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Assessment of Climate Factors on Benthic Fauna in Jabi Lake Federal Capital Territory Abuja

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ABSTRACT: Studies of climate factors on benthic fauna in Jabi Lake was conducted from November, 2016 to June, 2017 using combination of insitu and laboratory equipment. Three stations were selected to determine the climate characteristics based on activities in the various stations and proximity to terrestrial influence. The results of the climatic parameters showed that atmospheric temperature range 18.40 to 32.10^{0}C, rainfall from 1997-2016 range from 0.00 to 513.8mm, relative humidity range from 22.00 to 72.20%, wind speed range from 0.40 to 3.40m/s, variation with time in all the stations. There were significant differences ($P<0.05$) between these parameters, within the months, stations and seasons. A total of 1, 867 benthic fauna were collected and identified into 6 phyla, 27 families and 60 species. All the species identify were represented in all the stations. Faunistic composition and abundance of benthic fauna showed that Family Bithyniidae has the highest percentage composition 60% (1120) followed by Lymnaelidae and Nuculoidae with 4% each. Chironmidae has 3% while others has 2 to 1%. Similarity ratio computed by Jaccard's similarities index (0.63) shows that the three stations has about 63% species similarities between them. The relationship between climatic variable and fauna in the CCA diagram shows only torant organisms on positive axis i.e. representative of Nematoda, Mollusca, Polifera and Annelida has affinity to variables while Crustacean and Arthropoda were senstive to environmental condition. The Shannon Weiner species diversity index is 0.96 which is quite high.

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KEYWORDS: Meteorological and hydrochemical parameters, Benthic Fauna, CCA.

INTRODUCTION

The potential impacts of climate variable and associated social and economic impacts are widely recognized as major threat to biodiversity. Climate change will affect aquatic systems by warming water temperatures, altering lake patterns, and increasing storm events. These changes are expected to have profound effects on the distribution and phenology of species and the productivity of aquatic ecosystems (Alaku, 1991; Poff, *et al*., 2002; Hulme, 2005; Parmesan, 2006).

Lakes are stagnant water body with unique faunal compositions. Organisms living in such habitats are known to show some morphological differences from those found in flowing water bodies (Vadeboncoeur *et al.*, 2002). The quality of any water body is determined by the physical, chemical and biological factors which are the factors that influence the beneficial use of the water (Boyd, 1979; Idowu, 2004). Therefore, the availability and the good quality of organisms to be produced by any water body depend on the good water quality (Adebisi, 1989). The quality of water also affects abundance of species composition, diversity, stability, productivity and other physical condition of the indigenous population and the best water to be used for organism production.

The community of organisms that lives on, or in the bottom of a water body is known as "benthos". This word was introduced by the eminent German naturalist and artist Ernst Hackel (1834 – 1919) who also introduced the term "ecology". The benthic community is complex. It includes a wide range of organism from bacterial to plants (Phytobenthos) and animals (zoobenthos) and from the different levels of the food web (Barnes, 1994). Benthic animals are generally classified according to size; microbenthos <0.063mm, meiobenthos 0.063 – 1.0mm, macrobenthos > 1.0mm and sometimes megabenthos > 10.0mm (Rumohr, 1990). This exercise considers benthic animals (fauna), well-known groups of benthic animals are worms such as polychaetes and oligochaetes, molluscs such as bivalve and gastropoda, and crustaceans such as amphipods and decapods (Meador, 1993).

MATERIALS AND METHODS

The Study Area: Jabi Lake is located between the Jabi and Kado Districts of Abuja, within the Federal Capital Territory of Nigeria. It lies between Latitude 9°4'38"N and Longitude 7°25'18"E at an altitude of 480 meters above sea level. The lake is a man-made lake which, on the daily basis, witnesses a variety of human activities such as fishing, swimming, bathing and washing as well as sporting and recreational activities. Its amazing sites alongside its green vegetation make the natural environment to be comfortable for relaxation and other social activities. The lake is a multidirectional water body with shrubs and shady trees which provides canopy-like cover for other organisms in some parts of the lake. The vegetation comprises of fringing, floating, submerged and emergent plants. There are also some water hyacinth (evasive weeds) in some parts of the lake. Three stations chosen for this study were:

Station 1 is characterized by fishing, selling of wares and recreational activities while station 2 is dominated by washing of cars and clothes and station 3 has the least anthropogenic activity of the three stations; it is surrounded by thick vegetation consisting of both submerged and emergent macrophytes with the runoff from surrounding emptying into this station.

Methodology: Meteorological parameters were studied and recorded between the hours of 7.00am to 9.00am insitu, benthic sediment samples were collected by means of semi-scoop net. Sampling was carried out fortnightly and spanned between November, 2016 and June, 2017. Sediment samples for benthic fauna composition and abundance were collected from each sampling station using semi-scoop net and washed through a 5 steps sieve layer ranging from 2.5 mm – 0.5 mm (2.5 mm, 2 mm, 1.5 mm, 1 mm and 0.5 mm) sieve mesh at field. Sorted samples were emptied into separate 500ml jar bottle and preserved with 70% ethanol before taken to the laboratory for further analysis. Identification to the lowest possible taxonomic level was done using identification keys.

Sampling procedures

Table 1: Characteristics of sampling stations and their coordinates

Station	Predominant activity	Coordinates		Elevation (masl)
		Latitude	Longitude	
1	Fishing and Recreation	007^0 25’ 05.1”	09^0 04’ 25.6”	448
2	Washing of cars and clothes	007^0 25’ 11.9”	09^0 04’ 34.5”	448
3	Waste receptacle	007^0 25’ 08.4"	09^0 04’ 39.0”	450

The table 1 shows the coordinates of sampling points in the lake. This was achieved through Geographical Positioning System (GPS) device, (GPS 45 XL).

The hand-held device was switched on at each station, the Latitude and longitude of each station was displayed on the device dial and recorded. The elevation (altitude) above sea level also recorded.

Atmospheric Temperature: Ambient temperature was measured by raising an in-built temperature and humidity meter AR837 probe in-between eye level at each station, at a height of approximately two meters from ground level, as also suspected by Verere and Oluwagbenga, 2015.

Rainfall: The average monthly historical rainfall data from 1997 to 2016 was collected from Nigeria Metrological Agency (NIMET), Abuja.

Relative Humidity: Relative humidity was measured with the same device used for temperature as described above.

Wind Speed: Wind speed was measured and recorded using digital anemometer AM 4202. The device was held out in-between eye level at each station for 3-5minute of stable figure before taken the reading.

NIMET Data: Historical data (Temperature, Rainfall, Relative humidity and Wind speed) from 1997 to 2016 were collected from Nigeria Metrological Agency to compare changes in climate factors.

Statistical Analysis

The Meteorological parameters and benthic fauna percentage abundance were subjected to SPSS, Canonical Component Analysis (CCA) and Pearson correlation analysis.

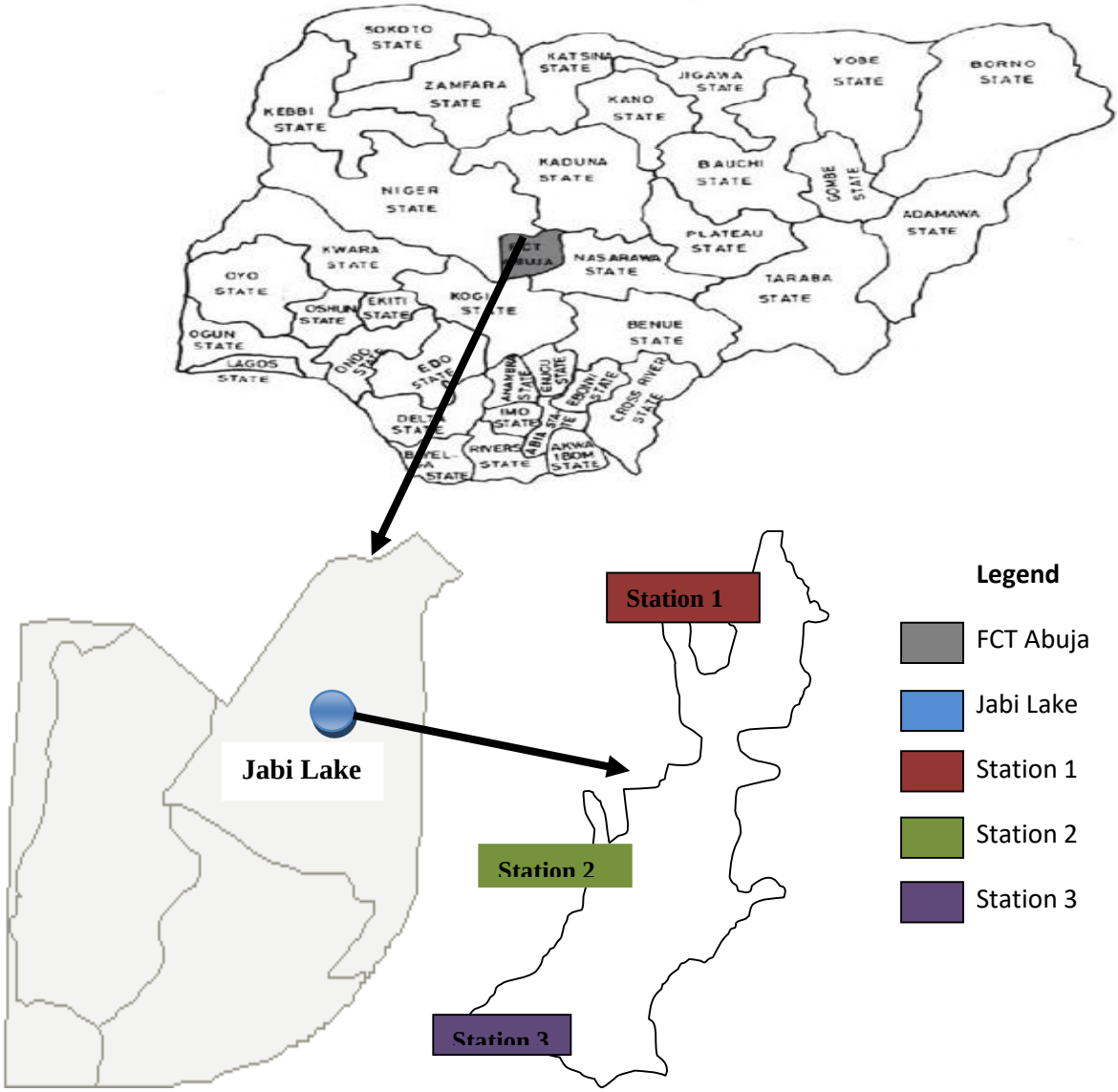


Fig.1: Map of Nigeria Showing the Federal Capital Territory (FCT) Abuja and the sampling stations at Jabi Lake. Source: FMEnv & field work, 2017.

RESULTS

Atmospheric Temperature

The result of the monthly means atmospheric temperature is shown in fig 2. The temperature value recorded in the present study range from 18.40 to 32.10^{0}C. The highest means temperature of 32.10±0.64^{0}C was recorded in April at station 2 followed by station 3 (31.10±1.41^{0}C) in May while the least temperature of 18.70±0.42^{0}C was recorded in the month of January. The pooled mean value for April 31.40±0.68, has the highest temperature and significantly different (P<0.05) from other months. Pooled means values for March and May varied from 27.97±1.46 to 28.72±0.38 which were not significantly different (P>0.05) but significantly different (P<0.05) from other months. The pooled mean values observed among the stations range from 24.65±0.44 to 25.36±0.56 shows no significant different (P>0.05).

The temperature of the previous years, (20 years) 1997-2016 shows that the minimum temperature of 14.20^{0}C was reported in December, 2007 while the highest temperature of 38.10^{0}C recorded in March, 1998 and 2007 at the same month (fig. 3&4).

Rainfall

The total monthly rainfall pattern for FCT Abuja during the sampling period through Minna weather station which is 260 m.a.s.l and 122.0 km away from Abuja is shown in fig. 5. Precipitation started late March, 2017 and gradually increasing till the end of the research period (June, 2017), although, the peak of the rainfall was August. There was no precipitation from November, 2016 (beginning of the study) to February, 2017.

The 20 years historical data shows that Rainfall was very minimal (negligible) in the month of January, February, November and December across the years (1997-2006 from NIMET) except 2009 in January that has 112.2mm rainfall. The NIMET report (fig. 6) also shows that August has highest rainfall of 513.8mm in year 2008.

Relative Humidity (RH)

The result of the monthly mean of relative humidity is shown in fig 7. The RH mean value recorded in the present study range from 22.00 to 72.20%. The highest mean RH of 72.20±0.07% was recorded in June at station 1 followed by station 2 (71.00±0.12%) while the least RH of 22.25±0.07% was recorded in the month of March at station 2. The pooled mean value shows that June and May has the highest RH follow by April. There was significance different ($P<0.05$) in the pooled mean value in all the months. Station 1 with 38.64±1.11% were not different from station 2 with 38.84±1.71 ($P>0.05$) but the two stations were significantly different from station 3 which has 40.19±2.83% ($P<0.05$).

NIMET report (1997-2016) shows that 2008 has low relative humidity compared to other years in Fig 8. The highest relative humidity was reported in August, 2012.

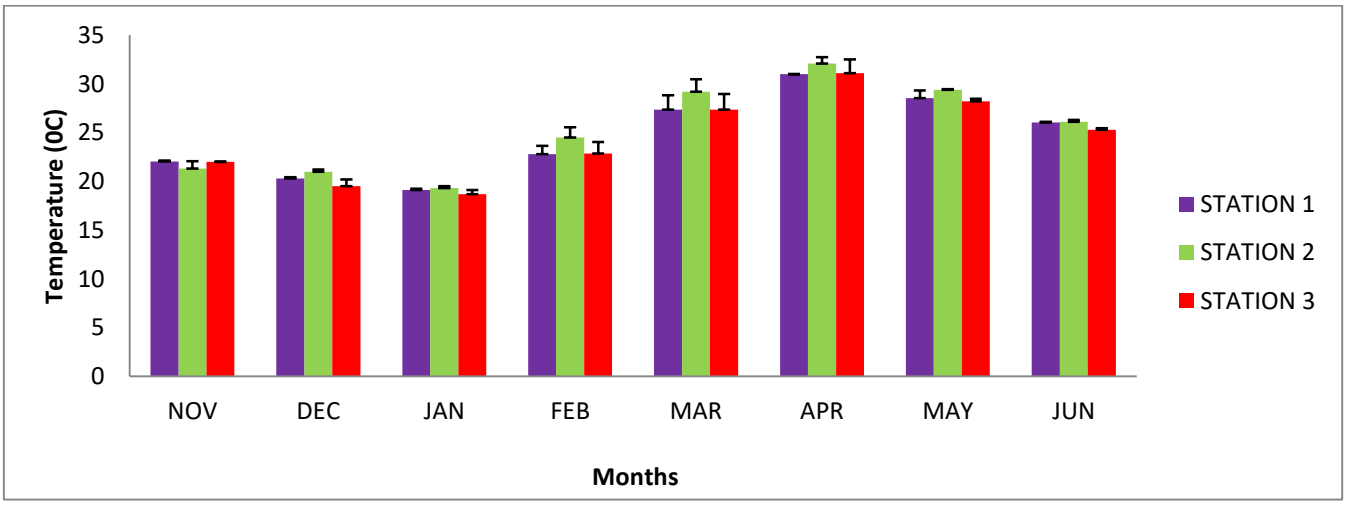


Fig. 2: The Monthly Means of Atmospheric Temperature (^{0}C) in relation to stations in Jabi Lake

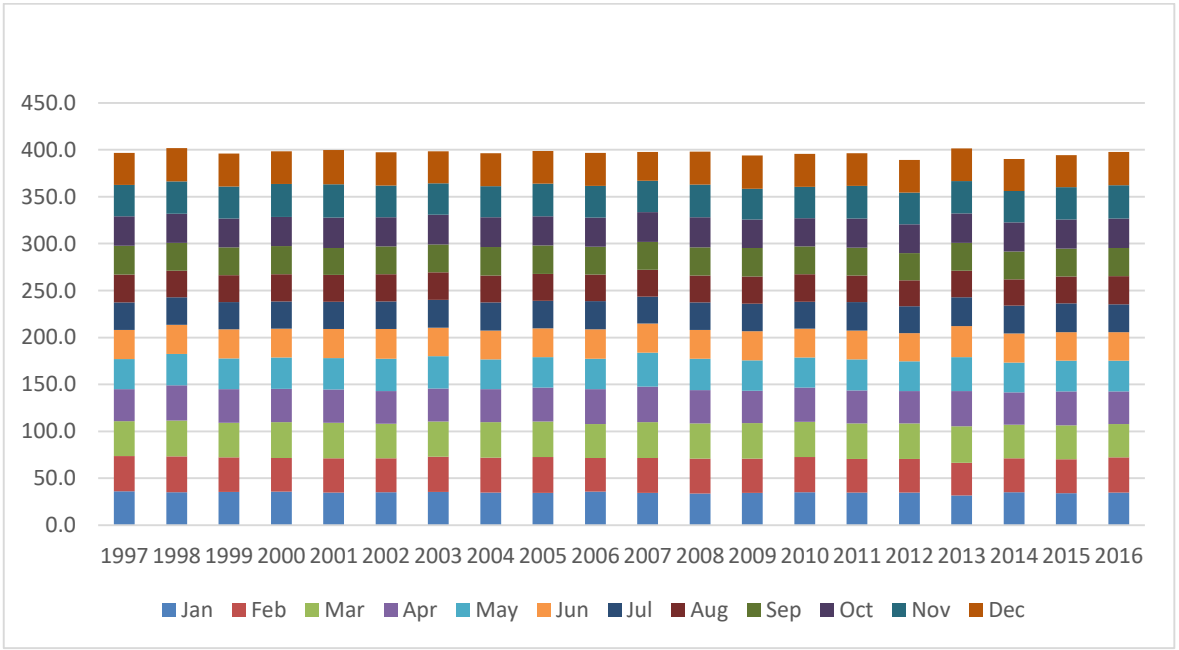


Fig. 3: The Monthly/Annual Maximum Atmospheric Temperature (^{0}C) of Abuja (1997-2016)
Source: NIMET

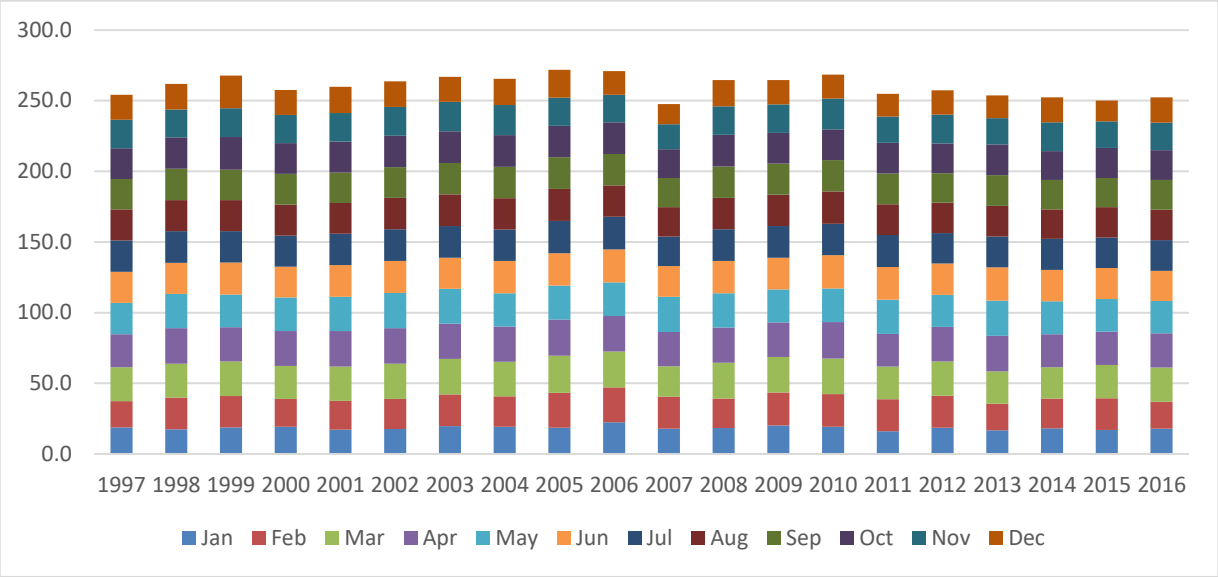
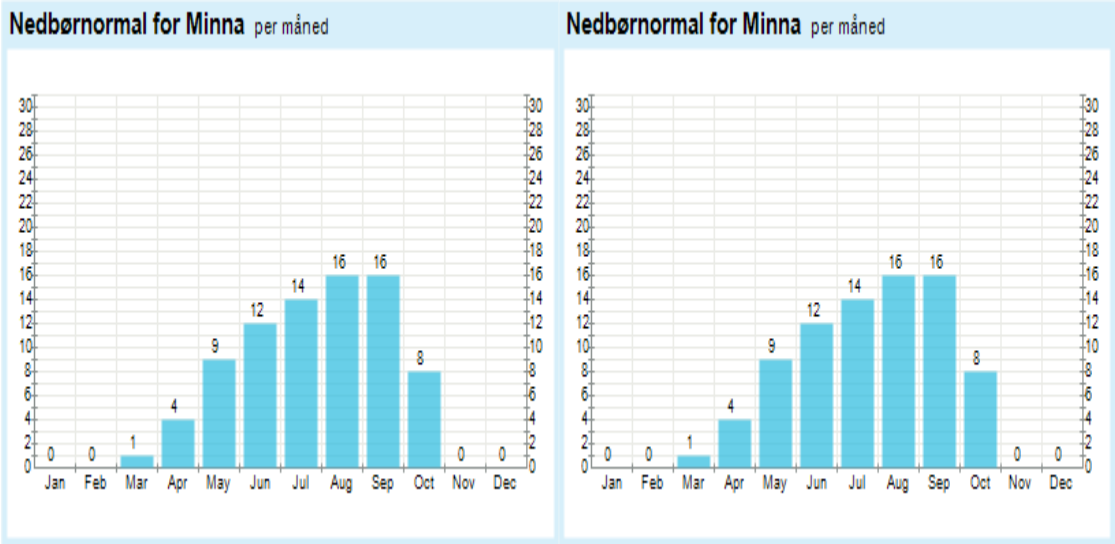


Fig. 4: The Monthly/Annual Minimum Atmospheric Temperature (^{0}C) of Abuja (1997-2016)
Source: NIMET



2016 **2017**

Fig. 5: Total Monthly/Annual Rainfall Pattern for FCT Abuja (2016 & 2017)
Minna weather station: 260m.a.s.l.
122.0 km away from Abuja
Source: NIMET

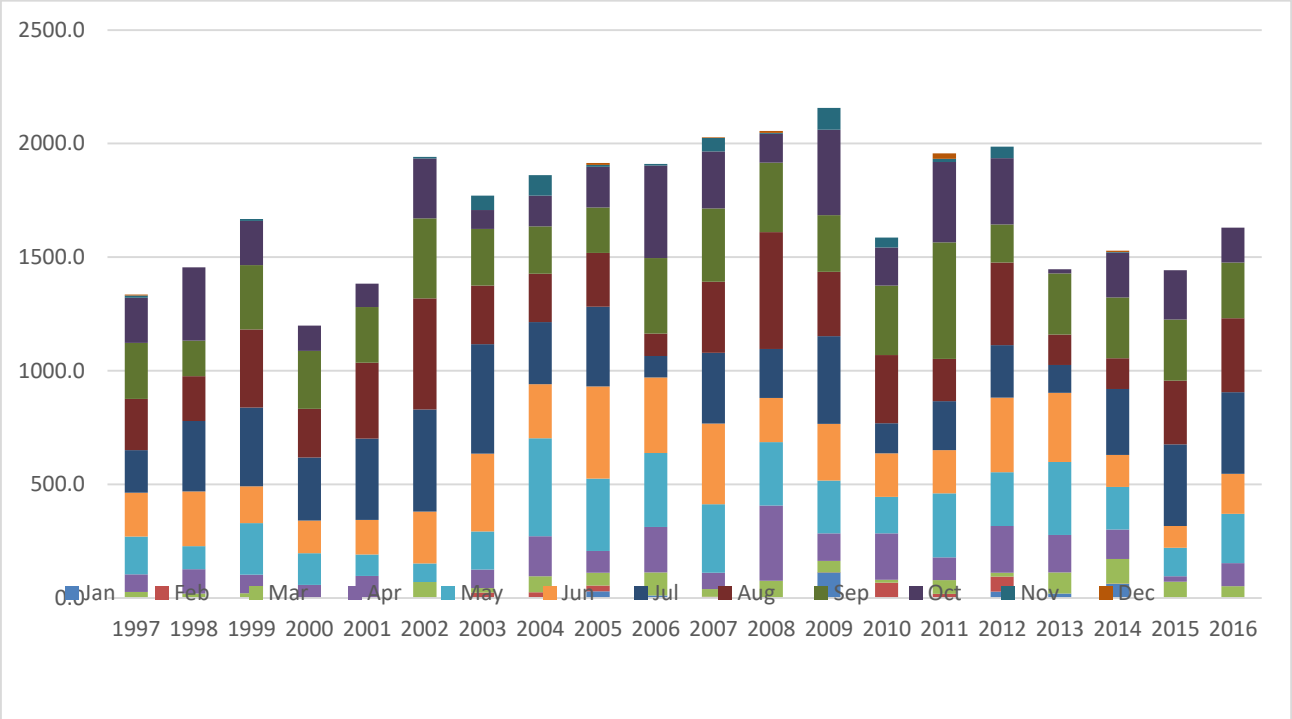


Figure 6: Total Monthly/Annual Rainfall Pattern for FCT Abuja (1997-2016)
Source: NIMET

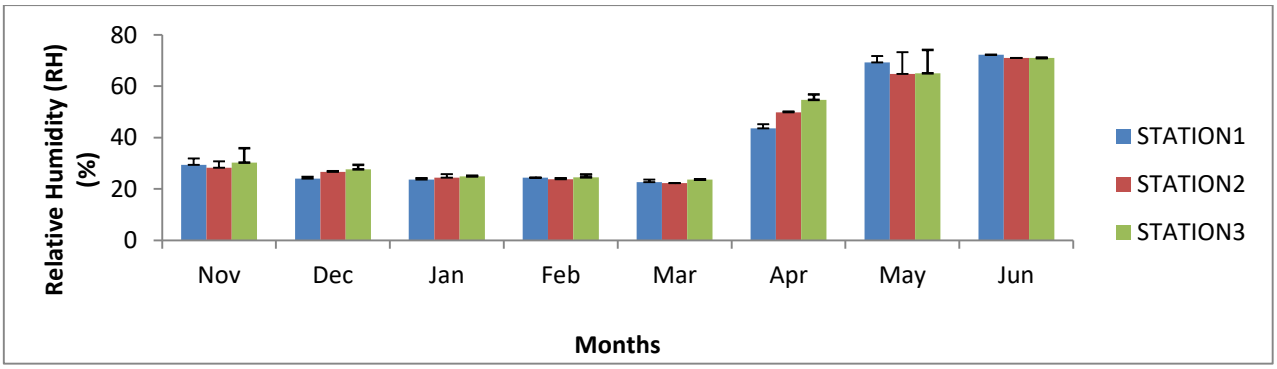


Fig. 7: The Monthly Means of Relative humidity (%) in relation to stations in Jabi Lake

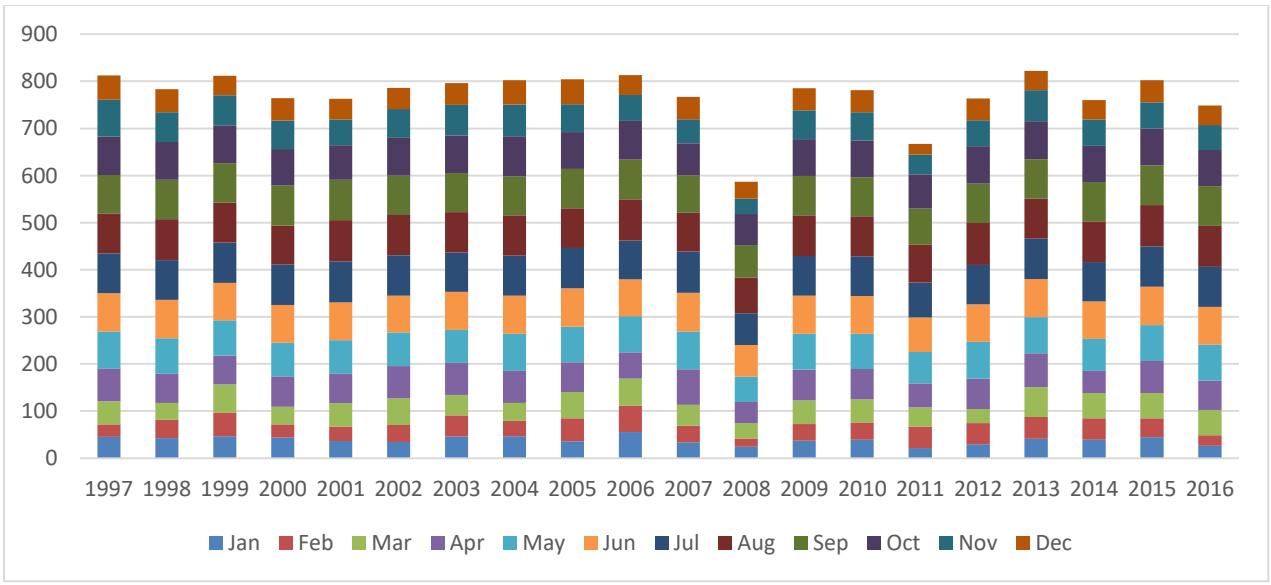


Fig. 8: Monthly/Annual Relative humidity of Abuja (1997-2016)
Source: NIMET

Wind speed

Monthly mean of wind speed observed is shown in fig 9. The wind speed value ranged from 0.40 to 3.40m/s with the highest of 3.20±0.28m/s in December at station 2 followed by station 1 with the value of 2.85±0.07m/s while the least wind speed of 0.40±0.40m/s was recorded in the month of May at station 3. The pooled mean value shows that November to January was significantly different (P<0.05) from other months. NIMET data has highest wind speed in August, 2005 (7knot) which is contrary to the present finding (fig. 10).

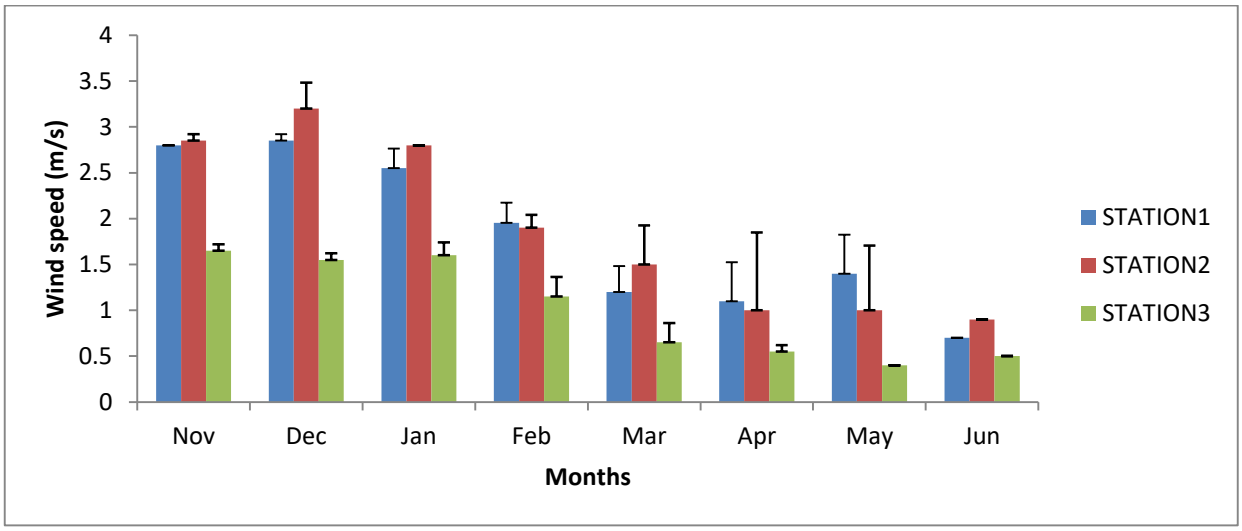


Fig 9: The monthly means of Wind Speed (m/s) for Jabi Lake

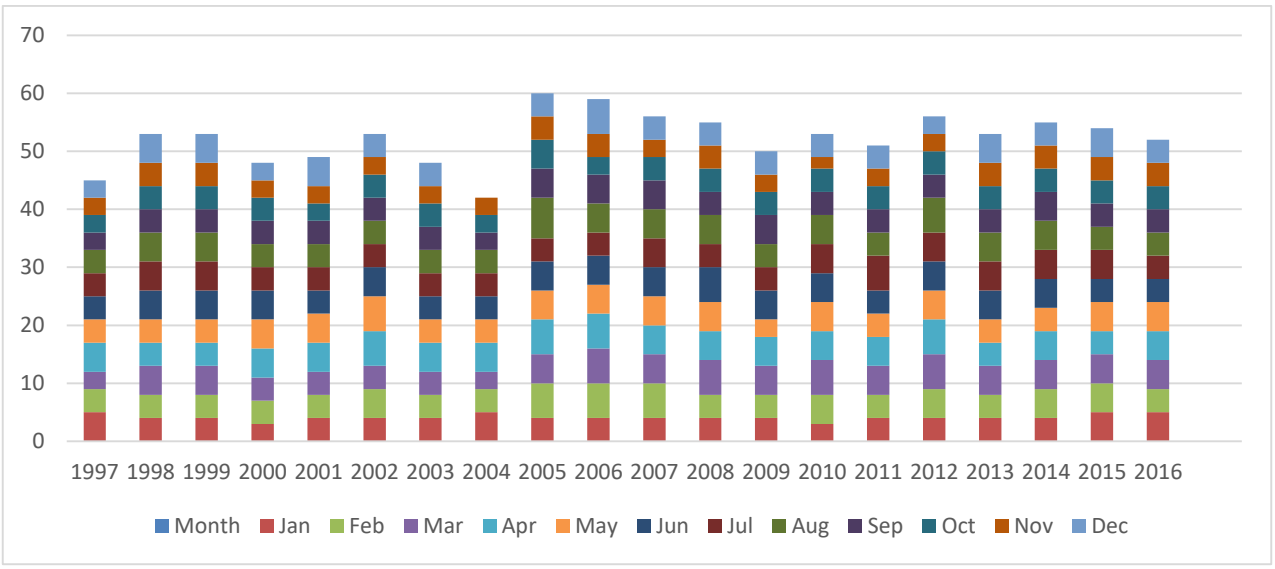


Fig. 10: Average Monthly/Annual wind speed of Abuja (1997-2016)
Source: NIMET.

4.18 Benthic Fauna Distribution

The samples collected from the three stations were made up of 6 phyla. 27 families and 60 species (Table 2). The total number of species encounter at station 1 throughout the sampling period was 720, station 2 was 622 and station 3 was 525. The total number of species sampled was 1, 867.

The most Abundant family in term of species was Candonidae (7 species), followed by Chiromidae and Naididae that has 4 species each. Unionoidae and Libellulidae has 3 species each. Majority of the families sampled has 2 species (Lymnaiidae, Viviparidae, Valvatidae, Hydrobiidae, Dreissenidae, Nuculoidae, Cordulegastridae, Simullidae, Aeshnidae, Culicidae, Pisaurudae, Spongillidae, Lumbriciidae and Tubificidae) while the remaining families are all having 1 species each.

The Phylum Mollusca, class Gastropoda and Bivalvia predominant the group in percentage composition and number. Family Bithyniidae has the highest percentage composition of 60% (1120), followed by Lymnaeelidae and Nuculoidae with 4% each. Chironmidae has 3% while others has 2%, 1% and 0%.

Similarity ratio computed by Jaccard's similarity index (0.63) shows that the three (3) stations has about 63% species similarity between them. The Shannon weiner species diversity index is 0.96 which is quite high.
The table 2 shows the Pearson correlation (r) between benthic fauna family and physico chemical parameters. Result shows that pearson correlation were negative against sampled variables therefore, the p- value were not Significant at $p<0.05$.

Table 2: Total number, percentage composition and species richness of benthic fauna collected in relation to station in Jabi Lake

S/N	Benthos class	Station1	Station2	Station3	Total all Stations	Percentage composition (%)
1.	Mollusca	**539**	**467**	**340**	1346	72.1
2.	Arthropoda	**75**	**66**	**83**	224	12.0
3.	Porifera	**2**	**13**	**13**	28	1.5
4.	Annelida	**63**	**36**	**50**	149	8.0
5.	Nematoda	**5**	**10**	**6**	21	1.1
6.	Crustacean	**36**	**30**	**33**	99	5.3
	Total	720	622	525	1867	100.0
	Percentage / Station	38.6	33.3	28.1	100	
	Margalef evenness Index (D)	0.76	0.78	0.80	0.66	
	Jaccard Similarity Index (Cj)	0.5				
	Shanon-Weiner Species diversity (H')	0.87	0.91	1.11	0.96	

Canonical Correspondence Analysis (CCA)
The relationship between climatic variable and fauna in the CCA diagram shows only torant organisms on positive axis i.e. representative of Nematoda, Mollusca, Polifera and Annelida has affinity to variables while Crustacean and Arthropoda were senstive to environmental condition.

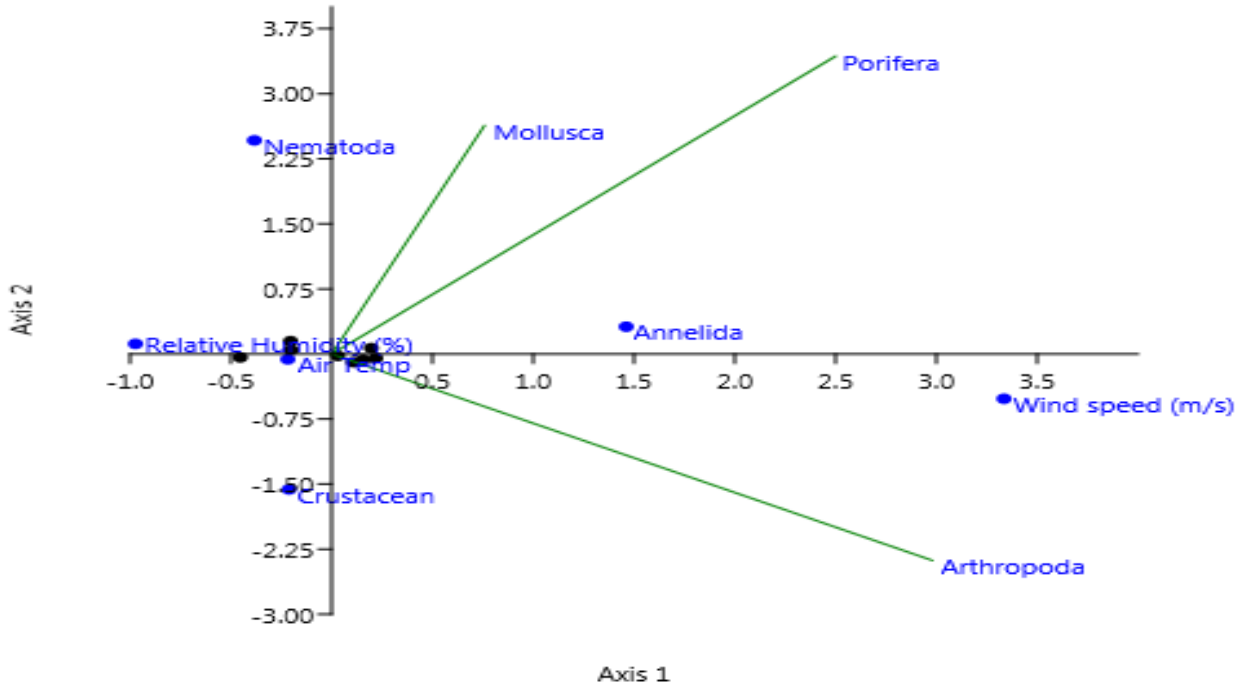


Fig. 11: Canonical Corresponded Analysis (CCA) for Benthic fauna family and Meteorological variables (Air Temperature, Wind speed & Relative humidty) at Jabi Lake.

DISCUSSION

The climate parameters and benthic fauna community in Jabi Lake varied with season and stations. Climate has long been known to explain considerable in distribution pattern of benthic species and that of species richness (Mbagwu, 1989). Benthic organisms' responds in term of abundance and richness were significantly different in the harmattan, dry and rainy period (November to June) in all the three stations. Although, some organisms abundance was higher in the rainy season. It is likely that the hydro period which gives organisms more opportunity to colonize different habitats contributes to the differences observed during the three seasons. The cooler and wetter environment may simply be a more suitable environment for a greater number of benthic species.

An increase in temperature will probably further decrease breeding in the hot months but increases breeding in the rainy season months of major benthic fauna. This also accounts for the low density recorded in the hot dry season for family Bithyniidae and Lymnaeiidae. The diversity and similarities ratio calculated using Jaccard and Margalef indices varied slightly among the study stations. Benthos numbers can be influenced primarily by the amount of quality of food available, water quality and other factors that may affect number include biotic factor (Predator and competition) and chemical characteristics of soil (sediment) e.g. acidity, dissolved nutrient.

Temperature is the most important parameter that influence both biotic and abiotic component of any ecosystem. Timms (2001), suggested that climatic factors were the determining factors for decrease or increase in temperature in the arid zone. The highest air temperature recorded in the month of April (32.10 ± 0.636^0C) followed May (31.10 ± 1.414^0C) was as a result of prevalent of hot dry wind from Sahara desert which does not accompany with precipitation and also due to high latitude of the location. Minimum temperature of 22.05 ± 0.07 - 18.70 ± 0.424^0C was recorded in November to January which coincided with the harmattan season of the region. The average monthly maximum temperature for Abuja from 1997 – 2016 shows that March, 2013 has the highest temperature of 38.8^0C while least temperature of 14.2^0 was recorded in Dec. 2007. The temperature regimes in many tropical aquatic systems are higher in the dry season than during the rains (Wellcome, 1985; Olusanya, 1988). NIMET (2008) reported that most parts of the country showed evidence of long term temperature except Jos area that is slightly cooling. The extreme northeast, extreme northwest and extreme southwest had increases of 1.4^0C – 1.9^0C. Long term average temperature anomaly in the country indicates general increasing temperatures within a tolerance of $\pm0.5^0$C. Also, maximum temperatures during the hot season (February-March in the South; March-April in the North) in the Country are on the increase with the north central region having the highest warming rate of 2.5 – 3.0^0C per decade (NIMET, 2011). This was reflected in sample population of benthic fauna collected in the dry season as shown in table 18. In this period of extremes heat, most of benthic organism were killed by heat or eaten by other organism.

The highest mean RH of 72.20 ± 0.07% recorded in June reflects high concentration of water within the atmosphere confirms the relatively high rainfall amount experienced in the month (Rainy season) which is of course beneficial for many aquatic families e.g. Culicidae, Lumbriciidae and Tubificidae. The Month of March has the least RH of 22.25 ± 0.07% which reflects the Sahara nature of the study environs. In general, Relative humidity is high in the three stations during the wet season and decreases in the dry season. The average monthly relative humidity for Abuja 1997 – 2016 also confirmed high humidity at pick of precipitation in August with 88% recorded in 2006. The least RH of 18% was recorded on February, 2008.

The report of rainfall from NIMET between 1997 – 2016 also shows that August has highest average rainfall of 513.8mm in year 2008.

The wind speed data for the study area is as presented in fig 9 with highest mean wind speed of 3.20 ± 0.28m/s recorded in December. Harmattan period has high prevalent wind compare to rainy (0.40 ± 0.40m/s) season. However as obtains from the meteorological data, average monthly wind speed for Abuja from 1997 – 2016 fluctuated between 3 – 7 Knots (1Knot = 0.51m/s). This is contrary to what was obtained in southern part of the country, Benin City where wind speed is generally low with a record of wind speed range of 0.0 – $1.5ms^{-1}$ at all sampling sites round the seasons (Ukpebor *et al.*, 2006). Low wind speed reduces the ability of the atmosphere to disperse high dose of emitted gases e.g. CO, NO_2, SO_2 and various degree of particulate matters (Verere and Oluwagbenga, 2015). The dominant wind direction during the cause of fieldwork was –North-Easterly in the dry season and South-westerly in the wet season. Winds from the general directions of the north, that is, north-westerly, north-easterly and northerly usually comprise most of the wind run within the study area. The climate conditions of the study area are influenced by two wind systems; the south-westerly monsoon (SW) and the north-easterly (NE). The former (SW) is due to the influence of the moist Atlantic Ocean air mass while the latter (NE) comes from the Sahara desert which is dry and cold (harmattan).

The relationship between climatic variable and fauna in the CCA diagram shows only torant organisms on positive axis i.e. representative of Nematoda, Mollusca, Polifera and Annelida has affinity to variables while Crustacean and Arthropoda were senstive to environmental condition. Many organisms specifically the indicators of good evironmental quality require high concentrations of certain variables such as temperature and dissolved oxygen for their survival (Bispo *et al.*, 2006). This situation was observed in this study, with a positive relationship between Nematoda, Mollusca, Polifera and Anneida to the climatic variables.

CONCLUSION

The Benthic fauna (macro invertebrate) abundance varied with the season which implies that the three climatic regimes (Dry, rainy and harmattan) had effects on their distribution and abundance. The species composition and abundance of the biological communities studied could be related to the prevailing abiotic factors in the aquatic ecosystem.

The influence of harmattan produced abrupt changes in some measured climate and physical – chemical parameters as well as biological community. This probably resulted from low night time air temperature, which reduced surface water temperature and to a lesser extent due to stronger wind speed prevailing at this time.

The biological communities studied (i.e. Botton dweller organisms) were affected by temperature, seasons and sampling stations through their species properties.

The variaties of some climatic parameters in three stations and the seasons showed similarities which may be interpreted as climatic variations, events in the Jabi Lake area, and possibly variations in the production rate of the Lake. It is difficult to designate a single factor as the sole agent responsible for marked seasonal changes in the biological component, it would appear that fluctuations in water depth, changes in nutrient concentration, atmospheric air temperature and the direct effect of rainfall are the most important factors, interacting to affect the seasonal patterns of the biological communities in Jabi Lake.

RECOMMENDATIONS

With considerable information on environmental factors obtained from this research work, the following recommendations are made:

- More research should be directed towards the study of species composition of the biotic communities in relation to their specific habitats in the Lake.
- Efforts should also be directed towards the study of benthic fauna in the lake. In doing so, a picture of dynamics of the lakes's components will provide broader understanding of the lake.
- It is also advisable that more research should be carried out by including more climatic variable like atmospheric air pressure, solar radiation etc.
- To maximize growth rates and economic returns of the Lake, optimum environmental requirements of all the biotic components must be presented in the water medium

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