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The Assessment of Water Quality via Physicochemical Parameters and Macro Invertebrates in Lake Geriyo, Yola, Adamawa State, Nigeria

Kefas M.
Assistant Lecturer, Department of Fisheries, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria
Abubakar K. A.
Professor, Department of Zoology, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria
Ali J.
Associate Professor, Department of Zoology, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria

Abstract:
A study on the water quality assessment of Lake Geriyo was carried out fortnightly using standard methods for the period of eighteen months. Physicochemical parameters and Macroinvertebrates have shown that temperature, transparency, hydrogen-on concentration (pH), free carbondioxide, conductivity, total alkalinity, total nitrogen, total phosphorus and total ammonia all were significantly different ($p<0.05$)in variability in both sites and within the months. A total of four hundred and thirty three (433) species of macroinvertebrates were recorded of which three phyla (Arthropoda, annelida and mullusca) were identified. Macroinvertebrates notably mayflies larvae, dragonflies larvae, blackflies larvae, damselflies larvae, diptera larvaeetc indicate presences of some pollution. Results of the present study showed that the value of physicochemical parameters and macroinvertebrates has confirmed that the pollution level of Lake Geriyo.

Keywords: *Water quality, Physicochemical, Macroinvertebrates, Lake Geriyo*

1. Introduction

Lakes and Rivers are a very important part of our natural heritage. They have been widely utilized by mankind over the centuries to the extent that very few, if any are now in a natural condition. Though water pollution is an old phenomenon, the rate of industrialization and consequence, urbanization has exacerbated its effect on the environment (Asonye*et al*., 2007). Availability of safe and reliable source of water is an essential prerequisite for sustained development. Water quality assessment is of immense importance to practices such as the use of water bodies for management of fisheries, water supply, pollution control, irrigation and sewage reservoir and impoundment etc. Pollution status of water bodies is usually expressed as biological and physicochemical parameters (Adakole*et al.,* 2008). Blockeel *et al.* (1999) suggested that physical and chemical properties give a specific picture of water quality in fresh water at a particular point in time, while the biota (biological property) act as a continuous monitor and give more general pictures of water quality over a period of time.

Macroinvertebrates are animals without backbone that live on or in the sediment of the water body or attached to rocks or debris at the bottom. The minimum size is 0.55mm in diameter. They include crustaceans, molluscs, aquatic worms and larval forms of aquatic insects. They are important in the aquatic ecosystem because they form part of the aquatic food chain. They are also used to assess water quality and as pollution indicators (Nkwoji *et al*., 2010).

Biological communities have been seen as effective tools for assessing organic pollution.

Macrobenthic animals are easy to monitor, because they can be sampled quantitatively and also respond to man-made disturbance (Otway *et al*,. 1996). Biological attributes of water quality examine bioindicators i.e. macroinvertebrates and fish. Benthic macroinvertebrates include crustaceans, mollusks, worms and many species of insect larvae such as may flies, stone flies caddis flies and beetles. The abundance of macro invertebrates belonging to the order *Ephemeroptera*, *Plecoptera*and *Trichoptera*are highly sensitive to pollution, they are often used as water quality indicators. Their presence indicates high quality of water while there absence suggests that water may be polluted (Cairns and Dickson, 1971). The health of resident fish species will be indicative of overall water quality. Condition factor is determined by comparing the length of the fish to its weight the heavier the fish for its length, the better the condition (Boyd, 1981).The aim of this research is to assess the water quality of Lake Geriyo using physicochemical parameters and Biological data of aquatic macroinvertebrates.

2. Materials and Methods

2.1. Study of Area

Lake Geriyo is located at the outskirts of Jimeta-Yola metropolis on the north- west region (Longitude 12^{o} $25^{'}$ E and between latitude 9^{o} $81^{'}$ N and 9^{o} $17^{'}$ N). It has a high level of 750ha and low level of 200ha. Storage at level about 7,500, 000cm^{2}. The area amiable to fisheries development is about 250ha; consequently, most of the settlers around the lake are fishermen (upper Benue River Basin Development Authority, 1985).

Lake Geriyo is a natural lake that started as a small gulley, but was later filled with water from rains and some influx from River Benue. The lake came into recognizable existence in 1950. Initially, the lake was not used for fishing. It has now become a major fishery, with fishing activities taking place all year round. It is also a major source of water for irrigation, during the dry season farming that takes place around the lake. The level of the lake is reasonably constant with regards to the movement of water in and out. This has given rise to a stable growth of water plants that give the basin the appearance of a typical lake.

The lake experiences two seasonal period; the rainy and dry seasons. The rainy season starts in the months of May and last till October and is characterized by heavy downpour which may sometimes result in extensive floods. The dry season on the other hand is from late October to April and is characterized by the cold, dusty dry winds of December and January (Harmattan) and intense heat of February, March through April. Atmospheric temperature can be as low as 20^{o} C in December and January and as high as 40^{o} C in March and April.

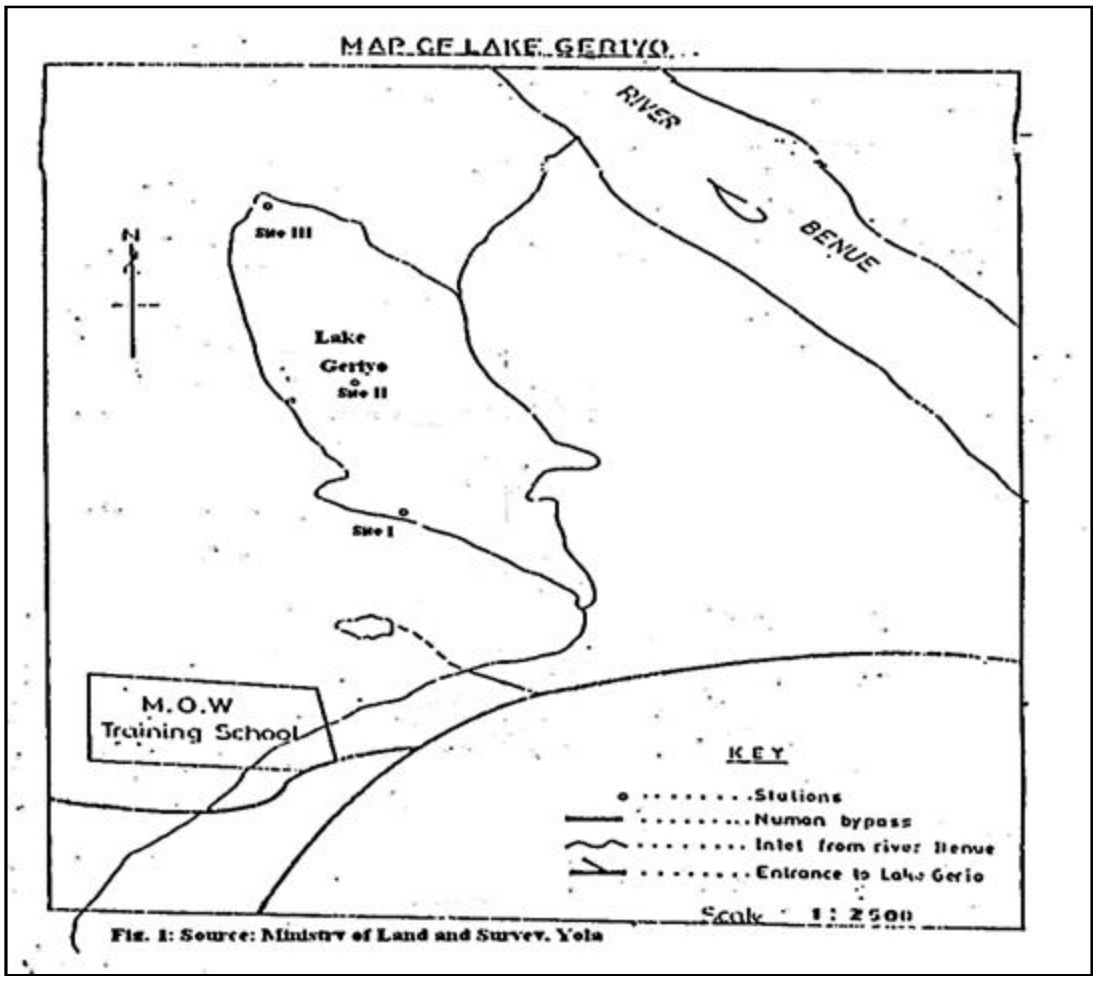

Figure 1

2.2. Sample Collection and Preservation

Samples of water were taken monthly over a period of eighteen (18) months (i.e. from January, 2013 to June, 2014) from 6am local time. Water samples for physicochemical studies were collected from three sites (site I, site II and site III) below the water surface, (Fig.1). Water samples were taken in triplicates at each sampling sites using sample bottles. The bottles were rinsed with the water before being filled with the samples. Sample bottle of 250ml was dipped below the water surface. The bottle was filled to the brim and covered immediately to avoid air bubbles inside. Water samples were preserved using chemical reagents before being transported to the laboratory for processing. Water samples were collected in labelled and fixed sampling bottles. Temperature, transparency, conductivity, hydrogen ion concentration (pH), dissolved oxygen were determined *insitu* while other parameters, total alkalinity, free carbondioxide, total ammonia, total phosphorus and total nitrogen were determined in the laboratory as described by APHA (1992).

2.3. Determination of Macroinvertebrates

Sampling of the Macroinvertebrates was carried out based on the modified sampling technigue described by Smith (1975) and Indabawa (2010). Counting and identification was carried out with the aid of light microscopes and identification guides by Mellanby (1977) and Andrew (1972).

3. Results

3.1. Physicochemical Parameters

The monthly mean variations in physicochemical parameter of Lake Geriyo are shown in table 1 and 2. The monthly mean variations of water temperature ranged from 24.7^{o}C in the month of December to 29.0^{o}C in the month of April. There was a significant difference in variability in both sites and within months (P<0.05). The monthly mean variations of transparency ranged from 15.7cm to 57.5cm in the months of May and December respectively. There was a significant difference in variability in both sites and within months (P<0.05). The monthly mean variations of water conductivity ranged from 18.68µs/cm in the month of April to 32.64 µs/cm in the month of May. There was significant difference in variability in both sites and within months (P<0.05).

The monthly mean variations of water pH ranged from 7.00 in the month of August to 8.23 in the month of January. Variation within the months and sites was significant at (P<0.05). The monthly mean variations of total alkalinity ranged between 6.80mg/L in the month of September and 27.85mg/L in the month of April. The variation was significant in both sites and within months (P<0.05). The monthly mean variations of free CO_2 ranged between 5.30mg/l in the month of December and 17.47 mg/l in the month of April. There was a significant difference in variability in both sites and within months (P< 0.05).

The monthly mean variations of total nitrogen ranged between 0.084mg/l in the month of December and 0.258mg/l in the month of June. There was a significant different in variability in both sites and within months (P<0.05). The monthly mean variations of total phosphorus ranged from 0.025mg/l in the month of September to 0.164mg/l in the month of April. There was significant difference in variation in both sites and within months (P<0.05). The monthly mean variations of total ammonia ranged from 0.021mg/l in the month of January to 0.108mg/l in the month of May. Variation was significant in both sites and within months (P<0.05). The monthly mean variations of DO ranged from 3.15mg/l in the month of April to 13.20mg/l in the month of December. There was significant difference in variation in both sites and within months (P<0.05).

3.2. Macroinvertebrates

The result of the macroinvertebrates composition in Lake Geriyo is shown in table 3. A total of four hundred and thirty three (433) number of macroinvertebrates belonging to three phyla (*Arthopod,annellida and mollusca*) were identified. Dragon flies larva was found to have the highest number of 108 (24.94%) followed by Damsel flies larvae with a total number of 86 (19.86%). Dragon fly and Damsel fly which belongs to the same class *insecta*of the order *Odonata*. The least occurred macroinvertebrates were the *Leeches*worms with a total number of 13 (3.00 %) followed by the Snails (*physafontinalis,aplecta*) 21(4.85%). Other macroinvertebrates with intermediate estimations were the Black fly (*siimulium*) with a total of 64 (14.78%), Ephemoreptera (mayfly Larva) with a total of 50 (11.55%), *Coleoptera*aquatic beetles (Dysticus ,bidessus) with total of 46(10.62%), and *Diptera*larva (*Chironomidae* ,culex) that has the total of 45 (10.39%) .

The highest number of macroinvertebratesrecorded was in the month of March with a total number of 36 while the least was in September and October with both having a total number of 19 each. Nine (9) species belong to the phylum *arthropoda*with 4 classes of *insecta*, phylum *annelida*with one representatives from class *Hirudinea*and phylum Mollusca with two represented from class Gastropoda. The dominant classes of *insecta*are the order *diptera*and *odonata*occurs twice while the nine (9) insects species of order *odonata*dragon fly *Ashna*, Lanthusspp, Damsel fly *Lestes*spp,*Diptera*, Black fly *Simulium*spp and Diptera Larvae *Chironomidae* ,culexoccurring in the following order 24.94%, 19.86% , 14.78% and 10.39% respectively.

Parameters	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June
Temperature ^{o}C	25.5	25.7	27.0	29.0	27.5	26.7	25.8	25.2	25.0	27.7	26.0	24.7	25.7	25.3	28.7	27.8	26.5	26.3
Transparency (cm)	29.3	21.5	20.5	18.1	18.0	17.2	28.4	45.1	46.3	52.0	55.3	57.5	41.6	31.2	16.7	15.9	15.7	19.5
pH	8.23	7.88	8.03	8.20	7.94	7.30	7.40	7.00	7.47	8.05	7.98	7.98	7.69	7.93	8.03	7.89	7.25	7.48
Conductivity µ/cm	28.60	27.19	27.66	26.98	32.64	20.95	19.97	20.59	23.21	27.35	26.26	24.67	21.19	21.31	20.39	18.68	23.04	19.42
Alkalinity mg/L	13.57	22.72	27.07	27.85	24.12	21.67	15.42	13.77	6.80	9.53	10.60	12.80	12.85	15.40	21.64	25.10	24.28	21.20
Free $CO_{2\ mg/L}$	8.16	8.65	13.70	15.42	10.65	7.27	6.83	15.17	12.13	15.97	15.40	5.30	8.40	7.73	16.80	17.47	16.07	11.86
Total nitrogen mg/L	0.180	0.193	0.201	0.229	0.218	0.155	0.124	0.119	0.132	0.222	0.117	0.084	0.131	0.143	0.155	0.199	0.245	0.258
Total phosphorus mg/L	0.136	0.153	0.161	0.164	0.087	0.057	0.046	0.033	0.025	0.041	0.044	0.081	0.101	0.106	0.088	0.103	0.136	0.140
Total Ammonia mg/L	0.062	0.068	0.061	0.087	0.108	0.068	0.058	0.029	0.028	0.032	0.033	0.043	0.020	0.035	0.034	0.046	0.085	0.089
Dissolved Oxygen mg/L	5.89	5.92	3.95	3.15	5.16	4.22	3.82	3.55	3.55	5.36	7.62	13.20	8.57	12.92	10.12	9.65	9.65	8.46

Table 1: Monthly mean Physicochemical parameters from January, 2013 to June, 2014 of Lake Geriyo, Yola, Adamawa State.

Parameters	Site I	Site Ii	Site Iii
Temperature ^oC	26.6	26.2	26.6
Transparency (cm)	30.6	30.9	27.8
pH	7.77	7.72	7.80
Conductivity µ/cm	23.65	24.31	23.73
Alkalinity mg/L	17.94	18.18	18.27
Free $CO_{2\ mg/L}$	12.46	11.18	11.86
Total nitrogen mg/L	0.179	0.163	0.175
Total phosphorus mg/L	0.093	0.100	0.091
Total Ammonia mg/L	0.054	0.052	0.059
Dissolved Oxygen mg/L	6.37	7.90	6.52

Table 2: Mean values of physicochemical parameters between and within sites of Lake Geriyo, Yola, Adamawa State.

Macroinvertebrates	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	Total	Percentage (%) estimate
Diptera Larvae (chironomide,culex,)	3	2	-	3	5	2	2	5	3	-	2	-	3	2	3	3	4	3	45	10.39
Dragon fly larvae (Aeshna, Lanthus)	6	9	9	7	4	5	8	7	4	5	5	7	6	5	4	7	5	6	108	24.94
Damsel fly larvae (Lestes)	5	8	9	8	7	4	4	5	4	4	7	2	3	2	4	3	4	3	86	19.86
Coleoptera Beetle (Dysticus ,bidessus)	1	5	6	4	3	5	-	2	-	2	-	4	2	4	-	2	3	3	46	10.62
Ephemoreptera (mayfly, Baetis,caenis, amelectus)	3	3	4	5	6	1	2	1	3	3	2	4	1	2	2	2	4	2	50	11.55
Blackfly larvae (Simulium)	3	4	5	4	4	3	3	5	3	4	5	2	4	3	4	3	3	2	64	14.78
Hirudinea (Leech, dorylamusspp)	-	-	1	-	-	2	1	1	2	-	1	-	-	1	-	1	2	1	13	3.00
Gastropoda(snail, physafontnalis, aplectaspp)	1	-	2	-	2	3	3	-	2	1	1	3	-	-	1	1	-	1	21	4.85
Total	22	33	36	31	31	25	23	26	19	19	23	22	20	21	20	22	25	21	433	100

Table 3: Results of Macroinvertebrates identified from Lake Geriyo, Yola, Adamawa State.

4. Discussion

The monthly mean water temperature of the Lake fluctuated between 24.7^{o}C and 29.0^{o}C in December and April during the period of the research. The low water temperature recorded in the December, might be due to the characteristic cool dry North-East trade wind known as Harmattan between November and February while the high water temperature in April was due to characteristic of hot weather in Yola. This pattern of variation has similarly been reported in Northern Nigeria by Ezra and Nwankwo (2001) in Gubi Reservoir, Ajibade*et al*. (2008) in the major rivers of Kainji Lake National Park and Adakole*et al*. (2008) in Kubanni Lake. The values of temperature observed are within the normal range of 8-30^{o}C recommended for tropical fish (Alabaster and Lloyd, 1980). The range of temperature recorded during the period of the research was almost in line with (26.0-29.0^{o}C) obtained by Adeyemi (2011) in Gbedikere Lake, Basssa, Kogi state and (25.8-28.0^{o}C) recorded by Ali *et al*. (2000) in Lake Geriyo, Adamawa State respectively**.** The almost high temperature observed in this Lake could be due to the shallow nature of the Lake, which could be favourable to fish growth and development (Haruna, 1992). The metabolic rate of aquatic organisms is also related to temperature and in warm waters,respiration rates increase, leading to increased oxygen consumption and increased decomposition of organic matter (Chapman and Kimstach, 1996).

The monthly mean value of transparency of the Lake was lowest in May and highest in December. The lower value recorded in May mighty be as a result of beginning of raining season to set in with corresponding high turbidity which might be attributed to increase in debris load. The high transparency mean value recorded in December could be due to absence of floodwater, surface run-offs and settling effect of suspended materials that followed the cessation of rainfall. The secchi disc depth is inversely related to turbidity and determines the conditions of availability of light in the water column to support photosynthesis by phytoplankton, and hence production (Stirling 1985). Higher turbidity increases water temperature because suspended particles absorb more heat; this in turn reduces the concentration of dissolved oxygen because it reduces the amount of light penetrating the water, which reduces photosynthesis (APHA, 1992). According to Abubakar (2006) suspended materials can clog fish gills, reducing resistance to diseases and growth rates. Abubakar, (2006) also pointed out that reduced activity on the lake and complete lack of rains accounted for very high transparency.Ufodike and Garba (1992) observed that decrease in water transparency reduces production of natural food in water. Conductivity values (18.68-32.64 µS/cm) in the lake were typical of a freshwater since the electrical conductivity of most freshwater ranges from 10-1,000µScm-1 (Chapman and Kimstach, 1996).The values observed are in line with 4.99- 44.19 µs/cm reported by Abubakar (2006) in Lake Geriyo. The high conductivity values observed may be due to the fluctuation of monthly mean values of pH around the neutral point of 7 recorded in the Lake. Stirling (1985) states that the very acidic (pH<4.5) or alkalinity (pH>10) waters have appreciate higher conductivity values. Carr and Neary (2006) pointed out that ions were lower in the rainy season than in the dry season since conductivity declines in the wet periods as the concentration of salts becomes more dilute .Therefore, discharges can change the conductivity of a river because of their make-up. Discharges could raise the conductivity because of the presence of chloride, phosphorus and nitrate (USEPA, 1991).

The monthly mean variation of the pH values ranged from 7.00 to 8.23 in August and January respectively. The recorded values fall almost within the EU recommended range of 6 to 9 for fisheries and aquatic life (Akindele*et al*.,2013) and the WHO pH guideline (<8.0) for drinking water for effective disinfectionswith chlorine (WHO, 1993).The pH values obtained for this work are similar to values (5.08-8.02) observed by Adeyemi (2011) in Gbedikere Lake, Bassa, Kogi State. The overall finding of the pH tends towards nutrient fair system this is similar to the result of Yakubu*et al*. (2007) in Nun River, Nigeria. Abubakar, (2006) reported that pH is an important parameter in many ecological studies because there is a strong relationship between pH and the physiology of most aquatic organisms. USEPA, (1991) observed that extreme pH values outside the range of 6.5 to 9.0 stressed the physical system of most aquatic organism and reduced reproduction. Abubakar (2006) observed that the low pH allows toxic elements and compound to become mobile and available for uptake by plants and animals.

The monthly mean variations of total alkalinity ranged between 6.80 and 27.85mg/l during the period of the study which is inline with 9.1 to 28.3 reported by Abubakar (2006) in Lake Geriyo and less than 84-128mg/l reported by Kolo and Yisa (2002) in river Suka. The pH values 7 and above observed in the Lake shows the high buffering capacity of the water body. ACTFR (2002) observed that the alkalinity buffering capacity in natural fresh water systems is mainly due to the presence of bicarbonate leached from the soils in rain water runs off. Saxena (1990) also states that increase pH values of water with high alkalinity (hard water) ranged from 8.5 upward. Stirling (1985) reported that the alkalinity is the measure of buffering capacity of the water i.e its ability to with stand pH changes.

The monthly mean variation of free CO_2 ranged between 5.30mg/l in December and 17.47mg/l in April. The low value of free CO_2 observed in the month of December may be attributed light intensity penetrating the clear water leading to photosynthesis while high CO_2 recorded in April could be as result dry season farming activities around the Lake which washed organic and inorganic chemicals in to the water body. However, the values obtained were higher than recommended safety limit of 10mg/l as observed by Haruna (2003). Saxena (1990) observed that high alkaline (hard water) water bodies are characterized by negative value of free CO_2. Waters with high free CO_2 content may cause problem of kidney stone formation in fishes (Stirling, 1985).

The monthly mean total nitrogen ranges between 0.084mg/l in December and 0.258mg/l in June which is less than 0.44 to 1.21mg/l as reported by Abubakar (2006) in Lake Geriyo. The higher nitrogen observed in June could be due to surface run-offs as well as the decomposition of organic matter. Ufodike*et al*. (2001) made similar observations for Dokowa Mine Lake. Ibrahimet al., (2009) stated that high nitrate concentrations in lake is related to inputs from agricultural lands. The values of total nitrogen obtained in Lake Geriyowere less than the danger limit of 10mg/l reported by Abubakar (2006) that excess nitrogen at higher concentration of 10mg/l or higher can cause low level of dissolved oxygen and become toxic to warm-blooded animals under certain conditions. The low values of total nitrogen observed in the river might be due to the high concentration of dissolved oxygen recorded during the period of research. The concentration of total nitrogen obtained within the tolerable limit of about or less than 1mg/l (USEPA, 1991).

The monthly mean variation of total phosphorus range from 0.025mg/l to 0.164mg/l in Lake Geriyois not in agreement with 0.04 to 0.05mg/l observed by Kolo and Yisa (2000) in river Suka. It could also be due to lower water hardness, thus less co-precipitation of phosphate with calcium carbonate, a phenomenon that has often been reported to occur in many fresh water lakes (Ibrahim *et al*., 2009). ACTFR (2002) states that artificial sources of phosphorus include fertilizers, detergent, waste water, industrial effluent and animal excreta amongst others. Which is typical of Lake Geriyo with increase in rains and accumulation of run-off water in Lake Geriyo, it was observed that concentration of phosphorus increased, but the concentration of phosphorus recorded during period of the study was within safety limit of about or less than 1mg/l (USEPA, 1991).

The monthly mean total ammonia variations ranged from 0.021mg/l to 0.108mg/l which is higher than 0.025mg/l recommended by Alabaster and LIoyd (1982). Ammonia in water is released as an end product of decomposition of organic matter and also as excretory product of some aquatic animal (Saxena, 1990). Ammonia is an important nutrient of phytoplankton (Philips, 1985). The high total ammonia observed during the period of the study might be due to decomposition of organic materials in the Lake.

The monthly mean variation of the DO ranged from 3.15mg/l in the month of April to 13.20mg/l in December. The monthly mean value of Do observed during the period of study is lower than 12.02mg/l to 19.50mg/l as obtained by Abubakar (2006). The fluctuation of DO during the period of research might be due to decomposition of organic matter resulting in use of oxygen. Abubakar (2006) pointed out that apart from the photosynthetic activities which added to the maintenance of high oxygen levels, the cool wind action cause the water to mix thereby the phenomenon of bottom-up and top-bottom is enhance. Super saturated oxygen conditions are caused by algal bloom while low oxygen (anoxic) conditions reduce the number of species being formed and frequently leads to the release of undesirable odours until aerobic or oxic condition develop (Mays, 1996). Dissolved oxygen values correlated positively with transparency values. The highest transparency recorded in Decembermay be due to low influx of suspended inorganic matter into the river.

A total of four hundred and thirty three (433) species belonging to four phyla were recorded. The highest percentage (24.94%) of macroinvertebrates occurrence investigated in Lake Geriyo was the dragon flies *Aeshna*spp. Followed by Damsel flies *lestesspp* (19.86%). This result was similar to the findings of Lang-Bertalot (1979) and Indabawa(2010). He further added that Damsel flies, Dragon flies and chironomidae are commonly found in freshwater that considerably have organic debris. The intermediate macroinvertebrates observed were the Black fly larvae (*simulium*), Ephemoreptera (mayfly Larva) ,*Coleoptera*aquatic beetles (Dysticus) and *Diptera*larva (*Chironomidae*) with 14.78%, 11.55%, 10.62%, and 10.39% respectively. The presence of the abovemacroinvertebrates recorded during the period of study indicate low level pollution, since all the species are clean water species (Emere and Nasiru, 2007). Emere and Nasiru (2007) reported that most aquatic beetles can renew their oxygen supply directly from the atmosphere, they are thus unaffected by oxygen depleting wastes while others possess special adaptations for obtaining oxygen (Emere and Nasiru, 2007). The least occurred macroinvertebrates were the *Leech* worms (3.00 %) followed by the Snails with 4.85%.

The low number could be due to physico-chemical conditions like high pH, low DO and low conductivity of the water. The factors probably caused disruption of the life cycle, reproductive cycle, food chain and migrations or imposed physiological stress on even the tolerant macroinvertebrates (Adakole and Annune, 2003). The result further revealed that of the 3 phyla identified, Arthropods were dominant. This conforms to the research findings of Mellanby (1997) that arthropods are adapted to life diverse habitats due to their mode of feeding, behaviour, physiology and physicochemical parameters. The monthly variation in the density of macro invertebrates as observed from the study could be to the variation in the physic-chemical factors which also indicates the presence of dissolved organic matter, inorganic chemical at Lake Geriyo. Indabawa, (2010) reported that the population density of living organisms in aquatic environment usually varies with the variation of environmental parameters.

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