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Composition, Abundance and Diversity of Plankton in Hand-Dug Wells in Ikpe Community, Akwa Ibom State, Nigeria

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Abstract:

Groundwater is one of the cheapest sources of freshwater for most human activities in the developing countries. Groundwater is also home to some aquatic biota which has been poorly studied in Nigeria. The composition, abundance and distribution of plankton in 5 hand-dug wells were assessed in relation to some physicochemical parameters. The study was carried out between April and November 2022 in Ikpe Community, Akwa Ibom State, Nigeria using standard methods. The physicochemical results were: temperature (24.2-29.8ºC), pH (6.0-7.9), electrical conductivity (60.3-136.4µs/cm), total dissolved solids (42.2-95.5mg/l), nitrate (0.22-3.73mg/1), chloride (13.8-134.3mg/l) and phosphate (0.42-1.85mg/L). All the parameters were within acceptable limits except pH while nitrate, chloride and phosphate were significantly higher in wells 4 and 5. The phytoplankton recorded 17 species and 415 individuals/l in the uncovered wells while the zooplankton recorded 24 species and 958 individual/l in all the wells. The plankton assemblage was rich and comparable to some surface water environments. However, the presence and dominance of indicator groups (Baccillariophyceae and Rotifera) especially in the uncovered wells (2, 4 and 5) is an indication that the water quality was deteriorating. The low values of the biodiversity indices also point to the poor water quality. It can be concluded that the composition, abundance and distribution of the plankton in the wells was influenced by the physicochemical conditions of the wells, which in turn was influenced by the location, construction, human activities and the general environmental conditions of the wells.

Keywords: Plankton, Diversity, Water quality, Hand-dug wells, Nigeria

1 - Introduction

Groundwater is a primary freshwater source in the hydrological cycle and importantly provides good quality water for humans as well as support groundwater-dependent ecosystems (Cavite et al., 2017). Wells are artificially created groundwater environment with stagnant water column and often enriched with nutrients (Hahn and Matzke, 2005; Korbel et al., 2017). Hand-dug wells provide a natural and cheap source of freshwater for drinking water and other domestic uses especially in the rural areas (Duncan et al., 2020; Bozkurt, 2022; Tula et al., 2022). Apart from these, groundwater and supported ecosystems is home to diverse assemblage of organisms (Brancelj et al., 2013) including plankton (Korbel et al., 2017; Khalil and Rabiu, 2022).

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Groundwater ecosystem assessment is increasingly becoming a requirement in environmental health assessment (Maurice, 2009); partly due to the importance of groundwater ecosystems in water quality maintenance and aquifer flow (Griebler and Avramov, 2015). Groundwater organisms may be very sensitive to anthropogenic impacts and environmental changes because they occur in habitats that are energy-limited as well as environments with comparable predictable conditions (Griebler and Avramov, 2015). Planktons are prone to changes in the aquatic environment because they are microscopic, non-motile, or weak swimming organisms; floating or drifting in the water column (Suthers and Rissik, 2009). Phytoplankton and zooplankton are primary and secondary producers; playing essential roles as part of the food chain and determinants of the aquatic ecosystem health (Znachor et al., 2020; Cavan and Hill, 2022). The composition, abundance and distribution of plankton help to predict the effects of environmental changes and human activities (Primo et al., 2015; Yusuf, 2020). Studies on the diversity of groundwater are essential because they can contribute needed information for the maintenance and sustenance of the biodiversity of such ecosystems and also provide useful bioindicators of connection between subsurface and surface waters (Cavite et al., 2017). Assessing the ecological conditions of groundwater is also necessary because healthy groundwater ecosystems are required for the provision of clean drinking water (Koch et al., 2021). A healthy aquifer acts as active biological filter, keeping and improving water quality as well as providing safe storage of water over a long time (Griebler and Avramov, 2015). The biodiversity of groundwater in Nigeria is poorly known compared to surface water habitats (Hassan et al., 2008; Khalil and Rabiu, 2022). Hence, this work is aimed at assessing the water quality and plankton diversity in hand dug wells in Ikpe community, Akwa Ibom State, Niger Delta, Nigeria.

2 - Materials and Methods

2.1 - Study area and Sampling stations

Ikpe community is situated in a coastal zone of Ini Local Government Area, Akwa Ibom State, Niger Delta, Nigeria. The samples were randomly collected in two villages (Ikpe Ikot Nton and Itie Ikpe). The inhabitants of the community engage in intense fishing, agricultural, sand and gravel mining activities. The community generally depends on the groundwater (hand dug wells) for drinking and other domestic purpose; most of the hand dug wells in the community are not properly constructed; many are not protected (uncovered), while few are protected with wooden and rusted metal sheets.

2.2 - Sampling Points

Five hand dug wells were randomly selected for this study based on observed human activities and the location (Fig. 1). Well 1 (Latitude 5º23’29.494N and Longitude 7º46’47.718E) was located in Ikpe Ikot Nkon, within the vicinity of Holy Catholic Church and covered with rusted metal sheet (Plate 1). It about 5.8 meter depth; the water is extracted for domestic use with underground water pump into plastic storage water tanks. No human activities were observed during the study.

Well 2 (Latitude 5º 23’36.918 N and Longitude 7º47’6.498E) was also located in Ikpe Ikot Nkon, about 1.4 meter depth. The well was located behind a roadside market, and automobile workshops with high surface runoffs. The well was properly constructed but uncovered (Plate 2).The well water was extracted for domestic use by the people using a plastic bucket. Wastes generated from the market were discarded into a stream beside the well.

Well 3 (Latitude 5º23'45.33N and Longitude 7º47'22.873E) is also located in Ikpe Ikot Nkon and it about 7.6 meter depth. The well was properly constructed and had a wooden cover (Plate 3). Minimal human activities were observed during the study.

Well 4 (Latitude 5º 22'50.496 North and Longitude 7º 47'53.49 East) was located in Itie Ikpe , having 2.1 meter depth The well was properly constructed but the edge was at the ground level, uncovered and unkempt (Plate 4). The area is low-lying and experience high runoff during the wet season. The well was located adjacent a wetland where rice and other crops were cultivated. Wastes are disposing indiscriminately near the water body.

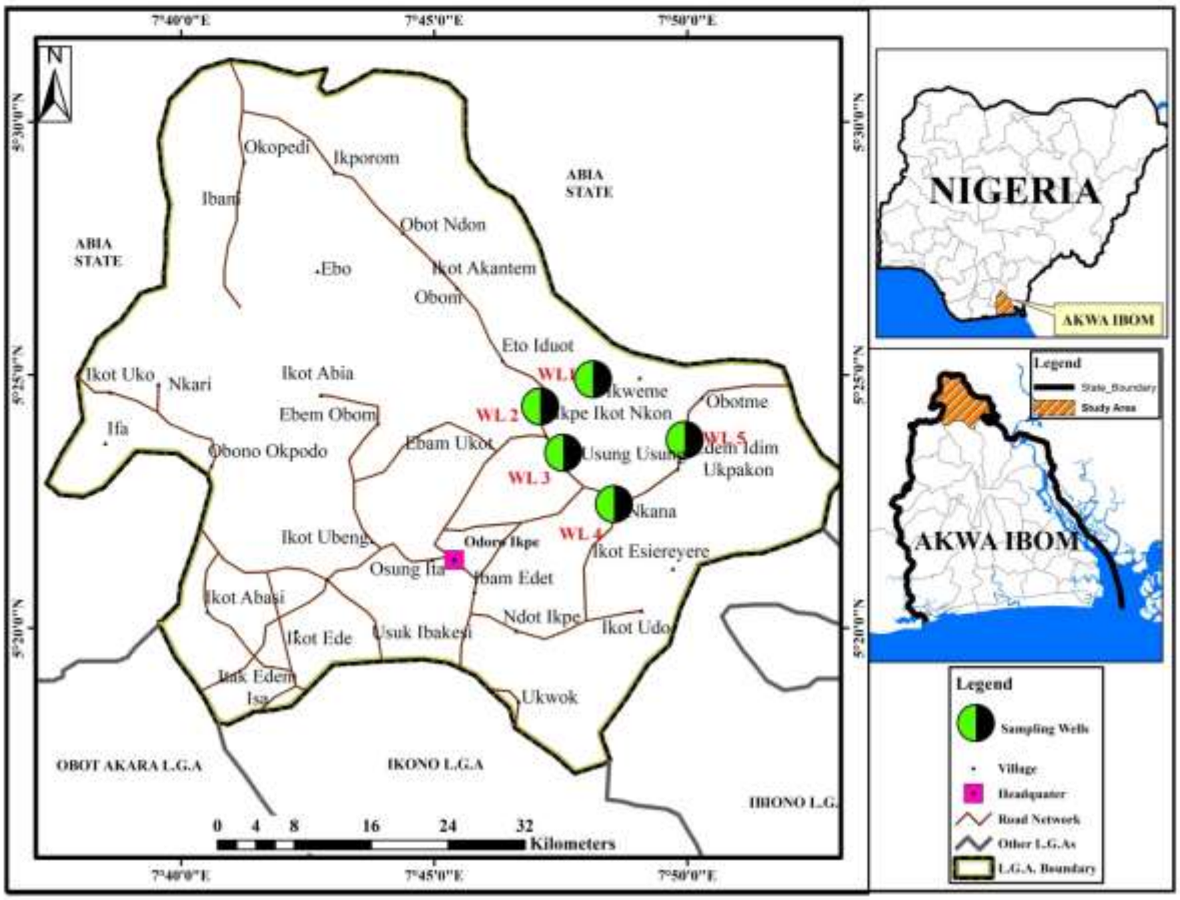

Fig. 1. Sampling wells in Ikpe community, Ini L.G.A., Akwa Ibom State, Nigeria

Well 5 (Latitude 5º22'37.028N and Longitude 7º48'22.086E) was also located in Itie Ikpe. The well is about 1.8 meter depth; properly constructed but the edge was at the ground level, unprotected and there are some grasses around the edge (Plate 5). The area is also low-lying and experience high runoff during the wet season. The well was located adjacent a wetland where rice and other crops were cultivated; domestic wastes are dumped very close to the wetland. The well is more prone to the flood influence from the wetland.

Plate 1: Well 1

Plate 2: Well 2

Plate 3: Well 3

Plate 4: Well 4. Red arrow point to the direction of the wetland.

Plate 5: Well 5. Red arrow point to the wetland.

2.3 - Samples collection and Analysis

Water samples for physicochemical parameters were collected in monthly basis, between April 2022 and November 2022. Water sample from each well was collected with pre-wash plastic bucket attached to a nylon rope; transferred to plastic bottles and transported to the Laboratory for analysis. Nitrate was determined by cadmium reduction method; phosphate was determined using molybdenum blue method using a UV-Vis spectrophotometer (DR/3800) and chloride was determined using Argentometric method (AOAC, 2000). Other parameters such as water temperature, hydrogen-ion (pH), electrical conductivity (EC) and total dissolved solids (TDS) were determined *in-situ* using Multi-parameter meter.

Plankton samples were collected by filtering 100 liters (10-litre bucket drawn 10 times from each well) through plankton net of 55µm mesh size into 100 mL plastic sampling bottles. The filtered samples were fixed with 4% formalin solution and transferred to the laboratory unit of Department of Marine Biology, University of Calabar, Calabar, Nigeria. In the laboratory, the quantitative plankton samples were concentrated to 10ml; 1 ml from the 10ml for each well was taken using pipette into counting chamber for analysis under an inverted microscope. Identification of species was with the aid of Taxonomic keys: Cander-Lund and Lund (1959), Needham and Needham (1962), Jeje and Fernando (1986), Korinek (1999) and Altaff (2004).

2.4 - Statistical Analysis

The data obtained were summarized with Microsoft Excel; while test for significant differences at $P<0.05$ level between mean of the stations was carried out with one-way ANOVA and Tukey Pairwise posthoc was used to determine the source of variation. Biodiversity indices like Shannon -wiener index (H); Margalef's index (D) and Evenness (E) were used to determine the community structure of the plankton. The diversity indices were calculated using PAST Statistical Software.

3 – Results and Discussion

3.1 - Physicochemical parameters

The composition, abundance and distribution of plankton can be used to reliably assess the water quality of aquatic bodies and no single particular physicochemical parameter is responsible for the fluctuations of plankton populations (Anyanwu and Mbekee, 2020; Jonah et al., 2020; Anyanwu et al., 2021a, b; Jonah and Archibong, 2022). The mean and range of the physicochemical parameters are summarized in Table 1.

The water temperature values ranged between 24.2°C and 29.8°C both in well 2. ANOVA showed no significant difference between mean of the wells ($p > 0.05$). The water temperatures of the wells were influenced by the prevailing weather conditions during sampling. The lowest value was recorded in October 2022 (late wet season) and highest was in November 2022 (onset of dry season) in well 2. This is probably because well 2 had no cover and easily influenced by air temperatures (Park *et al*., 2016); unlike wells 4 and 5 that had some vegetation cover (Plates 2, 4 and 5). Tula et al (2022) recorded lower values (19.3 – 26.6°C) in hand-dug wells in Mubi, Adamawa State, Nigeria. However, Jagaba et al (2020) recorded higher value (29.8 – 31.0°C) in Rafin Zurfi, Bauchi State, Nigeria, 29.6 – 31.7°C was recorded by Amoo et al (2021) in Gaya, Kano State, Nigeria and 26.0 – 30.0°C was recorded by Iloba et al (2022) in Eku Delta State, Nigeria; attributed to the prevailing weather conditions at the time of sampling.

Table 1: Mean and ranged values of physicochemical parameters evaluated in wells.

Parameter	Well 1	Well 2	Well 3	Well 4	Well 5	FMEnv (2011)
Temp. (°C)	27.29±0.42^{a} (25.8 – 28.5)	27.20±0.67^{a} (24.2 –29.8)	26.01±0.36^{a} (24.5 – 27.4)	26.97±0.54^{a} (24.3 –28.9)	28.15±0.44^{a} (26.5 – 29.4)	< 40°C
pH	7.57±0.11^{b} (7.0 – 7.9)	6.61±0.06^{a} (6.3 – 6.8)	7.43±0.07^{b} (7.2 – 7.7)	6.44±0.09^{a} (6.0 – 6.8)	7.54±0.11^{b} (7.2 – 7.9)	6.5-8.5
EC (µs/cm)	99.16±5.37^{a} (80.3 –120.8)	85.55±3.88^{a} (64.4 –98.3)	101.98±7.04^{a} (73.4 –136.4)	86.32±6.86^{a} (60.3–117.8)	83.8±2.58^{a} (75.6 – 98.2)	-
TDS (mg/L)	69.42±3.76^{a} (56.2 –84.6)	59.9±2.72^{a} (45.0-68.8)	71.56±4.92^{a} (51.4 -95.5)	61.07±4.39^{a} (42.2-82.51)	58.71±1.79^{a} (52.9 68.6)	-

Nitrate (mg/L)	0.39±0.05[a] (0.22 – 0.63)	0.77±0.14[a] (0.23 – 1.42)	0.65±0.07[a] (0.36 – 0.98)	1.93±0.17[b] (1.13 –2.52)	2.52±6.25[b] (1.54 – 3.73)	9.1
Chloride (mg/L)	38.06±5.76[a] (16.4 – 60.2)	49.97±6.96[ab] (26.2 – 89.3)	37.05±5.57[a] (13.8 – 58.2)	53.21±6.12[ab] (36.8 –90.6)	75.45±11.28[b] (37.2-134.3)	300
Phosphate (mg/L)	0.62±0.03[a] (0.48 – 0.73)	0.92±0.18[a] (0.42 – 1.75)	0.74±0.04[a] (0.58 –0.93)	1.48±0.09[b] (1.18-1.85)	1.57±0.07[b] (1.34 –1.84)	3.5

Means with different superscripts (a, b) across the rows are significantly different at p<0.05., FMEnv (2011) – National Environmental (Surface and Groundwater Quality) Regulations.

The hydrogen ion (pH) values ranged between 6.0 and 7.9 (slightly acidic – slightly alkaline). These values were within 6.5 – 8.5 required to support aquatic life (FMEnv., 2011). The lowest was recorded in well 4 (August 2022) while the highest were recorded in wells 1 (May 2022) and 5 (October and November 2022). Wells 1, 3 and 5 were significantly ($p<0.05$) higher than wells 2 and 4. The uncovered wells (2 and 4) had acidic pH suggesting pollution (Zaghloul et al., 2019); probably from atmospheric deposition (Kumar et al., 2017). Hassan et al (2008) also observed that due to the unprotected nature of wells, they are subjected to both allochthonous and autochthonous inputs of decaying organic matters. However, well 5 though uncovered had alkaline pH, which could be attributed to its location in a vegetated area and dilution due to its low-lying nature especially during the wet season (October – November 2022). On the other hand, the covered wells (1 and 3) had alkaline pH, which could be attributed to geology and less pollution. Acidic to alkaline pH values were also recorded elsewhere in Nigeria. For example, Jagaba et al (2020) recorded 5.9 – 9.1 in Rafin Zurfi, Bauchi State, Nigeria, 6.4 – 7.1 was recorded by Amoo et al (2021) in Gaya, Kano State, Nigeria and 5.3 – 7.1 was recorded by Iloba et al (2022) in Eku, Delta State, Nigeria. However, alkaline values (7.9 – 8.9) were recorded by Ali et al (2022) in Dutse, Jigawa State, Nigeria.

Electrical conductivity (EC) is an indirect indicator of pollution because of its close relationship with dissolved salts (de Sousa et al., 2014). EC values ranged between 60.3µs/cm and 136.4µs/cm. The lowest value was recorded in well 4 (June 2022) while the highest was recorded in well 3 (October 2022). The values were low and within 300 – 800 µS/cm prescribed for freshwater (Rusydi, 2018). There was no significant difference ($p > 0.05$) though the covered wells (1 and 3) were relatively higher. Values (77.0 – 119 µs/cm) within the range of this study were recorded by Iloba et al (2022) in Eku Delta State, Nigeria. However, Jagaba et al (2020) recorded higher values (57.0 – 254 µs/cm) in Rafin Zurfi, Bauchi State, Nigeria, 207.0 – 657 µs/cm was recorded by Amoo et al (2021) in Gaya, Kano State, Nigeria and value as high as 3999.0 µs/cm was recorded by Ali et al (2022) in Dutse, Jigawa State, Nigeria.

The total dissolved solids (TDS) ranged between 42.2 mg/L and 95.5 mg/L. The lowest value was in well 4 (June 2022) while the highest was recorded in well 3 (October 2022). These TDS values were low and lower than 1,000 mg/L prescribed for freshwater (Rusydi, 2018). TDS followed the same trend as electrical conductivity. There was no significant difference ($p > 0.05$) though the covered wells (1 and 3) were relatively higher. Elsewhere in Nigeria, for example, higher values were recorded. Jagaba et al (2020) recorded 36.0 – 163.0 mg/l in Rafin Zurfi, Bauchi State, Nigeria, 64.3 – 1006.0 mg/l was recorded by Ali et al (2022) in Dutse, Jigawa State, Nigeria and 944.0 – 1448.5 mg/l was recorded by Tula et al (2022) in four Local Government Areas of Adamawa State, Nigeria.

The values of nitrate (NO_3) ranged between 0.22 mg/L and 3.73 mg/L. The lowest value was recorded in well 1 (June 2022) while the highest was recorded in well 5 (September 2022). All nitrate values were lower than 9.1 mg/l set by FMEnv (2011) though wells 4 and 5 were significantly higher than wells 1 – 3. This could be attributed to general conditions of the wells (uncovered and poor sanitary condition). Similar conditions influenced nutrient and organic pollution of well waters in Eku, Delta State (Iloba et al., 2022). On the other hand, the two wells are located adjacent a wetland where rice and other crops were cultivated and domestic wastes are also dumped indiscriminately in the wetland. Well 5 was also more prone to the flooding from the wetland due to its low-lying condition. Domestic and agricultural wastes are major sources of groundwater contamination in Nigeria (Asen et al., 2019; Ibe et al., 2019; Jagaba et al., 2020; Amoo et al., 2021; Tula et al., 2022). Elsewhere in Nigeria, higher values were recorded. For example, Asen et al (2019) recorded 11.0 – 62050.0 mg/l in Makurdi, Benue State, Nigeria, Jagaba et al (2020) recorded 21.4 – 204.4 mg/l in Rafin Zurfi, Bauchi State, Nigeria, Amoo et al (2021) recorded 0.5 – 114.4 mg/l in Gaya, Kano State, Nigeria and Tula et al (2022) recorded 16.1 – 31.1 mg/l in four Local Government Areas of Adamawa State, Nigeria.

Chloride values ranged from 13.8 mg/L to 134.3 mg/L. The lowest value was recorded in well 3 (September 2022) while the highest was recorded in well 5 (August 2022). All chloride values were within 300 mg/l set by FMEnv. (2011); though well 5 was significantly ($p < 0.05$) higher than the covered wells (1 and 3). This could be attributed to general conditions of the well (low-lying, uncovered and poor sanitary condition) and contamination from discharged domestic and agricultural wastes around the surrounding environment as observed in nitrate (Asen et al., 2019; Ibe et al., 2019; Jagaba et al., 2020; Amoo et al., 2021; Iloba et al., 2022; Tula et al., 2022). Elsewhere in Nigeria, for example, Jagaba et al (2020) recorded lower values (2.1 – 8.4 mg/l) in Rafin Zurfi, Bauchi State, Nigeria and 6.4 – 17.5 mg/l recorded in Gaya, Kano State, Nigeria by Amoo et al (2021). On the other hands, some higher values were also recorded. Asen et al (2019) recorded 14.18 – 751.54 mg/l in Makurdi, Benue State, Nigeria and Ali et al (2022) recorded 1.8 – 343.4 mg/l in Dutse, Jigawa State, Nigeria.

Phosphate values ranged between 0.42 and 1.85 mg/L. The lowest value was recorded in well 2 (April 2022) while the highest was in well 4 (April 2022). All the values were within 3.5 mg/L set by FMEnv (2011); though wells 4 and 5 were significantly ($p<0.05$) higher than wells 1 – 3 as observed in Nitrate. This could be attributed to the same factors - the general conditions of the wells (low-lying, uncovered and poor sanitary condition) and contamination from discharged domestic and agricultural wastes around the surrounding environment. Elsewhere in Nigeria, for example, higher values were recorded. Asen et al (2019) recorded 12.3 – 1093.3 mg/l in Makurdi, Benue State, Nigeria and 2.0 – 9.2 mg/l was recorded by Iloba et al (2022) in Eku Delta State, Nigeria.

3.2 - Plankton composition, abundance and distribution

The composition, abundance and composition phytoplankton are presented in Table 2. A total of 415 individuals from 17 species and four (4) taxonomic groups were recorded. The number phytoplankton individuals recorded were lower than 430 individuals recorded by Khalil and Rabiu (2022) in Kano, Nigeria. However, number of taxa and taxonomic groups were higher than 13 and 3 respectively recorded by Khalil and Rabiu (2022). Baccillariophyceae had the highest abundance with 8 taxa and 273 individuals; contributing 65.31% of the total phytoplankton assemblage, followed by Chlorophyceae - 4 taxa and 97 individuals (23.20%). On the other hand, Cyanophyceae had 2 taxa and 25 individuals (5.98%) while Xanthophyceae had 3 taxa and 20 individuals (4.78%). Baccillariophyceae have been extensively used as bioindicators of pollution in water (Al-Tamimi and Al-Jumaily, 2021; Barinova et al., 2023; Metteb et al., 2023). Cyanophyceae was the most abundant recorded by Khalil and Rabiu (2022).

Table 2: Composition, Abundance and Distribution of phytoplankton in the wells

Group	Species	Well 1	Well 2	Well 3	Well 4	Well 5	Total
Cyanophyceae	*Anabaena cylindrical*	0	0	0	0	14	14
	Phormidium uncinatum	0	0	0	3	8	11
	Total	**0**	**0**	**0**	**3**	**22**	**25**
Chlorophyceae	*Hyalotheca mucosa*	0	5	0	0	6	11
	Spondylosium planum	0	4	0	0	5	9
	S. panduriforme	0	33	0	36	4	73
	Zygnema carteri	0	0	0	4	0	4
	Total	**0**	**42**	**0**	**40**	**15**	**97**
Bacillariophyceae	*Amphoria ovaries*	0	16	0	2	6	24
	Cymbella arctica	0	8	0	28	9	45
	Cocconeis pediculus	0	3	0	14	27	44
	Fragilaria crotonensis	0	0	0	5	6	11
	Gyrosigma distortum	0	44	0	9	15	68
	Melosira varians	0	0	0	0	7	7
	Navicula acacia	0	7	0	6	31	44
	Pinnularia hilseana	0	0	0	11	19	30
	Total	**0**	**48**	**0**	**75**	**120**	**273**
Xanthophyceae	*Tribonema viride*	0	0	0	9	0	9
	T. minus	0	0	0	3	0	3
	T. affine	0	0	0	8	0	8
	Total	**0**	**0**	**0**	**20**	**0**	**20**
	Total No. of taxa	0	8	0	13	13	34
	Total No. of Individual	0	120	0	141	157	418
	Shannon wiener index	0	1.676	0	2.216	2.350	
	Margalef index	0	1.462	0	2.435	2.373	
	Evenness	0	0.667	0	0.705	0.806	

Phytoplankton were only recorded in the uncovered wells (2, 4 and 5) as observed by Khalil and Rabiu (2022). Algae are generally lacking in groundwater (Griebler and Avramov, 2015) but usually have low biomass when they occur (Li et al., 2021) because light is a limitation (Maltsev et al., 2021). Since the wells were uncovered, the phytoplankton could have been introduced. Planktonic organisms can be dispersed outside of their normal environment by natural agents such as wind, extreme events, rain and other organisms such as birds, amphibious and land animals (Havel and Shurin 2004; Bergström et al. 2008; Cotoras and Zumbado, 2020; Jamieson, 2022). However, recently organism dispersal has highly increased accidentally or deliberately through human activities and man-made devices or instruments (Havel and Shurin 2004, Jamieson, 2022; Wejnerowski et al., 2022). Based on the foregoing, the buckets used in fetching water from these wells could also serve as a source of planktonic introduction. The presence of some taxonomic groups only and/or in high numbers in wells 4 and 5; suggests enrichment from the environment (Khalil et al., 2021; Jonah and Archibong, 2022). The community structure showed that number of taxa ranged between 8 (well 2) and 13 (wells 4 and 5) and the number of individuals ranged between 120 individuals (well 2) and 157 individuals (well 5). The number of taxa was within 7 – 13 recorded by Khalil and Rabiu (2022) while the spatial number of individuals (96 – 182) was higher. The biodiversity indices showed that Shannon-wiener Index ranged between 1.676 (well 2) and 2.350 (well 5) while Margalef Index ranged between 1.462 (well 2) and 2.435 (well 4). On the other hand, the evenness index ranged between 0.667 (well 2) and 0.806 (well 5). The biodiversity indices - Shannon-wiener Index and Margalef Index were less than 3; indicating low biodiversity (Morris et al., 2014; Li et al., 2021) while the evenness index was equally low; indicating dominance of a few species in the wells .

The composition, abundance and composition of zooplankton are presented in Table 3. A total of 958 individual from 24 taxa and 3 taxonomic groups were recorded. Studies on the composition, abundance and composition of zooplankton in Nigerian groundwater are lacking or sketchy as presented by Hassan et al (2008). However, the overall abundance was high and comparable to some surfacewater environment in Nigeria. Elsewhere across the globe groundwater zooplankton were well documented (Cavite et al., 2017; Korbel et al., 2017; Bozkurt, 2019; Pociecha, et al., 2021; Bozkurt, 2022). Rotifera had the highest abundance with 16 taxa and 659 individuals; contributing 68.8% of the total zooplankton assemblage, followed by Copepoda - 6 taxa and 228 individuals (23.8%) and Protozoa had 2 taxa and 71 individuals (7.4%).

Table 3: Composition, Abundance and Distribution of zooplankton in the wells

Group	Species	Well 1	Well 2	Well 3	Well 4	Well 5	Total
Protozoa	*Amoeba radiosa*	0	11	4	0	0	15
	Arcella mitrata	10	4	19	23	0	56
	Total	**10**	**15**	**23**	**23**	**0**	**71**
Rotifera	*Brachionus caudatus*	0	0	8	0	54	62
	Brachionus forficula	0	12	10	0	0	22
	Cephalodella gibba	12	3	0	38	0	53
	Conochilus unicornis	10	0	3	0	0	13
	Filinia opoliensis	0	0	0	18	13	31
	Keratella cochlearis	0	30	13	0	21	64
	Keratella quadrata	8	6	2	20	11	47
	Keratella tropica	0	0	16	10	8	34
	Lecane bulla	5	6	0	0	32	43
	Lecane pumila	8	17	2	33	14	74
	Monostyla bulla	0	0	1	0	11	12
	Notholca labis	0	11	24	2	2	39
	Polyarthra dolichoptera	0	0	0	16	2	18
	Synchaeta pectinata	0	3	0	33	4	40
	Testudinella emarginula	0	31	2	0	0	33
	Testudinella patina	42	2	3	11	16	74
	Total	**85**	**121**	**84**	**181**	**188**	**659**
Copepoda	*Cyclops scutifer*	7	22	15	0	5	49
	Cyclops nauplii	0	4	0	11	0	15
	Eucyclops agilis	26	0	2	0	13	41
	Paracyclops affinis	0	7	3	16	22	48

Group	Species	Well 1	Well 2	Well 3	Well 4	Well 5	Total
	Mesocyclops leuckarti	0	0	2	16	9	27
	Tropocyclops prasinus	33	11	1	0	3	48
	Total	**66**	**44**	**23**	**43**	**52**	**228**
	Total No. of taxa	10	16	18	13	17	24
	Total No. of Individual	161	180	130	247	240	958
	Shannon wiener index	2.156	2.678	2.722	2.504	2.519	
	Margalef index	1.945	3.373	4.084	2.322	2.991	
	Evenness	0.783	0.766	0.691	0.873	0.689	

Rotifera had the highest abundance in line with Bozkurt (2019, 2022) especially in the uncovered wells (2, 4 and 5). This could be attributed to their capacity to tolerate wide range of physicochemical parameters (Hamaidi-Chergui et al., 2013). However, Cladocerans recorded in related studies (Cavite et al., 2017; Korbel et al., 2017; Bozkurt, 2019; Pociecha, et al., 2021; Bozkurt, 2022) was completely absent. This could be an indication that the well waters have not deteriorated badly (Jahan and Tabassum, 2019). Though zooplankton was recorded in all the wells; the abundance was higher in the uncovered wells. The wells are fed by groundwater and rainfall. The abundance and distribution recorded could be due to introduction from the groundwater feeding the wells, plankton dispersal methods observed in the phytoplankton as well as physicochemical parameters. pH, conductivity, temperature, nutrients and food availability are among the parameters that regulate zooplankton assemblage (Jonah et al., 2020; Anyanwu et al., 2021b; Bozkurt, 2022); which has reflected in the dominance of different taxonomic groups in different wells. Zooplankton did not exhibit any particular trend, Rotifera recorded higher abundance in the uncovered wells (2, 4 and 5). *Lecane pumila* was the most abundant Rotifera. The dominant rotifera genera - *Brachionus, Keretella* and *Lecane* have been reported as bioindicator of pollution (Igwe et al., 2019). The community structure showed that number of taxa ranged between 10 (well 1) and 18 (well 3) and the number of individuals ranged between 130 individuals (well 3) and 247 individuals (well 4). The number of taxa and individuals is comparable to some freshwater environments. The biodiversity indices showed that Shannon-wiener Index ranged between 2.156 (well 1) and 2.722 (well 3) while Margalef Index ranged between 1.945 (well 1) and 4.084 (well 3). On the other hand, the evenness index ranged between 0.691 (well 3) and 0.873 (well 4). The Shannon-wiener Index and Margalef Index were less than 3; indicating low biodiversity (Morris et al., 2014; Li et al., 2021). However, Margalef Index in well 3 was greater than 3 even though the abundance was moderate; this is because the index is concerned about the richness and taxonomic composition instead of community abundance (Meng et al., 2020). As in the phytoplankton, the evenness index was equally low; indicating dominance of a few species in the wells.

4 - CONCLUSIONS

The physicochemical parameters were all within acceptable limits except pH. However, nitrate, chloride and phosphate were significantly higher in wells 4 and 5 due to location, unprotected nature and human activities around them. The plankton assemblage was rich and comparable to some surface water environments. However, the presence and dominance of indicator groups (Baccillariophyceae and Rotifera) especially in the uncovered wells (2, 4 and 5) is an indication that the water quality was deteriorating. The low values of the biodiversity indices also point to the poor water quality. It can be concluded that the composition, abundance and distribution of the plankton in the wells was influenced by the physicochemical conditions of the wells; which in turn was influenced by the location, construction, human activities and the general environmental conditions of the wells.

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