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Physico-chemical parameters and some heavy metals analysis of water samples collected from Shella Fadama, Usmanu Danfodiyo University Sokoto, Nigeria

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Abstract

This study was carried out to investigate the physicochemical parameters and some heavy metals concentration of Shella Fadama, Usmanu Danfodiyo University Sokoto to determine its water quality for agricultural purpose. The Fadama water was sampled and analyzed using standard methods. The range of the monthly values of the physicochemical parameters studied were temperature (23.1-37.2 ^{o}C), pH (6.2-7.3), turbidity (25.3-30.3NTU), electrical conductivity (120.1-268.7 µS/cm), Dissolved Oxgen (DO) (2.8-4.0 mg/l), Biological Oxygen Demand (5.1-10.6 mg/l), nitrate-nitrogen (0.06-1.08 mg/l), phosphate- phosphorous (0.04-0.19 mg/l) and total hardness $CaCO_3$ (2.01-10.00 mg/l). The values of the heavy metals studied (Cu, Fe^{2+} and Zn) were in the range of (0-0.04mg/l), (0.01-1.36mg/l) and (0-0.82mg/l) respectively. All the parameters of the samples and the heavy metals studied showed no significant difference ($p>0.05$) except in nitrate-nitrogen (NO_3-N) and Zn ($p<0.05$). All the values of the parameters at the period of study were within the limit set by FEPA, (1991) USEPA (1991) and FME (2001) for irrigation purpose except turbidity and BOD which are slightly above these standards. Some of the mean periodic values of Zn concentration are also slightly above the USEPA (1986) standard. However, the Shella Fadama during the study period is safe for agricultural activities.

Keywords: Assessment; Physicochemical Parameters; Heavy Metals; Shella Fadama

1. Introduction

A pond is an artificial or natural fresh water body which usually retains water for most part of the year. Ponds are useful in many ways and it is one of the methods of artificial infiltration of underground water. It is often over looked as a functional habitat that contains a wide variety of organisms, which all interact with one another in various food webs (Bukar, 2002). Animals as well as human activities on a water body greatly influence the characteristics of a water body. A report from Umma *et al.*(2014) stated that over the years, climatic changes and increase human activities such as farming activities, both rain fed and irrigation, with the catchments basin of most of the reservoirs have resulted to gradual silting up, nutrient building up and invasion of aquatic plants.

A healthy aquatic ecosystem is depended on the physicochemical and biological characteristics (Verma *et al.*, 2012). The physical and chemical parameters serve as pollution indicators in water quality monitoring which is a fundamental tool in the management of fresh water resources (Balarabe, 2001). Heavy metals are a general collective term which applies to the group of metals and metalloids with an atomic density greater than 4glcm^3 (Nazemi, 2012). They may results from industrial, mining, and agricultural runoff. Some of the heavy metals are essential micronutrients for living process when in low concentration. However, their presence in high concentration may be toxic to living organisms.

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A report from Waziri and Ogugbuaja (2010) stated that water quality parameters provide the basis for judging the suitability of the water for irrigation, drinking, bathing, fishing, and industrial processes. Shella Fadama is a small pond, yet a vital water body which is surrounded by farmland and grazing land located within Usmanu Danfodiyo University Sokoto. It is a vital source of irrigation for the local farmers and it also serve as a source of water for the livestock rearing around the area. Thus, this study aimed at assessing some of the physicochemical parameters and some heavy metals concentration of water samples collected from Shella Fadama, Usmanu Danfodiyo University Sokoto to determine its suitability for agricultural activities.

2. Materials and methods

2.1. Materials

The physico-chemical parameters were analysed in Agriculture Physical laboratory and physiology lab of UDUS and for the heavy metals analysis, the water samples were digested with nitric acid before taken to the old Energy Research Centre of Usmanu Danfodiyo University Sokoto for Atomic Absorption Spectrophotometer (AAS).

2.2. Study Area

The part of Shella Fadama studied was located very close to some farmlands near the student's hostel Usmanu Danfodiyo University, Sokoto. The Shella Fadama lies between latitude 13728 N and longitude 51210 E (global position system (GPS) Trex Garmin model) was used in marking the global position of the study area. It receives it main source of water from the rainfall that it receives from the main Shella pond at Unguwar Ruwa which is approximately 7.5km away from the UDUS Shella Fadama. The Fadama receives additional supplemental nutrients from the irrigation runoff from the nearby farmlands and also from animals (cattle, sheep, goats and birds) rearing around the area. Over the years, the Fadama has played a crucial role in the lives of the local community. Agricultural products such as millet, spinach, sweet potatoes, sugarcane, tomatoes, moringa etc were grown in the nearby farmlands and hence serves as a means of livelihood to the local farmers around the area and it also serves as a source of drinking water for domestic animals such as cow, sheep, birds etc rearing around the area.

2.3. Sampling sites

The water samples were collected from four different points along the pond as described by Ahmad and Indabawa (2015). GPS model (German, USA) was used in marking the global position of the points.

- Point A: The entry point of the Fadama and one of the shallow parts of the pond. It lies between latitude 13.125 E and longitude 5.203 N.
- Point B: The middle of the pond and it is located on latitude 13.124 E and longitude 5.203N
- Point C: This is very close to some farmlands and it is located on latitude 13.123 E and longitude 5.204 N. At this point, domestic animals such as cow, goats, birds etc are rearing along the area.
- Point D: This is also close to some farmlands and is located on latitude 13.124 E and longitude 5.204 N.

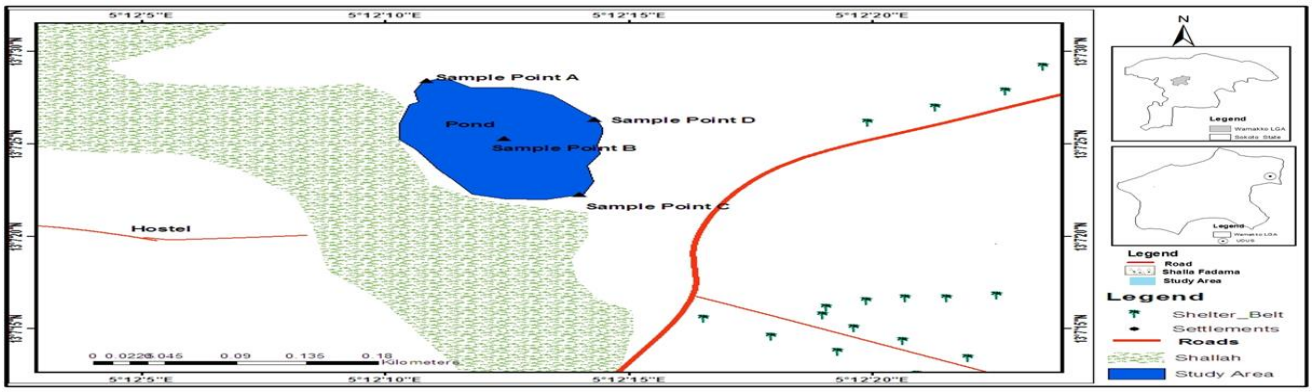

Figure 1 The map of the Shella Fadama and the sampling sites.

Source: Geographic Information System Laboratory, UDUS (GIS lab) (2021).

2.4. Sample Collection

The water samples were collected monthly for a period of twelve months from four different points along the Fadama in the morning from (8:00am – 10:00am). The water sample was collected by using 1 litre sterile plastic bottles that were labeled appropriately according to the protocol of Ahmad and Indabawa (2015). In this method, the water was sampled at the surface level by dipping a plastic sampling bottle and slides over the most upper surface of water with their mouth against passage of the water into the bottle. The samples were kept on ice and transported to the laboratory for analysis.

2.5. Determination of Physico-chemical parameters

All the physicochemical parameters (temperature, pH, turbidity, electrical conductivity, DO, BOD, nitrate-nitrogen (NO_3-N), phosphate-phosphorous (PO_4-P), and total hardness) were determined using standard methods of APHA (1998, 1999, and 2005), Hanna instruments (2004), Chriastian (2004), and Bremner and Mulvarey (1982). For the heavy metals analysis, the water samples were digested with nitric acid before taken to the old Energy Research Centre of Usmanu Danfodiyo University Sokoto for Atomic Absorption Spectrophotometer (AAS).

2.6. Statistical Analysis

The Data was subjected to one way ANOVA using SPSS statistical package version 23. Means were separated using post hoc test multiple comparison at 5% to compare the differences.

3. Results and Discussion

Table 1 shows the mean monthly variation in water temperature, pH, turbidity and electrical conductivity of the Shella Fadama. Water temperature refers to the degree of heat in a body of water, and is typically measured in degrees Celsius (^oC) or Fahrenheit (^oF). The mean water temperature was lowest (23.40±0.20^oC) in January with the highest (37.12±0.25^oC) in April. This is generally consistent with expectations, as during the cold months (harmattan) the temperature is low due to the Northeast trade wind blowing, and the high temperature in the hot months may be due to characteristics hot weather in Sokoto. This findings is in agreement with the results of Raji *et al.* (2015) in river Sokoto and slightly deviates from the results of Obaroh *et al.* (2016) in river Argungu and Rabiu *et al*. (2018) in Watari Dam, Kano. pH is a measure of the acidity or alkalinity of water, indicating the concentration of hydrogen ions (H^+) or hydroxyl ions (oH^-) in the water. The mean monthly pH value was lowest (6.30±0.08) in August and highest (7.15±0.03) in April. This value revealed that the water is slightly acidic and neutral in nature. The low pH in August may be attributed to the heavy rainfall which causes water runoff to enter the Fadama bringing in additional organic matter, sediments and other materials that can lower the pH of the water. The result of this finding agrees with the report of Obaroh *et al*. (2016) whom reported pH range of (6.30±0.02-7.17±0.01) and slightly deviates from the findings of Rabiu *et al.* (2018) and Nafiu and Ibrahim (2016) whom reported the range of (7.3-8.9) and (7.5-8.9) respectively in their studies.

Turbidity is a measure of clarity of water usually measured in Nephelometric Turbidity Units (NTU). The lowest mean monthly turbidity value (25.35±0.06 NTU) obtained was in February and the highest (30.13±0.15 NTU) in August. The highest turbidity value obtained in August may be as a result of surface runoff, erosion, sedimentation and algal blooms during the rainy period. The result of this study deviates from the range reported by Nafiu and Ibrahim (2016) whom reported turbidity in the range of (16.3-37.1 NTU) in Thomas Dam, Danbatta, Kano and Rabiu *et al*. (2018) who recorded turbidity range of (0.10-0.25NTU) in watari Dam, Kano. Electrical conductivity is a measure of the ability of water to conduct an electric current, expressed in microsiemen per centimeter (µS/cm). The mean monthly value of electrical conductivity was lowest (121.30±0.76 µS/cm) in June and highest (263.73±3-98 µS/cm) in August. The high electrical conductivity recorded may be possibly due to the water runoff containing fertilizers and other chemicals from the nearby farms that enters the Fadama during the rainy season. This finding corroborates with the result of Rabiu *et al*. (2018) whom reported the range of (156-245 µs/cm) and higher than the range reported by Ikhuoriah and Oransaye (2016) who reported the range of (62.3-70.11 µs/cm).

Similarly, table 2 revealed the mean monthly variation in Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), nitrates-nitrogen, phosphate-phosphorous and total hardness. Dissolved Oxygen is the amount of oxygen that is dissolved in water usually expressed in milligram per liter (mg/L) or Parts per million (ppm). The DO value was lowest (2.75±0.05mg/l) in May and highest (4.00±2.38mg/l) in March. The highest dissolved oxygen value recorded in March may be as a result of high photosynthetic activity of algae which increase the level of DO in the water. Similar observations were made by Rabiu *et al*. (2018) and Obaroh *et al.* (2016). Biological Oxygen Demand (BOD) is a measure of the amount of dissolved oxygen that is required by aerobic microorganisms in water to break down organic matter. It is expressed in milligrams of oxygen consumed per liter of water (mg/L/) over a specific period usually, 5 days at

20°C. The lowest BOD recorded was (5.38mg/l±0.31 mg/l) in December and the highest (10.10±0.14mg/l) in October. High BOD levels can lead to low dissolved oxygen which can cause death of aquatic organisms. The values recorded in this study are lower than the values reported by Obaroh *et al.* (2016) and higher than that of Rabiu *et al*. (2018). Nitrate-nitrogen is a form of nitrogen that is commonly found in aquatic environments usually expressed in milligrams per liter (mg/L). The lowest NO_3N (0.02±0.02mg/l) was obtained in November and the highest (1.06±0.02mg/l) in August. The lowest value recorded may be due to nutrient up take by plants and other aquatic organisms in the Fadama While the high value obtained may be as a result of excessive nutrients input from agricultural fields or urban areas which can introduce nitrogen into the water body. Statistically, there is significant difference ($p<0.05$) in NO_3-N between the months.

Phosphate-phosphorus (PO_4-P) is a form of phosphorus that is an essential nutrient for the growth of plants and algae in aquatic environments. It is usually expressed in milligrams per liter (mg/L) or part per million (ppm). The lowest PO_4-P (0.12±0.08mg/l) was in October and the highest (0.18±0.02 mg/l) in January. There was no significant difference in PO_4-P ($p>0.05$) between the months. Total hardness ($CACO_3$) is a measure of the combined concentration of calcium, magnesium and other metal ions in a water body. It is expressed as milligrams per liter (mg/L) or parts per million (ppm). The lowest mean monthly value of total hardness (2.20±0.18 mg/l) was in December and the highest (8.48±1.32) in June. Too low total hardness in water can cause excessive nutrient uptake by aquatic plants and algae leading to eutrophication and too high total hardness in a water body can cause water to become alkaline which can be toxic to some aquatic organisms.

The result in the mean monthly variation of heavy metals (Cu, Fe^{2+} and Zn) was shown in table 3. The mean monthly value of Cu was low (0.01±0.01mg/l) in most of the months and the highest (1.10±0.10 mg/l) in January. The lowest mean monthly value of Fe^{2+} was (0.24±0.32mg/l) in December and the highest (1.10±0.18mg/l) in August. Zinc mean monthly value was lowest (0.04±0.34mg/l) in August and the highest (0.61±0.22mg/l) in October. High levels of heavy metals in a water body can be toxic to many aquatic organisms. And also if they are too low or absent in the water body can limit the growth of some certain aquatic plants and algae, as they depend on some metals for their nutrient.

Table 4 shows the periodic variation in the physico-chemical parameters of Shella Fadama. The lowest mean periodic water temperature was observed in the harmattan with a mean of (24.83±0.39 °C) followed by the wet and hot periods with (31.29±0.75°C) and (36.16±0.21°C) respectively. The lowest mean periodic pH was in the Harmattan (6.6±0.05) followed by wet period (6.71±0.06), and the hot period (7.0±0.04). There was no significant difference between the periods ($p>0.05$). Turbidity variation during the harmattan was lowest (26.27±0.18 mg/l), followed by the hot period (27.57±0.15mg/l) and then the wet period (29.26±0.25 mg/l). The mean periodic variation in electrical conductivity was lowest (128.74±0.85µS/cm) in the hot period, followed by the Harmattan (169.47±1.57 µS/cm) and then the wet period (231.06±6.43 µS/cm).

DO lowest value (3.01±0.07mg/l) was in the hot period, followed by the wet period (3.06±0.05mg/l) and then the Harmattan (3.60±0.08mg/l). The BOD lowest values was (7.17±0.46mg/l) in Harmattan, followed by (8.39±0.27mg/l) in the hot period and (8.73±0.28mg/l) in the wet period. The Nitrate of the water varied according to the periods, it ranged from (0.27±0.23mg/l) during the hot period, (0.36±0.26mg/l) in the Harmattan and (1.05±0.21mg/l) in the wet period. Low level of Nitrate is an indication of low pollution level in water. The higher amount of nitrate level in the Fadama during the wet period may be attributed to the surface run offs containing domestic faeces and fertilizers applied to the nearby farm land. Similar observations were made by Nafiu and Ibrahim, (2016). The variation in phosphate between the periods are (0.13±0.02mg/l) in hot period, (0.15±0.04) in wet period and (0.17±0.02) in Harmattan. A report from Rabiu *et al*. (2018) reported the range of 13.5-23.3mg/l and 0.5-2.9mg/l of Nitrates and phosphate respectively. The periodic variation in water hardness was lowest (2.98 ±0.25 mg/l) during the Harmattan, followed by (4.82 ±0.22 mg/l) during the wet period and highest (7.21±0.50mg/l) during the dry period. This values were generally low compared to the values reported by other researchers such as Sarkinnoma *et al.* (2013) and Raji *et al.*(2015). The mean periodic values of Cu (0.01±0.01 mg/l) were found to be the same throughout the periods. The mean periodic value of Fe^{2+} is lowest (0.20±0.26mg/l) during the Harmattan, followed by (0.46±0.19mg/l) during the hot period and the highest (0.98±0.14mg/l) in the wet period. The mean periodic values of zinc were (0.11±0.02mg/l), (0.16±0.17mg/l) and (0.22±0.26mg/l) during the hot, harmattan and wet periods respectively (Table 5). Statistically, there is significant difference ($p<0.05$) in the Fe^{2+} concentration between the periods.

Table 1 Mean Monthly Variation in Temperature, pH, Turbidity and Electrical conductivity of Shella Fadama UDUS, Nigeria (March 2018 – April 2019)

Physico-chemical Parameters				
Months	**Temp (^{O}C)**	**pH**	**Turbidity (NTU) (ms/cm)**	**Electrical Conductivity (µS/cm)**
March	35.25 (± 0.96)	7.03(± 0.05)	27.10(± 0.08)	130.03(± 0.05)
April	37.12 (± 0.25)	7.15 (± 0.13)	27.30(± 0.19)	124.23 (± 3.59)
May	36.25 (± 0.50)	6.93 (± 0.13)	27.48 (± 0.34)	139.43 (± 2.30)
June	36.02 (± 0.05)	6.88 (± 1.00)	28.43 (± 0.43)	121.30 (± 0.76)
July	36.00 (± 0.08)	6.95 (± 0.05)	29.95 (± 0.13)	194.13 (± 2.67)
August	28.28 (± 0.05)	6.30 (± 0.08)	30.13 (± 0.15)	263.73 (± 3.98)
September	29.90 (± 0.25)	6.80 (± 0.08)	29.30 (± 0.29)	235.65 (± 1.95)
October	31.03 (± 0.12)	6.78 (± 0.05)	27.68 (± 0.15)	230.85 (± 2.52)
November	25.33 (± 0.22)	6.75 (± 0.06)	26.15 (± 0.17)	161.40 (± 1.60)
December	23.55 (± 0.06)	6.60 (± 0.07)	27.20 (± 0.18)	166.90 (± 2.20)
January	23.40 (± 0.20)	6.40 (± 0.15)	26.38 (± 0.34)	172.85 (± 2.87)
February	27.02 (± 0.34)	6.70 (± 0.18)	25.35 (± 0.06)	176.75 (± 0.52)

Values in parenthesis are standard deviation of mean

Table 2 Mean Monthly Variation in DO, BOD, NO3-N, PO4-P and Total hardness of Shella Fadama UDUS, Nigeria (March 2018 – April 2019)

Physico-chemical Parameters					
Months	DO (mg/l)	BOD (mg/l)	(NO_3-N) (mg/l)	(PO_4-P) (mg/l)	Total hardness (mg/l)
March	4.00(±2.38)	9.60(±0.43)	0.12(±0.23)	0.13(± 0.12)	7.34(±2.03)
April	2.88 (±0.96)	7.20 (±0.37)	0.14(± 0.02)	0.14(± 0.17)	7.10 (±1.59)
May	2.75 (±0.05)	8.93 (±0.25)	0.54 (±0.32)	0.13(± 0.01)	5.73 (±2.10)
June	3.30 (±0.20)	7.85 (±0.90)	0.27(± 0.07)	0.14(± 0.02)	8.48 (±1.32)
July	2.98 (±1.00)	7.23 (±0.46)	1.05(±0.01)	0.16(± 0.02)	5.78 (±0.18)
August	3.32 (±0.05)	9.20 (±0.28)	1.06(±0.02)	0.17(± 0.02)	5.46 (±0.44)
September	3.13 (±0.96)	8.40 (±0.37)	1.04(±0.03)	0.17(± 0.02)	4.29 (±0.42)
October	2.83 (±0.50)	10.10 (±0.14)	1.04(±0.02)	0.12(± 0.08)	3.78 (±0.96)
November	3.10 (±0.08)	7.93 (±0.54)	0.02(±0.02)	0.17(± 0.03)	4.67 (±0.76)
December	3.70 (±0.08)	5.38 (±0.31)	1.00(±0.11)	0.16(± 0.02)	2.20 (±0.18)
January	3.86 (±1.00)	5.75 (±0.42)	0.71(±0.02)	0.18(± 0.02)	2.53 (±0.22)
February	3.73 (±0.00)	9.63 (±0.74)	0.03(±0.08)	0.16(± 0.03)	2.74 (±0.49)

Values in parenthesis are standard deviation of mean

Table 3 Mean Monthly Variation in some heavy metals of Shella Fadama UDUS, Nigeria (March 2018 – April 2019)

Heavy Metals Concentration			
Months	Cu (mg/L)	Fe^{2+} (mg/L)	Zn (mg/L)
March	0.01 (± 0.01)	0.68 (± 0.22)	0.13 (±0.03)
April	0.50 (±0.11)	0.50 (±0.11)	0.11 (±0.01)
May	0.01 (±0.0.01)	0.37 (±1.00)	0.11 (±0.04)
June	0.02 (±0.01)	0.29 (±0.01)	0.10 (±0.03)
July	0.03 (±0.01)	0.95 (±0.10)	0.05 (±0.08)
August	1.10 (±0.18)	1.10 (±0.18)	0.04 (±0.34)
September	0.01 (±0.01)	1.05 (±0.04)	0.17 (±0.10)
October	0.02 (±0.01)	0.86 (±0.15)	0.61 (±0.22)
November	0.01 (±0.01)	0.27 (±0.05)	0.29 (±0.28)
December	0.01 (±0.01)	0.24 (±0.32)	0.19 (±0.84)
January	0.02 (±0.01)	0.45 (±0.03)	0.11 (±0.13)
February	0.0 (±0.01)	0.26 (±0.44)	0.06 (±0.97)

Values in parenthesis are standard deviation of mean

Table 4 Mean Periodic Variation in Some Physicochemical Parameters of Shella Fadama UDUS, Nigeria (March 2018 – April 2019)

Periods				
Parameters	**Hot Period**	**Wet Period**	**Harmattan**	**Standard Limit**
Water temp (^oC)	36.16(± 0.85)	31.29 (±2.98)	24.8 (±1.54)	< 40^oC*
pH	7.00(±0.14)	6.7(±0.26)	6.6(±0.19)	6.0 - 9.0*
Turbidity (NTU)	27.5(± 0.59)	29.26 (±1.01)	26.27(±0.71)	< 25 NTU**
Electrical Conduct. (µS /cm)	128(±7.40)	231.06 (±25.70)	169.47(±6.28)	<1000 µS /cm**
DO (mg/L)	3.01(±0.26)	3.06(±0.20)	3.60(±0.31)	5.0 – 9.0 mg/L**
BOD (mg/L)	8.39(±1.07)	8.73(±1.13)	7.17(±1.83)	3.0 – 6.0 mg/L**
Nitrate (NO_3) (mg/L)	0.27(±0.23)	1.05(± 0.20)	0.36(± 0.26)	10 mg/L***
Phosphate (PO_4) (mg/L)	0.13(±0.02)	0.15 (± 0.04)	0.16 (± 0.02)	0.1 mg/L**
Total hardness (mg/L)	7.21(± 1.89)	4.82(± 0.90)	2.98(± 1.00)	-

* FEPA (1991), **FME (2001), ***USEPA (1991); Values in parenthesis are standard deviation of mean

Table 5 Mean Periodic Variation in Some Heavy Metals of Shella Fadama UDUS, Nigeria (March 2018 – April 2019)

Periods				
Parameters	**Hot**	**Wet**	**Harmattan**	**USEPA Standard (µg/L)**
Cu (mg/L)	0.01 (± 0.01)	0.01 (± 0.01)	0.01 (± 0.01)	-
Fe2+ (mg/L)	0.46 (± 0.19)	0.98 (± 0.14)	0.20 (± 0.26)	1000a
Zn (mg/L)	0.11 (± 0.02)	0.22 (± 0.26)	0.16 (± 0.17)	120b

* FEPA (1991), **FME (2001), ***USEPA (1991); Values in parenthesis are standard deviation of mean

4. Conclusion

The values of the physico-chemical parameters determined in the Shella Fadama, UDUS Nigeria, slightly fluctuate during the research period which may be attributed to changes in the local environmental condition and also as a result of agricultural activities. However, the physicochemical parameters are found to be within the FEPA, (1991) USEPA (1991) and FME (2001) standard limit for irrigation water except turbidity and BOD which are slightly higher than these standards. Some of the mean monthly values of zinc recorded are slightly above the USEPA (1995) standard. The result showed that the physico-chemical parameters studied are safe for agricultural activities.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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