution. After about 10 minutes, the vanadate-molybate reagent was added and the absorbance of the sample against the blank on a spectrophotometer at 470nm was measured. The colour was stable for days and unaffected by variations in room temperature. Phosphate is then calculated as (Apha, 2012)

$$PO_{3}\text{-}_{4}\ (mg/l) = \frac{\text{Reading from curve x 1000 x dilution factor}}{\text{Volume of sample}}$$

3.4.12 SULPHATE

Sulphate was determined using the turbidimetric method. 100ml of the sample was put into 250ml Erlemmeyer flask and 5ml conditioning reagent was added. The solution was mixed in the stirring apparatus. Then a calibration curve was prepared by preparing a standard solution at 5m/L increment in 0 to 40gm/L sulphate range. While stirring the solution in the Erlemmeyer flask, a spoonful of barium chloride crystals was added and it was timed. It was stirred for one minute at a constant speed. Some of the solution was poured into and absorption cell and the absorbance at 425m was read in the second minute. The absorbance was recorded and the corresponding sulphate concentration was determined by extrapolation from the calibration curve. (Apha, 2012)

$$SO_4\ (mg/L) = \frac{\text{Mass of } SO_4 \text{ read from curve x 1000}}{\text{Volume of sample}}$$

3.4.13 CALCIUM

This was determined using the titrimetric method. 2ml of 1ml of sodium hydroxide (NaOH) was added to 50ml of water samples and 200mg of erichronic blue-black indicator was also added. The mixture was then filtered slowly against 0.01m until there was a color change from red to light-blue which marked the end point. Calcium was calculated as thus;

$$Ca\ (mg/l) = \frac{A \times B400.8}{\text{Volume of sample}}$$

Where A = volume of titrant

B = mass of $CaCO_3$ equivalent to 4.00ml EDTA filtrate at the calcium indicator and end point. (Apha, 2012)

3.4.14 MAGNESIUM

This was determined using the EDTA titrimetric method in the laboratory. 50ml of water sample was placed in a conical flask, 2ml of 1m of Sodium hydroxide (NaOH) was used as a buffer solution and merexide indicator was added. The solution was then filtered against 1m EDTA and the resulting volume was recorded as V1. 25oml of water sample was placed in another flask and 2ml of ammonia was added to serve the purpose of buffer solution and enrichrum indicator was also added. The solution was then filtered against 1m EDTTA and the resulting volume was recorded as v2. (Apha, 2012)

The volume of magnesium was calculated thus,

V2 = v1 x 4.86 = value of magnesium

3.4.15 TOTAL HARDNESS

Total hardness was determined titrimetrically using EDTA (Ethylene diamine tetraacetic acid) using Eriochonl as described by WEDC (1984).

3.4.16 TOTAL DISSOLVED SOLIDS AND TOTAL SUSPENDED SOLIDS

Solids are the residue of evaporation. The solids thus measured are known as total Solids (TS), which is then divided into two fractions: the Total Dissolved Solids (TDS) and the Total Suspended Solids (TSS). The Total Solids (TS) in water is determined gravimetrically by evaporating to dryness 100mL of unfiltered water in a pre-weight and pre-dried evaporating basin. The TDS is determined as above using the filtered water, and the difference in weight between total and dissolved solid is equal to the Suspended Solids in mg/L.

3.5 ZOOPLANKTON SAMPLING

Zooplankton were collected using a plankton net with a collecting bottle at the base. At each of the three stations, the net was immersed just below the water surface and then bowed across the water. The content of the collecting bottle was transferred into a sampling bottle and fixed with 4% formalin on the field and the sample was labelled.

The collected samples were sorted with the aid of a dissecting microscope. Sorting was done using a sorting pipette, petri dish and dissecting needles. The light source of the microscope was either an electric or sun reflection. Samples were poured into the petridish in small amounts and viewed through the microscope. The dissecting needles were used to separate the organism from the debris and the organisms were picked. The organism were then persevered in 4% formalin in small film containers for identification and counting.

The zooplankton were identified using an Olympus microscope and identification keys of Jeje and Fernando (1986).

3.6 STATISTICAL ANALYSIS

Inter station comparisons tests were carried out to determine the significant difference in the parameters using parametric analysis of variance (One-way ANOVA). If the significant value ($p<0.05$) were obtained, Duncan multiple range (DMR) tests were performed to trace the location of the significant differences. These analyses were done using the Microsoft Excel and SPSS (version 21.0) statistical application.

3.7 CORRELATION

Correlation analysis was used to determine the relationship between the physicochemical Characteristics and with zooplankton families. Non-parametric Spearman correlation was used.

Spearman's correlation was used to describe the degree of relationship (Zar, 1999) between zooplankton abundance and physicochemical characteristics of water. The result shows how strongly pairs of variables such as temperature, pH, dissolved oxygen and water transparency are related to zooplankton abundance. Spearman correlation was performed and the range of values was between +1 to – 1. When the coefficient, r exceed 0.5, thus it indicates that the correlation is strong.

3.8 DIVERSITY INDICES

Diversity indices (Simpson Index and Shanon-Wiener Index), richness indices (Margalef Index and Menhinick Index) and evenness index (Pielou Index) was also determined according to Ogbeibu (2011) with the aid of SPSS (version 21.0) and Paleontological Statistics software (PAST 4.00 version). All of the data has been compiled into Microsoft Excel and PAST spreadsheet based on sampling stations and sampling months.

Species richness was computed using Margalef's index (D) expressed as

a) **Margalef's index (D)** for species richness **(**Margalef's 1949**)**

It was used to calculate the taxa richness

$$d = \frac{S - 1}{\ln N}$$

Where d = Margalef's index

S = total number of species

N = Number of Individual of species in the sample

ln = natural logarithm

This measure relies only on zooplankton abundance and the number of taxa. Richness increases when abundance is spread over a greater number of categories, but it does not take into account the evenness of that distribution. Also, between two samples with the same S, richness will be higher in the one with the lower abundance.

b) Shannon-Weiner Index (H)

This was used to calculate the general diversity (total number of individuals) (Shannon and Weaner, 1949)

$$H = \frac{N\log \sum k \text{ ix-ni} (\log ni)}{N}$$

Where N = total number of individuals

K = total number of species

This index takes into account the total number of species present, as well as their respective abundance, thus providing a more convenient means of comparing differences within ecological communities. Since changes in the environment are reflected in the types and number of organisms present, diversity indices provide a tool doe monitoring changes.

c) **Evenness Index (E)**

Evenness index (Pielou, 1966) expresses the degree of uniformity in the distribution of individuals among the taxa in the collections (Magurran, 1988), was calculated as

E = H

Hmax

Where Hmax = maximum expected diversity

H = Shannon-Weiner diversity

Simpson Index (D)

Simpson index (D) is given as

$$D = \frac{\sum n-(n-1)}{N\ (N-1)}$$

n = the total number of organisms of a particular species

N = the total number of organisms of all species

CHAPTER FOUR

4.0 RESULTS

The summary of the physical and chemical characteristics of the selected ponds in Oghara, Delta State for the months of January to March 2021 is presented in Table 1. Figures 2-22 shows the spatial and monthly variation of the physicochemical characteristics studied in this work. The relative abundance and is presented in figure 25 and 26 respectively

4.1 PHYSICAL CHARACTERISTICS

4.1.1 AIR TEMPERATURE (°C)

The Air temperature ranged from (25.50–31.00) °C in station 1, (27.00 – 29.00) °C in station 2, (26.00– 29.00) in station 3 (Fig. 2). The highest and the lowest value were recorded from st ation 1 with mean value of 27.83°C. The values obtained across the stations were compared u sing one way Analysis of variance (ANOVA) and showed no significance difference.

4.1.2 WATER TEMPERATURE (°C)

The spatial variation in water temperature for the studied water bodies are shown below in (Fig. 3). The water temperature ranged from (25.00–27.00) °C in station 1, (27.00 – 29.00) °C in station 2, (27.50 – 30.00) °C in station 3. The lowest mean value was recorded in sta tion 1 with a mean value of 28.25 °C and the highest temperature were recorded in station 3 with a mean value of 28.50 °C. However there was no significant difference ($p>0.05$) in the m ean water temperature at the three stations.

Parameters	Station 1			Station 2			Station 3			P-Value	Sig.
	Mean ± S.E	MIN	MAX	Mean ± S.E	MIN	MAX	Mean ± S.E	MIN	MAX		
Water Temperature	26.00 ± 0.577	25.00	27.00	28.83 ± 1.589	27.00	32.00	28.83 ± 0.726	27.50	30.00	0.376	P > 0.05
Air Temperature	27.83 ± 1.740	25.00	31.00	28.17 ± 0.60	27.00	29.00	27.67 ± 0.88	26.00	29.00	0.955	P > 0.05
Depth	2.83 ± 0.601	2.00	4.00	3.00 ± 0.288	2.50	3.60	3.33 ± 0.260	2.90	3.90	0.699	P > 0.05
pH	6.76 ± 0.140	6.48	6.90	6.05 ± 0.029	6.00	6.10	6.07 ± 0.235	5.60	6.32	0.032	P < 0.05
Conductivity	69.33 ± 16.292	37.00	89.00	20.13± 3.514	18.00	154.00	27.67 ± 7.218	15.00	40.00	0.033	P < 0.05
Turbidity	18.32 ± 7.882	4.73	32.04	30.49 ± 14.910	7.20	58.27	12.82 ± 3.806	8.60	20.43	0.484	P > 0.05
Suspended Solid	11.66 ± 0.881	10.00	13.00	12.33 ± 4.333	8.00	21.00	10.00 ± 3.055	6.00	16.00	0.864	P > 0.05
Dissolved Oxygen	2.84 ± 0.683	2.00	4.20	2.93 ± 0.480	2.00	3.60	3.60 ± 0.721	2.20	4.60	0.678	P > 0.05
BOD	5.80 ± 1.562	3.00	8.40	5.93 ± 1.507	3.00	8.00	4.53 ± 1.338	3.00	7.20	0.768	P > 0.05
COD	14.00 ± 5.291	6.00	24.00	13.33 ± 3.711	6.00	18.00	10.00 ± 1.154	8.00	12.00	0.738	P > 0.05
Total Hardness	21.35 ± 0.537	20.82	22.43	4.87 ± 0.862	3.42	6.41	6.40 ± 0.926	4.80	8.01	0.00 *	P < 0.01 *
Alkalinity	12.91 ± 0.713	12.20	14.34	10.16 ± 4.066	6.10	18.30	5.08 ± 2.033	3.05	9.15	0.188	P > 0.05
Potassium	5.66 ± 1.733	2.21	7.56	1.72 ± 0.135	1.45	1.86	0.80 ± 0.059	0.69	0.90	0.030	P < 0.05
Calcium	5.55 ± 0.213	5.13	5.77	3.41 ± 2.465	0.64	8.34	0.85 ± 0.213	0.64	1.28	0.146	P > 0.05
Sodium	3.40 ± 0.642	2.16	4.30	2.63 ± 0.403	2.19	3.44	1.62 ± 0.460	0.73	2.27	0.123	P > 0.05
Magnesium	1.81 ± 0.128	1.56	1.95	1.29 ± 0.564	0.39	2.33	1.03 ± 0.343	0.39	1.56	0.410	P > 0.05
Manganese	0.054 ± 0.017	0.03	0.09	0.082 ± 0.049	0.03	0.18	0.044 ± 0.024	0.02	0.09	0.710	P > 0.05
Chloride	16.71 ± 2.989	11.10	21.30	5.77 ± 0.721	4.62	7.10	7.86 ± 2.198	4.50	12.00	0.026	P < 0.05
Sulphate	2.86 ± 1.167	0.85	6.06	6.43 ± 2.207	2.05	9.07	3.17 ± 0.686	1.84	4.12	0.301	P > 0.05
Phosphate	0.048 ± 0.015	0.02	0.07	0.123 ± 0.025	0.08	0.17	0.069 ± 0.019	0.03	0.10	0.096	P < 0.05
Nitrate	2.25 ± 1.047	0.25	3.80	3.71 ± 0.570	0.57	4.31	2.34 ± 1.476	0.51	5.27	1.476	P > 0.05

Table 1: Summary of Physical and Chemical Parameters among the Stations

***P<0.01 – Slightly Significant   ** P<0.05 – Significant**

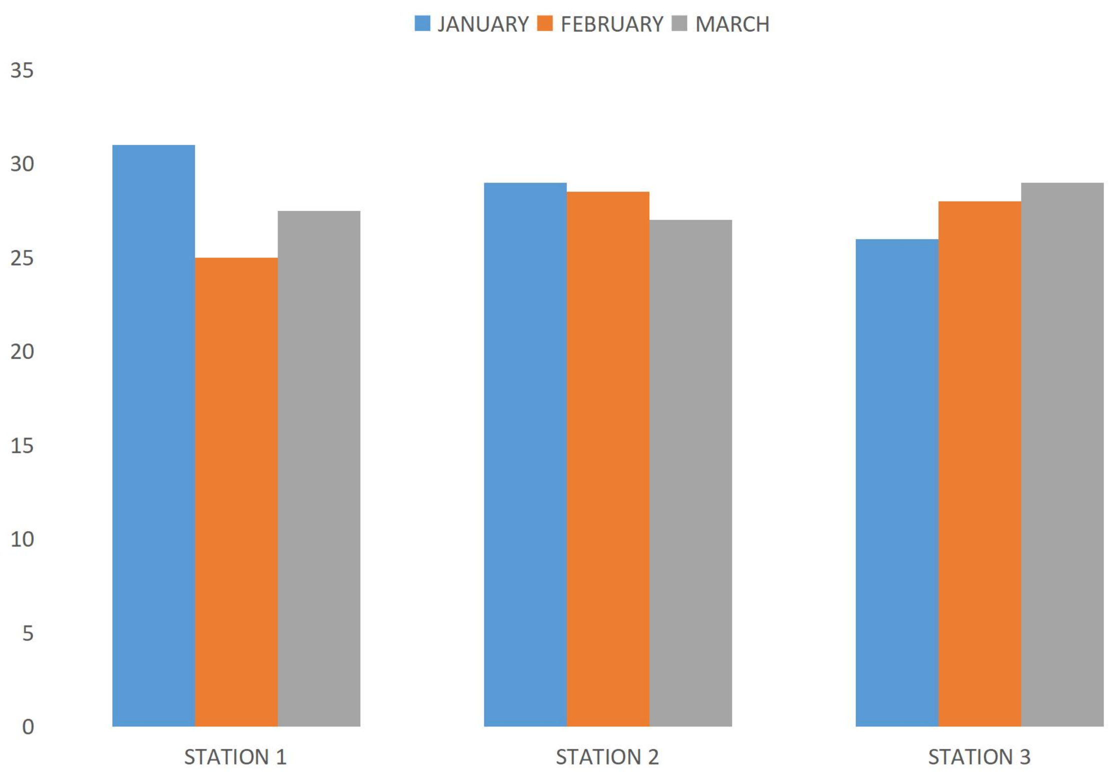

Fig. 2: Spatial and Monthly Variation in Air Temperatures at the study statio n

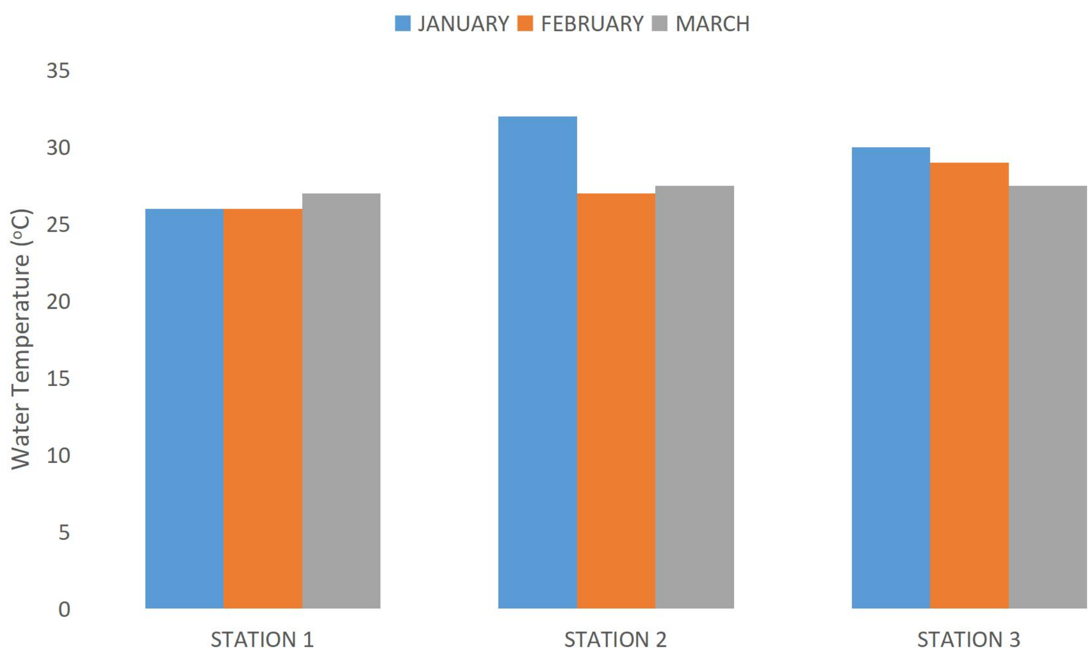

Fig. 3: Spatial and Monthly Variation in Water Temperatures at the study Stations

4.1.3 DEPTH (m)

Depth ranged from (2.00-4.00) m in station 1, (2.5 –3.6) m in station two, (2.90 – 3.90) m in station 3 (Fig. 4). The highest value (3.60 m) was recorded in station 2 and the lowest value (2.00m) was recorded in station 1. There was no significant difference ($p>0.05$) in the mean depth across the three (3) stations.

4.1.4 TOTAL SUSPENDED SOLID (mg/l)

Total suspended solid TSS ranged from (10.00 -12.00) mg/l in station 1, (8.00 - 21.00) mg/ in station 2 and (6.00-16.00) mg/l in station 3 (Fig. 5). The highest mean value (12.33 mg/l) wa s recorded at station 2 and the lowest mean value (10.00 mg/l) was recorded at station 3. Ther e was no significant difference ($p>0.05$) in the TSS.

4.1.5 TURBIDITY (NTU)

Turbidity ranged from (4.73 – 32.04) NTU in station 1, (7.20 – 58.27) NTU in station 2 and (8.60 – 20.43) NTU in station 3 (Fig. 6). The highest mean value (30.49 NTU) is found in station 2 and the lowest mean value (12.82 NTU) is found in station 3. ANOVA revealed no significant difference ($p>0.05$) amongst stations.

4.2 CHEMICAL CHARACTERISTICS

4.2.1 HYDROGEN ION CONCENTRATION (pH)

In the present study, the value of pH ranged from (6.48-6.90) in station 1, (6.00-6.10) in station 2 and (5.60-6.32) in station 3 (Fig. 7). The highest mean value 6.76 was recorded at station 1 and the lowest mean value 6.05 was recorded at station 2. There was significa nt difference ($p<0.05$) in the mean pH

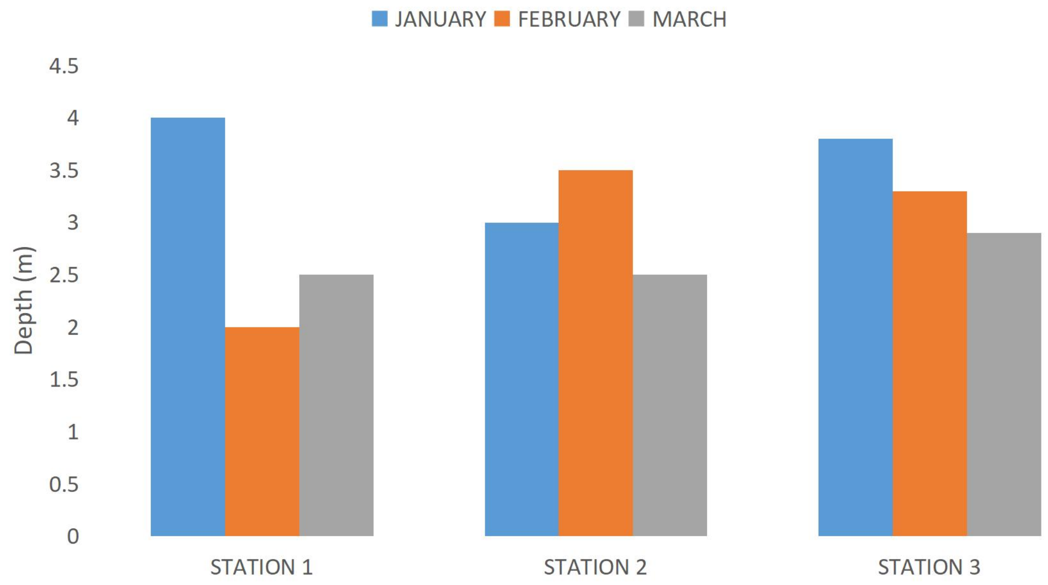

Fig. 4: Spatial and Monthly Variation in Depth at the study stations

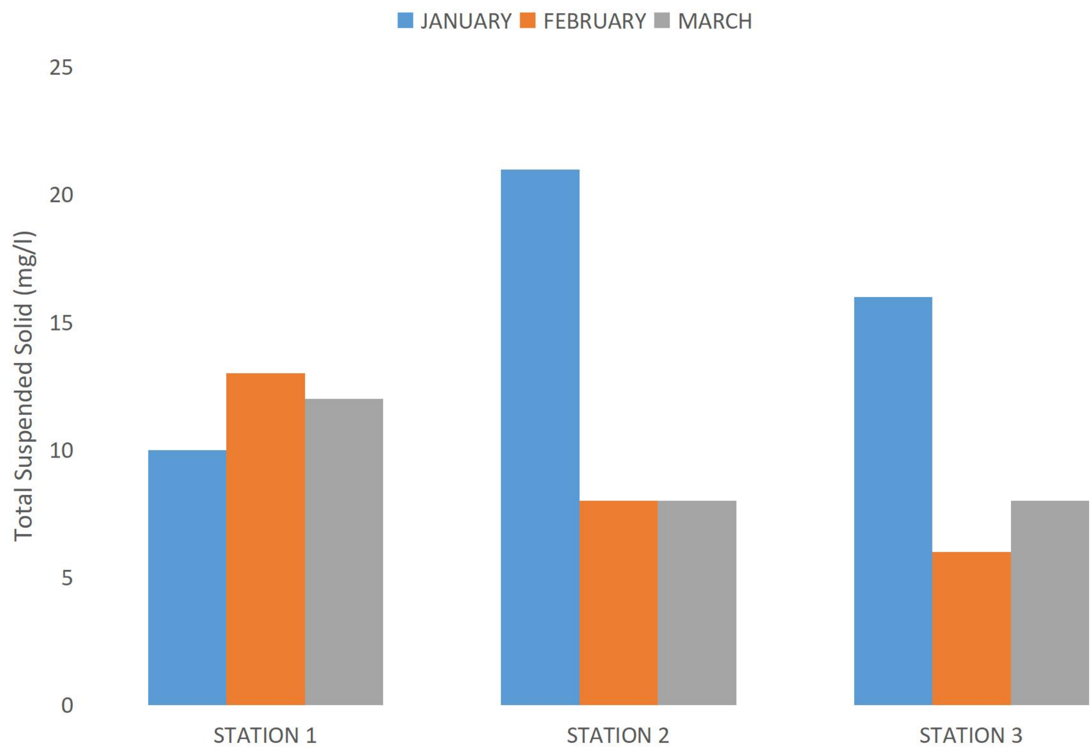

Fig. 5: Spatial and Monthly Variation in Total Suspended solid at the study stations

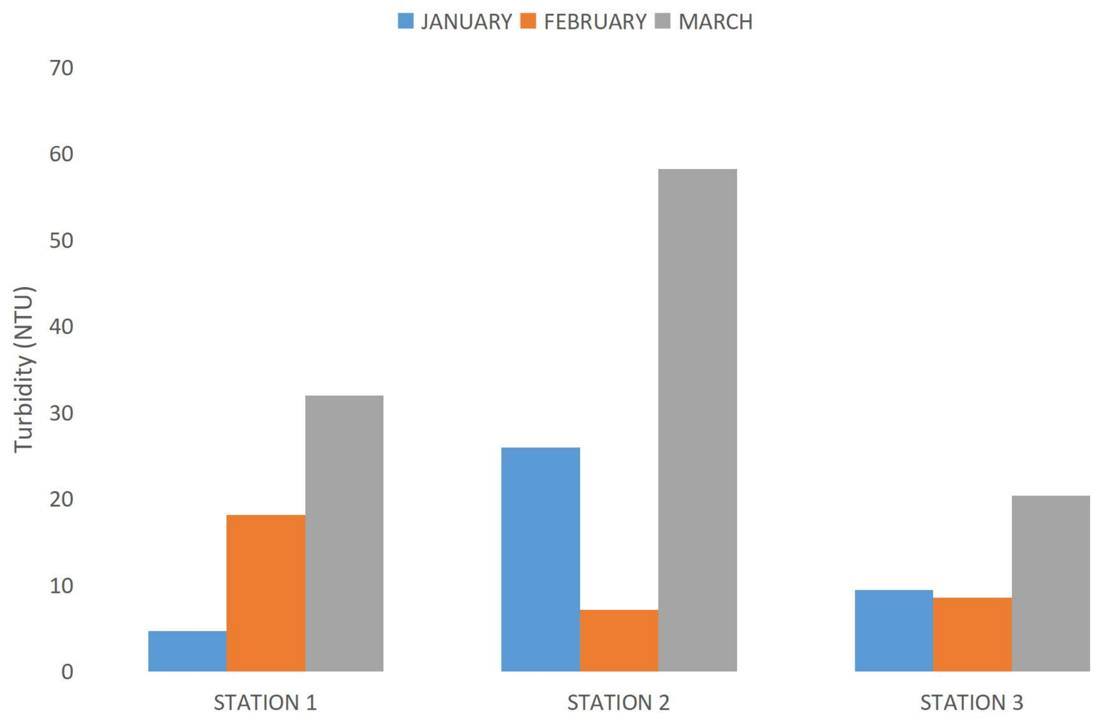

Fig. 6: Spatial and Monthly Variation in Turbidity at the study stations

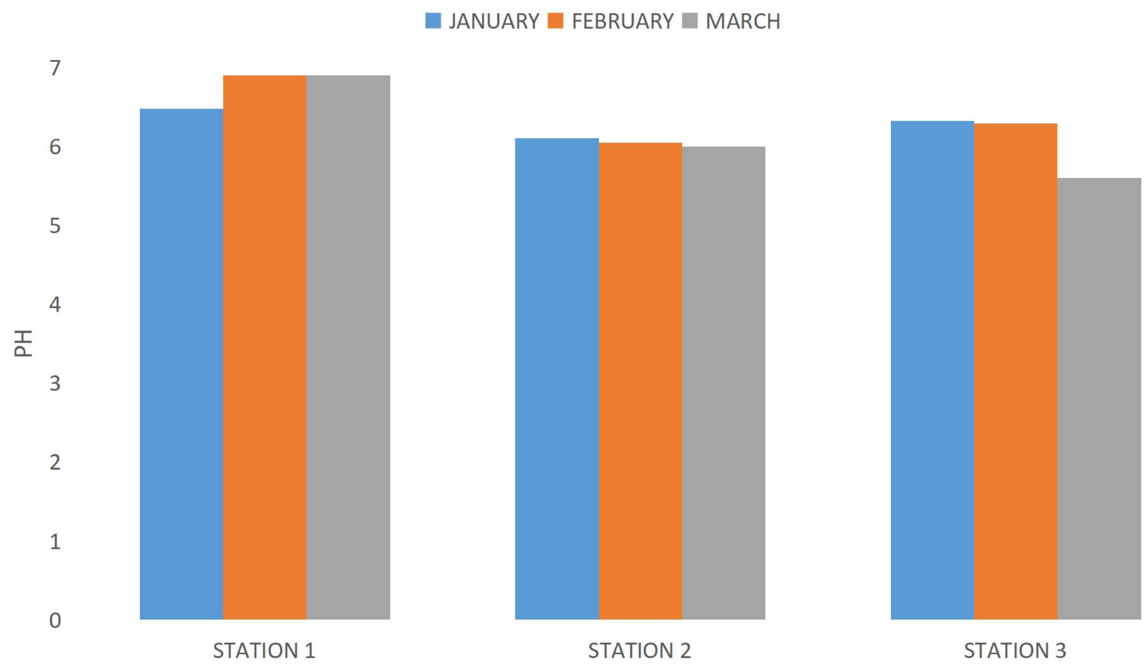

Fig. 7: Spatial and Monthly Variation in pH at the study stations

4.2.2 ELECTRICAL CONDUCTIVITY (EC) (uS/cm)

The values of the electrical conductivity ranged from (37.00-89.00) uS/cm in station 1, (18.00-154.00) uS/cm in station 2 and (15.00-40.00) uS/cm in station 3 (Fig. 8). The lowest mean value (20.13 uS/cm) was recorded at station 2 and the highest mean value (69.33 uS/cm) was recorded at station 1. There was significant difference ($p<0.05$) in the electrical conductivity.

4.2.3 DISSOLVE OXYGEN (DO) (mg/l)

The values of DO ranged from (2.0-4.2) mg/l in station 1, (2.0-3.6) mg/l in station 2 and (2.2 0-4.60) mg/l in station 3 (Fig. 9). The lowest mean value (2.84 mg/l) was recorded in station 1 and the highest mean value (3.60 mg/l) was recorded in station 3. There was no significant difference ($p>0.05$) on the mean value of dissolved oxygen.

4.2.4 BIOCHEMICAL OXYGEN DEMAND (BOD) (mg/l)

The values of BOD ranged from (3.00-8.40) mg/l in station 1, (3.00-8.00) mg/l in station 2 an d (3.00-7.20) mg/l in station 3 (Fig. 10). The highest mean value (5.93 mg/l) was recorded in station 2 and the lowest value (4.53 mg/l) was recorded in station 3. There was no significant difference ($p>0.05$) in the mean value of BOD.

4.2.5 SODIUM (mg/l)

The values of Sodium ranged from (2.16-4.30) mg/l in station 1, (2.19-3.44) mg/l in station 2 and (0.73-2.27) in station 3 (Fig. 11). The lowest mean value (1.62 mg/l) was recorded in stat ion 3 and the highest mean value (3.40 mg/l) was recorded in station 1. There was no signific ant difference ($p>0.05$) observed in the mean value of sodium.

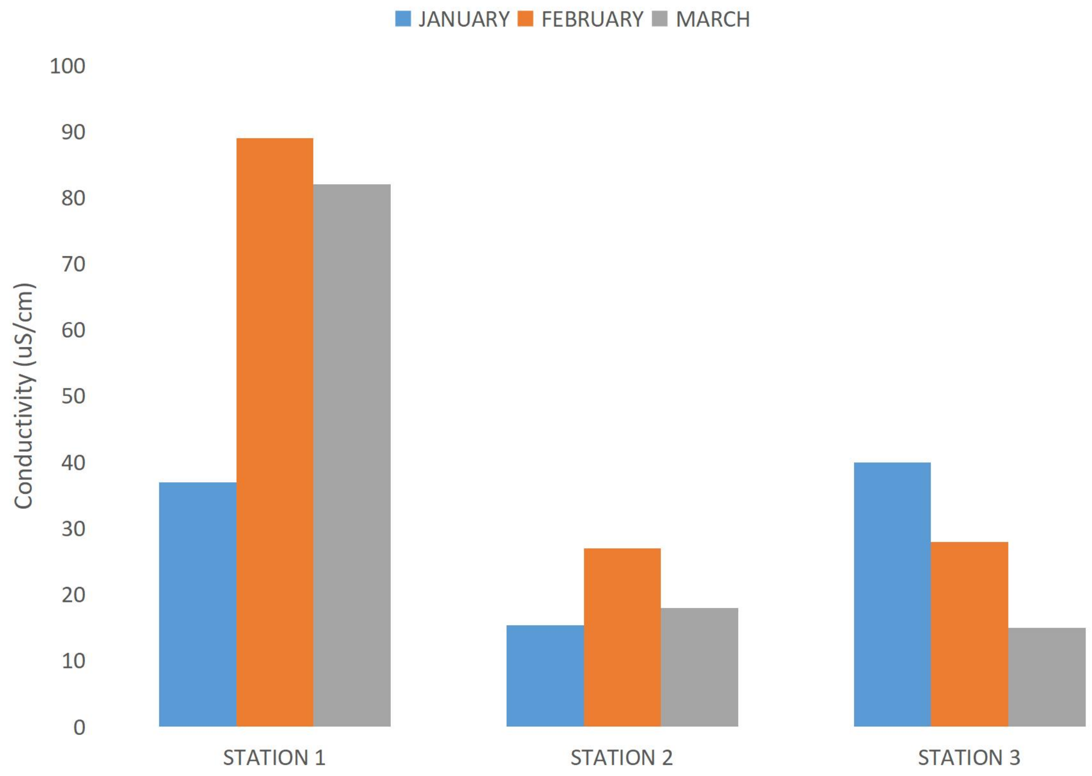

Fig. 8: Spatial and Monthly Variation in Conductivity at the study stations

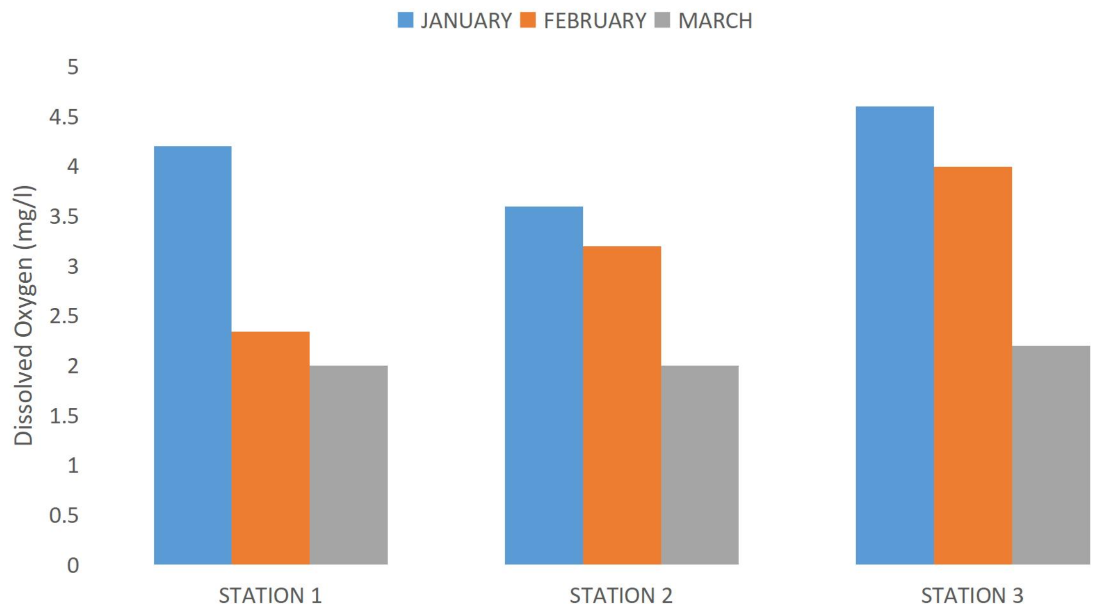

Fig. 9: Spatial and Monthly Variation in Dissolved Oxygen at the study stations

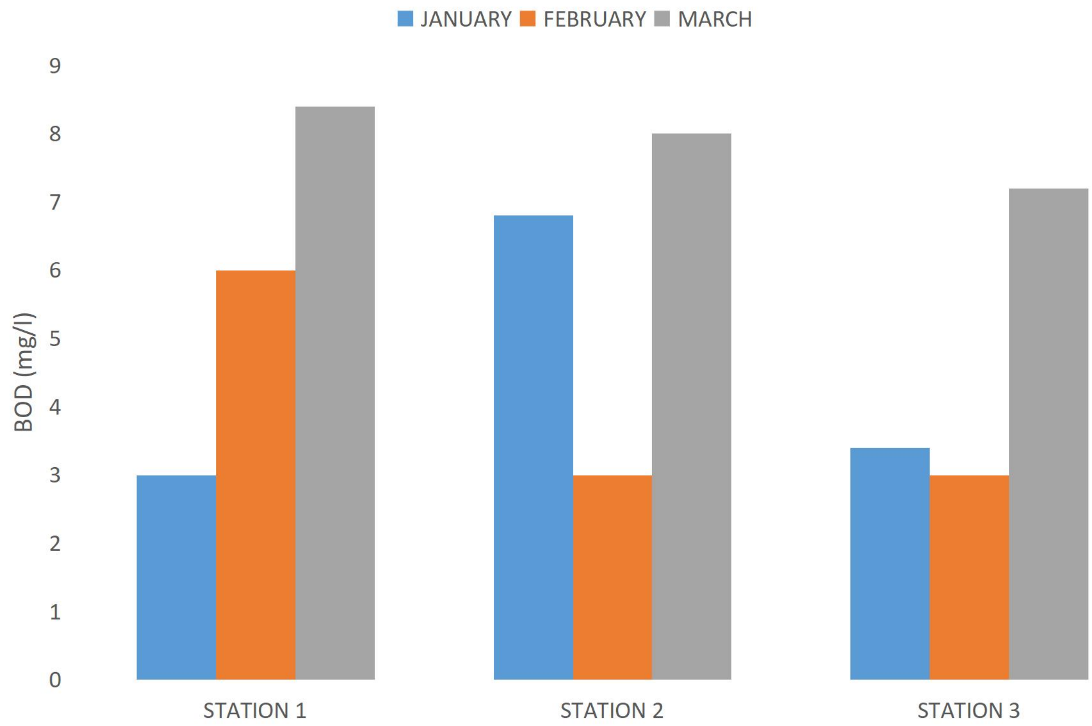

Fig. 10: Spatial and Monthly Variation in Biological Oxygen Demand at the study stations

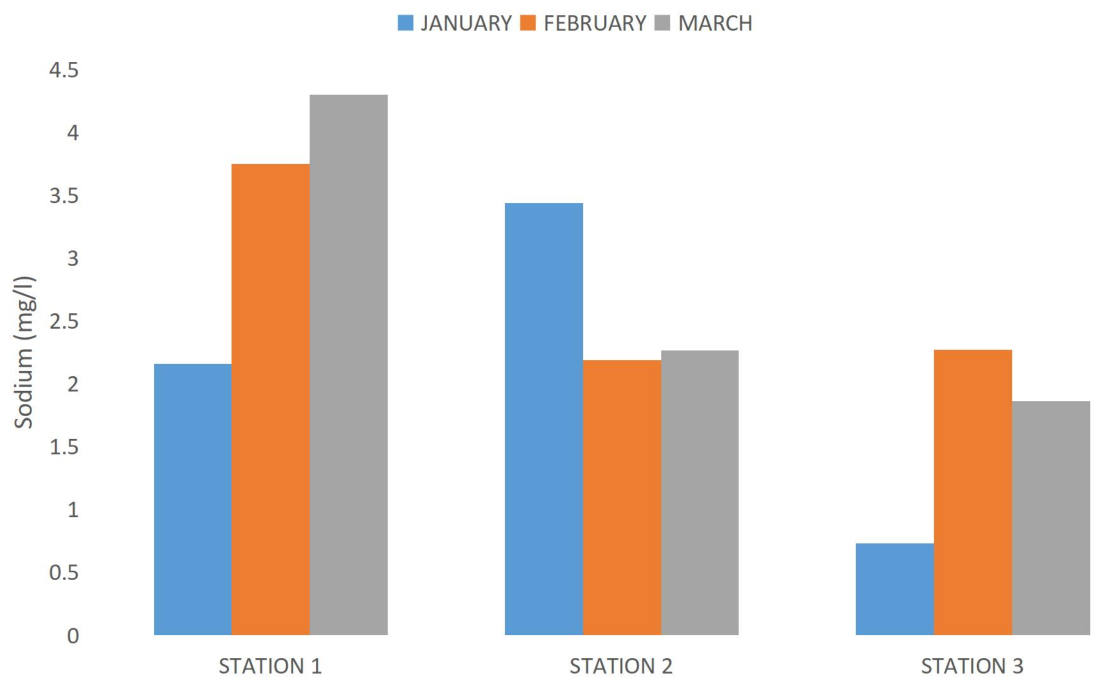

Fig. 11: Spatial and Monthly Variation in Sodium at the study stations

4.2.6 MAGNESIUM (mg/l)

The values of Magnesium on the study area ranged from (1.56-1.95) mg/l in station 1 (0.39-2. 33) mg/l in station 2 (0.39-1.56) mg/l in station 3 (Fig. 12). The maximum mean value (1.81 mg/l) was recorded in station 1 and the minimum value (1.03 mg/l) was recorded in station 3.

There was no significant difference (p>0.05) was observed in the mean value of magnesiu m.

4.2.7 NITRATE (mg/l)

The values of nitrate ranged from (0.25–3.80) mg/l in station 1, (0.50 – 4.31) mg/l in station 2, (0.51– 5.27) mg/l in station 3 (Fig. 13). The highest and the lowest value were recorded from station 3 and 1 respectively with mean values of 2.34 and 2.25 mg/l. There was no significan t difference (p>0.05) in the mean value of nitrate.

4.2.8 MANGANESE (mg/l)

The values of manganese ranged from (0.03–0.09) mg/l in station 1, (0.03 – 0.18) mg/l in station 2, and (26.00– 29.00) mg/l in station 3 (Fig. 14). The highest value was recorded i n station 2 while the lowest value was recorded from station 3. There was no significant diffe rence (p>0.05) in the mean value of manganese.

4.2.9 CHEMICAL OXYGEN DEMAND (COD) (mg/l)

COD values ranged from (6.00–24.00) mg/l in station 1, (6.00 – 18.00) mg/l in station 2, (8.0 0– 12.00) in station 3 (Fig. 15). The highest value was recorded from station 1 while the lowe st values were recorded both from station 1 and 2 with mean value of 14.00 and 13.33 respe ctively. There was no significant difference (p>0.05) in the mean chemical oxygen demand.

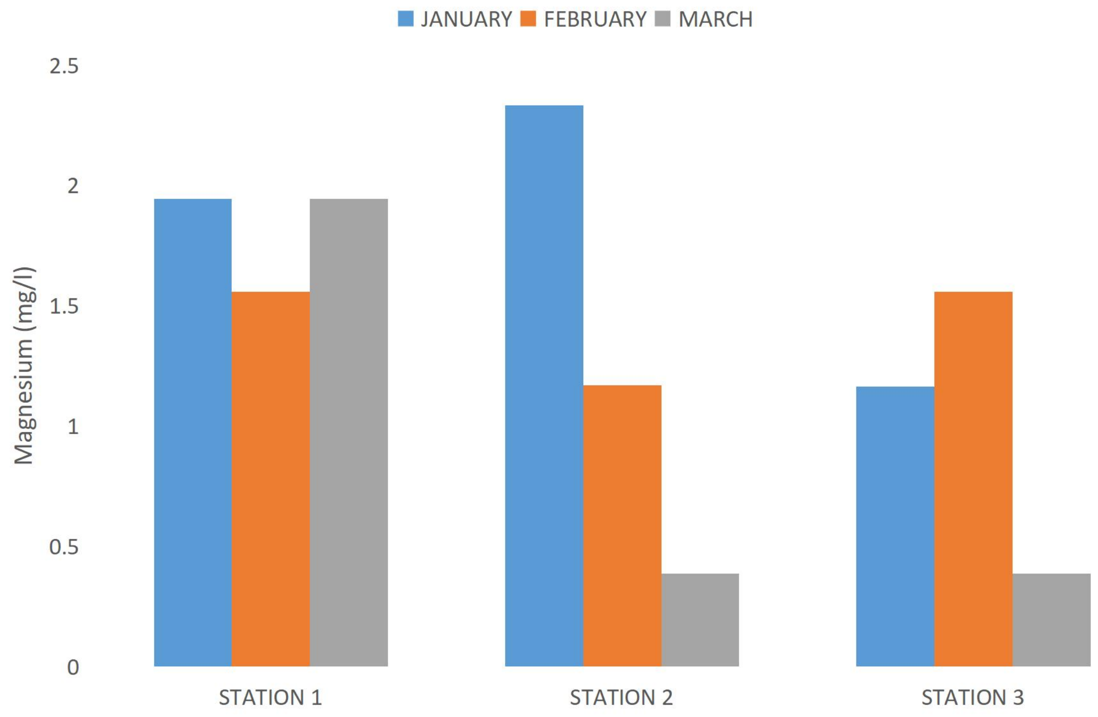

Fig. 12: Spatial and Monthly Variation in Magnesium at the study stations

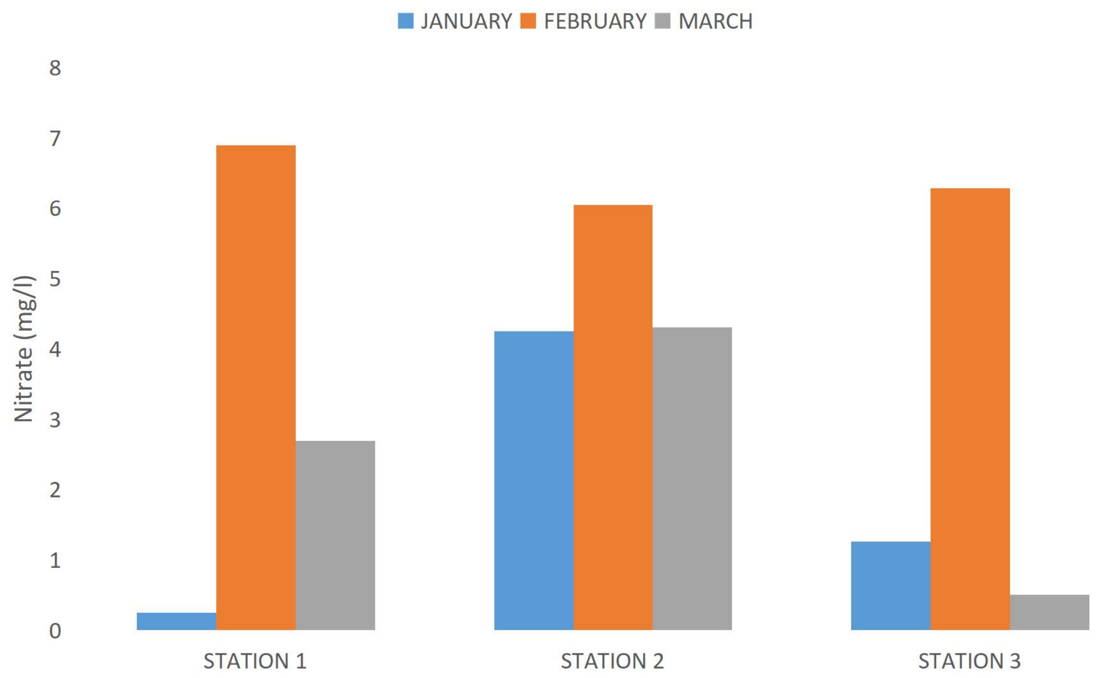

Fig. 13: Spatial and Monthly Variation in Nitrate at the study stations

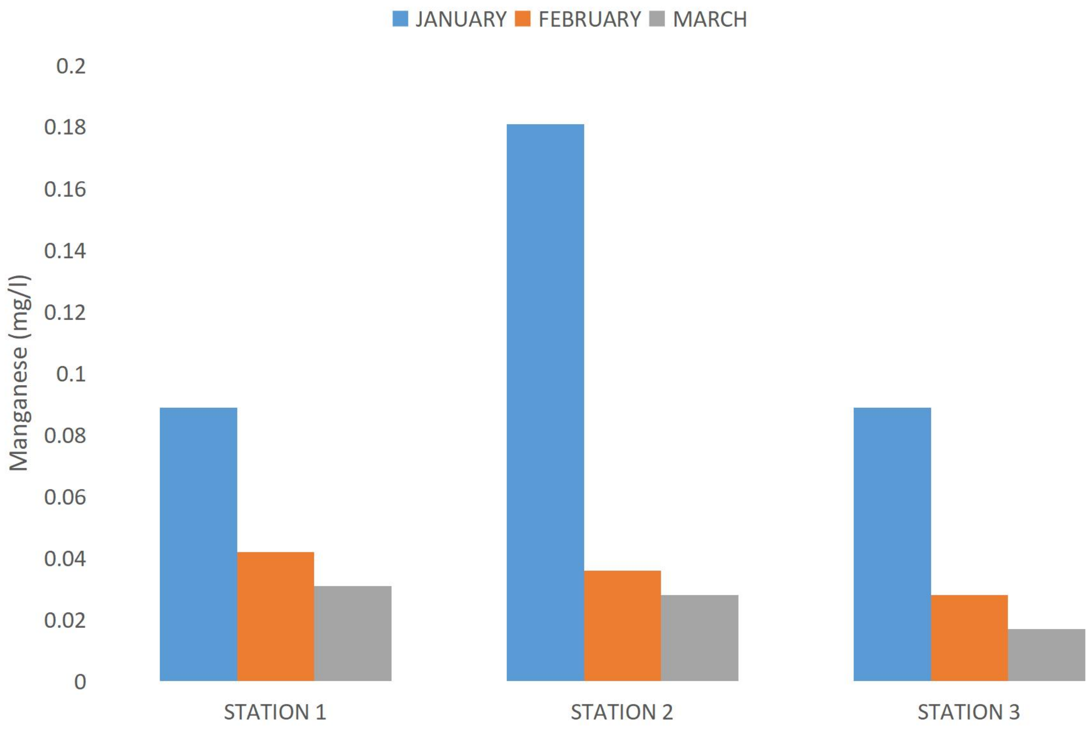

Fig. 14: Spatial and Monthly Variation in Manganese at the study stations

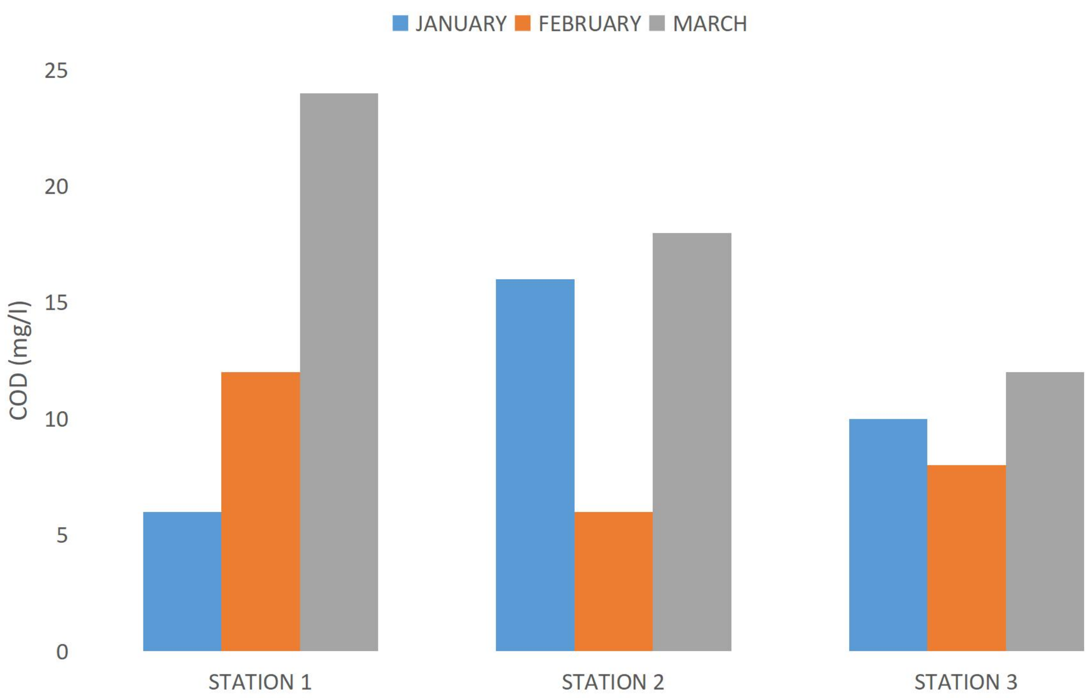

Fig. 15: Spatial and Monthly Variation in Chemical Oxygen Demand at the study stations

4.2.10 TOTAL HARDNESS (mg/l)

The values for total hardness ranged from (20.80–22.43) mg/l in station 1, (3.42 – 6.41) mg/l in station 2, (4.80– 8.01) mg/l in station 3 (Fig. 16). The highest and the lowest value were recorded from station 1 and station 2 with mean value of 21.35 and 4.87 respectively. There was observed significant difference ($p<0.05$) in the mean total hardness.

4.2.11 ALKALINITY (mg/l)

The values for alkalinity ranged from (12.20–14.34) mg/l in station 1, (6.10 – 18.30) mg/l in station 2, (3.05– 9.10) mg/l in station 3 (Fig. 17). The highest value was recorded in station 2 while the lowest value was recorded in station 3 with mean values of 10.16 mg/l and 5.08 mg/l respectively. There was no significant difference ($p>0.05$) in the mean value of alkalinity

4.2.12 POTASSIUM (mg/l)

The values for potassium ranged from (2.21–7.56) mg/l in station 1, (1.45 – 1.86) mg/l in station 2, (0.69– 0.90) mg/l in station 3 (Fig. 18). The highest and the lowest value were recorded from station 1 and station 3 respectively with mean values of 5.66 and 0.80. There was significant difference ($p<0.05$) in the mean values of potassium.

4.2.13 CALCIUM (mg/l)

The values of calcium ranged from (5.13–5.77) mg/l in station 1, (0.64 – 8.34) mg/l in station 2, (0.64– 0.90) mg/l in station 3 (Fig. 19). The highest value was recorded from station 1, mean value of 5.55, while the lowest values was recorded from station 2 and 3 with mean values of 3.41 and 0.85 respectively. There was no significant difference ($p>0.05$) in the mean values of calcium.

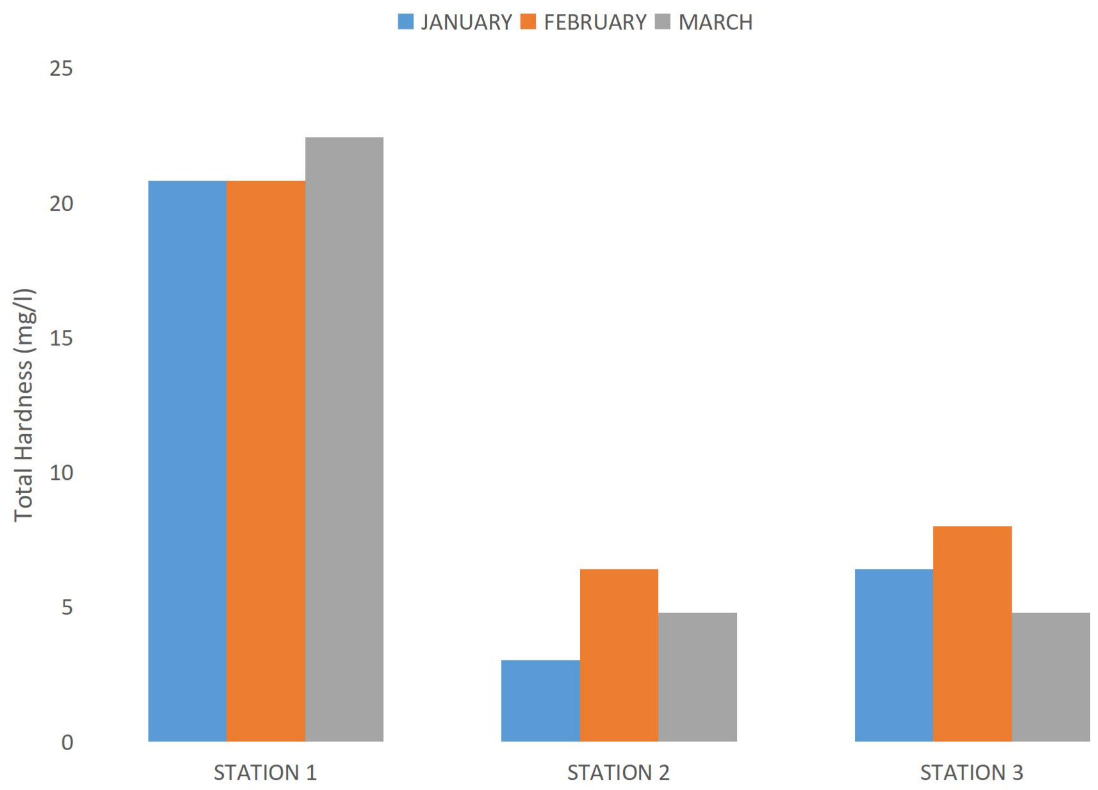

Fig. 16: Spatial and Monthly Variation in Total Hardness at the study stations

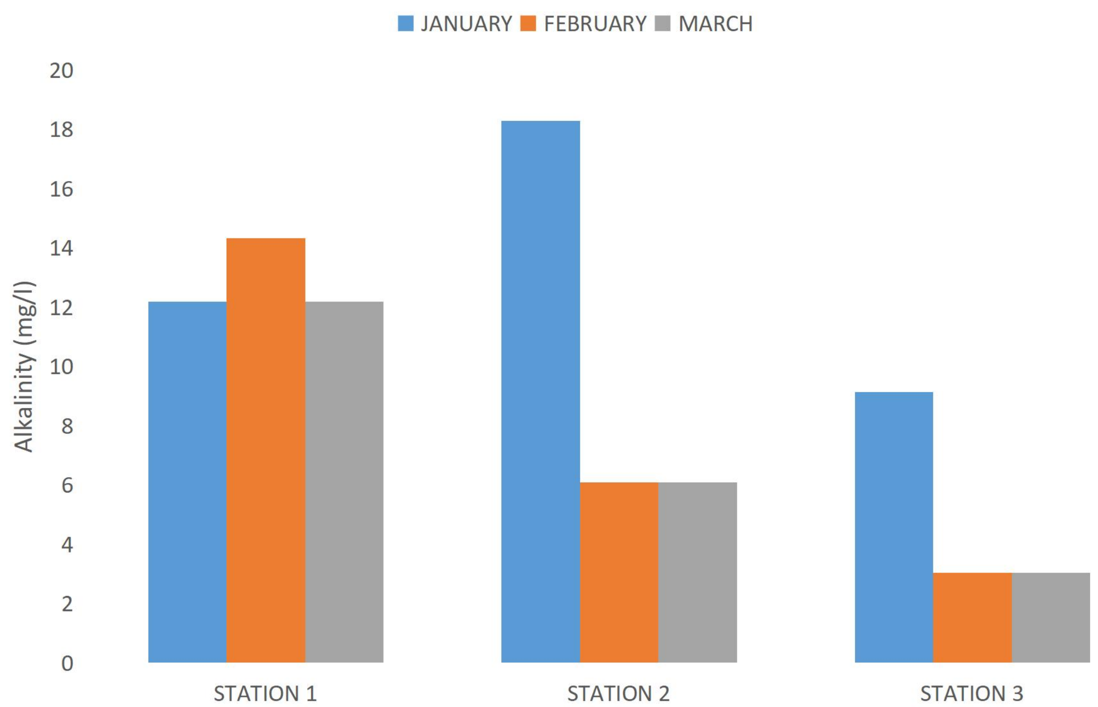

Fig. 17: Spatial and Monthly Variation in Alkalinity at the study stations

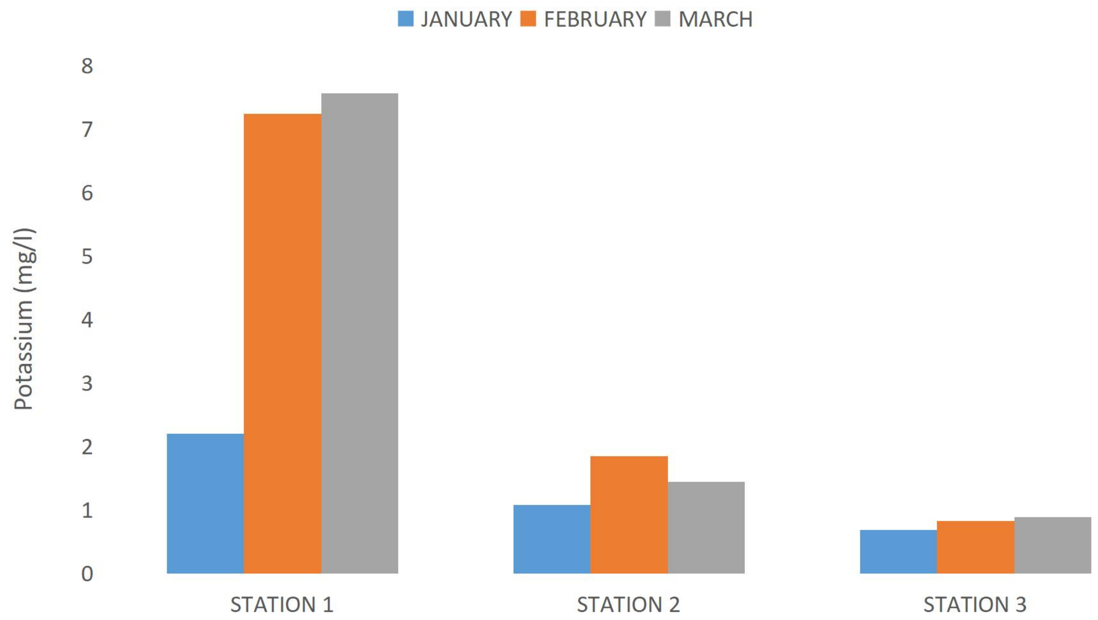

Fig. 18: Spatial and Monthly Variation in Potassium at the study stations

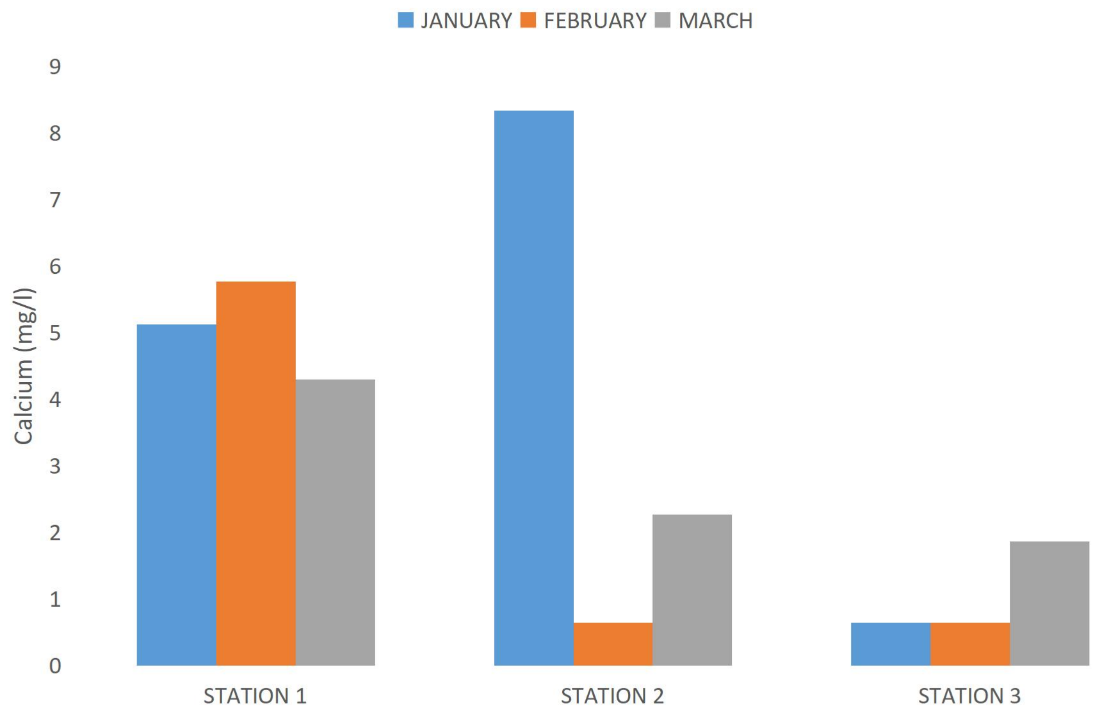

Fig. 19: Spatial and Monthly Variation in Calcium at the study stations

4.2.14 CHLORIDE (mg/l)

The values of chloride ranged from (11.10–21.30) mg/l in station 1, (4.62 – 7.100) mg/l in station 2, (4.50– 12.00) mg/l in station 3 (Fig. 20). The highest and the lowest value were recorded from station 1 and station 3 respectively with mean values of 16.71 and 7.86. There was slightly observed significant difference ($p<0.05$) in the mean values of chloride.

4.2.15 SULPHATE (mg/l)

The values of sulphate ranged from (0.85 – 6.06) mg/l in station 1, (2.05 – 9.07) mg/l in statio n 2 and (1.84 - 4.12) in station 3 (Fig. 21). The lowest mean value (2.86 mg/l) was recorded i n station 1 and the highest mean value (6.43 mg/l) was recorded at station 2. There was no significant difference ($p>0.05$) in the mean value of sulphate in the study area.

4.2.16 PHOSPHATE (mg/l)

The values of phosphate ranged from (0.02 - 0.07) mg/l in station 1, (0.08 - 0.17) mg/l in station 2 and (0.03 - 0.10) mg/l in station 3 (Fig. 22). The lowest mean volume (0.048 m g/l) was recorded in station 1 and the highest mean value (0.123 mg/l) was recorded at stati on 2. There was observed significant difference ($p<0.05$) in the mean value of phosphate in the study area.

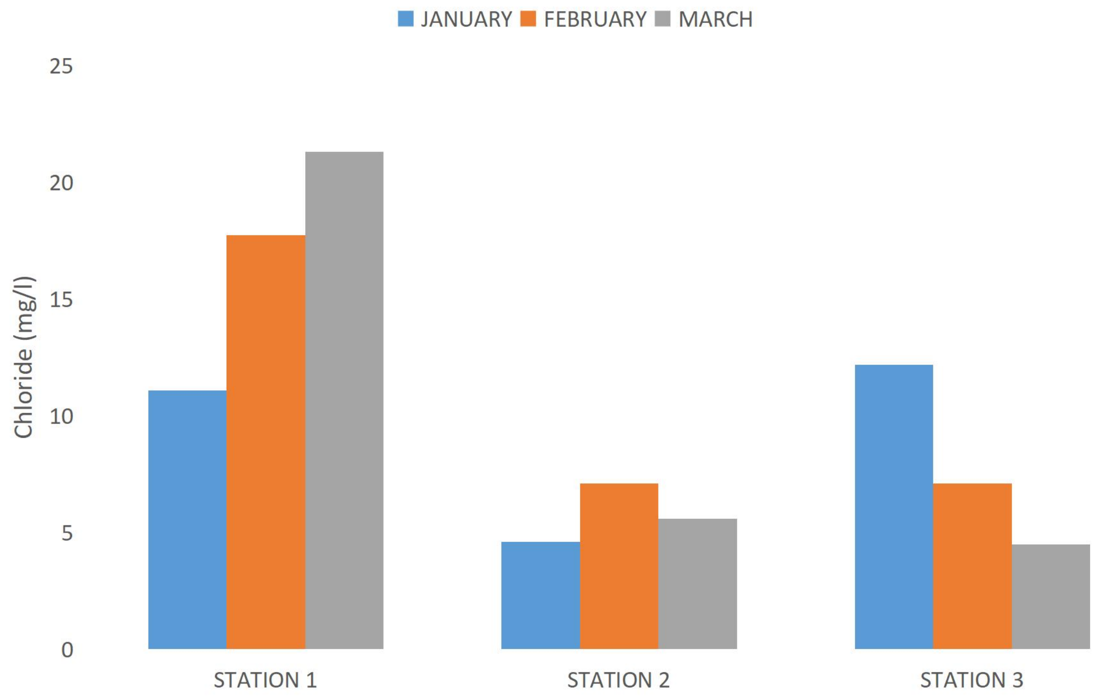

Fig. 20: Spatial and Monthly Variation in Chloride at the study stations

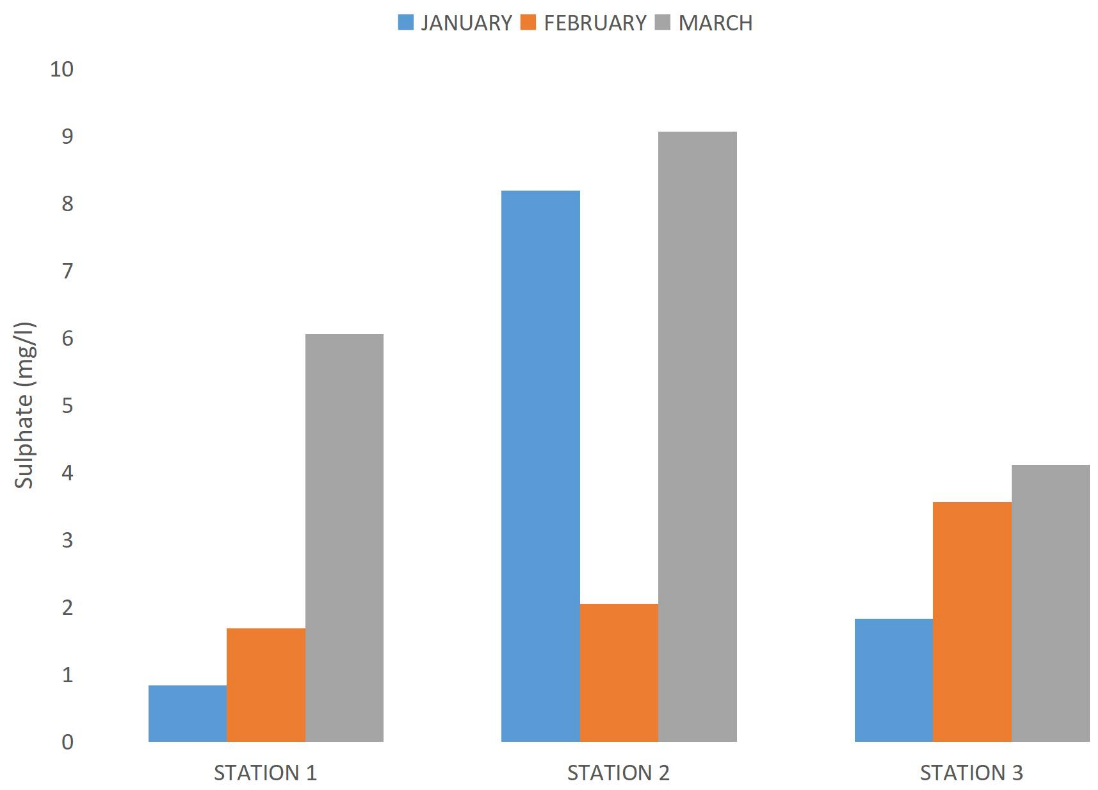

Fig. 21: Spatial and Monthly Variation in Sulphate at the study stations

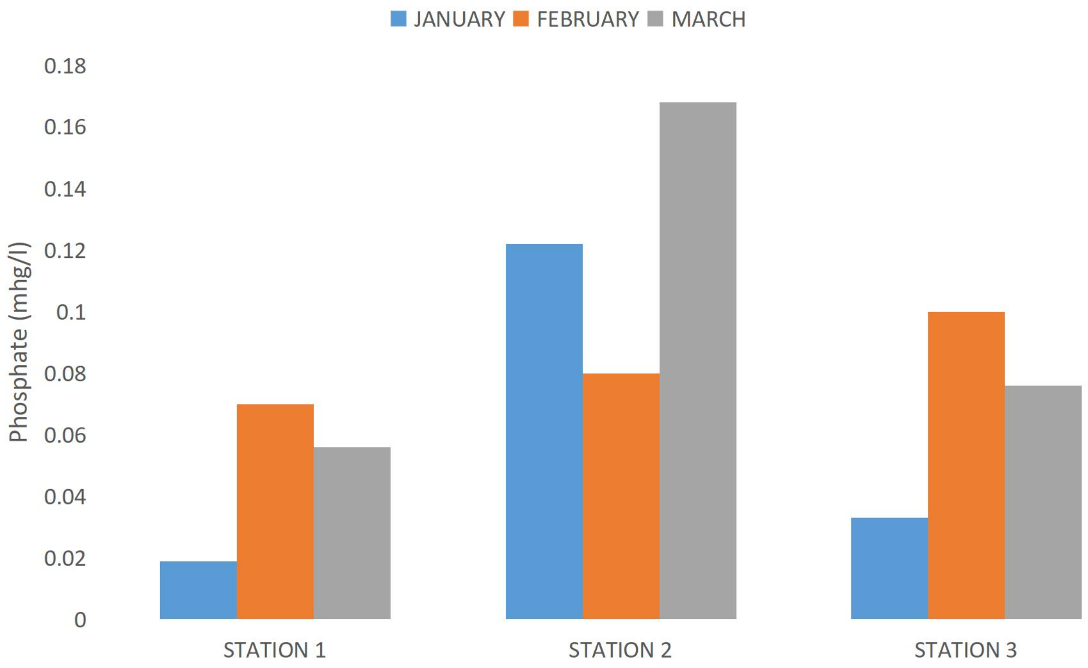

Fig. 22: Spatial and Monthly Variation in Phosphate at the study stations

4.3 CORRELATION RELATIONSHIP BETWEEN PHYSICOCHEMICAL CHARACTERISTICS OF WATER

Table 2. Shows the summary of the correlation relationship (matrix) between physicochemical characteristics of water with each other. Conductivity which is the ability of a sample of water to conduct electric current showed positive correlation with suspended solid, turbidity, BOD, potassium, calcium, hardness, chloride, alkalinity, COD, Sulphate and manganese. The relative high conductivity in the study stations was attributed to the increasing deposition of inorganic ions due to waste water runoff, erosion from neighboring drains and washing away of organic pesticides used in farming in the habitats surrounding the study area.

Phosphate showed high positive correlation with nitrate. Phosphate was found to increase as nitrate increases and vice versa. Both contributed to the high amount of nutrients found in the study area.

Total hardness showed high positive correlation with alkalinity, chloride, COD, Sulphate and manganese. On the other hand, Calcium showed highly positive correlation with total hardness. Calcium in this study was found to be the most important constituent contributing to the hardness of the water body.

Dissolved oxygen showed negative correlation with BOD, sodium and COD. This is true of most water bodies as a reduction in DO would result invariably to the increase of BOD as more oxygen would be needed to be oxidized by organisms, thereby enhancing their survivability. On the other hand, higher BOD would lead to a decline in DO.

Turbidity showed positive correlation with BOD, potassium, calcium, sodium, chloride and Sulphate. Similarly, turbidity strongly negative correlation with DO. This is attributed to the fact that increasing turbidity reduces light penetration into a water body, hence reducing photosynthesis by autotrophs in the water body which would have otherwise increase oxygen content.

Table 2: Summary of correlation matrix of physico-chemical Characteristics

	Ph	Conductivity	Turbidity	Suspended solid	Dissolved Oxygen	BOD	Potassium	Sodium	Calcium	Magnesium	Total Hardness	Alkalinity	Chloride	COD	Sulphate	Phosphate	Nitrate	Manganese
Ph	1																	
Conductivity	0.2436	1																
Turbidity	-0.261	**0.667**	1															
Suspended solid	0.201	**0.846**	0.4847	1														
Dissolved Oxygen	0.2674	0.128	**-0.6571**	0.1664	1													
BOD	-0.284	**0.558**	**0.97099**	0.39387	**-0.7422**	1												
Potassium	0.2295	**0.958**	**0.72895**	**0.71412**	-0.3294	**0.64752**	1											
Sodium	0.1797	**0.676**	**0.72336**	0.23899	**-0.6464**	**0.66958**	**0.83294**	1										
Calcium	0.3078	**0.882**	**0.63537**	**0.6779**	-0.2234	**0.59733**	**0.94157**	**0.75294**	1									
Magnesium	-0.229	0.352	-0.4476	-0.3914	-0.0344	-0.479	-0.3031	-0.1779	-0.473	1								
Total Hardness	0.3518	**0.885**	**0.57595**	**0.67189**	-0.1249	**0.50883**	**0.93339**	**0.74492**	**0.9882**	0.4465	1							
Alkalinity	0.459	**0.893**	0.47039	**0.83753**	-0.0082	0.39974	**0.89161**	**0.5776**	**0.9181**	0.3463	**0.9239**	1						
Chloride	0.1081	**0.976**	**0.63113**	**0.87278**	-0.0136	**0.51161**	**0.90821**	**0.56573**	**0.8437**	0.3343	**0.8547**	**0.8572**	1					
COD	-0.192	**0.613**	**0.95736**	0.47177	**-0.5521**	**0.89892**	**0.67585**	**0.69376**	**0.5993**	0.4864	**0.5679**	0.472	**0.5788677**	1				
Sulphate	-0.45	**0.695**	**0.81401**	**0.51371**	-0.2868	**0.71139**	**0.65856**	**0.53004**	**0.5375**	0.3098	**0.5287**	0.3774	**0.758224**	**0.7461**	1			
Phosphate	-0.273	0.408	0.3055	0.11767	-0.2023	0.21684	0.33351	0.32231	0.1147	0.1691	0.117	-0.003	0.4231045	0.1236	**0.6293**	1		
Nitrate	0.2743	0.464	0.20686	0.12188	-0.0363	0.04911	0.39608	0.48062	0.1959	0.0029	0.2629	0.1569	0.3982582	0.1742	0.4057	**0.7478**	1	
Manganese	0.1585	**0.732**	0.18018	**0.85917**	0.47659	0.0846	**0.5809**	0.06427	**0.6232**	0.2979	**0.6531**	**0.7439**	**0.826926**	0.1485	0.4505	0.1786	0.1057	1

**** shows significant difference at P> 0.5**

4.4 ZOOPLANKTON FAUNA AND SPECIES COMPOSITION

A total of Thirty-three (33) Zooplankton taxa comprising of 21 species of Cladocera, 9 species of Copepoda and 3 species of Rotifera were encountered in the ponds. Cladocera families include: Daphinidae, Chydoridae, Macrothricidae, Sididae, Illocryptidae, Bosminidae, Moinidae, and Leptodoridae. Copepods comprised of Family Cyclopidae while Rotifers were prominently family, Proalidae, Asplanchidae, and Lecanidae. The zooplankton fauna was dominated by the family Cladocera with family Sididae recording the highest abundance. As in most tropical freshwater, the cladoceran fauna included *Ceriodaphnia cornuta, Bosmina longirostris* and Moina micrura. The Cyclopoda was the only group of copepod in the selected Oghara Ponds with 9 species namely: *Acanthocyclops vernalis, Halicyclops troglodytes, Mesocyclops leuckarti, Thermocyclops negletus, Tropocyclops prasinus, Eucyclops serralatus, Ergasilus spp, Cryptocyclops bicolor and Metacyclops minutus*.

From the studies conducted it was found that cladocerans was predominant and occurred more at all three (3) contributing 96.09%, 85.71% and 95.34% at station 1, 2 and 3 respectively of the total zooplankton found across all stations. Copepods accounted for 3.9%, 12.54% and 4.64% at station 1, 2, 3 respectively while no rotifers were recorded at station 1 and 3 during the study period. However, in station 2, rotifers accounted for 1.74% of the total zooplankton recorded in the station.

According to Slack et al. (1979), the percentage abundance of the zooplankton families are as follows; Dominant families include Daphinidae (15.69%), Moinidae (27%) and Sididae (41.94%) while the subdominant families include: Macrothricidae (6.33%) and Cyclopidae (6.07%). Zooplankton abundance followed the order Cladocera > Copepoda > Rotifera in the ponds.

4.4.1 CHECKLIST OF ZOOPLANKTON

PHYLUM	Arthropoda		
CLASS	Crustacean		
ORDER	Cladocera		
FAMILY	Moinidae		
	Moina micrura	Kurz, 1874	Plate. 4
	Moina recticulata	Daday, 1905	Plate. 5
	Moinodaphnia macleayi	King, 1853	Plate. 6
FAMILY	Sididae		
	Diaphanosoma sarsi	Sars, 1855	Plate. 7
	Diaphanosoma excisum	Richard, 1895	Plate. 8
	Pseudosida bidentata	Herrick, 1884	Plate. 9
	Sida sp	Straus, 1820	Fig. 10
FAMILY	Macrothricidae		

	Macrothrix geoldi	Richard, 1897	Plate. 11
	Echnisca capensis capensis	Sars, 1916	Plate. 12
	Echnisca triseralis	Brady, 1886	Plate. 13
FAMILY	Bosminidae		
	Bosminopsis deitersi	Richard, 1895	Plate. 14
FAMILY	Chydoridae		
	Pleuroxus similes	Vavra, 1900	
	Chydorus sphaericus	Muller, 1785	Plate. 15
	Alona davidi	Richard, 1895	Plate. 16
FAMILY	Daphinidae		
	Ceriodaphnia cornuta	Sars, 1885	Plate. 17
	Simocephalus ventulus	Muller, 1776	Plate. 18
	Simocephalus serratulus	Koch, 1841	
	Scapholeberis kingi	Sars, 1903	Plate. 19
	Daphnia longispina	Muller, 1785	

FAMILY	Leptodoridae		
	Leptodora kindtii	Focke, 1844	Plate. 20
FAMILY	Illocryptidae		
	Illocryptus spinifer	Herrick, 1882	Plate. 21
CLASS	Copepoda		
ORDER	Cyclopoida		
FAMILY	Cyclopidae		
SUBFAMILY	Cyclopinae		
	Acanthocyclops vernalis	Fischer, 1853	
	Halicyclops troglodytes	Keifer, 1954	Plate. 22
	Mesocyclops leuckarti	Claus, 1857	
	Thermocyclops negletus	Sars, 1909	Plate. 23
	Tropocyclops prasinus	Fischer, 1860	
	Eucyclops serralatus	Fisher, 1851	
	Ergasilus spp	Nordmann, 1832	

	Cryptocyclops bicolor	Sars, 1863	
	Metacyclops minutus	Claus, 1863	Plate. 24
PHYLUM	*ROTIFERA*		
CLASS	*MONOGONONTA*		
ORDER	*PLOIMA*		
FAMILY	*ASPLANCHIDAE*		
	Asplanchna sp	Gosse, 1850	
FAMILY	*LECANIDAE*		
Lecane spp	*Lecane spp*	Nitzsch, 1827	Plate. 25
FAMILY	*PROALIDAE*		
Proales spp	*Proales spp*	Gosse, 1886	

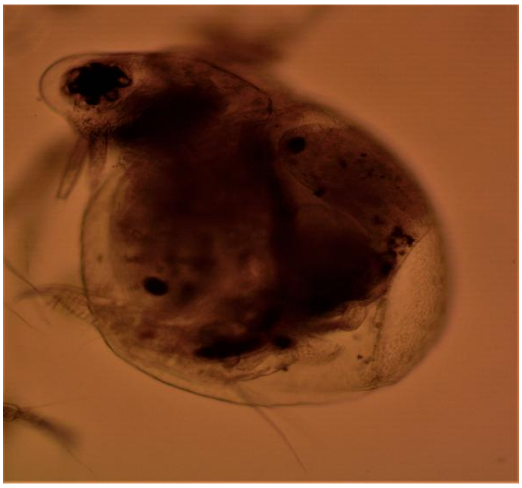

Plate 4: ***Moina micrura***

Plate 5: ***Moina recticulata***

Plate 6: ***Moinodaphnia macleayi***

Plate 7: ***Diaphanosoma sarsi***

Plate 8: ***Diaphanosoma excisum***

Plate 9: ***Pseudosida bidentata***

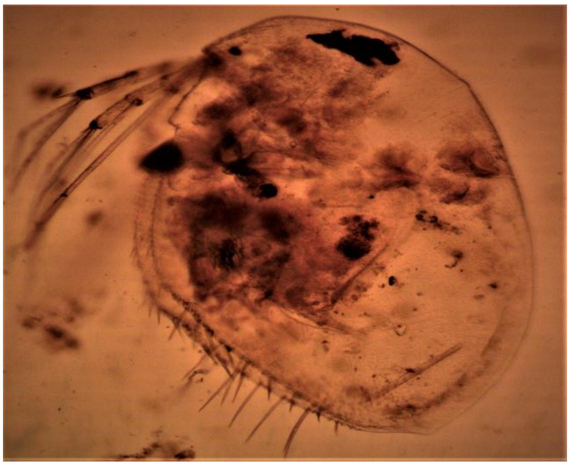

Plate 10: ***Sida spp***

Plate 11: ***Macrothrix geoldi***

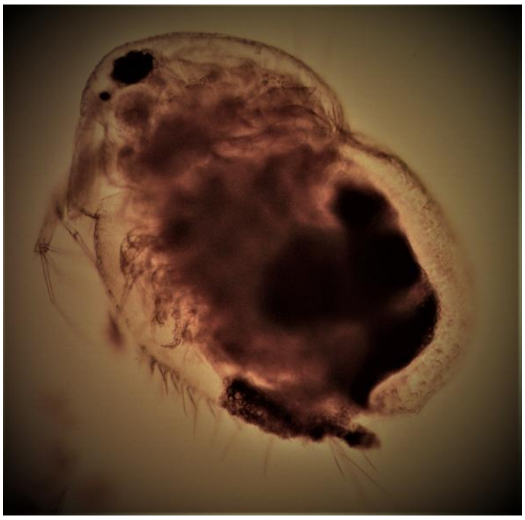

Plate 12: ***Echnisca capensis capensis***

Plate 13: ***Echnisca triseralis***

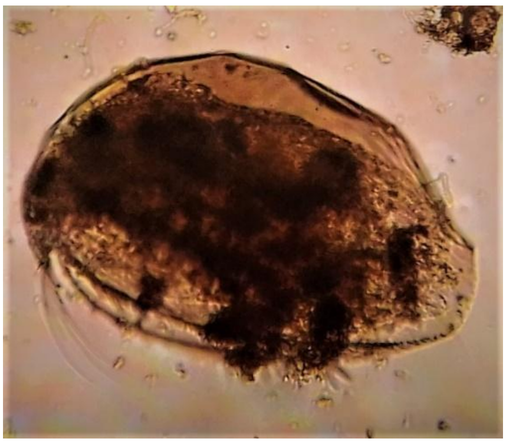

Plate 14: ***Bosminopsis deitersi***

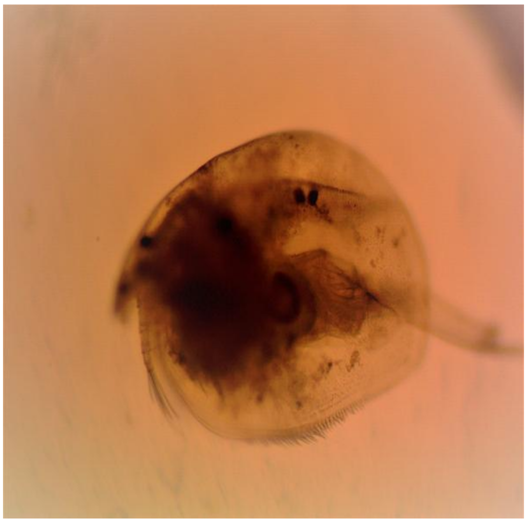

Plate 15: ***Chydorus sphaericus***

Plate 16: ***Alona davidi***

Plate 17: ***Ceriodaphnia cornuta***

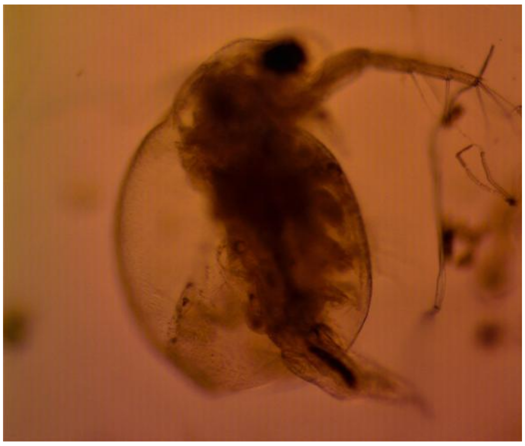

Plate 18: ***Simocephalus ventulus***

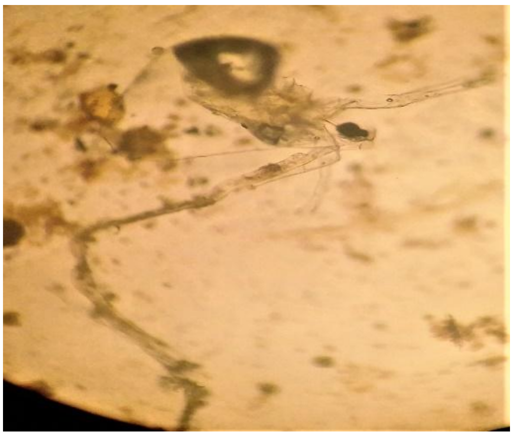

Plate 19: ***Scapholeberis kingi***

Plate 20: ***Leptodora Kindtii***

Plate 21: ***Illocryptus spinifer***

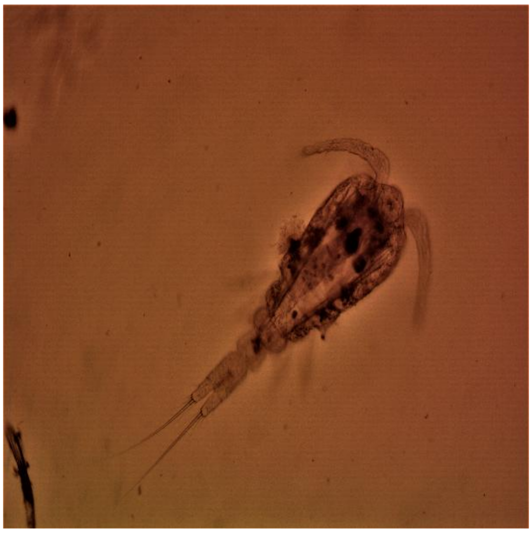

Plate 22: ***Halicyclops troglodytes***

Plate 23: ***Thermocyclops negletus***

Plate 24: ***Metacyclops minutus***

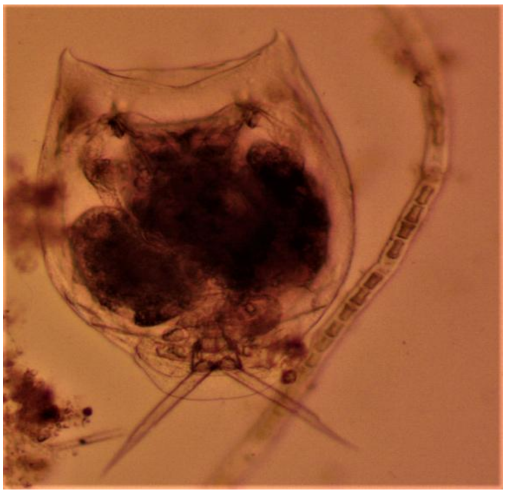

Plate 25: ***Lecane spp***

4.5 COMMUNITY STRUCTURE

Zooplankton taxa include: Cladocera, Copepoda and Rotifera. They were analyzed to determine the taxa, composition, distribution, abundance and diversity.

4.5.1 COMPOSITION, DISTRIBUTION AND ABUNDANCE OF ZOOPLANKTON

The overall taxa composition, distribution and abundance of zooplankton are present in Table 3 while Table 4 shows the Monthly Variation (diversity of zooplankton in study stations from January through March) of zooplanktons. A total number of 33 taxa comprising of 1185 individuals of zooplankton was recorded during the study period. Station 1 comprise of 25 taxa with 769 individuals. In station 2, 24 taxa was recorded with 287 individuals while station 3 has 21 taxa with 129 individuals. Individuals collected during the study period was dominated by Cladocera which constitute 93.5% density occurrence while Copepoda constituted 6.07% and Rotifera made up 0.40% composition.

Figures 23-25 shows the percentage composition of cladocerans, Copepods and Rotifers respectively while Figure 26 shows the overall percentage composition of zooplankton families at the study area.

TABLE 3: COMPOSITION, DISTRIBUTION AND ABUNDANCE OF ZOOPLANKTON FAUNA IN SELECTED OGHARA PONDS (JANUARY – MARCH 2021)

TAXONOMIC GROUPS	Station 1	Station 2	Station 3
CLASS CRUSTACEA			
SUBCLASS BRANCHIOPODA			
ORDER CLADOCERA			
FAMILY DAPHINIDAE			
Scaphaloberis kingii	35	-	-
Simocephalus ventulus	81	26	3
Simocephalus serratulus	7	-	-
Ceriodaphnia cornuta	15	-	3
Daphnia longispina	10	6	-
FAMILY BOSMINIDAE			
Bosminopsis deitersi	8	2	-
FAMILY CHYDORIDAE			
Pleuroxus similes	1	1	-
Camptocercus lilijeborji didayi	2	-	2
Oxyurella ciliata	-	-	1
FAMILY ILLOCRYPTIDAE			
Illocryptus spinifer	2	1	3
FAMILY MACROTHRICIDAE			
Echnisca capensis capensis	8	5	17
Echnisca triseralis	9	5	7
Macrothrix goeldii	2	10	12
FAMILY MOINIDAE			
Moina micrura	40	28	15
Moina recticulata	110	49	18
Moinodaphnia macleayi	56	1	3
FAMILY SIDIDAE			
Diaphanosoma sarsi	116	47	8
Diaphanosoma excisum	35	14	9

*Sid*a	14	1	11
Pseudosida bidentata	184	50	8
FAMILY LEPTODORIDAE			
Leptodora kindtii	4	-	3
CLASS CRUSTACEA			
ORDER CYCLOPOIDA			
FAMILY CYCLOPIDAE			
SUBFAMILY CYCLOPINAE			
Acanthocyclops vernalis	-	-	1
Halicyclops troglodytes	-	2	1
Mesocyclops leuckarti	8	10	1
Thermocyclops negletus	5	4	2
Tropocyclops prasinus	-	13	-
Eucyclops serralatus	-	6	-
Ergasilus spp	3	1	1
Cryptocyclops bicolor	2	-	-
Metacyclops minutus	12	-	-
PHYLUM ROTIFERA			
CLASS MONOGONONTA			
ORDER PLOIMA			
FAMILY ASPLANCHIDAE			
Asplanchna sp	-	3	-
FAMILY LECANIDAE			
Lecane spp	-	1	-
FAMILY PROALIDAE			
Proales spp	-	1	-

TABLE 4: MONTHLY VARIATION OF ZOOPLANKTONS FROM (JANUARY – MARCH)

Taxa	Station 1			Station 2			Station 3		
	JAN	FEB	MAR	JAN	FEB	MAR	JAN	FEB	MAR
PHYLUM ARTHROPODA									
SUBPHYLUM CRUSTACEA									
CLASS BRANCHIOPODA									
ORDER CLADOCERA									
SUBORDER ANOMOPODA									
FAMILY DAPHINIDAE									
Scapholeberis kingii	2	33	-	15	-	-	-	-	-
Simocephalus ventulus	35	46	-	26	-	-	2	1	-
Simocephalus serratulus	6	1	-	-	-	-	-	-	-
Ceriodaphnia cornuta	5	10	-	-	-	-	1	2	-
Daphnia longispina	6	3	1	6	-	-	-	-	-
FAMILY BOSMINIDAE									
Bosminopsis deitersi	3	4	1	-	2	-	-	-	-
FAMILY CHYDORIDAE									
Pleuroxus similes	1	-	-	1	-	-	-	-	-
Camptocercus lilijeborji didayi	-	2	-	-	-	-	1	1	-
Oxyurella ciliata	-	1	1	-	-	-	2	1	-
FAMILY ILLOCRYPTIDAE									
Illocryptus spinifer	1	1	-	-	1	-	1	2	-
FAMILY MACROTHRICIDAE									
Echnisca capensis capensis	1	2	5	3	1	1	6	1	10
Echnisca triseralis	1	1	7	4	1	-	1	1	5
Macrothrix goeldii	-	1	1	5	4	1	3	4	5
FAMILY MOINIDAE									
Moina micrura	16	18	6	27	1	-	2	3	10
Moina recticulata	49	56	5	47	2	-	3	6	9
Moinodaphnia macleayi	1	15	40	1	-	-	1	2	-
FAMILY SIDIDAE									
Diaphanosoma sarsi	69	42	5	35	11	1	5	3	-
Diaphanosoma excisum	13	18	4	9	5	-	4	5	-
*Sid*a	-	14	-	-	-	1	-	6	5
Pseudosida bidentata	83	86	15	33	16	1	3	5	-
FAMILY LEPTODORIDAE									
Leptodora kindtii	-	4	-	-	-	-	2	1	-
ORDER CYCLOPOIDA									

FAMILY CYCLOPIDAE									
SUBFAMILY CYCLOPINAE									
Acanthocyclops vernalis	-	-	-	-	-	-	1	-	-
Halicyclops troglodytes	-	-	-	1	-	1	1	-	-
Mesocyclops leuckarti	-	8	-	5	4	1	1	-	-
Thermocyclops negletus	-	5	-	1	-	3	-	2	-
Tropocyclops prasinus	-	-	-	8	5	-	-	-	-
Eucyclops serralatus	-	-	-	5	-	1	-	-	-
Ergasilus spp	-	-	3	-	-	1	-	1	-
Cryptocyclops bicolor	-	-	2	-	-	-	-	-	-
Metacyclops minutus	-	10	2	-	-	-	-	-	-
PHYLUM ROTIFERA									
CLASS MONOGONONTA									
ORDER PLOIMA									
FAMILY ASPLANCHIDAE									
Asplanchna sp	-	-	-	1	-	2	-	-	-
FAMILY LECANIDAE									
Lecane spp	-	-	-	1	-	-	-	-	-
FAMILY PROALIDAE									
Proales spp	-	-	-	-	-	1	-	-	-

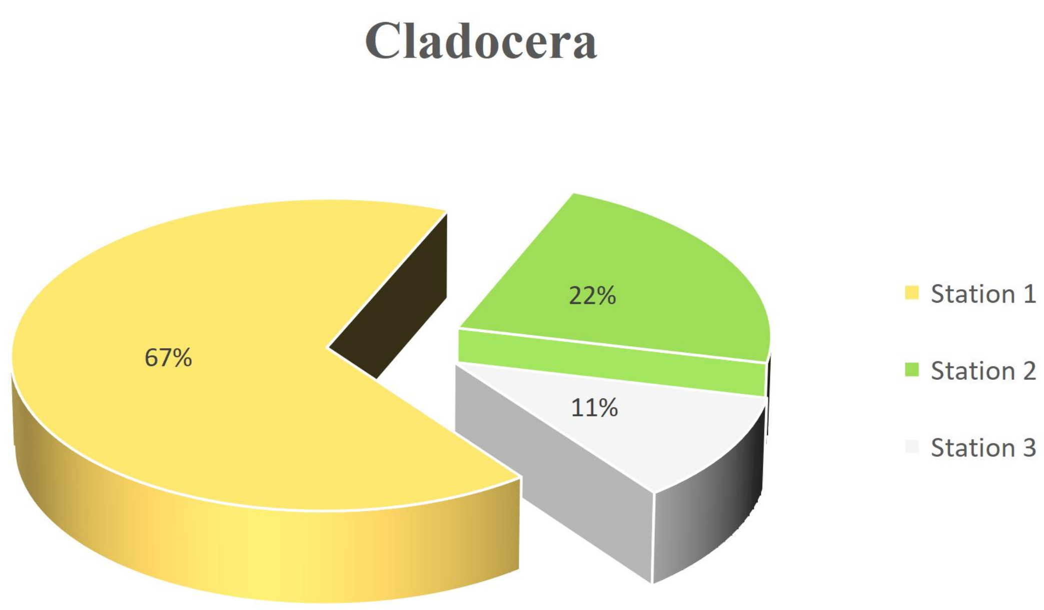

Fig 23: Percentage composition of Cladocerans at the study stations

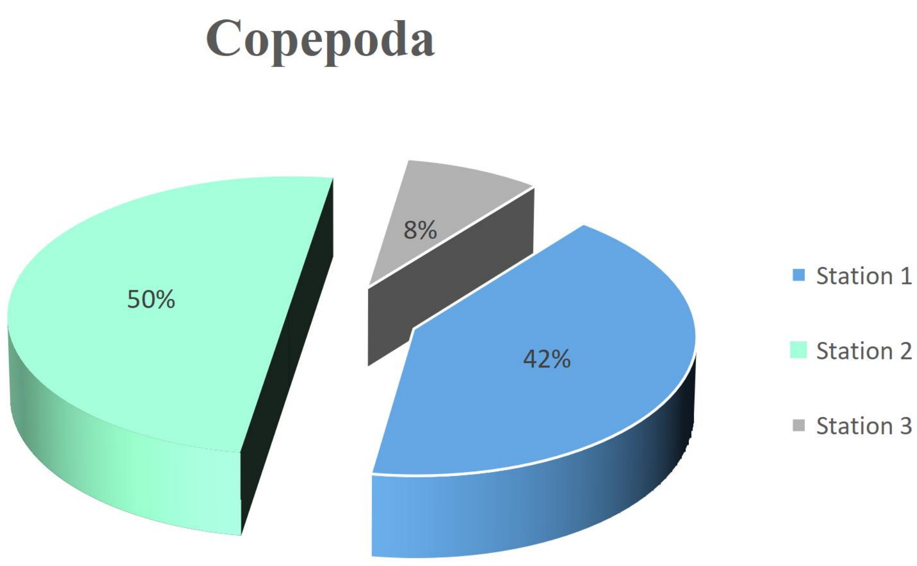

Fig 24: Percentage composition of Copepods at the study stations

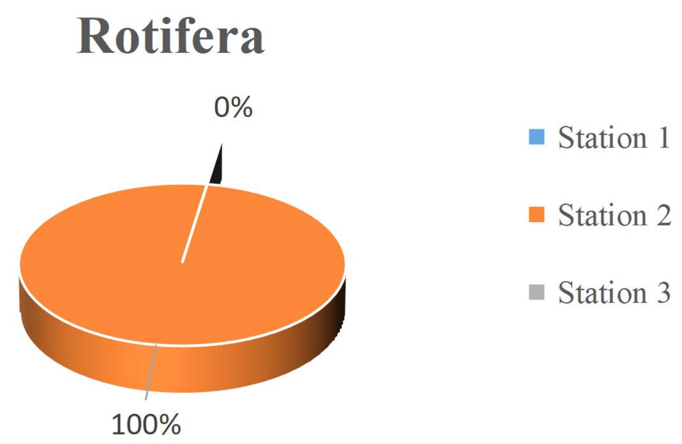

Fig 25: Percentage composition of Rotifers at the study stations

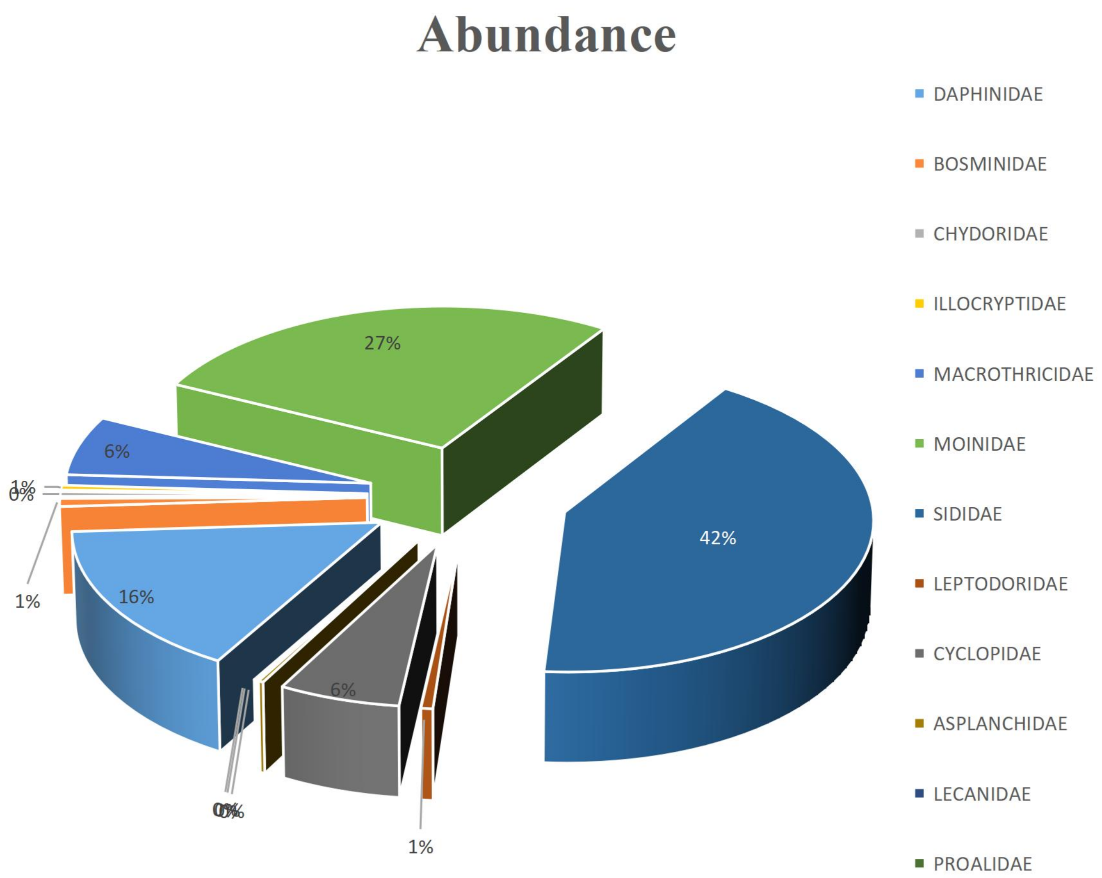

Fig 26: Overall Percentage composition of Zooplankton Families at the study area

4.5.2 DOMINANT FAMILIES

The Dominant Families were Daphnidae (15.69%), Moinidae (27%) and Sididae (41.94%)). Figures 27-29 shows the percentage composition of dominant families across the three (3) stations found in this study. Species of Daphnidae encountered in this study include: *Scaphaloberis kingii, Simocephalus ventulus, Simocephalus ventulus, Ceriodaphnia cornuta, and Daphnia longispina*. The peak of Daphnidae was observed in January station 1 while in February and March station 2, no species was recorded. A total of 19.24% of Daphnidae occurred in station 1 while 11.14% and 4.64% occurred at stations 2 and 3 respectively during the study duration.

Species of Moinidae encountered in this study include: *Moina micrura, Moina recticulata, and Moinodaphnia macleayi*. The peak of Moinidae was observed in February station 1. The least value was observed in February station 2, while in March station 2, no species was recorded. A total of 26.78% of Daphnidae occurred in station 1 while 27.17% and 27.90% occurred at stations 2 and 3 respectively during the study duration.

Family Sididae which comprises of Sida spp, Diaphanosoma excisum, Diaphanosoma sarsi, Pseudosida bidentata, contributed the highest percentage of 45.38%, 39.02% and 27.90 at station 1, 2 and 3 respectively. The peak of Sididae was observed in February station 1 while the least value was observed in March station 2.

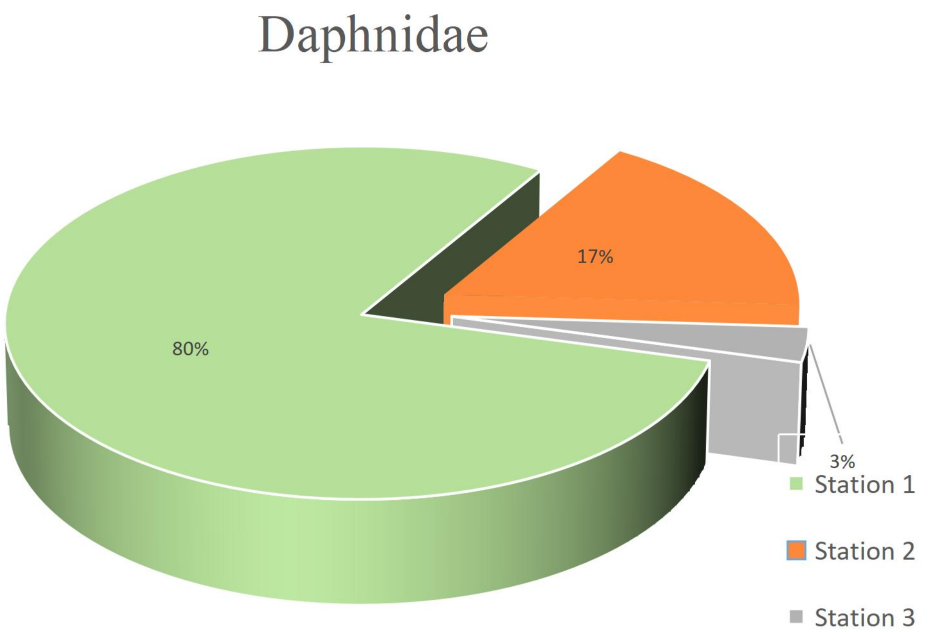

Fig 27. Percentage Composition of Daphnidae at the study stations

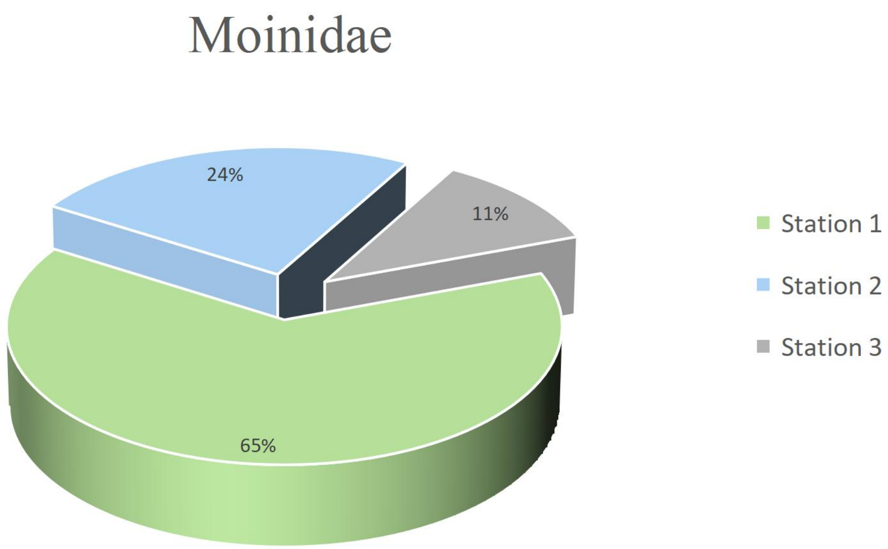

Fig 28. Percentage Composition of Moinidae at the Study Stations

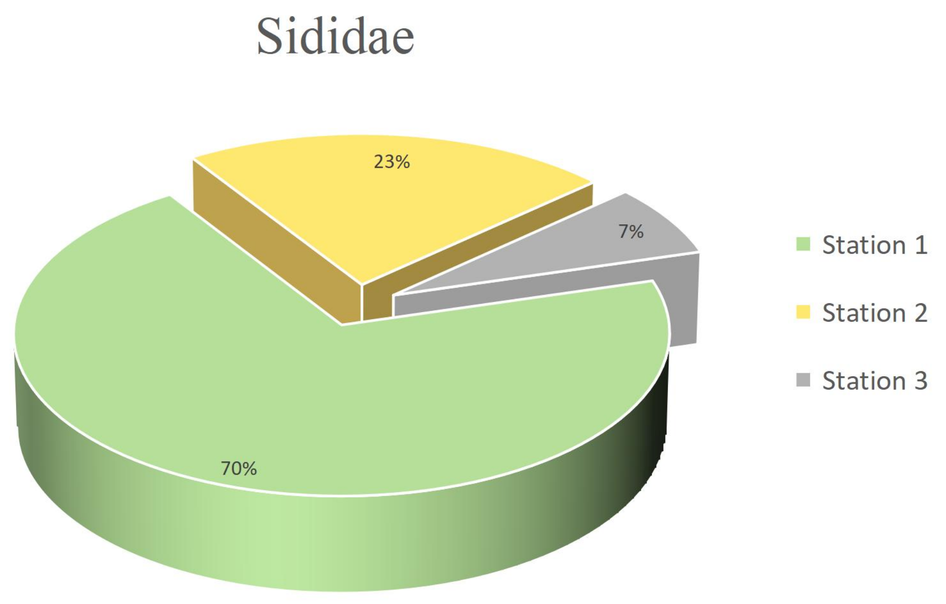

Fig 29. Percentage Composition of Sididae at the Study Stations

4.5.3 SUBDOMINANT FAMILIES

The subdominant families include: Macrothricidae (6.33%) and Cyclopidae (6.07%). The Percentage composition of the subdominant families found across the three (3) stations in this study are shown in Figures 30-31. The species of Macrothricidae encountered during this study include: *Echnisca capensis capensis, Echnisca triseralis,* and *Macrothrix goeldi.* The peak of Macrothricidae was encountered in March station 3 while the least value was observed both in January station 1 and March station 3. A total of 2.47% of Macrothricidae occurred in station 1 while 6.97% and 27.90% occurred at stations 2 and 3 respectively during the study duration.

The species of Cyclopidae encountered during this study include: *Acanthocyclops vernalis, Halicyclops troglodyte, Mesocyclops leuckarti, Thermocyclops negletus, Tropocyclops prasinus, Eucyclops serralatus, Ergasilus spp, Cryptocyclops bicolor and Metacyclops minutus*. A total of 3.90% of Cyclopidae occurred in station 1 while 12.54% and 4.65% occurred at stations 2 and 3 respectively during the study. The peak of was Cyclopidae encountered in February station 1 while the least value was observed both in January station 1 and February station 2. However, in January station 1 and March station 3, no species were recorded.

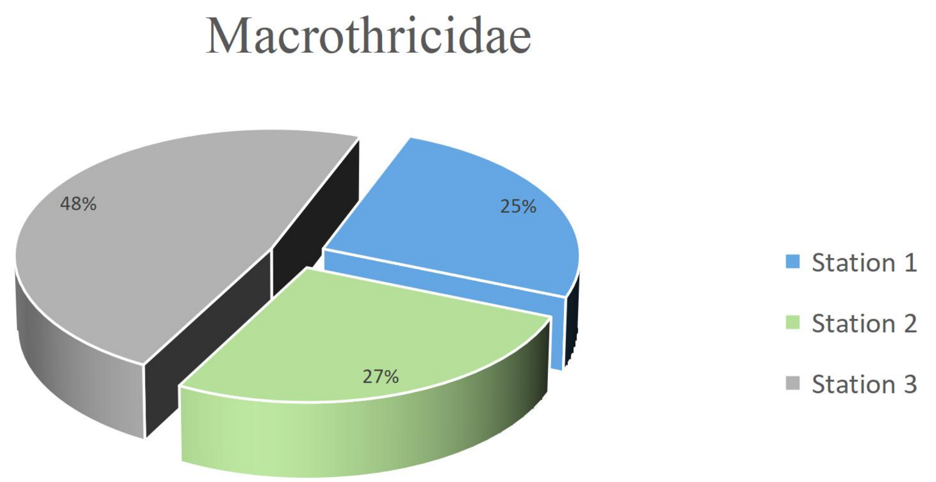

Fig 30. Percentage Composition of Macrothricidae at the study Stations

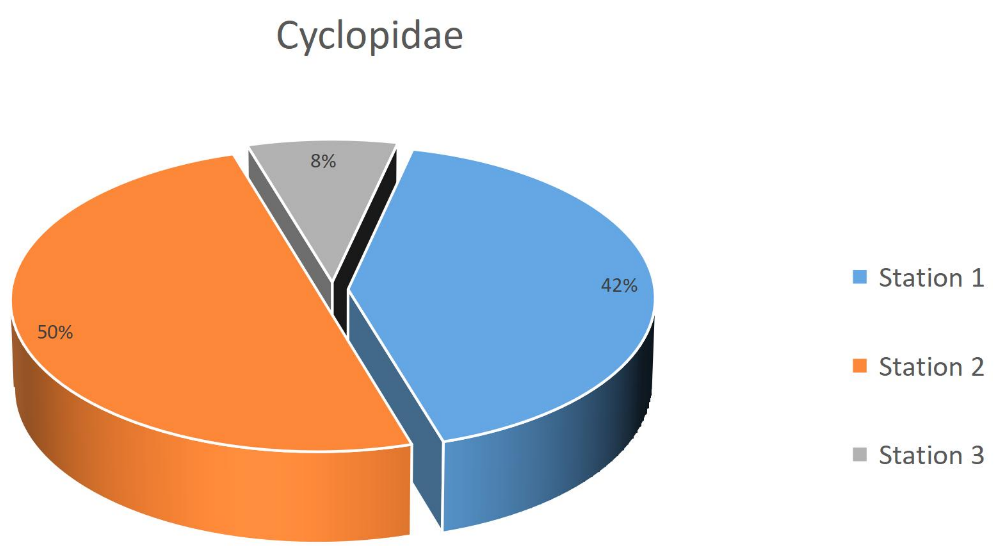

Fig 31. Percentage Composition of Cyclopidae at the study stations

4.6 Diversity Indices for zooplankton

Shannon Weiner, Evenness, Dominance and Margalef's index were used in assessing the occurrence of zooplankton. The Dominant index was highest in station 1, followed by station 2 and 3. The higher the dominance the lower the Shannon wiener's index, Equitability and Evenness index. Table 5 shows the summary of various diversity indices determined in the study.

4.6.1 Diversity of Fauna

The highest number of zooplankton species (taxa) 25 was recorded in station 1 while station 2 and 3 both had 24 and 21 taxa respectively.

4.6.2 Taxa Richness

The taxa richness calculated for stations using Margalef's index (d) showed that station 2 had the highest diversity followed by station 3 and 1 respectively. The highest value of Margalef's index was observed in station 2 while the lowest value was encountered in station 1.

4.6.3 General Diversity

The diversity calculated using Shannon wiener's index (H) showed that station 3 had the highest diversity followed by station 2 and 1 respectively.

4.6.4 Evenness and Simpson's dominance

Evenness index (E) and Simpson's dominance index showed that maximum evenness and dominance of species was at station 3 while the least dominance and evenness were found in station 3.

Table 5: Summary of Diversity of Indices

Stations	I	II	III
No of species/ taxa	9	11	8
Density (total no of individuals)	769	287	128
Shannon Diversity index (H)	1.358	1.573	1.598
Evenness Diversity	0.4323	0.4383	0.618
Simpson Dominance Index ©	0.682	0.740	0.757
Margalef's index (d)	1.204	1.767	1.443
Equitability (J)	0.618	0.656	0.768
Dominance (D)	0.317	0.259	0.243
Brillouin	1.335	1.513	1.499
Menhinick	0.324	0.649	0.7071
Fisher-alpha	1.431	2.269	1.892
Berger-Parker	0.453	0.390	0.281

4.7 Correlation analysis for Zooplankton

Correlation analysis was used to establish the relationship between each zooplankton families and physical parameters (Table 6). Family Daphinidae, Bosminidae, Moinidae and Sididae showed strongly negative correlation with conductivity, turbidity, BOD, phosphate, nitrate, and water temperature and strongly positive correlation for Dissolved Oxygen. Family Chydoridae also showed positive correlation with dissolved oxygen, however showed strongly negative correlation with conductivity, phosphate and nitrate and slight negative correlation with Ph, turbidity, DO and water temperature.

Family Illocryptidae and Macrothricidae showed negative correlation with PH. However, Illocryptidae showed very weak correlation with Dissolved oxygen while on the other hand, Macrothricidae showed strongly positive correlation with turbidity, BOD, and weak positive correlation with water temperature.

Copepod family Cyclopidae, showed strongly negative correlation with turbidity, BOD, sulphate, water temperature and strongly positive correlation with alkalinity. It however showed fairly weak correlation with dissolved oxygen.

Rotifer families, Asplanchidae, Lecanidae and Proalidae showed strongly positive correlation with PH, conductivity, Phosphate, and Nitrate. It however showed no correlation with water temperature.

Table 6: Test of Relationship of Zooplankton abundance and Physicochemical Characteristics of the Ponds. Critical Value of Correlation Coefficient (p< 0.05)

	Ph	Conductivity	Turbidity	Dissolved Oxygen	BOD	Sulphate	Phosphate	Nitrate	Suspended Solid	Water Temperature	Alkalinity	Chloride
DAPHINIDAE	0.20971	**-0.95617**	**-0.93642**	**0.999586**	**-0.95917**	**-0.74922**	**-0.90403**	**-0.88611**	**-0.87455**	**-0.9391**	-0.34364	**-0.98436**
BOSMINIDAE	0.27735	**-0.93344**	**-0.9586**	**0.995151**	**-0.97655**	**-0.79356**	**-0.87204**	**-0.85165**	**-0.83863**	**-0.96077**	-0.27735	**-0.99425**
CHYDORIDAE	-0.46632	**-0.92135**	-0.4933	**0.785283**	-0.55442	-0.1499	**-0.96773**	**-0.97708**	**-0.98198**	-0.5	**-0.86603**	**-0.64215**
ILLOCRYPTIDAE	**-0.99926**	-0.12403	0.506669	-0.14355	0.443533	**0.781288**	-0.26565	-0.3042	-0.32733	0.5	**-0.86603**	0.342802
MACROTHRICIDAE	**-0.85896**	0.436485	**0.894519**	**-0.65945**	**0.860155**	**0.995199**	0.302349	0.263778	0.240192	**0.891042**	-0.45392	**0.799183**
MOINIDAE	0.27434	**-0.93456**	**-0.9577**	**0.995454**	**-0.97587**	**-0.79165**	**-0.87357**	**-0.85329**	**-0.84033**	**-0.9599**	-0.28036	**-0.9939**
SIDIDAE	0.269997	**-0.93615**	**-0.95639**	**0.995874**	**-0.97488**	**-0.78888**	**-0.87575**	**-0.85564**	**-0.84277**	**-0.95862**	-0.28469	**-0.9934**
LEPTODORIDAE	**-0.69338**	**-0.77739**	-0.23269	0.582758	-0.30184	0.130193	**-0.85988**	**-0.87972**	**-0.89104**	-0.24019	**-0.97073**	-0.40435
CYCLOPIDAE	**0.956802**	-0.2076	**-0.76096**	0.459576	**-0.71247**	**-0.94256**	-0.06455	-0.02437	0	**-0.75593**	**0.654654**	**-0.63141**
ASPLANCHIDAE	**0.846154**	**0.603551**	-0.00772	-0.37051	0.064018	-0.36453	**0.712096**	**0.73975**	**0.755929**	0	1	0.172829
LECANIDAE	**0.846154**	**0.603551**	-0.00772	-0.37051	0.064018	-0.36453	**0.712096**	**0.73975**	**0.755929**	0	1	0.172829
PROALIDAE	**0.846154**	**0.603551**	-0.00772	-0.37051	0.064018	-0.36453	**0.712096**	**0.73975**	**0.755929**	0	1	0.172829

The correlation analysis to determine the relationship between the zooplankton abundance and physicochemical characteristics of Oghara Ponds revealed that there was strong correlation between zooplankton and the physicochemical characteristics.

CHAPTER FIVE

DISCUSSION

Water and zooplankton play intricate roles in the lives of top-most trophic levels feeders. Zooplanktons are mere players in the build-up of ecological communities as they transfer energy from one trophic level to another and have been found to be influenced by prevailing physicochemical parameters in the environment. The physico-chemical parameters of Selected Oghara freshwater (prominently ponds) were recorded during the period of study, January to March 2021. Changes in physical and chemical parameters of freshwater ecosystems impact zooplanktons and other aquatic taxa found resident in a water body (Combs, 2003).

The variation in water temperature followed closely with that of air temperature, with water temperature being higher in the month of February and January and relatively lower during the month of March. This observation was supported by the findings of (Egborge, 1971, 1978) who attributed changes in surface water temperature to be dependent on amount of water received by the water body, substrate composition, turbidity, vegetation cover and heat exchange in air. Generally, surface water changes followed those of air closely (Egborge, 1994).

Water temperature of the ponds fluctuated within months in all the three sampling stations. The high water temperature recorded in the ponds within the months of study was in the dry season. This could be attributed to seasonal changes in air temperatures. This observation was supported by the findings of (Ladipo *et al.,* 2012), which attributed variations in water temperature in the dry season to the effect of harmattan. High water temperature poses stress on aquatic life forms by reducing the ability of water to hold essential dissolved gases like oxygen (Kumar and Bahadur, 2009). This could have resulted in the low diversity of fishes and other macroinvertebrates in the study area.

Higher water and ambient air temperature accounted for higher rate of primary productivity (Siddique *et. al.,* 1980). This accounted for higher Nutrient levels in the early months of January and February.

Ph plays an important role in the distribution of aquatic organisms as certain organisms are well suited for life in habitat that are either acidic or alkaline in nature. The water was slightly acidic to neutral at all the stations. The pH range observed in this study (5.6 to 6.9) was similar to those recorded in most Nigerian inland water bodies (Asonye *et. al.,* 2007). Anyanwu *et al.* (2013) also recorded pH values of water which were moderately acidic to moderately alkaline, with a range of 5.4 to 8. This was similar to results recorded at various stations.

Dissolved Oxygen fluctuated between 3.00 mg/l to 8.40 mg/l. these range and patterns of fluctuations are similar to those reported from Warri river (Olomukoro and Egborge, 2003), Ogba river (Anyanwu, *et. al.,* 2013), Ovia river (Imoobe, 2009). The fluctuations in dissolved oxygen was as a result of influx of pollutants, waste water runoff from the surrounding through anthropogenic activities like agricultural activities, grazing and deposition of faeces by animals. The lowering of Dissolved oxygen due to pollution is a major and relevant factor in the distribution of biota (Jampani, 1985). Concentrations below 5 mg/l could adversely affect the functionality and survivability of biological communities and subsequent decrease may further lead to death of most fishes (Chapman 1996).

Zooplankton fauna of Oghara freshwater (ponds) appear to be unique in its community structure. A total number of 1185 individuals belonging to 3 major groups (Cladocera, Copepoda and Rotifera) were collected from the three stations throughout the duration of the study. Cladoceran group were represented by Families (Daphinidae, Bosminidae, Leptodoridae, Sididae, Moinidae, Macrothricidae, Chydoridae, Illocryptidae, Cyclopidae, Lecanidae, Proalidae, Asplanchidae)

In this study, Cladoceran were more diverse and predominant than the Copepods and rotifers. There were 21 species of cladocerans and 1108 individuals while Copepods were represented by 9 species with 72 individuals. Rotifers were the least represented groups with 3 species and 5 individuals. The relative high abundance of zooplanktons found in this study is attributed to the fact that lentic waters are more diverse than fast flowing lotic waters of rivers and contemporary streams. This fact is supported by Idris and Fernando (1981) who recorded that flowing water is a poor habitat for zooplanktons. High current velocity hardly permits stable zooplankton community (Ogbeibu and Edutie, 2002). The general preference of zooplankton to nutrient rich environments (Jeje and Fernando, 1986) was also demonstrated in the present study as relatively high densities of zooplanktons could be attributed to the unperturbed state of the ponds, low current velocity due to it being a lentic body, and continuous inundation by sediments deposition and other anthropogenic activities.

The high number of species (35) found in this study were similar to the studies carried out on River Niger and Ovia River by Arazu and Ogbeibu (2017) and Imoobe & Adeyinka (2009) respectively. The former recorded which recorded 26 species of cladocera, 8 Species of copepoda and 23 species of rotifers while the latter recorded 40 species, although dominated by rotifer communities.

The order Cladocera was represented by 8 families namely: Daphinidae (186), Bosminidae (10), Macrothricidae (75), Moinidae (320), Sididae (497), Illocryptidae (6), Leptodoridae (7) and Chydoridae (7). These families are similar to those found in the works of Imoobe and Adeyinka (2009) on Ovia River, although the family Daphinidae was completely absent. These various families are typical of freshwater cladocera (Egborge, 1987; Dumont, 1981). The relative high biomass and abundance of cladoceran may be attributed to stable water flow, nutrient enhancement and the consequent higher phytoplankton productivity (Okogwu *et al.* 2009). Sharma *et al.* (2010) also recorded high biomass of cladoceran during the dry season.

The dominant families in this study were Sididae, Moinidae and Daphinidae containing 497, 320 and186 individuals respectively. This was similar to the works of Imoobe and Adeyinka (2009) on Ovia River who recorded dominance of Moinidae, Daphnidae, but Sididae was absent amongst the dominant groups. In contrast, other works by Omoigberale and Oronsaye (2011) recorded Chydoridae as the dominant cladoceran taxa while Otene *et. al.* (2019) and Imoobe (2011) recorded dominance in Protozoan and rotifer groups.

In this study, Pseudosida bidentata was the most abundant species having 242 individuals, followed by Moina recticulata and Diaphanosoma sarsi which recorded 177 and 171 individuals. In contrast to those, *Pleuroxus similis, Alona exima* and *Moina micrura* amongst the Cladocerans dominated in Okhuaihe River (Omoigberale and Oronsaye, 2011).

Also in this study, Family Chydoridae consist of 3 individual taxa only; *Pleuroxus similes, Alona davidi, and Chydorus sphaericus*. Relatively stable to high abundance and species richness of this family is characteristic of tropical freshwater zooplankton (Green 1962; Dumont 1981).

In this study, the copepods consisted of 6.07% of the total zooplankton encountered. The copepods were singly represented by the cyclopoid family Cyclopidae which included 9 species: *Acanthocyclops vernalis (1), Halicyclops troglodytes (3), Mesocyclops leuckarti (19), Thermocyclops negletus (11), Tropocyclops prasinus (13), Eucyclops serralatus (6), Cryptocyclops bicolor (2), Metacyclops minutus (12) and Ergasilus spp (5)*. This is similar to findings of Akin-Oriola (2003), Akoma *et al.* (2014) and Anyanwu *et al.* (2013). Low abundance of copepod during the study may be associated with increase in predation by juvenile fishes, hereby makes it difficult for a stable population to be established (Nwinyimagu *et al. 2018)*

Also in this study, Rotifers were the least abundant of all zooplankton encountered. 3 families and 3 species of rotifers were recorded in this study as contrast to the 15 (257 individuals) species that was reported by Akoma *et al.* (2014) and relatively low compared to the 49 and 32 species recorded by Arimoro & Oganah, (2010) and Akin-Oriola (2003) respectively. This study is similar to Anyanwu *et al.* (2013) who recorded just one species (*Lepadella ovalis)* of rotifer. The low numbers of Rotifers recorded in this study may be due to habitat insatiability (Ibemenuga, *et al.* 2013). Sensitive species disappear as the water becomes polluted while tolerant ones survive the pollution stress and readily recovers (Ogbeibu and Edutie, 2005)

Asplanchidae was the most dominant of the rotifer families which comprised 60% of the total rotifer. This was in contrast to Usman and Yerima (2017) who recorded *Branchionus angularis, Kellicottia longispina, Rotaria neptunia, Euchlanis dilatata and Lecane lunaris* as the most dominant species.

Station 2 recorded the highest number of rotifers. Rotifers were completely absent in station 1 and 3 respectively. Rotifers relative low density associated with. Additionally, Thirty-five (35) species were recorded in all station. The highest number of individuals were recorded in the month of January and the least was recorded in the month of March. Station 1 recorded the highest number of zooplankton while station 2 and 3 recorded and respectively. This low abundance may be attributed to increase selective grazing by fishes in both stations (2 and 3).

Calculation of diversity using Shannon-wiener and Margalef's indices revealed that station 3 was the most diverse of the three stations while station 1 was the least diverse. Evenness is greater in station 3 (0.9030) which indicated that zooplankton fauna re evenly distributed in the station than that of station 1 and 2.

Cladocerans generally showed strongly negative correlation with nitrate and phosphate with the exception of Macrothricidae and phosphate which showed slightly positive correlation to phosphate and nitrate. Copepods showed slightly negative correlation with nutrients while Rotifers showed fairly positive correlation with Nitrate. Cladoceran groups also showed slightly positive correlation and slightly negative correlation with Ph showing their adaptive behavior to slightly acidic or neutral water bodies. Rotifers showed very slow negative correlation with dissolved oxygen indicative of their ability to tolerate environmental stress.

CONCLUSION

The results from the study shows a strong relationship between the physicochemical parameters and zooplanktons. Water temperature followed closely with air temperature with water temperature fluctuating across all stations. Ph however, was quite important in determining the diversity of zooplanktons, as organisms recorded during the study were those typical of slightly acidic to neutral environment. The relatively high abundance and species composition of zooplanktons recorded showed the highly eutrophic to mesotrophic nature of the pond as more zooplanktons were recorded during the dry season month of January. This is attributed to the accumulation and retaining of nutrients, and further suspension of organic matters in station 1. Stations 2 and 3 recorded declining abundance during the months of February and March. This may have resulted from the selective grazing effects of fishes and other carnivorous zooplanktons. Correlation analysis of Zooplankton showed strong relationship between physicochemical characteristics. Further work is recommended to be done on diverse southern ponds to determine the assessment of physicochemical characteristics of water in relationship to their zooplankton abundance, composition and analysis.

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APPENDIX

ANOVA

Variables

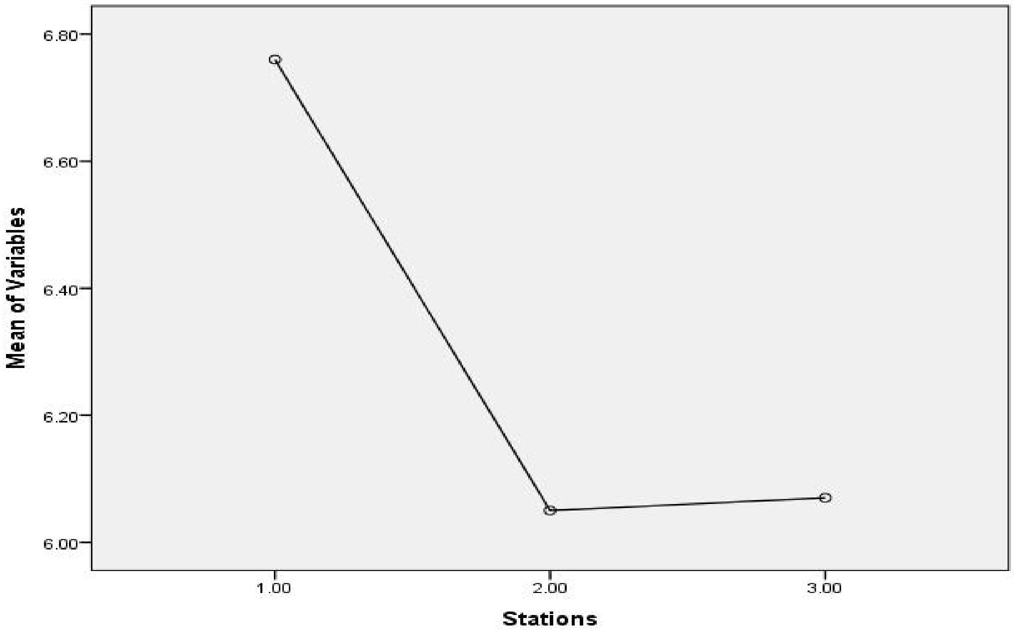
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.981	2	.490	6.474	.032
Within Groups	.454	6	.076		
Total	1.435	8			

Robust Tests of Equality of Means

Variables

	Statistic[a]	df1	df2	Sig.
Welch	9.973	2	2.813	.053
Brown-Forsythe	6.474	2	3.332	.071

a. Asymptotically F distributed.



Notes

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Descriptives

Variables

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	3	69.3333	28.21938	16.29247	-.7675	139.4342	37.00	89.00
2.00	3	66.3333	76.05480	43.91026	-122.5973	255.2639	18.00	154.00
3.00	3	27.6667	12.50333	7.21880	-3.3933	58.7267	15.00	40.00
Total	9	54.4444	45.70862	15.23621	19.3097	89.5792	15.00	154.00

Descriptives

Variations

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	3	5.8000	2.70555	1.56205	-.9210	12.5210	3.00	8.40
2.00	3	5.9333	2.61024	1.50702	-.5509	12.4175	3.00	8.00
3.00	3	4.5333	2.31805	1.33832	-1.2250	10.2917	3.00	7.20
Total	9	5.4222	2.30748	.76916	3.6485	7.1959	3.00	8.40

Test of Homogeneity of Variances

Variations

Levene Statistic	df1	df2	Sig.
.019	2	6	.982

ANOVA

Variations

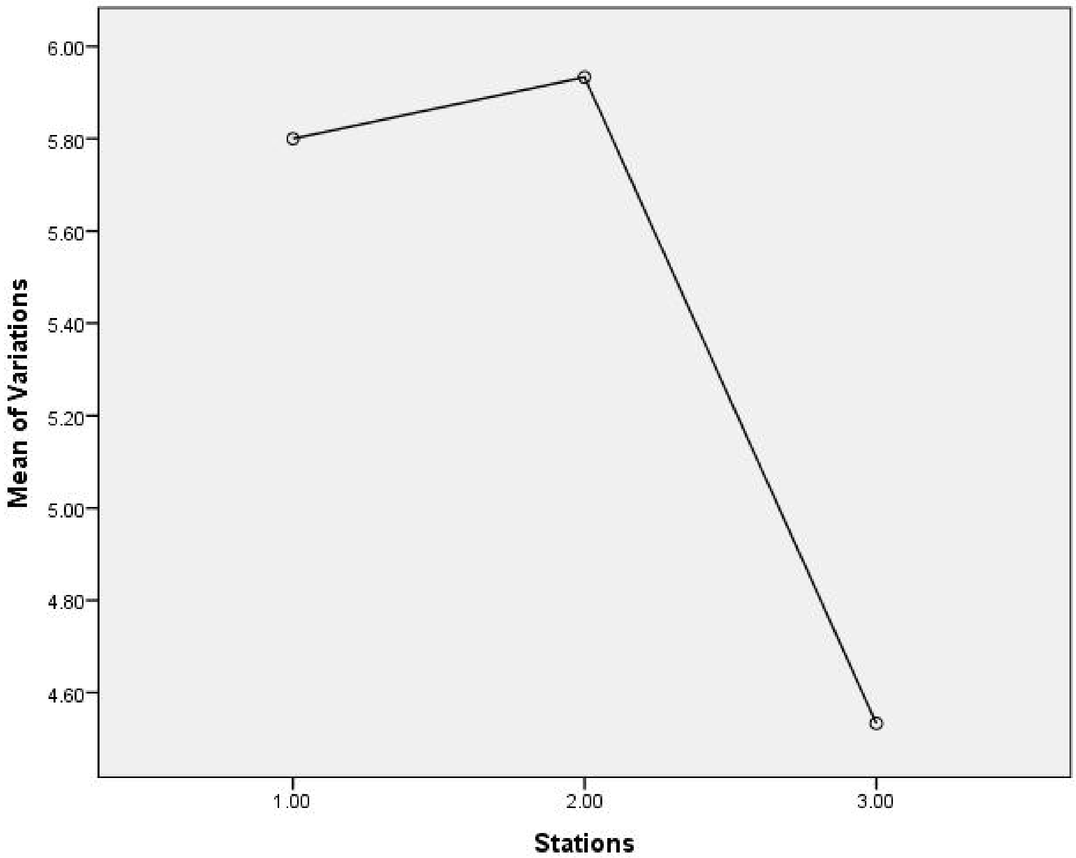
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.582	2	1.791	.275	.768
Within Groups	39.013	6	6.502		
Total	42.596	8			

Robust Tests of Equality of Means

Variations

	Statistic[a]	df1	df2	Sig.
Welch	.259	2	3.981	.784
Brown-Forsythe	.275	2	5.905	.768

a. Asymptotically F distributed.



Descriptives

Variables

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	3	18.3217	13.65291	7.88251	-15.5940	52.2374	4.73	32.04
2.00	3	30.4933	25.82538	14.91029	-33.6605	94.6471	7.20	58.27
3.00	3	12.8283	6.59294	3.80644	-3.5494	29.2061	8.60	20.43
Total	9	20.5478	16.89681	5.63227	7.5597	33.5358	4.73	58.27

Test of Homogeneity of Variances

Variables

Levene Statistic	df1	df2	Sig.
1.956	2	6	.222

ANOVA

Variables

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	490.378	2	245.189	.820	.484
Within Groups	1793.638	6	298.940		
Total	2284.016	8			