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Impacts of human activities on the limnology and water quality index of Ajiwa Dam, Katsina state

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Abstract
Present study was conducted to determine the impacts of human activities on the limnology and water Quality Index of Ajiwa Dam, Katsina State. Three sampling sites (A, B and C) were chosen for the study. Results obtained revealed that the mean depth ranged from (3.9 ± 5.23 ft – 2.57 ± 4.27 ft), Transparency (0.67± 0.25 ft-0.1±0.1 ft), Temperature (37.2± 5.88 ^{0}C -23.4± 2.31 ^{0}C), Electrical Conductivity (91.6 ±3.79 µS/cm-66.33±2.31 µS/cm), Total dissolved solids (44.33 ±2.09 mg/l -32 ±1.73 mg/l), Dissolved oxygen (4.27 ±0.78 mg/l -2.23 ±0.68 mg/l), Biochemical oxygen demand (1.23 ±0.75 mg/l -0.68 ±0.03 mg/l) Nitrate (57.67 ±5.51 mg/l-37.3 ±8.67mg/l), Phosphate (1.8 ±0.04mg/l -0.5±0.06mg/l), Hardness (42.67mg/l±7.77-39.67mg/l±15.4), and pH (7.8±0.63-7.07±0.29). Depth, Dissolved oxygen, and pH recorded significant difference during the study period ($P<0.05$) while there was no significant difference recorded in the other physicochemical parameters ($P>0.05$). A WQI value of 54 was obtained, which classified the dam quality as medium. Nineteen species of phytoplankton were identified in which Bacillariophyta had 40%, Chlorophyta (25%), Cyanophyta (15%), Dinophyta (1%), Desmidiaceae (2%) and Euglenophyta (1%). Average Shannon diversity index (H) of 2.9 indicates moderate diversity of the phytoplankton. The presence *Euglena* sp., *Nitzchia* sp. and *Oscillatoria* sp. which are pollution indicators dictates to some extent the degree of pollution through various anthropogenic activities. There is the need to control the rate of discharge of agrochemicals through irrigation and other activities into the dam.

Keywords: dam, impact, limnology, water quality

Introduction

Many aspects of the environment, economy and society are dependent upon water resources, and changes in the hydrological resource base have the potential to severely impact upon environmental quality, economic development and social well-being [6]. However, water resources in terms of quantity and quality are critically influenced by human activities, including but not limited to; agriculture and land use change, construction and management of reservoirs, pollution emissions and wastewater treatment [10]. As a result, the world is facing a fresh water crisis and what historically has been a problem of water quality is fast becoming a double-faceted problem of quality and quantity [14]. Initially, WQI was developed by [19] in United States by selecting 10 most commonly used water quality variables like dissolved oxygen (DO), pH, coliforms, specific conductance, alkalinity and chloride etc. and has been widely applied and accepted in European, African and Asian countries. The assigned weight reflected significance of a parameter for a particular use and has considerable impact on the index. Furthermore, a new WQI similar to Horton's index has also been developed by the group of Brown in 1970 [12], which were based on weights to individual parameter. Recently, many modifications have been considered for WQI concept through various scientists and experts [11, 16]. A water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both cultured and wild fishes. Pollution of the aquatic environment by inorganic and organic chemicals is a major factor posing serious threat to the survival of aquatic organisms including fish. The use of water quality index (WQI) simplifies the presentation of results of an investigation related to a water body as it summarises in one value or concept a series of parameters analysed. In this way, the indices are very useful to transmit information

Concerning water quality to the public in general, and give a good idea of the evolution tendency of water quality to evolve over a period of time. A single WQI value makes information more easily and rapidly understood than a long list of numerical values for a large variety of parameters. Additionally, WQI also facilitates comparison between different sampling sites and events [32]. Inadequate management of water resources as directly or indirectly resulted in the degradation of hydrological environment. Therefore, a continuous periodical monitoring of water quality is necessary so that appropriate steps may be taken for water resource management practices [16]. This research is aimed at determining the impacts of human activities on the limnology and water Quality Index of Ajiwa Dam, Katsina State, Nigeria.

Methodology

Description of Study Area

Ajiwa Dam is located at latitude 12.9831887, 7.7395248, in Ajiwa town, Batagarawa Local Government Area of Katsina state, Nigera. Majority of the people of Ajiwa town are farmers and fishermen. They also engage in irrigation during the dry season.

Sampling Sites

Three (3) sampling sites were chosen for the purpose of this study and designated as A, B, and C on the water course of the dam. The choice of the sites was based on the ecological setting of the sampling area.
Site A: it is one of the shallow parts of the dam. At this site, human activities like washing and bathing take place.
Site B: Is the mid shore of the dam where there are less human activities apart from fishing.
Site C: The water here is partially contaminated with mainly detergent from car, motor cycle washings and other laundry activities. Irrigation activities take place during the dry season. Vegetation is subjected to chemicals input from fertilizer application.

Fig 1: Google map of Ajiwa dam showing sampling sites (*Source*: Google Maps)

Sample Collection and Analysis

Physicochemical Parameters

Water samples were collected for analysis monthly from August to December 2016. Surface water temperature was measured in situ using a mercury thermometer. pH, total dissolved solids and electrical conductivity were measured using HANNA instrument (pH/Electrical Conductivity/ Temperature meter model 210). Transparency was determined using a Secchi disk. Total hardness, dissolved oxygen (DO), biological oxygen demand (BOD), Nitrate (NO_3^-) and Phosphate ($^-PO_4^{3-}$) were determined by methods described by [8].

Water Quality Index (WQI)

WQI was calculated online by the Water Research Center WQI calculator. The result obtained was obtained using the legend provided by the Water Research Center, which is shown below:

Table 1: Water Quality Index Legend

Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

(Brian, 2014) [12]

Phytoplankton

The phytoplankton was collected using conical shape plankton net of 20 cm diameter with a 50 ml collection vial attached to it [27]. Samples were collected at three sampling points. Phytoplankton was identified by consulting texts from [29].

Statistical Analyses

Analysis of variance (ANOVA) was used to compare the means of variations of plankton species composition and physico chemical parameters during the study period between sampling sites to find out if there was significant difference or otherwise.

Results

Physicochemical Parameters

The results and the mean values of physicochemical parameters and Water Quality Index at the different sampling stations in Ajiwa Dam during the period of the study, (August 2016–December 2016) are presented in Table 2, Table 3 and Figure 2 to 12. Mean depth ranges from 3.97 ft ± 5.23 to 2.57 ft ± 4.27. The highest depth was recorded in August and the lowest was recorded in December. Site B has the highest depth of 10 ft which was recorded in October while the depth in site A was 0 ft from October to December. Mean depth values were highly significant across the sampling sites ($P<0.05$). Mean transparency ranged from 0.67 ± 0.25 in August to 0.1 ± 0.1 in August.
The highest transparency (0.9 ft) across the sampling sites was recorded from site A in August and the lowest (0.0 ft) was also recorded in site A from October to December. There was no significant difference in transparency between the sampling sites ($P>0.05$). Mean values for temperature ranged from 37.2 ^{0}C ± 5.88 to 23.4 ^{0}C ± 0.85. The highest temperature was recorded in September while the lowest temperature was recorded in December. Site A had the highest temperature of 38.3^{0}C while the lowest temperature of 22.6 ^{0}C was recorded in December from site B. The result from ANOVA shows that there was no significant difference in temperature across the sampling sites ($P>0.05$).
Electrical conductivity (EC) ranged from 91.6±3.79 µS/cm in November to 66.33 ± 2.31 µS/cm in August, while across the sampling sites, site B had the highest EC of 96µS/cm in November and sites A and C recorded the lowest EC of 65 µS/cm in August. No significant difference in EC was observed across the sampling sites during the period of study ($P>0.05$). The mean values of total dissolved solids (TDS)

ranged from 45.33±2.09 mg/l in December to 32+1.73 mg/l in August. Site B had the highest TDS of 47 mg/l in December and site C had the lowest TDS of 31 mg/l in August. The results did not differ significantly across the sampling sites during the study period ($P>0.05$).
Mean dissolved oxygen (DO) ranged from 4.27±0.78mg/l in August to 2.23±0.68 mg/L in October. Site A recorded the highest DO of 4.9 mg/l in August and site C recorded the lowest DO of 1.7 mg/l in October. There was significant difference in DO values across the sampling sites ($P<0.05$). Mean Biochemical oxygen demand (B.O.D) ranged from 1.23±0.75 mg/l in September to 0.68±0.03 mg/l in October. The highest B.O.D of 2.1 mg/l across the sampling sites was recorded from site B in September and the lowest value of 0.1 mg/l was recorded from site C in August. No significant difference in B.O.D results was recorded across the sampling sites during the study period ($P>0.05$).
The mean values of nitrate ranged from 57.67±5.51 mg/l in December to 37.3±8.67 mg/l in August. Site C recorded the highest nitrate value of 63.4 mg/l in December and site B recorded the lowest value of 27.3 mg/l in August. There was no significant differences in nitrate concentrations from the sampling during the study period ($P>0.05$). Mean phosphate concentration ranged from 1.8±0.04mg/l in August to 0.5±0.06mg/l in October. Site B recorded the highest value of 1.21 mg/l and site C recorded the lowest value of 0.43 mg/l. The results shows no significant difference across the sampling sites during the study period ($P>0.05$). The mean hardness recorded ranged from 42.67±7.77 mg/l to 39.67 ± 15.04 mg/l. The highest value was recorded in August while the lowest was recorded in November. Site A recorded the highest concentration of 59 mg/l in October while site C recorded the lowest concentration of 30 mg/l in October and November.
The highest mean pH of 7.8 ± 0.63 was recorded in September and the lowest pH of 7.07 ± 0.29 was obtained in August. Site A recorded the highest pH of 8.3 in September and the lowest pH of 6.7 was recorded from site C in December. There was a significant difference in pH values across the sampling sites ($P<0.05$). The result from the WQI calculator shows a WQI value of 54 (Table 3).

Table 2: Monthly values of depth, transparency, temperature, EC, and TDS of Ajiwa dam, katsina state from august to december, 2016

SITE	DEPTH (FT)	TRPC	TEMP ◦C	EC	TDS mg/l	DO mg/l	BOD mg/l	NO_3^-	$P0_4^{3-}$	HARDNESS mg/l	pH
A (AUG)	1.1	0.9	38	65	34	4.9	1.5	42.6	1.13	49	7.4
B (AUG)	10	0.4	34	69	31	4.5	0.8	27.3	1.21	45	6.9
C (AUG)	0.8	0.7	32.9	65	31	3.4	0.1	42	1.2	34	6.9
A (SEP)	0.4	0.3	38.3	72	33	4.9	0.9	48.4	0.77	49	8.3
B (SEP)	8.9	0.2	36.1	66	35	2.9	2.1	50.6	0.68	41	7.1
C (SEP)	0.7	0.3	27.2	81	40	3	0.7	51.3	0.43	45	8
A (OCT)	0	0	27.2	81	40	3	0.7	51.3	0.51	59	7.7
B (OCT)	9	0.8	26.1	91	41	2	0.65	58.7	0.43	31	7.2
C (OCT)	0.5	0.4	27	86	40	1.7	0.68	59.3	0.55	30	7
A (NOV)	0	0	25	89	45	3.6	0.9	55.4	0.52	57	7.4
B (NOV)	8	0.2	23.5	96	46	2.7	0.82	51.7	0.45	32	7.1
C (NOV)	0.3	0.1	26	90	42	1.9	0.75	61.2	0.62	30	6.9
A (DEC)	0	0	24.2	92	46	3.4	0.85	57.2	0.62	58	7.6
B (DEC)	7.5	0.2	22.6	90	47	2.5	0.85	52.4	0.51	33	7
C (DEC)	0.2	0.1	23.9	91	43	1.8	0.69	63.4	0.73	32	6.7
MEAN	3.16	0.31	28.8	81.6	39.6	3.08	0.866	51.52	0.69	41.67	7.28
STD	4.08	0.29	5.49	11.19	5.54	1.06	0.44	9.11	0.27	10.82	0.45
P value	0.0001**	0.823*	0.688*	0.919*	0.977*	0.039**	0.215*	0.476*	0.949*	0.0002**	0.038*

Significant at $P<0.05$ ** not significant at $P>0.05$

Table 3: Water Quality Index

Factor	Weight	Quality Index
Dissolved Oxygen	0.17	29
pH	0.11	79
Biochemical oxygen	0.11	97
Temperature Change	0.10	11
Total Phosphate	0.10	2
Nitrates	0.10	96
Total Solids	0.07	86
Overall WQI		54

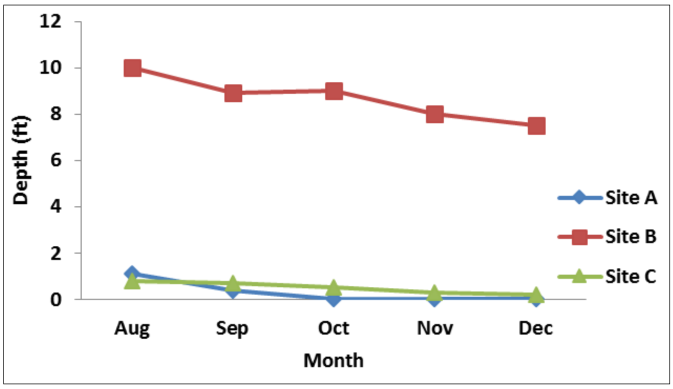

Fig 2: Monthly variations of depth across the sampling stations during the study period

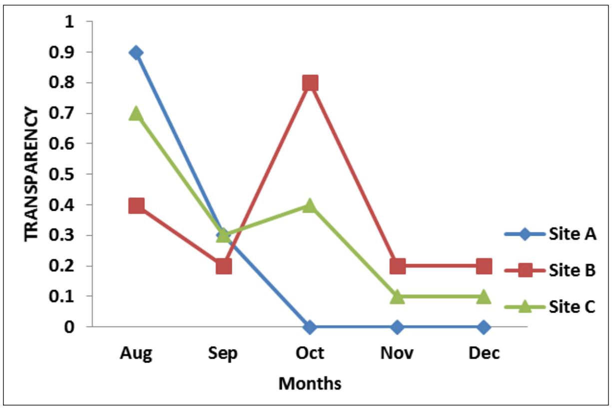

Fig 3: Monthly Variations of Transparency across the Sampling Stations during the Study Period

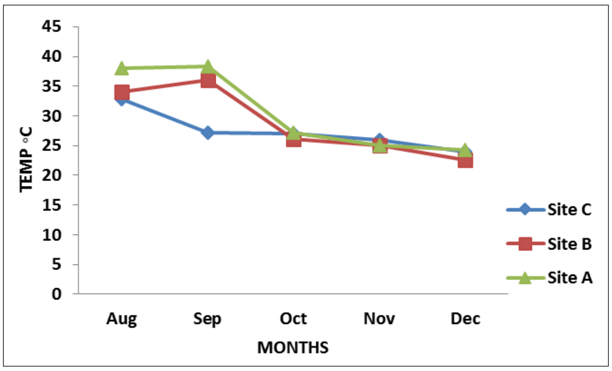

Fig 4: Monthly Variations of Temperature across the Sampling Stations during the Study Period

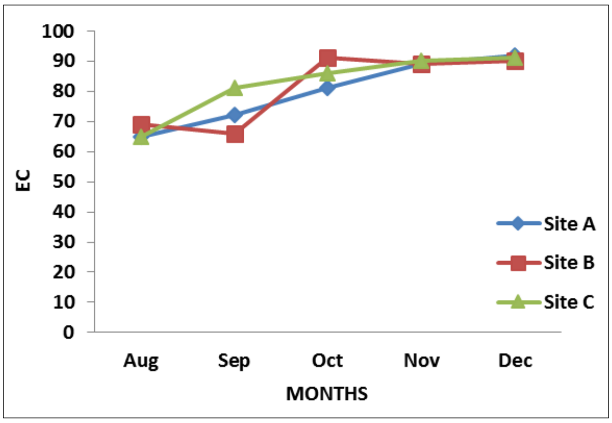

Fig 5: Monthly Variations of Electrical Conductivity across the Sampling Stations during the Study Period

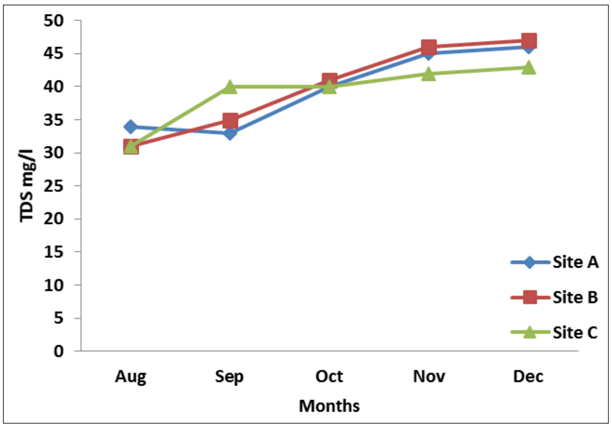

Fig 6: Monthly Variations of Total Dissolved Solids across the Sampling Stations during the Study Period

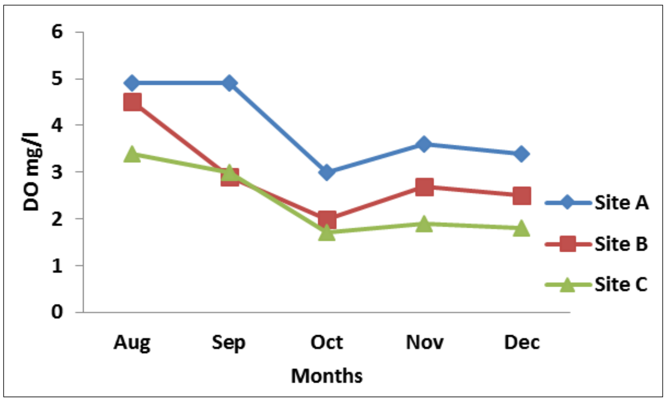

Fig 7: Monthly Variations of Dissolved Oxygen across the Sampling Stations during the Study Period

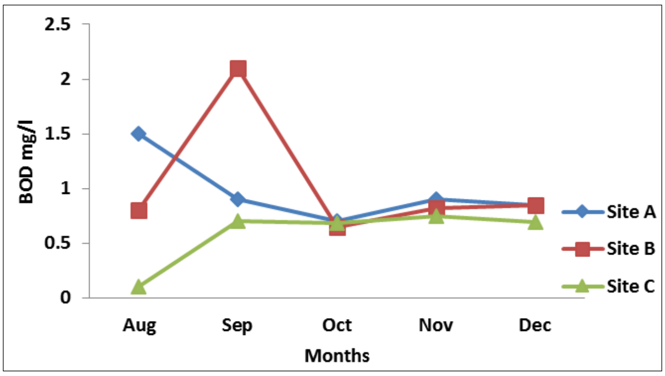

Fig 8: Monthly Variations of Biochemical Oxygen Demand across the Sampling Stations during the Study Period

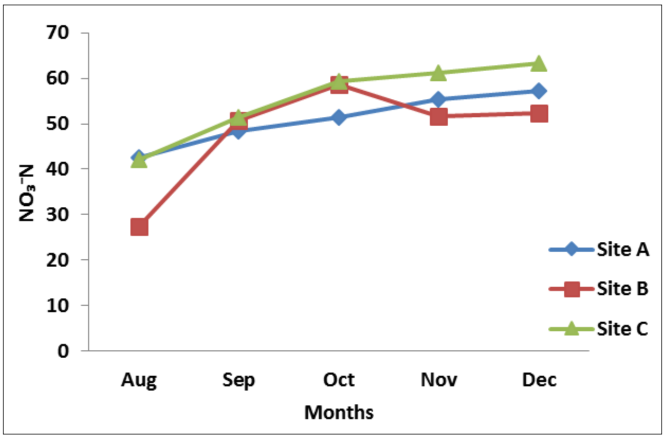

Fig 9: Monthly Variations of Nitrate across the Sampling Stations during the Study Period

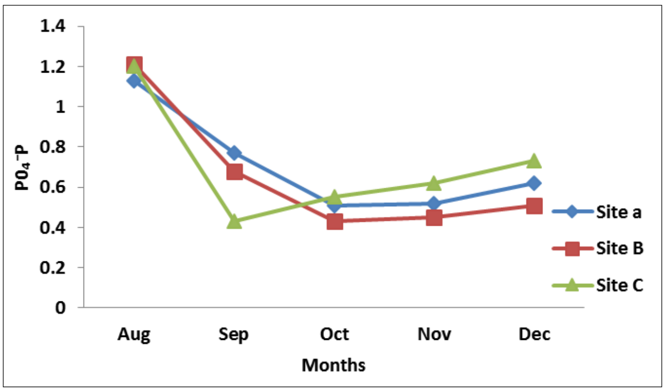

Fig 10: Monthly Variations of Phosphate across the Sampling Stations during the Study Period

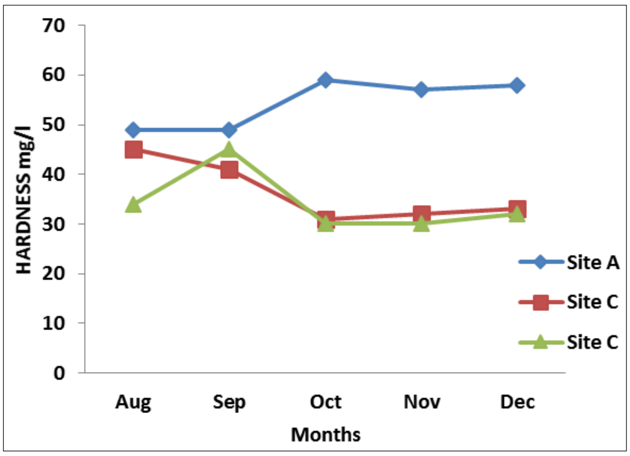

Fig 11: Monthly Variations of Hardness across the Sampling Stations during the Study Period

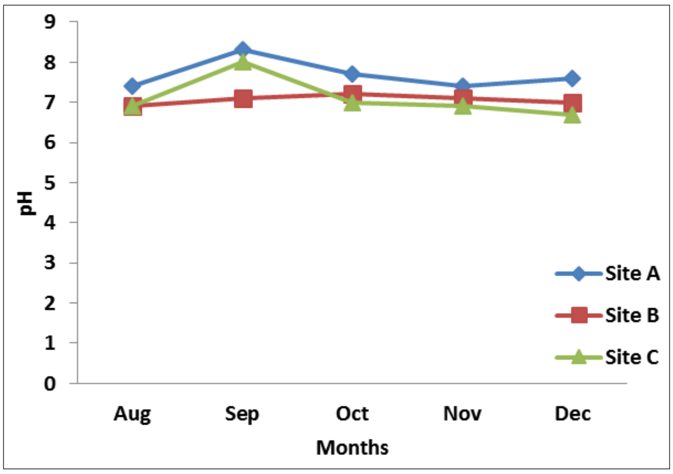

Fig 12: Monthly variations of ph across the sampling stations during the study period

Biological Parameters

The total composition and the relative abundance of the phytoplankton species of Ajiwa Dam were presented in Table 4. A total of 450, 206 and 545 org/ltr were identified in sites A, B, and C respectively, belonging to the following classes: Bacillariophyta (40%), Chlorophyta (25%), Cyanophyta (15%), Dinophyta (1%), Desmidiaceae (2%) and Euglenophyta (1%). Among the nineteen species of phytoplankton identified, *Cymbella* sp. was the most abundant (7.99%) and the least abundant species was *Micrastarias* sp. (2.67%). A highly significant difference was observed in the phytoplankton composition and abundance across the sampling sites during the study period ($P<0.05$).The results from Shannon weiner biodiversity index (H) across the sampling sites were site A (2.86), site B (2.9) and site C (2.91) and Shannon equitability was site A (0.98), Site B (0.98) and Site C (0.91) (Table 4).

Table 4: Phytoplankton composition, distribution and relative abundance of Ajiwa Dam, Katsina (August - December, 2016)

Species Composition	Site A	Site B	Site C	Total Org./Ltr	Frequency%
Bacillariophyta (40%)				0	
Cymbella sp.	36	20	40	96	7.993339
Nitzchia sp.	28	12	35	75	6.244796
Desmidium sp.	20	9	32	61	5.079101
Skeletonema sp.	30	15	35	80	6.661116
Pseudonitzchia sp.	20	10	27	57	4.746045
Closterium sp.	28	12	31	71	5.91174
Flagilariaforma sp.	18	8	20	46	3.830142
Chlorophyta (25%)				0	0
Chlamydomonas sp.	32	13	38	83	6.910908
Ulothrix sp.	25	10	27	62	5.162365
Cladophora sp.	28	8	30	66	5.49542
Zygnema sp.	32	11	34	77	6.411324
Westella sp.	29	14	33	76	6.32806
Cyanophyta (15%)				0	0
Oscillatoria sp.	20	9	28	57	4.746045
Synechococcus sp.	18	7	22	47	3.913405
Microcystis sp.	22	10	30	62	5.162365
Dinophyta (1%)				0	0
Ceratium sp.	14	8	17	39	3.247294
Desmidiaceae (2%)				0	0
Pleurotaenium sp.	15	10	17	42	3.497086
Micrastarias sp.	10	5	17	32	2.664446
Euglenophyta (1%)				0	0
Euglena sp.	25	15	32	72	5.995004
No. of Spp per site	450	206	545	1201	100
Shannon Diversity (H)	2.86	2.9	2.91		
Species Evenness	0.98	0.98	0.97		

Discussion

As depicted from the results above, there are fluctuations in the physicochemical parameters of Ajiwa Dam. The decrease in depth observed during the period coincides with decrease in rainfall and the high evaporation rate experienced during the dry season. The highest depth recorded in August is attributed to the fact that rainfall in Katsina is highest in August. The significant difference in depth recorded across the sampling sites is because site B is at the center of the Dam where the depth is very high. Transparency was found to be highest in August and it gradually decreased towards October to December. This decrease could be attributed to heavy harmattan winds causing turbulence of the water and also introducing dusty particles, thereby reducing transparency. The Lowest temperature values recorded in December are characteristic of the Harmattan season in northern Nigeria [21]. Variations in water temperature in the dry season can be attributed to intensified heat radiation and effect of harmattan. Conductivity is a measure of ions concentration in aquatic systems [21]. Seasonal variations in conductivity are due to weather differences, being higher and lower during dry and rainy periods respectively [29]. The electrical conductivity of Ajiwa dam gradually increases from rainy season to the dry season, and this similar to the findings of [25] who reported that the mean values of conductivity, DO, sulphate and iron were higher during the dry season. Variations in TDS and EC in the ponds are common to other lenthic water bodies found in Zaria and northern Nigeria [2]. These changes may be linked to climatic conditions, and human activities around the catchment which range from surface runoff of fertilizers from neighboring farms and other substances from the catchment area. The lowest value for total dissolved solids was recorded in August and the highest was in December. This is similar to the findings of [18],who reported that The highest value of Malav lake TDS was recorded in the month of December and lowest was recorded in the month of August. The highest dissolved oxygen value was recorded in August and the lowest was in October. The distribution of Dissolved Oxygen in water body has been reported to be governed by a balance between input from the atmosphere, rainfall, photosynthesis and losses by the chemical and biotic oxidations. BOD is a fair measure of cleanliness of any water on the bases that values of less than 2 mg/l are clean, 3 -5 mg/l, fairly clean and 10 mg/l definitely bad and polluted. The results of the present study showed that the water body was fairly clean. The higher values of phosphate and nitrate concentrations could be attributed to the inputs from agricultural activities around the study area [6, 4, 1, 20]. The highest value of hardness recorded in August which is similar to the findings of [25]. Seasonal variation of physico-chemical properties of groundwater was probably due to regular addition of large quantities of sewage and detergent through runoff from the nearby localities [24, 26]. The pH values were mostly maintained between the optimum ranges of (7.8-7.07) for most biological activities. All the results agree with the [31] who show that pH ranges between 6 and 9 for most open water lakes worldwide and is distributed uniformly in shallow lakes and reservoirs. A WQI value of 54 indicates that the water quality of Ajiwa dam is medium, which implies that there is no serious threat of human activities in the dam. A medium WQI value is an indication of a marginal concern for a given water body. The phytoplankton community in the present study was characterized by six classes: Bacillariophyta (40%), Chlorophyta (25%), Cyanophyta (15%), Dinophyta (1%), Desmidiaceae (2%) and Euglenophyta (1%). A total of 450, 206 and 545 org/ltr were identified in sites A, B, and C respectively. The monthly and seasonal variation of composition and abundance of phytoplankton may be due to the fluctuations of water and physicochemical parameters in the river [3]. made similar observation in which he reported that; in tropical regions the dry and rainy seasons show distinct fluctuations with abundance of phytoplankton. Analysis of community structure using Shannon Weiner diversity index adopted by [20] in that when the index value is < 1, the water body is heavenly polluted ; 1 -3, moderately polluted and > 3, clean water. The results from the present study indicate a moderate pollution. The distribution of species as depicted by the Shannon equitability and species diversity index was relatively even. The presence *Euglena* sp., *Nitzchia* sp. and *Oscillatoria* sp. which are pollution indicators dictates to some degree pollution through various anthropogenic activities.

Conclusion

A research on the impacts of human activities on the limnology and water Quality Index of Ajiwa, Katsina State was carried out between August to December, 2016.The dam is affected by fluctuations in environmental variables such as pH, temperature, water hardness, phosphate, nitrate and other physicochemical parameters. The nutrient status of the Dam and a WQI value of 54 which are attributed to agricultural practices and other human activities within the periphery of the dam show some level of pollution. Therefore proper measures should be put in place

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