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Original article

Benthic Macro Invertebrates as Potential Indicator of Water Quality in Ajiwa Reservoir Katsina State North Western Nigeria

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ABSTRACT

Benthic macro invertebrate's ability to indicate various types of anthropogenic stressors is widely recognized as an integral component of freshwater biomonitoring. In case of pollution, biodiversity of the aquatic community can be affected and the species composition changes from natural species to tolerant species. Study on the benthic macro invertebrates as potential indicator of water quality in Ajiwa reservoir, Katsina State was carried out from November, 2015 to October, 2016, in terms of physical and chemical parameters and biotic indices. For this purpose, macro benthic invertebrates and water samples were taken from five sampling location once monthly. Benthic macro invertebrate samples were collected with the aid of Ekman grab and was transferred into labelled plastic storage bottle and preserved with 70% ethanol prior to sorting and identification with the aid of standard keys. Physicochemical parameter were determined using standard methods, procedures and instruments. The results of identification and counting of the abundance of benthic macro invertebrate was used to determine some biotic indices (Biological Monitoring Working Party-BMWP and Average Score Per Taxon -ASPT) and diversity indices (Margalef, Simpson and Shannon and Weaver Diversity indices). Fifteen physicochemical parameters were determined. Some of their mean value were; Water Temperature (27.15±2.42°C), pH, (7.85±2.01), Free CO_2 (3.47±0.78mg/L), Turbidity (98.0±2.28NTU), TDS (85.68±2.71mg/L), Electrical Conductivity (158.55±3.04µS/cm), Total Hardness (72.16±2.37mg/L), DO (6.10±0.13mg/L), BOD (3.41±2.31mg/L), Calcium (64.34±1.35mg/L), Total alkalinity (96.27±3.09mg/L), COD (4.11±1.10mg/L), Magnesium (5.36±2.46mg/L), Phosphate (1.42±0.96mg/L) and Nitrate (2.07±1.13mg/L). Thirty five (35) different taxa belonging to twenty four (24) families from a total of 4550 individuals' organisms were recorded. The relative percentage composition of the major taxonomic groups to the overall macro benthic population at the different stations revealed that the study area was inhabited by the following order Oligochaete (40.28%), Molluscs (24.08%), Diptera (19.29%), Odonata (5.78%), Coleoptera (3.94%), Nematodes (3.38%) and Hemiptera (3.24%). BMWP had 57 scores; indicating moderately polluted water body in station 1 and 5 with abundance of pollution tolerant taxa such Chironomidae, Lymnaeidae, Tubificidae and Planorbidae which revealed the impact of anthropogenic activities at some sampling locations of the reservoir. It is therefore recommended that uncontrolled discharge of agrochemicals within the vicinity of the reservoir through irrigation and other anthropogenic activities such as cattle rearing, bush burning etc. should be controlled in order to curtail degradation of the aquatic biota over a period of time.

Keywords: Ajiwa reservoir, benthic macroinvertebrate, biotic indices, diversity indices, water quality

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INTRODUCTION

Benthic macro-invertebrates are integral part of aquatic ecosystem as they form the basis of the trophic level and any negative effects caused by pollution in the community structure can in turn affect trophic relationships [1]. Bio-survey involves collecting processing and analysing organisms to determine the health of the biological community in a water body [2]. The three most common biological organisms studied are fish, algae and macro-invertebrates [3].

Benthic macro invertebrate assemblages and distribution frequently change in response to pollution stress in predictable ways, hence their ability to indicate various types of anthropogenic stressors is widely recognized as an integral component of freshwater biomonitoring. In case of pollution, biodiversity of the aquatic community can be affected and the species composition changes from natural species to tolerant species [4]. Biological methods are valuable for determining natural and anthropogenic influences on water resources and habitats because biota respond to stresses from multiple spatial or time scales interactively ([5]; [6]). In addition, the use of aquatic organisms in ecological studies has proven more effective than environmental variables because the aquatic community integrates structural and functional characteristics and reflects the health of the studied water body ([7]; [8]). Among others, macro invertebrates are the most commonly used assemblages [9] because they integrate various desirable characteristics, such as ubiquity, different levels of tolerance to perturbations, and sampling cost-effectiveness ([7]; [10]).

Biotic indices are numeric expressions that classify water quality based on the ecological sensitivity of the taxa present and the richness of the taxa [11]. Many biotic indices have been established based on macroinvertebrates, because they occupy a central role in the aquatic ecosystem by participating in the decomposition of organic matter and by constituting the major food source for other aquatic invertebrates, fishes, and some birds [12]. Unification in classifying water reservoir and the use of a common biotic index are impossible due to the differing geographic distributions of macroinvertebrate species and bio typological differences among water bodies [13]. Therefore, researchers have used a variety of indices that have been mainly based on the Biological Monitoring Working Party (BMWP) index, they take into account the sensitivity or tolerance of species or group of species to pollution and assign them a value which gives an index of pollution for a site [14]. The Biological Monitoring Working Party (BMWP) is one of the procedures for measuring water quality using families of macro-invertebrates as biological indicators [2]. The method is based on the principle that different aquatic invertebrates have different tolerances

to pollutants. It identifies families of macro invertebrates of a water body independent of time, season or region in quality assessment studies and has been standardized by the International Organization for Standardization [15]. The average sensitivity of the families of the organisms present is known as the Average Score Per Taxon (ASPT) and can be determined by dividing the BMWP score by the number of taxa present. A high ASPT score is considered indicative of a clean site containing large numbers of high scoring taxa [16].
An important advantage of multimetric indices is that they are flexible and can easily be adjusted by adding or removing metrics or fine-tuning the metric scoring system [17]. Moreover, they allow objective classification of biological quality of sites belonging to different, natural, modified, artificial and variously degraded systems ([18]; [19]). Most interestingly, freshwater macro invertebrate species vary in sensitivity to organic pollution and, thus, their relative abundances have been used to make inferences about pollution loads. In natural pristine rivers, high diversity and richness of species could be found [20]. However, high impact due to human activities caused many changes to the assemblages and biodiversity of aquatic fauna ([21]; [22]). In view of the foregoing, this study aimed at assessing the water quality of Ajiwa reservoir using benthic macro-invertebrates as potential indicator.

MATERIALS AND METHODS

Study site

Ajiwa reservoir is located at Batagarawa Local Government Area of Katsina State on latitude
and longitude 12°54'69" - 12°57'58" N and 7°42'53" - 7°47'50" E (Figure1). It is in the Sudan savannah zone of Nigeria with two distinct seasons (wet and dry). The wet season period on the average last from May to Oct. and dry season from Nov. to April. The main purpose of the reservoir is irrigation and water supply to the people of Katsina, Batagarawa, Mashi, and Mani local government areas. The reservoir was constructed in 1973 and commissioned in 1975. Its major source of water is River Tagwai [23].

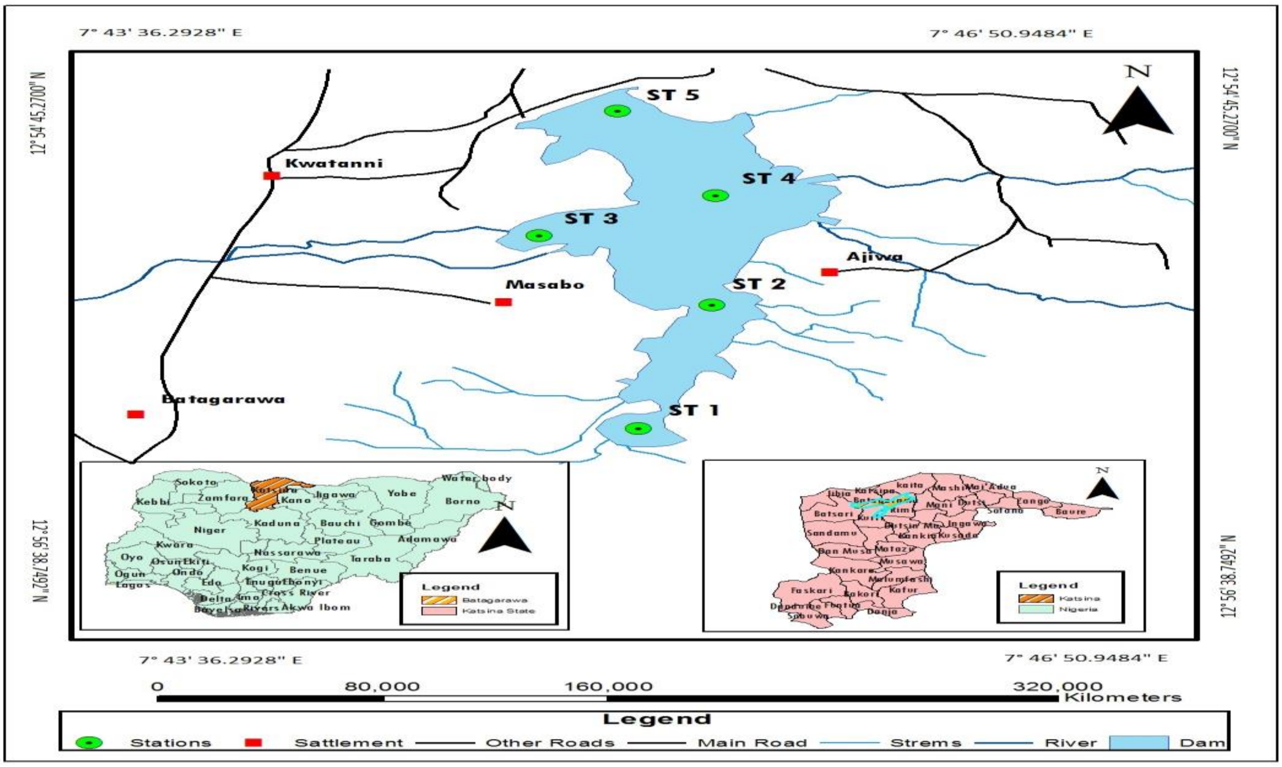

Figure 1: Map of Ajiwa reservoir Katsina state Nigeria, showing sampled stations. (Source: NASA/NOAA Spot Image 2014).

Sampling techniques

Physicochemical parameters

Water sample was collected from five different stations by dipping 1 litre plastic sampling bottle sliding over the surface of the water with their mouth against the water current to permit undisturbed passage of the water into the bottle. Parameters such as water temperature (WT), Turbidity, pH, dissolved oxygen (DO), total dissolved solids (TDS) and electrical conductivity (EC) were recorded immediately before sampling the benthic macroinvertebrates. Three replicates of selected physicochemical water quality parameters were measured. Water samples from each sampling station were stored in polyethylene bottles (500 mL).Total Hardness, Calcium, Total alkalinity, COD, Magnesium, Phosphate and Nitrate were determined in accordance with the standard method procedures [24].

Benthic macroinvertebrates sampling and identification

Sampling of macro benthic fauna was carried out monthly around 7:30am from each sampling stations using an Ekman grab from all the five sampling locations. At each station, three (3) grabs were taken, dredge materials and samples of the periphytic macrofauna on rocky substrates were collected and sieved with a set of Tyler sieves of 20cm diameter and mesh sizes of 2mm, 1mm, and 150µm respectively. The remaining benthic samples were washed through a sieve of 1mm x 1mm mesh size to collect the benthos. The residues were immediately transferred into labelled plastic storage bottle and preserved with 70% ethanol. In the laboratory, macroinvertebrates collected were poured into a white enamel tray and sorted out. The sorting was effective by adding moderate volume of distilled water into a container to improve visibility [25]. Large macro-invertebrates were picked out using forceps while the smaller ones were pipetted out. Sample was picked with the aid of a pair of forceps or a pipette as required. Dissecting and compound microscope was used for the identification of the specimens. The identification of the benthic macro invertebrates collected in the study were based mainly on the keys provided by [26]; [27]; [28]; [29]; [30]; [31]; [32]; [33]. Description of specimens of taxa was based on scale drawings, photographs and/or microphotography of parts. Fauna diversity of the macro benthic community was determined using diversity indices such as Magalef"s index (d), *Shannon-Weiner* index (H) and Evenness (E). To assess the ecological health status of the reservoir each family of macro invertebrate was allocated some biotic indices (Biological Monitoring Working Party-BMWP and Average Score Per Taxon -ASPT) as adopted by [35] and [36]. The BMWP system considers the sensitivity of invertebrates to pollution and families are assigned a score between 1 and 10 accordingly. The BMWP Score is the sum of the values for all families present in the sample. In general, a reservoir with good water quality has a BMWP score of 100 [37]. ASPT was calculated as ASPT = BMWP Score/Number of scoring taxa. A high ASPT was considered indicative of a clean site containing large numbers of high scoring taxa. The BMWP scoring system was based on sensitivity/tolerance of macro invertebrate to pollution in aquatic ecosystem. The higher the BMWP score the cleaner the water as indicated in Table 1.

Table 1: BMWP Classes, Scores, Categories and Interpretation of the Result

Class	BMWP score	Category	Interpretation
I	>150	Good	Very clean water
	101-150		clean or not significantly altered
II	61-100	Acceptable	Clean but slightly impacted
III	36-60	Questionable	Moderately impacted
IV	15-35	Critical	Polluted or impacted
V	<15	Very critical	Heavily polluted

Source: [38]

Data Analysis

Analysis of Variance was conducted using SPSS software (20.0 version) to test the significant difference of macro-invertebrates between the five sampled locations. Shannon and Weiner index (H); Evenness Index (E) and Margalef's index (d) were used to assess the macro-invertebrates diversity in the water body.

Shannon Index (H) = -Σ1ln pi ln pi

Where pi = the proportion of the ith species in the sample - i.e. number of individual species divided by total number of samples; H = the Shannon – wiener` index of diversity;

Evenness Index = E = $H\ HMax$

Hmax = Maximum diversity.

Margalef's index (d) measures species richness and diversity in the community structure. It was calculated as follows: d = $S{-}1In\ N$ Where d = species richness index, S = Number of species population, N= Total number of individual species ([39]; [40]).

RESULTS

Physicochemical parameters

The results of physicochemical parameters variables measured at the five stations are presented in Table 2.

The mean variations in water temperature of Ajiwa reservoir for all stations ranged between 23.42 ± 5.78℃ to 28.25 ± 4.16℃ during the study period. The result shows that there was a drop of temperature in station 2 (23.42 ± 5.78℃) while station 3 has the highest temperature (28.25 ± 4.16℃).

The lowest mean conductance of 135.03 ± 5.41µS/cm was recorded in station 3 and it progressively built up 189.36 ± 4.22µS/cm in stations 5.

DO fluctuated between mean values of 5.84 ± 0.37mg/l to 6.94 ± 0.12mg/l throughout the study period. Mean range value of calcium ion concentration was found to range from 58.14 ± 2.09mg/l to 71.31 ± 2.03mg/l. Mean values of Nitrate nitrogen in Ajiwa reservoir fluctuated throughout the period of study and ranged from 1.64 ± 0.11mg/l to 2.53 ± 0.46 mg/l.

Table 2. Mean values of the physicochemical variable per stations in Ajiwa reservoir (November, 2015 to October, 2016)

Station/ Parameters	ST1	ST2	ST3	ST4	ST5	p-value
WT (°C)	27.32±4.31	26.42±4.33	28.25±4.16	23.42±5.78	26.53±2.38	0.639
pH	5.97±0.29	6.14±0.41	6.95±2.39	7.26±3.16	6.83±4.02	0.081
CO_2	4.35±0.28	5.28±0.44	5. 86±2.47	4.32±1.33	3.47±0.78	0.531
Turbid(NTU)	35.33±1.29	28.41±0.23	24.97±3.22	32.83±4.39	48.76±3.92	0.374
TDS (mg/L)	96.84±0.43	89.38±0.36	77.37±3.42	82.18±4.42	93.24±2.07	0.000
EC (µS/cm)	156.13±3.27	150.14±1.76	135.03±5.41	168.44±3.67	189.36±4.22	0.002
T/Hard (mg/L)	78.23±1.49	66.13±0.33	62.39±3.29	70.38±2.40	84.37±3.18	0.356
DO (mg/L)	6.94±0.12	6.38±0.51	5.84±0.37	6.23±2.42	6.75±1.30	0.65
BOD (mg/L)	3.63±0.40	3.20±1.68	2.99±2.45	3.09±3.59	3.41±2.08	0.217
Ca (mg/L)	64.07±1.47	58.14±2.09	60.19±3.44	68.21±0.39	71.31±2.03	0.000
T/alkal (mg/L)	95.84±0.43	91.38±0.33	84.67±3.26	89.68± 2.42	98.02± 2.03	0.002
COD (mg/L)	4.11±1.03	4.24±1.46	4.07±3.03	4.38±0.67	4.61±0.39	0.324
Mg (mg/L)	5.34±1.33	5.08±2.49	4.99±1.47	5.22±0.43	5.54±2.11	0.002
PO_4-P (mg/L)	1.64±0.49	1.50±2.13	1.02±2.03	1.48±0.68	1.98±3.56	0.000
NO_3-N	2.41±3.20	2.38±0.29	1.64±0.11	1. 99±4.48	2.53±0.46	0.002

Biological results

In this study, 30 taxa comprising 4,120 individuals belonging to 19 families were collected in total as shown in Table 3. The most individuals were collected at station 5, while the fewest individuals were collected at station 3. The individuals collected from the stations belonged to Chironomidae (4 taxa), Lymmnidae and Dystiscidae (3 taxa each), Hydrophilidae, Baetidae, Planorbidae and Naididae (2 taxa each), Haploimidae, Dorylaimidae, Diplogasteridae, Lumbriculidae, Thiaridae, Culicidae, Tubificidae, Hirudinidae, Simuliidae, Corixidae, Nemouridae and Gomphidae (1 taxon each). Distributions and dominancy (%), along with a list of the recorded macroinvertebrate taxa, are given in Table 3. Station 5 shows the highest dominancy with 35.9% while station 3 shows the least dominancy with 5.6%.

BMWP and ASPT indices were applied for determining biological water quality. Score values of biotic indices and water quality classes are shown in Table 3. Results from the study shows BMWP indices as 57 score and ASPT as 3.0. Shannon–Wiener and Simpson diversity indices were calculated for each station to examine whether there was diversity of the macroinvertebrate species. Both indices showed that the lowest diversity was seen at the second station and the highest diversity was found at the fourth and fifth stations (Table 3).

The overall macro-invertebrates composition and abundance recorded at the sampling sites are presented in Table 3. Arthropoda was represented by Gomphidae (Dragon fly), Nemouridae (stone fly), Dystiscidae, Corixidae (water bugs), Baetidae (May fly), Hydrophilidae (water beetle), Simuliidae (black fly) and Chironomidae (Midges). Annelida was represented by Hirudinidae, Tubificidae and Culicidae. Mollusca was represented with Planorbidae, Lymnaeidae and Thiaridae. Oligochaeta Was represented with Naididae, Lumbriculidae, Diplogasteridae, Dorylaimidae and Haploimidae. Figure 2 revealed the percentage frequency of the identified macro-invertebtrates and the increasing dominance of benthic macro-invertebrates fauna family follows the order: Chironomidae (13.81%) > Dystiscidae (11.94%) > Baetidae (7.94%) > Hydrophilidae (6.07%) > Naididae (5.89%) > Lumbriculidae (5.72%) > Planorbidae (5.65%) > Thiaridae (5.41%) > Nemouridae (5.36%) > Gomphidae (5.34%) > Culicidae (5.15%) > Simuliidae (4.76%) > Corixidae (4.37%) > Lymnaeidae (4.13%) > Tubificidae (2.4%) > Hirudinidae (2.26%) > Haploimidae (1.56%) > Dorylaimidae (1.55%) and Diplogasteridae (0.58%).

Seasonal variation indicated that wet season (May– October) had the highest number of macroinvertebrates identified of 2755 individuals representing 66.9% compared to dry season (November -April) with 1365 (33.1%) which showed significant difference between the two seasons at p = 0.05 (Table 4).

Table 3: Benthic Macro-invertebrates Species Composition, Abundance and Distribution in Ajiwa Reservoir (November, 2015 to October, 2016)

Macro-invertebrates Taxa/Station (St.)	BMWP Score	St.1	St.2	St.3	St.4	St.5	Total
Arthropoda							
Family: Gomphidae (Dragon fly)							
Stylurus sp	8	37	29	14	46	94	220
Family: Nemouridae (stone fly)							
Neoperla sp	7	23	44	8	74	62	221
Family: Dystiscidae							
Agabetes sp	3	97	36	21	63	59	276
Acilus sulcatus	5	26	15	6	32	58	137
Dyticus marginalis	5	12	7	2	22	36	79
Family: Corixidae (water bugs)							
Hespercorixa sp	3	34	12	4	58	72	180
Family: Baetidae (May fly)							
Baetis sp	4	23	14	9	43	94	183
Ameletus sp	4	19	28	5	39	53	144
Family: Hydrophilidae (water beetle)							
Hydrobius sp	3	24	16	8	36	49	133
Amphiops gibbon	5	24	13	6	12	45	117
Family: Simuliidae (black fly)							
Simulium sp	5	42	20	14	52	68	196
Family: Chironomidae (Midges)							
Chironomus fractilobus	2	78	49	22	48	104	301
Tanytarsus sp	2	36	28	18	22	44	148
Polypedilum pedestre	4	18	10	4	6	26	64
Tanypus sp	4	32	8	0	0	16	56
Annelida							
Family: Hirudinidae							
Hirudo medicinalis	3	22	13	8	14	36	93

Family: Tubificidae							
Tubifex tubifex	1	18	9	2	26	44	99
Family Culicidae							
Culex richeti	4	64	36	12	48	52	212
Mollusca							
Family: Planorbidae							
Bulinus globosus	3	23	6	2	31	42	104
Bulinus rohlfsi	3	18	11	6	38	56	129
Family: Lymnaeidae							
Lymanea stagnalis	3	13	8	3	26	34	84
Anodonta anatine	3	9	0	0	12	26	42
Pila ovate	3	16	2	4	8	14	44
Family: Thiaridae							
Melonoides tuberculate	3	62	41	16	23	81	223
Oligochaeta							
Family Naididae							
Nais sp	1	48	36	13	17	64	177
Aulophorus vagus	1	12	18	0	0	36	66
Family Lumbriculidae							
Lumbricula sp	1	44	62	18	52	60	236
Family Diplogasteridae							
Diplogaster sp	1	14	2	0	0	8	24
Family Dorylaimidae							
Dorylaimus stagnalis	1	12	26	2	4	20	64
Family Haploimidae							
Haplolaimus sp	1	14	6	2	19	27	68
No. of family	57	19	19	19	19	19	
ASPT		3	3	3	3	3	
No. of individuals		907	612	232	889	1480	**4120**
% of individuals		22.00%	14.90%	5.50%	21.60%	35.90%	
Shannon-diversity (H)		0.88	0.83	0.99	0.86	1.39	
Evenness (E)		0.79	0.76	0.83	0.77	0.78	
Margalef's index (d)		2.31	2.29	2.51	2.47	2.32	

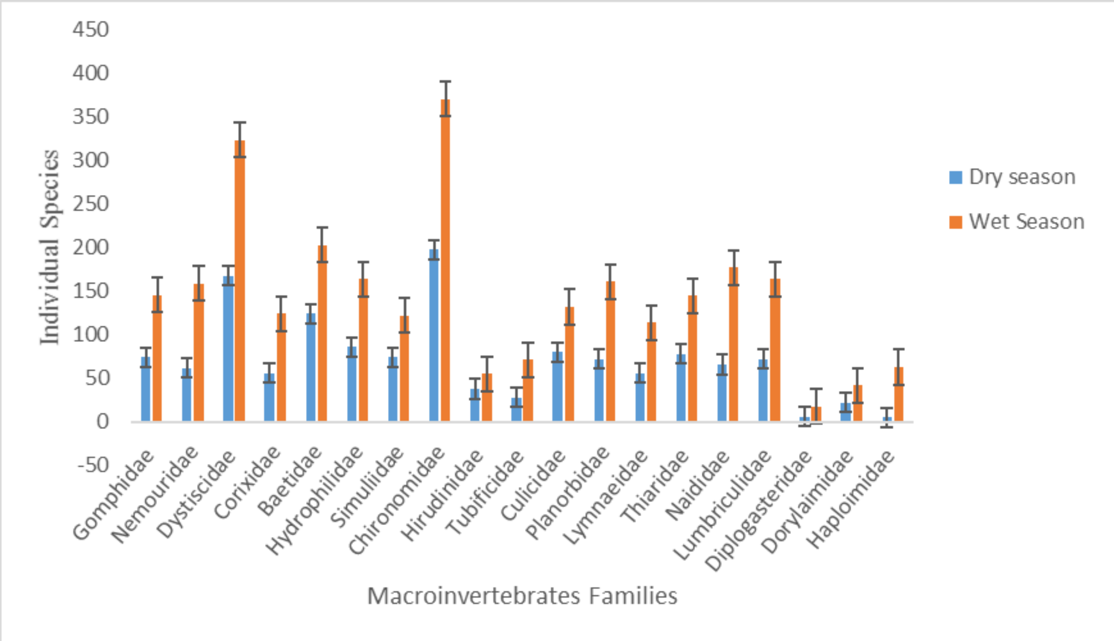

Figure 2: Seasonal Variation of Macroinvertebrate abundance in Ajiwa Reservoir, Katsina State Nigeria.

Table 4: Seasonal Comparism of Macroinvertebrate Family Identified from the Sampling stations in Ajiwa reservoir

Macroinvertebtrates taxa	BMWP Score	Dry season	Wet Season	Total	%
Arthropoda					
Family: Gomphidae (Dragon fly)	8	74	146	220	5.34
Family: Nemouridae (stone fly)	7	62	159	221	5.36
Family: Dystiscidae	3	168	324	492	11.94
Family: Corixidae (water bugs)	3	56	124	180	4.37
Family: Baetidae (May fly)	4	124	203	327	7.94
Family: Hydrophilidae (w/beetle)	3	86	164	250	6.07
Family: Simuliidae (black fly)	5	74	122	196	4.76
Family: Chironomidae (Midges)	2	198	371	569	13.81
Annelida					
Family: Hirudinidae	3	38	55	93	2.26
Family: Tubificidae	1	28	71	99	2.4
Family Culicidae	4	80	132	212	5.15
Mollusca					
Family: Planorbidae	3	72	161	233	5.65
Family: Lymnaeidae	3	56	114	170	4.13
Family: Thiaridae	3	78	145	223	5.41
Oligochaeta					
Family Naididae	1	66	177	243	5.89
Family Lumbriculidae	1	72	164	236	5.72

Family Diplogasteridae	1	6	18	24	0.58
Family Dorylaimidae	1	22	42	64	1.55
Family Haploimidae	1	5	63	68	1.56
No. of family	57	19	19		
No. of individuals		1365	2755	**4120**	
% of individuals		33.10%	66.90%		
Shannon-diversity (H)		0.78	1.09		
Evenness (E)		0.76	0.84		
Margalef's index (d)		2.16	2.68		

DISCUSSION

Benthic macroinvertebrate community composition of a particular habitat reflects the habitat characteristics. The presence of a particular population is governed by a specific set of ecological conditions prevailing at that period of time. In the present study, Water quality of Ajiwa reservoir at five different stations was measured based on physical and chemical characteristics. Water temperature fluctuated within all the five sampling stations. The low water temperature recorded in the reservoir was in the dry season this could be attributed to seasonal changes in air temperatures associated with the cool dry North-East winds. High water temperature stress aquatic ecosystem by reducing the ability of water to hold essential dissolved gases like oxygen which cause fish and other invertebrate mortality [41]. Ajiwa reservoir showed high water temperature during the wet season. The high dry season electrical conductivity value may be due to the higher rate of evaporation that reduces the water level and increase in nutrients due to run off from inorganic fertilizer from irrigation farm lands. Decrease in conductivity values during the rainy season might be due to increase in rainwater which cause dilution of the dissolved solids in the reservoir. Increases in total dissolved organic matter results in increase in electrical conductivity [42]. Turbidity of water is affected by the amount of the suspended solids in it, hence restricts the light penetration and indirectly affects the phytoplankton growth [43]. High turbidity observed in Ajiwa reservoir during the rainy season could be due to increase in surface run-off, which cause re-suspension of dissolved materials. Lowest turbidity observed during the dry season could be as a result of prevailing condition of less-surface run-off. Ajiwa reservoir has higher value of TDS during the dry season than wet season. This could be due to decaying of vegetation and higher rate of evaporation. Similar observation was made. The total dissolved solids negative correlation with dissolved oxygen and biochemical oxygen demand may be due to inflow of substance during the rainy season and settling effect of the substance in dry season. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement) and as a waste product of photosynthesis [41]. Rainy season showed higher concentration of dissolved oxygen than the dry season. Lowest concentration during dry season could be attributed to the peak time of biochemical oxygen demand due to bacteria and other decomposers uptake. The higher the temperature the lower the dissolved oxygen and the lower the temperature the higher dissolved oxygen.

In this study, macroinvertebrates fauna of Ajiwa reservoir was examine and biotic indices based on these organisms were applied. A total of 4120 taxa were determined during the survey, and Chironomidae was found to be the most dominant group among macroinvertebrates. The lowest number of individuals was determined in dry season while the highest was in wet season. Species diversity values ranged from 0.83 to 1.39. The lowest species diversity value was found during dry season. According to [44] and [14], if the Shannon–Weaver index value ranges from >3 it indicates clean water, 1–3 indicates moderate pollution, and <1 indicates heavy pollution. Accordingly, the studied reservoir has high water quality in terms of species diversity indices in station 2 and 4, higher values of species diversity in this stations may be ascribed to less human interference and better water quality because species diversity indices appear to be especially sensitive to habitat change [45]. According to ([4];[42]) regions with high species diversity are in better condition and show less degradation, while the opposite condition of low biological diversity often indicates an area with more degradation. Biological results of this study also revealed that stations 1, 4 and 5 of the Ajiwa reservoir were dominated by Dystiscidae, Baetidae, Gomphidae and Nemouridae. However, a tolerant group such as Chironomidae (order Diptera) was also found in the reservoir with highest density at station 5. This station was characterized by the high level of total dissolved solids, which proved Chironomidae to be a good conductor of pollution.

The BMWP and ASPT scores allocated to each family of the identified macro-invertebrate which presents the total of pollution indicator species in the reservoir. The cumulative BMWP score during the study period was 57 while the ASPT score is 3.00. Based on this score Ajiwa reservoir belong to class III (36 - 60) category of 'Questionable' interpreting a moderately polluted water body especially with the identification of pollution tolerant families such as Chironomidae (midges), Corixidae (Water bugs) and Simuliidae (Blackfly). Moreover indicators of clean water/ pollution sensitive family such as Baetidae (Mayfly) and Nemouridae (stone fly) were also identified which indicates the influence of anthropogenic activities to pollute the reservoir over a period of time.

The aquatic life in a water body is governed by physicochemical and biological conditions of the water body [46]. The variation among the sites in benthic fauna density could be due to the variation in the physicochemical factors which favours their survival and perhaps due to the presence of high organic matter within the site as reported by [47] in Kunda water body India. The highest species composition recorded of *Chironomus fractilobus* (301 individuals) followed by *Agabetes* sp (276 individuals) followed by *Melonoides tuberculate* (223 individuals) and the least *Diplogaster* sp (24 individuals) conform with that of [48] who recorded *M. tuberculata* as one of the dominant species in their work on benthic species composition in Lagos Lagoon. Their abundance might be as a result prevailing physic chemical condition that favours their survival as they showed no habitat restrictions by occurring in the four sampling sites as reported by [25]. [49] reported that *M. tuberculata* is the commonest and most wide ranging member of family Thiaridae found in almost any kind of freshwater. [50] reported that member of Thiaridae are quick colonizers, tolerance to habitat diversity and variability due to a very strong and thick shell, many forms are parthonogenetic females capable of multiplying in a short time, viviparous and have average longevity of five years. *Chironomus fractilobus* being the most abundant macroinvertebrate encountered with (301 individuals). The adaptations of *Chironomus* sp. include possession of pigment hemoglobin which gives it a high affinity for oxygen, hence their tolerance of low dissolved oxygen (DO) [14]. The Chironomidae family has been considered as pollution tolerant organisms by early workers ([42]; [51]). The presence of pollution-tolerant macro-invertebrate such as *Chironomus* sp. and *Lymnaea* sp. could be attributed to the effect of domestic wastes and agricultural activities around the reservoir. [53] reported that damsel flies, Dragon flies and midges are commonly found in freshwater that considerably have organic debris. The abundance of pollution tolerant macro-invertebrates is a common feature of organically polluted water bodies ([53]; [54]). During the sampling period (November, 2015 to October, 2016) Ajiwa reservoir was dominated by Arthropods macro-invertebrate taxa such as Dragonfly, Water bugs and Midges. These kinds of macro-invertebrates are moderately pollution-tolerant organisms as reported by ([32]; [55]). They can survive in fair water quality because their habitat requirements are not as strict as pollution-sensitive organisms such as mayfly and Stonefly ([56]; [57]). The presence of these macro-invertebrates indicates that the Reservoir is moderately polluted. However presence of pollution sensitive species such as *Baetis* sp., *Agabetes* sp. and Stonefly in station 3 during the study period indicates low level pollution as reported [58]. [58] reported that most aquatic beetles (Coelopterans) 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.

Benthic macroinvertebrate species are differentially sensitive to many biotic and abiotic factors in their environment [59]. In many studies diversity indices are also used for assessing water quality but the biotic index and score systems are better for assessing organic pollution and eutrophication [60]. In addition, the ASPT and BMWP indices identify the taxa at the family level but none of them use the species level ([61]; [62]). This reduces the sensitivity of the indices used.

CONCLUSION

Variation in physicochemical parameters and diversity of macro-invertebrates as observed from the study could be due to anthropogenic activities such as irrigation and other domestic activities within the vicinity of the Reservoir. Presence of pollution tolerant species such as *Tubifex tubifex*, *Chironomus* sp. *and Melanoides tuberculata* along with pollution sensitive species such as *Baetis* sp., *Neoperla* sp. and *Agabates* sp. indicates clearly apparent anthropogenic induced source of pollution from indiscriminate discharge of domestic wastes around the sampling stations. The water quality status in the reservoir is moderately polluted based on BMWP and ASPT scores. It is therefore recommended that uncontrolled discharge of agrochemicals within the vicinity of the reservoir through irrigation and other anthropogenic activities such as cattle rearing, bush burning etc. should be controlled in order to curtail degradation of the aquatic biota over a period of time.

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