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Assessment of The Lamingo Dam Water Quality For Irrigation Purposes In Jos North Local Government of Plateau State, Nigeria

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Abstract
One among the major problems confronting the world today is water scarcity; the water resources of many countries of the world are insufficient to meet the present demand for irrigation, municipal industries and other allied uses. The construction of dams and reservoir is considered as the most effective means of solving human problems of water storage, due to prolonged dry periods and severe drought. This study was carried out to access physicochemical parameters and to investigate the variation of the elements at different sections of Lamingo dam reservoir situated in Jos North. Water samples were collected in three (3) different locations namely the upper, middle and lower section; analyzed in Bauchi state water quality laboratory. The temperature ranged from 23.4- 32.8^{0}C, P^{H} ranged from 6.7 - 8.06; EC ranged from 72 - 109.7 µs/l; TDS ranged from 32 -56mg/l, total hardness ranged from 5 – 120 mg/l; Nitrate ranged from 0.5- 1.38mg/l; Sulphates ranged from 1- 15mg/l. Others are Potassium which ranged from 0.5- 25mg/l and Phosphate which ranged from 0.02-11.7 mg/l. The result of the analyzed parameter when compared to the standard for irrigation water quality of NESREA (2011) and FME were within the permissible limits, but phosphates was high with respect to NESREA and FME standards; which could lead to loss of biodiversity, excessive growth of algae and aquatic plant, death of aquatic life, creation of imbalances which destroys other forms of life and produce harmful toxins which can affect human life adversely.
Keywords: *Lamingo, water quality, permissible limit, physical and chemical properties.*

Introduction
Water is an important element for all human beings in the world. One third of the world's population, roughly 2.4 billion people, live in water stress countries and by 2025 the number is expected to rise to two thirds (Daniel *et al.,* 2007). We need water for domestic purposes, industries and irrigation, among others; it is usually taking for granted because of its availability but when in scarcity, it becomes our most precious resources (Vivan *et al*., 2014).

Among the myriads of problems confronting the world today is water scarcity; the water resources of many countries of the world are insufficient to meet the present demand for irrigation, municipal, industries and other allied uses. Even countries that are richly endowed with water still practice irrigation to supplement rainfall, because rainfall may not be sufficient and may not occur at the right time (Marc, 2008, Oiganji *et al.,* 2011).

The quality of water for irrigation, depends on the nature of the composition of the soil, sub-soil depth and depth of water table. Good water quality is important to the success of any irrigation project; every water supply has some chemical and physical effects on soil when applied over some period of years (FAO, 1991). Climatic change will likely increase water demand for irrigation, due to prolonged dry periods and severe drought. Among other forces, urbanization is one of the most detrimental force affecting stream health and one of the biggest challenges facing water users with myriads of results (Kearns *et al*., 2005). Amadi *et al.* (2012) reported that water quality is important in water supply, irrigation, fish production, recreation and other purposes to which the water must have been impounded. WHO (2004) reported that irrigation has been practiced throughout the world for several millennia, but it is only in this century that the

importance of irrigation water quality has been recognized. Water quality is a complex subject which involves physical, chemical, hydrological and biological characteristics of water and their complex and delicate relations from the user's point of view (Mauskar, 2008).
Poor quality of irrigation water reduces soil productivity, changes soil chemical properties, create crop toxicity and ultimately reduces yield, it has great effect on soil fertility, seed germination, plant susceptibility to pest and diseases, among others (Talukder *et al.*, 1998; Odjugo and knoyeme, 2008).
The construction of dams and reservoir is considered as the most effective means of solving human problems of water storage in sub-humid and arid regions. Dams have been essential in establishing and supporting towns and farms as well as producing food by irrigation of crop land (Adams, 2000). A dam is a barrier that stops or restricts the flow of water; reservoirs created by dams do not only suppress floods but also provide water for activities such as irrigation, human consumption, industrial use, aquaculture and navigation (Bartleby, 2009). A reservoir carries several deposits like organic, vegetable growth and algae, thus causing change in the taste of water; most dam gets sewage discharge from a city or town, hence, it becomes contaminated (Sentina Usen, 2001).
Dam water managers require high quality scientific information on the quality and quantity of the water under their control. The physico-chemical characteristics of fresh water bodies are determined largely by the climatic, geomorphological and geochemical conditions prevailing in the drainage basin and the underlying aquifer (Chapman, 1992).
The Lamingo dam is an earth dam meant for urban water supply; it was constructed in 1973 by Plateau State Government (Vivan *et al.,* 2014). Major uses of dam water can be summarized as portable water supply, irrigation of agricultural lands, industrial and municipal water supplies, fishing, recreation and aesthetic value (Adams and Peck , 2008).
Most of the waste that are discharged into the dams are industrial, domestic and agricultural which contain harmful chemicals such as heavy metals, oil, settle-able solids, ammonia and nutrients which may affect the quality of the reservoir of dams (Sentina Usen, 2001). In view of this, there is need to investigate the concentration levels of some elements in the reservoir water of dams, so that the source of contaminant can be traced and also ways of monitoring such contamination.
The water in Lamingo Dam has been contaminated by human activities as reported by Vivan *et al.,* (2014), the concentration levels of most of the elements were beyond the permissive limit for irrigation, which has profound effect on irrigation water quality for crop production in the study area. According to Dhembare (2012), irrigation of agricultural crops with poor quality water decreases the yield; hence there is need to monitor the concentration levels of some key elements of the reservoir of the dam, which has not been carried out for about five years. Assessing the suitability of water for irrigation purposes is needed to avoid low crop yield, health issues for humans and animals.
The Lamingo community depends on the Lamingo Dam water for irrigation purposes, domestic activities and as source of drinking water for straying animals in the environment; therefore, if the water quality is altered by toxins it will be harmful to both man, animal and plants which will in turn reduce crop yield and nutrients in the soil. Therefore, this research attempts to investigate the concentration levels of some elements in the Dam of the study area, this will also enable us to identify any element that is beyond the permissible limit according to set standards and propose ways of regulating such contaminations.

Materials and Method

Description of the Study Area

A field study to investigate the suitability of water quality for irrigation purposes was conducted at the Lamingo Dam which is located in Jos North local government; Plateau State is located on latitude $9^0$56N and longitude $8^0$53E. The Lamingo dam is an earth dam meant for urban water supply, the Lamingo dam was constructed by the Plateau State Government 1973. The dam has a height of 15.72m and a length of 3.62 km with storage capacity of $90m^3$ per daym (Vivan *et al.,* 2014).

Water Collection

The dam was divided into three zones namely the upper, center and lower zone. The latitude, longitude and elevation above sea level of the upper, center and lower section of the dam where samples were collected were $9^0$53N, 08^0.56E, 1276m; 09^0.33N, 08^0.56E, 1275m, and 09^0.35N, 08^0.56E, 1278m, accordingly. Water samples were taken from these zones by sitting in canoe through these points. Collection of water samples was done in the morning between 7-9 am using Grab method as specified by World Bank (2008). Water samples were collected by lowering pre-cleaned plastic bottles to depth of 30 cm into clean bottles, three samples were collected bi-monthly during the month of September and November 2017 and January 2018, and were taken to Bauchi state water quality laboratory within twenty-four hours for analysis. A total of thirty (30) samples were collected, 10 samples from each of the three zones of the dam and the means were estimated as reported by Oiganji *et al.,* (2011).

Chemical and Physical Analysis

The chemical analysis of water involves the chemical test which was carried out to determine some chemical parameters and corresponding chemical characteristics of water. The chemical analysis includes: total dissolve solid, P^H, total hardness, electrical conductivity, nitrate, Sulphates, chloride, potassium and phosphate (Modi, 2006; Ayers and Westcott, 1985). The parameters analyzed, unit and methods used are presented in Table 1.

Table 1: Parameters analyzed, Unit and Methods used

Parameters	Unit	Method Used
pH		pH meter
Electrical conductivity	µs/cm	Conductivity meter
TH as ($CaCO_3$)	Mg/l	EDTA titrometric
Phosphate	Mg/l	Gravimetric
Potassium (K^+)	Mg/l	Photometer
Sulphates (SO_4^{2-})	Mg/l	Sulfa ver 4
Total Dissolve Salt	Mg/l	Conductivity meter
Calcium (Ca^{2+})	Mg/l	EDTA titrimetric
Chloride (Cl^-)	Mg/l	Agerntometric

Statistical Analysis

Data obtained was analyzed using prism windows version 7.04 to compare the means of the physicochemical parameters. T -test was used to test for significant differences between means and Federal ministry of environment (FME) and National Environment Standards and Regulation Enforces Agency (NESREA, 2011) standards.

Results and Discussion

Temperature and pH

The temperature of the water sample obtained at the lower section of the Dam, throughout the period of study (September 2017– January 2018) ranged from 23.4 – 32.2 ^{0}C as shown in Table 2. The lowest temperature value of 23.4^{0}C was obtained in the month of January, while the highest temperature value of 32.2^{0}C was obtained in the month of September; during the month of November and January, the temperature values were below the permissible limit for irrigation water with respect to NESREA standard, which was not the case for WHO and FME standard for temperature for irrigation water.

Table 2 Parameters at lower Section of the Lamingo Dam

Parameter	13/09/17	13/11/17	13/01/18	mean	max	min	STDEV	NESREA	FME
Temperature (^{0}C)	32.2	25.6	23.4	27.1	32.2	23.4	4.6	27-28	<40
pH	7.01	7.4	7.58	7.3	7.6	7.0	0.3	6.5-8.5	6.0-9.0
EC (μScm^{-1})	72	109.7	84.8	88.8	109.7	72.0	19.2	0-1000	1000
TDS (mg/l)	32	56	42.7	43.6	56.0	32.0	12.0	500	1000
TH (mg/l)	5	45	120	56.7	120.0	5.0	58.4	150	200
Nitrate (mg/l)	1.2	0.5	0.54	0.7	1.2	0.5	0.4	10	20
Sulphates (mg/l)	0	10	13	7.7	13.0	0.0	6.8	500	500
Chloride (mg/l)	1.5	0.2	4.8	2.2	4.8	0.2	2.4	350	250
Potassium (mg/l)	5.6	3.6	25	11.4	25.0	3.6	11.8	50	<1
Phosphate (mg/l)	0.02	3.9	11.7	5.2	11.7	0.0	5.9	0.5	5

The temperature of the water samples at the center section of the Lamingo dam ranged from 23.4^{0}C in the month of January to 32.8^{0}C in the month of September. The temperature value of 32.8^{0}C and 32^{0}C of the water samples collected in the month of September at the center and upper section of the dam were too high with respect NESREA standard but acceptable with respect to FME standard**.** The pH of the water samples collected at the center of the Dam throughout the period of study ranged from 7.07 - 8.06 as shown in Table 3 and Table 4 which are within the permissible limit for both NESREA and FME standard for irrigation water.

Water gives plant thermal stability with respect to the environment, because more calories are required to raise the temperature of water than any other common substance. Thus, the mean temperature of water obtained during the study period does not pose any harm, if Lamingo dam water is used for irrigation. However, the pH of the water samples collected throughout the study period were within the permissible limit (6-9) with respect to the range provided by NESREA and FME. The highest pH value of 7.58 was obtained in the month of January while the lowest pH value of 7.01 was obtained in the month of September.

Electrical Conductivity and Total Dissolved Solid

Electrical conductivity is a measure of the ability of water to pass an electrical current which is affected by the presence of dissolved solids. The ability depends on the presence of ion and their total concentration, mobility, valence relative concentrations and temperature of measurement (Shinde *et al*., 2011). The electrical conductivity values obtained from the lower section of the dam ranged from 72 -109.7 μScm^{-1} The highest EC value of 109.7 μScm^{-1} after values was obtained in the month of November while the lowest pH value of 72 μScm^{-1} was obtained in the month of September as shown in Table 2. The EC of the water samples collected at the lower section of the Lamingo Dam from the month of September to January were within the permissible limit for irrigation water with respect to NESREA and FME. The EC value at the Centre of the Dam ranged from 8.32 μScm^{-1} in the month of November to 96.8 μScm^{-1} in the month of January; while the EC value at the upper section of the dam ranged from 83.2 in the month of January to 96.8 μScm^{-1} recorded in the month of November. EC values recorded in the Lamingo dam were within the permissible limit for irrigation water with respect to NESREA and FME as shown in Table 2, Table 3 and Table 4.

Table 3 Parameters at Centre Section of the Lamingo Dam

Parameter	13/09/17	13/11/17	13/01/18	mean	max	min	STDEV	NESRE	FME
Temperature (^0C)	32.8	26	23.4	27.4	32.8	23.4	4.9	27-28	<40
pH	7.07	7.65	8.06	7.6	8.1	7.1	0.5	6.5-8.5	6.0-9.0
EC (μScm^{-1})	91.6	96.8	83.2	90.5	96.8	83.2	6.9	0-1000	1000
TDS (mg/l)	45.8	48.3	41.6	45.2	48.3	41.6	3.4	500	1000
TH (mg/l)	9	35	96	46.7	96.0	9.0	44.7	150	200
Nitrate (mg/l)	1.38	0.56	0.76	0.9	1.4	0.6	0.4	10	20
Sulphates (mg/l)	1	15	0	5.3	15.0	0.0	8.4	500	500
Chloride (mg/l)	0.9	0.1	1	0.7	1.0	0.1	0.5	350	250
Potassium (mg/l)	0.6	0.5	5	2.0	5.0	0.5	2.6	50	<1
Phosphate (mg/l)	0.07	3	11.3	4.8	11.3	0.1	5.8	0.5	5

Furthermore, excessive salts in the root zone restrict plant root from withdrawing water from the surrounding soils, which lowers the amount of available water to the plant irrespective of the actual amount of water in the root zone. The total dissolved solid (TDS) obtained ranged from 32 – 56 mg/l at the lower section of the dam with the highest TDS value of 56 mg/l obtained in the month of November while the lowest TDS value of 32 mg/l was obtained in the month of September. The TDS value at the center of the dam ranged from 41.6 mg/l in the month of January to 48.3 mg/l in the month of November. Also, The TDS value recorded at the upper section of the dam ranged from 41.6 in the month of January to 48.3 mg/l in the month of November. The TDS status in the water samples collected during the period of study were within the permissible limit for irrigation with respect to NESREA and FME.

Total Hardness and Nitrate

Total hardness is a measure of the mineral content in a water sample, which is irreversible by boiling (Rao *et al.,* 2000). Therefore, total hardness can be equivalent to the total calcium and magnesium present in water sample. The total hardness (TH) for the lower section of the Lamingo dam ranged from 5-120 mg/l as shown in Table 2. The highest TH value of 120 mg/l was recorded in the month of January while the lowest TH value of 5 mg/l was recorded in the month of September. The TH at the Centre and upper section of the dam ranged from 9 mg/l in the month of September to 96 mg/l in the month of January as shown in Tables 3 and 4. According to NESREA and FME standards, the value of TH should not exceed 150 and 200 mg/l respectively; however, the TH values obtained during the study period were within the permissible limit for irrigation water.

The Nitrate level recorded were slightly beyond unity in the lower section of the dam, though the limit reported by NESREA and FME was 10 and 20mg/l respectively. At the center and upper section of the dam the Nitrate value ranged from 0.56 mg/l in the month of November to 1.38 mg/l in the month of September as shown in Tables 3 and 4. This is an indication of the fact that the nitrate levels of the water samples collected were within the permissible limit for irrigation water.

Table 4: Parameters at Upper section of the dam

Parameter	13/09/17	13/11/17	13/01/18	mean	max	min	STDEV	NESREA	FME
Temperature (^{0}C)	32	25	23.4	26.8	32.0	23.4	4.57	27-28	<40
pH	6.7	7.3	7.9	7.3	7.9	6.7	0.60	6.5-8.5	6.0-9.0
EC (μScm^{-1})	98.7	98.3	86.8	94.6	98.7	86.8	6.76	0-1000	1000
TDS (mg/l)	49.1	55.2	43.7	49.3	55.2	43.7	5.75	500	1000
TH (mg/l)	12	30	100	47.3	100.0	12.0	46.49	150	200
Nitrate (mg/l)	0.86	0.5	0.68	0.7	0.9	0.5	0.18	10	20
Sulphates (mg/l)	9	5	0	4.7	9.0	0.0	4.51	500	500
Chloride (mg/l)	1.3	0	7.4	2.9	7.4	0.0	3.95	350	250
Potassium (mg/l)	6.4	6.2	2.5	5.0	6.4	2.5	2.20	50	<1
Phosphate (mg/l)	0.56	9	10.3	6.6	10.3	0.6	5.29	0.5	5

Sulphates and Chlorine

The Sulphates value ranged from 0 - 13 mg/l as shown in Table 2 for the lower section of the dam. The highest Sulphates value of 13 mg/l was recorded in the month of January, while no trace of Sulphates was observed in the month of September. At the center of the dam the Sulphates value recorded was null in the month of January and 15 mg/l in the month of November as shown in Table 3. No trace of Sulphates was observed in the month of January at the upper section of the dam. Nevertheless, the range of Sulphates values obtained in this study were within the permissible acceptable limit for irrigation water.

The chlorine status of the samples of water collected at the lower section of the dam ranged from 0.2 - 4.8 mg/l. The highest chlorine value of 4.8 mg/l was recorded in the month of January, while the lowest was recorded in the month of November. At the Centre and upper sections of the dam, the chlorine value of 0.1mg/l as recorded in the month of November, while a value of unity was obtained in the month of January. Therefore, the chlorine level in the samples of water collected at the Lamingo Dam is safe for irrigation purposes.

Potassium and Phosphate

The potassium level in the samples of water collected in the lower section of the Lamingo dam ranged from 3.6 -25 mg/l as presented in Table 2. The lowest Potassium value of 3.6 mg/l was recorded in the month of November, while the highest (value) was recorded in the month of January. At the center and upper sections of the dam, the potassium value ranged from 0.5 mg/l in the month of November to 5 mg/l in the month of January. With respect to the permissible limit for Potassium for any water to be used as source of irrigation water, it is obvious that according to FME standard the potassium level is beyond the acceptable level for irrigation, but if NESREA standard for irrigation water quality is employed, then, the potassium level in the samples of water collected at the lower section of dam is safe for irrigation purposes.

The phosphate level at the upper, center and lower section of the Dam for some sections were above 0.5 mg/l. According to NESREA standard the acceptable limit for Phosphate should not exceed 0.5 mg/l, a such, it is deem not fit for irrigation purpose; however, in the months of November and January the Phosphate level were 3.9 and 11.7 mg/l , while 3 and 11.3 mg/l were recorded in the month of November and January at the center section of dam, Phosphate values at the upper section of the dam were 9 and 10.3 mg/l; hence the level of Phosphate in the water collected is not safe for irrigation purposes mostly in the month of January. Though if FME

standard is to be applied, the water samples collected in the month of September and November may be considered safe for irrigation purposes.
Furthermore, at the upper section of the Lamingo dam the Phosphate level were 0.56, 9 and 10.3 mg/l ; if NESREA and FME standard are to be employed to check how fit the Lamingo water dam is for irrigation purpose, as shown in Table 4, the phosphate level was far above the maximum permissible level, hence it is not fit for irrigating crops that are sensitive to high level of phosphorus like cereals, because it may delay formation of grain.
Phosphorus is essential for plant life but excess can speed up eutrophication - reduce dissolved oxygen in water bodies, which can lead to loss of biodiversity, excessive growth of algae and aquatic plant, death of aquatic life, creation of imbalances which destroys other forms of life and produce harmful toxins which can affect human life adversely. Soil erosion is a major contributor of Phosphorus to reservoirs which is the biggest cause of water quality degradation, also over fertigation can increase the level of phosphorus in the Dam; erosion control measures should be employed to check buildup of silt and sedimentation in the study area.

Variation of the concentrations of the physicochemical parameters
A t-test was used to compare the parameters at the upper, center and lower section of the Lamingo dam to ascertain if there are variations in the parameters considered at the different sections. The following were compared: upper and center, upper and lower, center and lower. Table 5 showed that there was no significant difference between the parameters when the upper and center sections were compared at 95% probability level.

Table 5 comparing the upper and center section of Lamingo dam

Parameters	Difference	t	P value	Summary
Temperature	0.60	0.04	P > 0.05	ns
pH	0.29	0.02	P > 0.05	ns
EC	-4.07	0.29	P > 0.05	ns
Total dissolve solid	-4.10	0.30	P > 0.05	ns
Total hardness	-0.67	0.05	P > 0.05	ns
Nitrate	0.22	0.01	P > 0.05	ns
Sulphates	0.67	0.05	P > 0.05	ns
Chloride	-2.23	0.16	P > 0.05	ns
Potassium	-3.00	0.21	P > 0.05	ns
Phosphate	-1.83	0.13	P > 0.05	ns

ns: not significant

Table 6 comparing the upper and lower section of Lamingo dam

Parameters	Difference	t	P value	Summary
Temperature	0.27	0.019	P > 0.05	ns
pH	0.03	0.002	P > 0.05	ns
EC	-5.77	0.41	P > 0.05	ns
Total dissolve solid	-5.77	0.41	P > 0.05	ns
Total hardness	9.33	0.67	P > 0.05	ns
Nitrate	0.067	0.01	P > 0.05	ns
Sulphates	3.00	0.21	P > 0.05	ns
Chloride	-0.73	0.05	P > 0.05	ns
Potassium	6.37	0.46	P > 0.05	ns
Phosphate	-1.41	0.10	P > 0.05	ns

ns: not significant

The same trend occurred when the upper and lower, and the center and lower sections were compared as shown in Table 6 and Table 7, respectively. It was observed that in both scenarios there was no significant difference between the parameters considered at 95% probability level in both instances.

Table 7 Comparing the center and lower section of Lamingo dam

Parameters	Difference	t	P value	Summary
Temperature	-0.33	0.024	P > 0.05	ns
pH	-0.26	0.02	P > 0.05	ns
EC	-1.70	0.12	P > 0.05	ns
Total dissolve solid	-1.67	0.12	P > 0.05	ns
Total hardness	10.00	0.72	P > 0.05	ns
Nitrate	-0.15	0.01	P > 0.05	ns
Sulphates	2.33	0.17	P > 0.05	ns
Chloride	1.50	0.11	P > 0.05	ns
Potassium	9.37	0.67	P > 0.05	ns
Phosphate	0.42	0.03	P > 0.05	ns

ns: not significant

Conclusion and Recommendations

Vivan *et al.* (2014) reported that the level of total dissolved solids (TDS), pH, temperature and electrical conductivity in the water sample collected at the upper, mid-stream and lower section of the Lamingo dam were quite high; which could be as a result of the human and socio-economic activities around the Lamingo dam. However, from the results obtained from this study, it shows that temperature, pH, electrical conductivity, total dissolved solids, total hardness, nitrate, Sulphates, chlorine, were within acceptable range of the standard for irrigation water quality according to NESRAEA and FME except for potassium levels which was high in the month of January when compared to the permissible limit for the standard of irrigation water quality according to FME and Phosphorus which was beyond the acceptable level.

Farming and mining activities taking place close (less than 20m) to the dam should be avoided to prevent contamination of the water through agricultural chemicals such as fertilizers, herbicides and heavy metals. Farmers in the study area are advised to plant more of vegetables instead of cereal crops during the dry season, since the Phosphorus level seems to be high during the said period. Furthermore, an irrigation water quality monitoring program should be established for the Lamingo Dam in order to document changes over time.

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