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Determination of Physicochemical and Bacteriological Quality of Water for Irrigation Purpose: A Case Study of Shika Dam, Zaria, Kaduna State, Nigeria

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ABSTRACT

This research work aimed to ascertain physicochemical and bacteriological quality of Shika Dam Zaria, Kaduna State for irrigation purpose. Three samples of water were collected from the reservoir, at the beginning, middle and end horizontally. The physicochemical parameters and biological characteristics such as temperature, taste, odor, color, pH, electrical conductivity, boron, sodium, magnesium, total dissolved solid, sodium adsorption ratio, heavy metals (Zinc, Lead, and Molybdenum), Escherichia coli, Shigella sp., Salmonella sp., Enterobacter sp., Klebsiella sp. were determined for all the samples. The results were compared with the Food and Agricultural Organization (FAO) and showed that the water quality of Shika dam is within the acceptable standard of FAO water quality for irrigation purposes in terms of physicochemical parameters while in terms of biological characteristics is not safe for irrigation purpose due to presence of some harmful microorganisms. Therefore, it is recommended that the water should be protected from further deterioration by anthropogenic activities.

1. INTRODUCTION

Water of good quality is the most important natural resource that is necessary to man for domestic, industrial and agricultural purposes, and it exists as rain, surface, or ground water. Most of the time the quality of these water sources is unknown therefore, the approach to ascertain the quality of water in terms of physical, chemical and bacteriological has great advantages in promoting human health (Okwagi *et al.,* 2019). The biggest challenge affecting water resources and agricultural water management is climatic variation (Narges *et al.,* 2017). The impact of seasonal change on water quality as a result of climatic change has significant effect on water condition (Mtinda, 2007). Thus, there is need to investigate the physicochemical and bacteriological level of Shika Dam for irrigation purposes since that farmers are reporting low yield of crops as well as stunted growth of crop plant.

Retno *et al.,* (2015) reported that canals or irrigation channels are important hydraulic structure used for water supply through surface irrigation while rivers, lakes, and spring water are sources of irrigation water that are facing pollution problems. Furthermore, crops grown under irrigation depend on adequate water supply of usable quality. The irrigation water quality affects the quality of the soil and the crops grown on the soil. Poor irrigation water quality has a negative effect on crop productivity, crop product quality, and public health of consumers and the farmers who come in direct contact with the irrigation water (Qadir *et al*., 2007; Listkas *et al*., 2010; Muthanna, 2011).

Before water is used for irrigation, domestic and industrial purposes, it is very important to know its quality status. Water contain different types of pollutants; therefore, selection of physicochemical, microbiological parameters and bacteriological assessment is highly dependent on the purpose for which the water will be used (Patil *et al.,* 2012). The evaluation of quality of water helps to determine the causes, relationship and effects among water constituents and level of acceptability. Certain constituents emerge as indicators of quality-related problems with sufficient reported experiences and measured responses (FAO, 2013). The basic chemical parameters used to assess irrigation water quality are total dissolved solids (TDS), sodium absorptions ratio (SAR), electrical conductivity (EC) and residual sodium carbonate (RSC) (Muhammad and Amir, 2017).

In the production of leafy crops such as spinach and cabbage which are eaten raw, some microorganism may affect the leaves which causes some patches on them and also deactivate indole acetic acid (IAA) which inhibits growth in leaves. Sixty five percent of disease in Nigeria are caused by microbiological contamination of vegetables during irrigation farming for example in the case of *E. coli* which stay in the intestine of humans causing kidney diseases (APHA, 1998). The lack of safe water creates a remarkable burden of diarrheal disease and other debilitating, life-threatening illnesses for people in the developing world (Sobsey, *et al.,* 2008). Previous researches showed that numerous pathogenic microbes from human and animal wastes migrated to water. These include *Campylobacter jejuni, E. coli, Enteropathogenic E. coli, Salmonella typhi, Salmonella paratyphi, Adenoviruses, Enteroviruses, Polio viruses, Coxsackie viruses, Entamoeba histolytica, Naegleria fowleri, Acanthamoeba castellani* etc (Ashbolt, 2004; WHO, 1993).

Therefore, this study focuses on assessing physicochemical and bacteriological parameters of Shika Dam Reservoir, Zaria Kaduna State, Nigeria for irrigation purpose.

2. MATERIALS AND METHODS

2.1. The Study Area

Shika Dam (Zaria Dam) is located on latitudes 11°07'45" E to 11°08'20" E and longitudes 07°46' N to 07°48' N. Two settlements (Shika and Anguwan Bello) are located immediately upstream on the right and left side of the reservoir where the raw water intake is located (Tanko *et al.,* 2012). Tanko *et al.* (2012) reported that Shika dam was constructed in 1975 on the river Galma to carter for Zaria township water supply and other benefits. The dam has a designed live reservoir capacity of 15.875 million m^3, length of 900 meters and a maximum height of 15 meters from the river bed.

2.2. Methods

The research commenced with preliminary site investigation through reconnaissance survey to understand farming and human activities within the study area and nature of the reservoir. Three water samples were collected at the beginning (sample A), middle (sample B), and end (sample C) of the reservoir December, 2019 respectively with 2 liters plastic containers. The sample containers were pre-washed with detergent,

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rinsed with distilled water and then with hydrochloric acid (HCl) and finally with distilled water. The plastic containers were further rinsed twice with the water sample at each sampling point collection. During the collection, no floating object was allowed to enter the bottle. The samples were taken for laboratory analysis of physicochemical and bacteriological parameters.

2.2.1. Physicochemical characterisation

From each sample (A, B, and C) 100 ml of the water samples were collected in beakers and examined for the following parameters: Color, odor, taste, temperature, pH, Sodium, Calcium, Magnesium, Electrical conductivity (EC), Total dissolved solid (TDS), Sodium adsorption ratio (SAR), Boron, Zinc, Molybdenum, Lead, and Chromium at Institute for Agricultural Research Soil and Water Laboratory ABU, Zaria as follows.

The electrical conductivity was measured with an electrical conductivity meter. Temperature, Sodium adsorption ratio, and color were determined following the standard methods outlined by APHA, (1998). The pH of water was measured electrometrically using glass electrode pH meter (Mclean, 1965). Sodium and boron were determined using flame photometer. Calcium and magnesium were determined using atomic absorption spectrophotometer (AAS) (Mclean, *et al.,* 1965). Total dissolved solids in water was determined by evaporation-drying (Chopra and Kanwar, 1991). Taste and odor were demined following the standard methods outlined by (SCA, 2014). Zinc, Molybdenum, Lead, and Chromium were measured with Absorption Spectrophotometer (AAS Model: SpectrAA 55B, Varian) after it was linearly calibrated as described by (APHA, 1998).

2.2.2. Bacteriological assessment

The bacteria examined for each sample were *Escherichia coli, Shigella sp., Salmonella sp., Enterobacter sp.* and *Klebsiella sp.* and was done at the Microbiology Laboratory, ABU, Zaria. A serial dilution of the water samples to be tested were made and inoculated into LTB growth media. Samples were then incubated at 37 ˚C for 24 h for the presumptive tests for the *Escherichia Coli, Shigella sp., Salmonella sp., Enterobacter sp.* and *Klebsiella sp.* The tests were carried out following standard procedures reported by (Cheesebrough, 2004).

3. RESULTS AND DISCUSSION

The physical properties of Shika Dam is presented in Table 1 the water in Samples A and B were odorless while that in sample D has pleasant odor this it might be because of some domestic activities that are taking place by the side of the reservoir such as washing setting pumping machine etc. that introduce sediment and organic substance in to the reservoir. The result of Sample A sported what Muhammad and Amir (2017) and Patil *et al.* (2012) reported that odor is as result of biological degradation, algae, and waste in to receiving water body. The water in all the samples were milky in colour and this agrees with the report of CWT (2004) that water color represents the type of solid material present in it. Transparent water with low level of dissolved solids has blue color while yellow or brown color is due to the dissolved organic matter. The water in samples A and B are tasteless while the water in Sample C has sediment taste.

Table 1: Physical characteristics of the water

Sample	Color	Odor	Taste	Temperature
A	Milky	Odorless	Tasteless	28 ^oC
B	Milky	Odorless	Tasteless	27.5 ^oC
C	Milky	Pleasant	Sediment	28 ^oC

It was observed from Table 2 that pH, EC, TDS, and SAR of sample A, B and C were within the acceptable limit for irrigation purpose because the degree of restriction of water to irrigation is slight to moderate. Likewise, Sodium, Magnesium, Calcium and Boron (B) were also within the acceptable level terms of irrigation. These results agree with what Tanko *et al.* (2012) found in their study that levels of chemical parameters were below maximum acceptable levels.

Sample A has less pH value than Samples B and C this might be as a result of different domestic activities taking place and density of green plant where the samples were collected. Since the reduced rate of photosynthetic activity, the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH (Karanth, 1987). Patil *et al.* (2012) reported that high EC decrease pH value. Therefore, this agree with EC results in Table 2 since EC value in Sample A is greater than Samples B and C.

Because of improper irrigation practices which may lead to migration of dissolved salts in to the reservoir, the level of TDS in Sample A is higher than that of Samples B and C, this shows that the point where Sample A collected has higher migration of dissolved salts than the points where Samples B and C collected. This also is the leading factor that lead to variation of SAR, Sodium and Boron in the samples.

The level of Calcium in Samples A, B, and C had no significant difference and that of Magnesium remained the same in the samples.

Table 2: Chemical parameters concentrations

Parameters	Acceptance limit (FAO, 1994)	Sample A	Sample B	Sample C
pH	6-8.5	6.50	6.61	6.70
EC (dS/m)	0-3	0.87	0.80	0.75
TDS (mg/L)	0-2000	556.8	512	489
SAR	0-15	2.36	1.94	1.94
Sodium (mg/L)	0-919.6	17.00	14.00	14.00
Calcium (mg/L)	0-100.2	80.00	80.00	80.00
Magnesium (mg/L)	0-60.75	24.00	24.00	24.00
Boron (mg/L)	0-2	0.5	0.4	0.4

Table 3 presents the concentration of heavy metals in Samples A, B and C. It is evident from the table that Zn Pb, and Cr in samples A, B and C were within the permissible limit of FAO standard for irrigation water. Likewise, Mo in samples A and C were within the acceptable limit while Mo in Sample B was slightly above acceptable limit of the standard. Therefore, the water is good for irrigation in relation with heavy metals (Zn Pb, and Cr) concentration while with respect to Mo the water is severe. The higher levels of Mo in Sample B and Pb in sample A was as a result high concentration of waste where the samples were collected. These results conformed with FAO (1994) reports that in almost all cases where heavy metals are at high levels, they are the result of man's activities, particularly wastewater disposal.

Table 3: Heavy metals concentrations

Parameters (mg/L)	Recommended maximum concentration (mg/L) (FAO, 1994)	Sample A	Sample B	Sample C
Zinc (Zn)	2.0	0.02	0.021	0.02
Molybdenum (Mo)	0.01	0.01	0.02	0.01
Lead (Pb)	5.0	0.6	0.5	0.5
Chromium (Cr)	0.10	0.1	0.1	0.1

For the bacterial assessment of the water samples, it shows in Table 4 that the most probable number test (MPN) at 100 ml of each water sample (A, B and C) shows that there were bacteria species in the water samples indicating the presence of bacteria in Shika Dam. From the Table, the presence of *Escherichia coli, Shigella sp., Salmonella sp. and Klesbsiella sp.* was confirmed in water Sample A. The presence of *Shigella sp., Escherichia Coli, Salmonella sp. and Enterobacter sp.* was confirmed in Samples B and C which have harmful effect for irrigation activities. This is in line with the reports of Allamin *et al.* (2015) and Devangee *et al.* (2017).

Table 4: Gram's reaction, cell morphology and biochemical characteristics of bacteria isolates

Organism	Samples	Gram's reaction	Call morphology	Indole	MR	VP	Citrate	TSI (H_2S)	Motility
Escherichia Coli	A	-	Rods	-	+	-	-	-	+
	B	-	Rods	-	+	-	-	-	+
	C	-	Rods	-	+	-	-	-	+
Shigella sp.	A	-	Rods	+	+	-	-	+	-
	B	-	Rods	+	+	-	-	+	-
	C	-	Rods	+	+	-	-	+	-
Salmonella sp.	A	-	Rods	-	+	-	+	-	+
	B	-	Rods	-	+	-	+	-	+
	C	-	Rods	-	+	-	+	-	+
Klebsiella sp.	A	-	Rods	-	-	+	+	-	+
Enterobacter sp.	B	-	Rods	-	-	+	+	-	+
Entrobacter sp	C	-	Rods	-	-	+	+	-	+

Key: MR = Methyl red, VP = Voges-Proskaeur, TSI = Triple sugar iron ager, H_2S = hydrogen Sulfide, + = Positive reaction, and - = Negative reaction

4. CONCLUSION

Results obtained showed that the water in Shika Dam reservoir is safe for irrigation purpose because of low physicochemical while in terms of biological characteristics is not safe for irrigation purpose due to present of some harmful microorganisms. It is therefore recommended that the water should be protected from further deterioration by anthropogenic activities.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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