Evaluation of Lower Usuma Dam Water Quality for Domestic Supply (FCT) Abuja, Nigeria

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Abstract: **Dams are physical attempt of human being to reserved water for distribution in period of scarcity. Lower Usuma Dam was constructed to meet to the demand of quality water supply to the inhabitant of FCT, Abuja. This study evaluates the water quality of Lower Usuma dam for domestic supply. Qualitative research design was used for ten (10) samples that were collected covering specific points of procurement, processes and delivery of quality water supply which were analysed accordingly in a laboratory base on standard measurement for physical, chemical and bacteriological parameters. Using National Standard for Drinking Water Quality (NSDWQ) standard to evaluate water quality of Lower Usuma Dam, the result revealed acceptance in the physical and chemical parameters in a large extent but high concentration in bacteriological parameters above the maximum recommendation given by NSDWQ. Thus, the water quality of Lower Usuma Dam in Abuja has not met the acceptable standard for drinking at random but can be used for other domestic purpose.**

Keywords: **Abuja, Bacteriological, Chemical, Physical, Water quality, Usuma Dam**

I. INTRODUCTION

The availability of water is required in quantity and quality for the sustenance of human population, animals and agricultural. Most especially, human activities intensely increases much more than it had been in the past (Ujoh, Ikyernum and Ifatimehin, 2012. Despite advances in drilling, irrigation and purification, the location, quality, quantity, ownership and control of potable water remains of important concern. This is in light of the fact that the earth's total stock of water resources are hardly increasing, but water demand continues to increase due to population increase even in the face of surface and ground water pollution. Fresh water supply wanted to sustain human population is now becoming a major global concern on how best to harness such resource. The rationale behind dam construction is the attempt a re-distribution of water from regions and seasons of abundance to regions and seasons of scarcity, as well as to appropriate it for other uses that require large volumes of water. This possibly led to the unprecedented increase in the construction of large dams witnessed by the world in the latter half of the 20th Century [World Commission on Dams] (WCD,2000). Whereby, every country tends to construct dam as a source of reserving and supply water for its teaming population for domestic usage and necessitate Abuja (FCT) to develop Lower Usuma Dam.

The spontaneous and geometrical growth of population in Abuja Metropolis has created enormous challenges on the natural resources such as water supply and the only source of public pipe borne water supply is from Lower Usuma Treatment Plant (LUTP) commissioned in1987 by the Federal Government of Nigeria to ensure portable water supply to the emerging new capital city (Ibrahim, Onyenekwe and Nwaedozie, 2014). The inadequacy of public pipe borne water supply in Abuja metropolis necessitated the scaling up of the Lower Usuma Water Treatment Plant from its original capacity of 5,000m3 per hour to its present capacity of 10,000m3 in 1992. Lower Usuma Treatment Plant was Turn-key project agreement between Nigerian Government and Japanese Company in early 80's but since the commencement of the operation, there is clear dearth information on the efficiency of the plant, at least to ascertain that it delivers safe water to the public. It requires a combination of treatment processes most appropriate to treat the contaminants found in the raw water used by the system. Some include flocculation/ sedimentation, filtration, ion exchange, absorption and disinfection. The type of treatment applied by a public water system varies with the source type and quality. Many ground water systems can satisfactorily, all federal requirements without applying any treatment, while others need to add chlorine or additional treatment (Ugwu and Wakawa, 2012, Ojutiku, Kolo, Mananaso, 2014). The Lower Usuma Water treatment plant treats the raw water from the nearby open surface earth reservoir. Through its in it operation, it ensures that dangerous microscopic pathogens are inactivated along the 73.770 kilometer water distribution in Abuja Metropolis (Ibrahim, Onyenekwe and Nwaedozie, 2014).

Water quality is determined by the physical and chemical limnology of a reservoir and includes all physical, chemical and biological factors of water that influences the beneficial use of the water (Amos and Nwagilari, 2014). Water quality measured the condition of water relating to the requirements of one or more biotic species and to any human need or purpose. It is mostly used by reference to a set of standards against which compliance are usually assessed (Bakobie, Sukairazu and Duwiejuah, 2015). The most common standards used to assess water quality relate to drinking water, safety of human contact and for the health of ecosystems (Diersing, 2009).

However, increase in some parameter such as organics, nitrogen, silicon, and phosphorus loading, which in turn could lead to the eutrophication and thus reduced water quality

(Akbarzadeh et al. 2015; Ding et. al, 2018; Karami et. al. 2012). Surface water resources, such as reservoirs, rivers, and lakes are more likely to be contaminated as compared to groundwater (Ding et al. 2018). The natural characteristics of a catchment area, quality and quantity of water entering a reservoir, regional climate characteristics (temperature, wind, and rainfall), and various anthropogenic activities in the related watershed are the factors affecting the water quality of the reservoirs (Karamouz et al. 2001). On the other hand, construction of a dam and storage of surface flow can enhance evaporation, cause water stagnation, and thus thermal layering in the reservoir, settlement of suspended solids, enrichment of nutrients, and changes in the physical, chemical, and biological properties of water in these reservoirs (Ding et al. 2018).

According to Razmkhah, et al 2010 and Tajziehchi, 2014) that in Iran, dams serve as the seasonal largest sources of drinking water after underground water, while they are subjected to the risk of quality degradation due to reduced atmospheric precipitation, disproportionate land uses, excessive operations, and loss of cultural and social identity. In addition, factors, such as traditional irrigation, energy production, developments of industries requiring plentiful water, intermediate water transfers, and inefficient management of water consumption, have led to the reductions of the quality and quantity of water resources (Darko et al. 2017; Karamouz et al. 2001; Saadatpour et al.2017).

Dam (Reservoir) of natural water sources are at risk of contamination from numerous sources of contaminants (Lukubye, and Andama, 2017) e.g., extensive agricultural industrial activities and urbanization results into the contamination of aquifer(Arumugam and Elangovan (2009) . Other sources of these contaminants include agricultural fertilizers and pesticides, industrial and domestic wastes, leakages from landfills and pit latrines (Narendra and Sharma, 1993). Furthermore, there are many pollutants in groundwater due to seepage of organic substances and inorganic chemicals, heavy metals (Temgoua, 2011), and pathogenic microbes from human and animal wastes. Water intended for consumption, preparation of food and drinks or for personal hygiene should not contain agents pathogenic for humans (WHO, 1996). However, varieties of microorganisms continue living in water including bacteria, fungi, protozoa, algae, and viruses, where they form a complex ecosystem whose dynamics are usually difficult to understand (Chrysanthus,2014).Those varieties of microbes play an essential role for contamination of water and results in a variety of outbreaks of diseases and death. This research examines the quality of domestic water supply to inhabitants of Abuja base on physical, chemical and Bacteriological standard of water.

II. MATERIALS AND METHODS

.2.1 Study Area

Abuja, Federal Capital Territory (FCT), Nigeria is located between latitude 8^{o}25’ and 9^{o}25’ North of the Equator and longitudes 6^{o}45’ and 7^{o}45’ East of Greenwich. The boundaries starting from the village called Izon on 7^{o} east longitude and 9^{o}15’ latitude, project a straight line West-ward to point of Lehu on the Kemi River, then project a line along 6^{o}47.5 southwards passing close to the village called Semusu, Zui and Bassa down to a place a little well of Abji in Kwara State. A line along the parallel, 8^{o}27½’ North latitude to Aluza village 7^{o}6’ East longitude with a line northwards joining the village of Idu, Karshi, and Karu from the line should proceed along the boundary between North-central and North-Western State up to a part of just North of Bwari village. This covers straight to Zuba village and their straight to Izon (FCT, Act 1976). The River Usuma is one of the West North flow tributaries of the Gurara river in Abuja rise in the belt of highland running along the entire eastern boundary of the territory. In the FCT where Usuma dam is located at Bwari District experiences three weather conditions annually; warm, humid rainy seasons and a blistering dry season. In between the two, three is a brief interlude of harmattan occasioned by the north-east trade wind, with the main feature of dust haze, intensified coldness and dryness. The Usuma Dam and the Treatment Plant came into operation in 1986, and were managed by the Water and Sewage Division of the Engineering Department of the Federal Development Authority to ensure the supply of potable water of adequate quantity and quality for the territory at an economic rate, and harness all water resources of the territory for economic development.

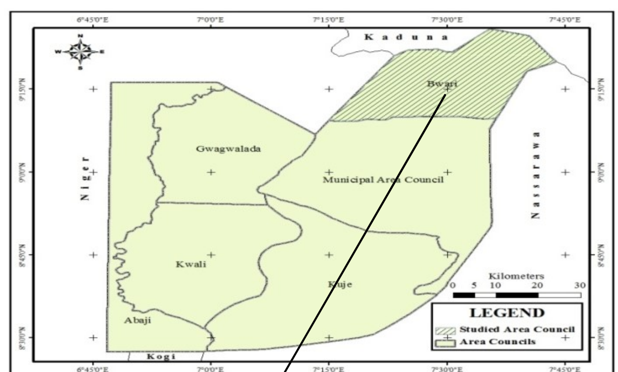


Figure1. Map of FCT Abuja-Nigeria Showing Study area

Figure 2 Imagery of Lower Usuma Dam, Abuja

The nature of the data was of infinite due to the fact that it was derived from continues distribution of river flow and dam. The data was, however reduced from continues distribution to discrete by taking water samples at ten (10) points within the following locations as seen in Table1 below:

Table 1: Sample Points Locations of Lower Usuma Dam

Samples	Code	Locations	Stages for treatment	No. of Samples
1	A	Usuma	Procurement	1
2	B	Saddle		1
3	C	Treatment Plant	Processing	1
4	D	Intake Tower (Aeration)		1
5	E	Storage Tank(After Treatment)		1
6	F	Storage Tank at Bwari		1
7	G	Storage Tank at Kubwa		1
8	H	In-house Tap	Delivery	1
9	I	Public Tap at Bwari		1
10	J	Public Tap at Kubuwa		1
	Codes	Samples Points		10

For easier assessment, samples were categorized base on the intake position of procurement; (Main Dam, saddle dam) processing (Treatment plant, Intake tower, Storage tank, Bwari, kubuwa storage) and delivery (In-house tap, Public tap at Bwari and Kubuwa). The method used for data collection for the purpose of this research was purposive sampling approach based on the procedure stated in the National Agency for Food Drug and Administration Commission(NAFDAC) Guidelines for Drinking Water Quality in Nigeria. It was on this note, water samples were collected for quality analysis by using a fetcher tied to a rope and dipped into the water and poured inside a plastic bottles capped and labelled with respect to their points of collections and uses to which the raw water from the dam is put to as well as the treated water from the treatment plant was collected from the tap ready for supplied to households. Samples collected in bottles were transferred from the collection points to the laboratory in a cooler to maintain steady temperature of the water.

Figure 3 Samples Bottled for Laboratory Analysis

The samples of water were collected and subjected to laboratory analysis, using all the required materials, equipment and procedures as practiced in a standard laboratory. These were parameters of water were analyzed:

i. Physical parameters: temperature, *colour and turbidity*
ii. Chemical parameters: *PH, conductivity, total dissolved solids, total hardness, Zinc, Iron calcium magnesium; copper, florine, mangase,nitrate, nitrite, total Chlorine, chlorine and chloronnium*
iii. Biological Parameters: Presumptive Coliform *and Total Aerobic Coliform*

The parameters are supposedly common to contaminate found in water supply to households in Abuja that be the causes cholera, typhoid fever, skin irritation, bilherziosis among others. In examining the levels of those parameters in water supply, It will enhance the quality of the water from the Lower Usuma dam for human consumption. The results of the laboratory analysis were compared with that of NSDWQ, maximum limits of water quality parameters for drinking water which are world and national standard for quality drinking water. However, presented in statistical description as well as testing the standard deviation of each sample points.

Table 2 National Standard for Drinking Water Quality (NSDWQ, 2015)

S/N	Parameter	UNIT	NSDWQ
1.	Temperature	o C	Ambient
2.	pH	-	6.5-8.5
3.	Colour	TCU	15
4.	Turbidity	NTU	5
5	E. Conductivity	µ/cm	1,000
6.	TDS	mg/l	500
7.	Nitrate ion (NO3)	mg/l	50
8.	Nitrate ion (NO2)	mg/l	0.2
9.	Chloride ion (Cl)	mg/l	250
10.	Fluoride ion (F-)	mg/l	1.5
11.	Manganese ion (Mn12)	mg/l	0.2
12.	Magnesium (mg)	mg/l	20
13	Total Hardness		150
14	Total Chlorine	Mg/l	0.2
15	Iron	Mg/l	0.3
16.	Calcium (Ca)	mg/l	75
17.	Copper ion (CU)2	mg/l	1.0
18.	Zinc ion (Zn)		3
19.	Chromium (Cr+6)	mg/l	0.05
20	Presumptive coliform	Cfu/100ml	0
21	Total Aerobic Coliform Count	Cfu/mL	10

(NSDWQ, 2015)

III. DISCUSSION OF RESULT

The results for the physical properties of the Lower Usman Dam Domestic water derived and represented in the line graph below showed that samples S3, S5and S10 have same temperatures of 29. 1^{o}c, similarly S4 and S9 have a temperature of 29.4^{o}c, while S7 and S8 both had similar temperatures of 29^{o}c, and S6 had 28,4^{o}c, all temperatures above the standard temperature of 27^{o}c stated by NSDWQ while the temperature of the sample S2 indicated a decrease of 25.7^{o}c which is below the standard temperature and sample S1 at 27.1^{o}c was same as the standard temperature of NSDWQ though slightly higher with a negligible 0.1 difference. The colour values for the samples S4, S6 and S9 indicated same value of 1 TUC, and S7 and S8 showed identical value of 7 TUC while S5 and S10 have values indicating 9 and 2 TUC correspondingly, all below the 15 TUC standard for Water stated by NSDWQ except for samples S3 which was 15 TUC same as the standard, sample S2 with 16 TUC slightly above the standard and sample S1 peaked at 32 TUC, way above the standard value of NSDWQ. The turbidity level for samples S3 and S5 specified identical values of 2 NTU, similarly S4, S6, S9 and S10 showed same value of 0 NTU, as well as S7 and S8 which indicated similar value of 1 NTU, all below the turbidity level: 5 NTU stated for the NSDWQ standard. Contrastingly, samples S1 and S2 specified 8 and 6 NTU, levels above the standard given by NSDWQ.

Figure 4.Temperature

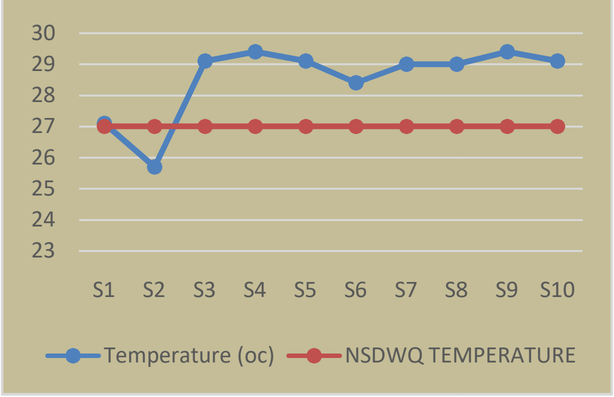


Figure 5. Colour

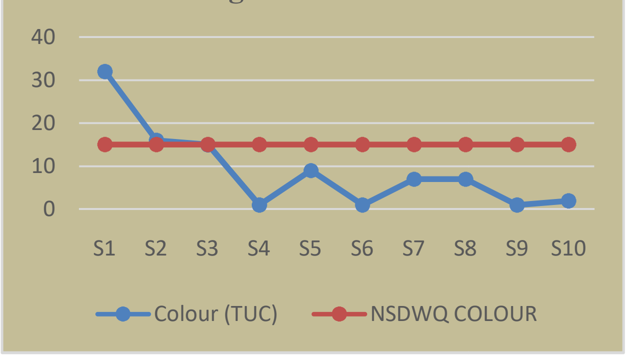


Figure 5.Turbidity

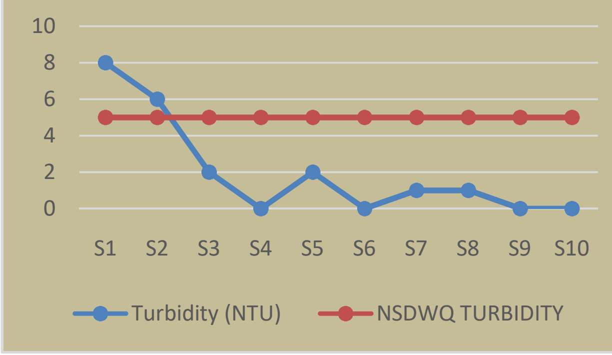


Table 3 indicated the following about chemical parameters for Lower Usuma Dam domestic water quality: the PH for water samples at points S1 to S5 were 6.98, 6.79, 7.03, 7.03 and 6.79 respectively, all the PH are within the NSDWQ limits of 6.5-8.5. The conductivity for water samples S1 – S5 was 120, 101, 75, 99 and 104 which is also within stipulated standard measurement approved by Nigerian government. Total Dissolve solid of the samples S1 to S5 are 63, 49, 38, 46, and 51; Total Hardness measured were 1.2, 1.4, 1.3, 1.2 and 1.5; Zinc was 0.01, 0,0,0, and 0.02 for S1 to S5 which is also below acceptable range of NSDWQ. Iron form S1 to S5 showed a measure 0.04, 0.06, 0.02, 0.05 and 0.01mg/l, here sample point S1, S2 and S4 were above NSDWQ; Calcium measured 1.4, 0.03, 1.3, 1.1 and 1.3 in all sample points of S1 to S5 were below standard as accepted ranged; Magnesium from S1 to S5 revealed 0.06, 0.24, 0.09, 0.4 and 0.6 were all accepted values,. Copper value from S1 to S5 were 0.04, 0.02, 0.04, 0.01 and 0.04 were all below NSDWQ value of 1.5mg/l; Floride from sample point S1 to S5 were 0.22, 0.21, 0.12, 0.03 and 0.08 also below standard on acceptable level,; Mangase were 0.1, 0.2, 0.01, 0.02 and 0.4 fell on accepted value except sample point S5 which was above minimum value. However, Nitrate, Nitrite, Total Chlorine, Chloride cl and Chromium (mg/l) were all within the acceptable standard for water consumption in the (FCT) Abuja.

Table3. Chemical Parameter of Lower Usuma Dam Water Quality

			Samples			
Parameters	S1	S2	S3	S4	S5	NSDWQ
PH at 25	6.98	6.79	7.03	7.03	6.79	6.5 – 8.5
Conductivity(µS/cm)	120	101	75	99	104	1000
Total Disolve solid (PPM)	63	49	38	46	51	500mg/l
Total Hardness	1.2	1.4	1.3	1.2	1.5	150
Zinc	0.01	0	0	0	0.02	3.0 mg/l
Iron	0.04	0.06	0.02	0.05	0.01	0.3mg/l
Calcium	1.4	0.03	1.3	1.1	1.3	75mg/l
Magnesium (mg2+)	0.06	0.24	0.09	0.4	0.6	150 mg/l

Copper	0.04	0.02	0.04	0.01	0.04	1.0mg/l
Floride	0.22	0.21	0.12	0.03	0.08	1.5mg/l
Mangase	0.1	0.2	0.01	0.02	0.4	0.2 mg/l
Nitrate (NO3	3.2	4.5	1.01	2.01	0.4	50mg/l
Nitrite (NO3)	0.006	0.005	0.003	0.004	0.005	0.2mg/l
Total Chlorine	0.14	0.005	0.01	0.02	0.09	0.2mg/l
Chloride cl	30	10	5	20	10	250mg/l
Chromium (mg/l)	0.003	0.004	0.002	0.001	0	0.06

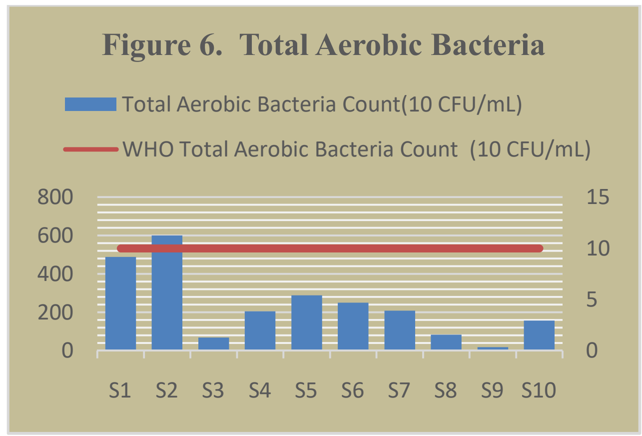
Laboratory Analysis Result, 2020

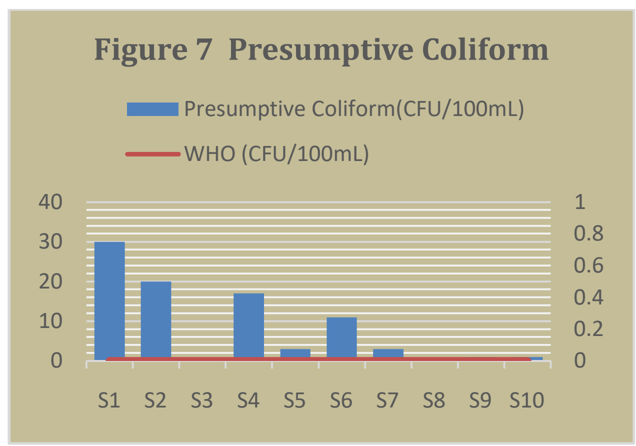
Table 4 Continuous of Chemical Parameters of Lower Usuma Dam Water Quality

	Sample					
Parameters	S6	S7	S8	S9	S10	NSDWQ
PH at 25	6.99	6.98	7.2	6.89	7.01	6.5 – 8.5
Conductivity	85	98	120	35	85	1000
Total Disolve solid (PPM)	44	45	60	16	44	500mg/l
Total Hardness	1.2	2.1	1.3	1.5	1.4	150
Zinc	0	0	0.01	0.02	0	3.0 mg/l
Iron	0.03	0.09	0.14	0	0.9	0.3mg/l
Calcium	0.09	1.5	1.2	2.1	1.3	75mg/l
Magnesium (mg2+)	0.45	0.21	0.45	0.11	1.1	150 mg/l
Copper	0	0.02	0	0.01	0.02	1.0mg/l
Floride	0.09	0.11	0.21	0.08	0.05	1.5mg/l
Mangase	0.02	0.02	0.01	0	0.01	0.2 mg/l
Nitrite (NO3	1.1	2.2	1.3	2.1	0.9	50mg/l
Nitrite (NO3)	0.002	0.008	0.001	0.004	0.009	0.2mg/l
Total Chlorine	0.7	0.02	0.04	0.13	1.2	0.2mg/l
Chlorine cl	10	20	10	5	10	250mg/l
Chloronnium (mg/l)	0	0	0	0	0	0.06

Laboratory Analysis 2020

Table 4 Revealed the continuous chemical parameters for Lower Usuma Dam domestic water quality: the PH valuesr samples at points S6 to S10 were 6.99, 6.98, 7.2, 6.89 and 7.01 respectively, all the PH are within the NSDWQ limits of 6.5-8.5. Conductivity for water samples S6 – S10 was 85, 98, 120, 35 and 85 which is also within specification standard limit measurement. Total Dissolve solid of the samples S6 to S10 were 44, 45, 60, 16, and 44 under acceptable limit measure; Total Hardness measured were 1.2, 2.1, 1.3, 1.5 and 1.4; Zinc were 0, 0,0.01 and 0 for S6 to S10 which is also below acceptable range of NSDWQ. Iron form S6 to S10 showed a measure 0.03, 0.09, 0.14, 0 and 0.9mg/l, here samples within limit measure NSDWQ except sample S9 which above with 0.09; Calcium measured 0.09, 1.5, 1.2, 2.1 and 1.3 in all sample points of S6 to S10 were below standard as accepted ranged; Magnesium from S6 to S10 showed that 0.45, 0.21, 0.45, 0.11 and 1.1 were all accepted values,. Copper value from S6 to S10 were 0, 0.02, 0, 0.01 and 0.02 were all below NSDWQ value of 1.5mg/l; Floride from sample point S6 to S10 were 0.09, 0.11, 0.21, 0.08 and 0.05 within limit of standard acceptable level,; Mangase were 0.02, 0.02, 0.01, 0 and 0.01 accepted value; Nitrate showed values of 1.1, 2.2,1.3, 2.1 and 0.9 form sample point of S7-S10, Nitrite, values of 0.002, 0.008, 0.001, 0.001, 0.004, and 0.009 while Total Chlorine showed value of 0.7, 0.02, 0.04, 0.13 and 1.2, here sample point S6, S8 and 10 were above NSDWQ limit and Chloride cl have values of 10, 20, 10, 5 and 10 were all accepted limit standard value, thus, Chromium (mg/l) values for sample S6-S10 were 0 and 0.006 of acceptable standard for water consumption.





The results for the concentration of bacteriological parameters derived and represented in the bar chart below showed the concentrations of presumptive coliform in the samples where sample S1, S2, S4 and S6 peaked with values 30, 20, 17 and 11, while S5 and S7 assumed same values 3 CFU/100mL, similarly S9 and S10 had same values of 1CFU/100mL, above the standard: 0 CFU/100mL concentration of presumptive coliform given by NSDWQ; samples S3 and S8 have the same values 0 CFU/100mL which is standard accepted by NSDWQ. Total Aerobic Bacteria Count of all samples S1 – S10 have values of 488, 600, 68, 205, 289, 250, 209, 84, 18 and 156

CFU/mL all above the Standard Total Aerobic Bacteria Count of 10 CFU/mL given by NSDWQ.

IV. CONCLUSIONS

The results have revealed that physical parameters (properties) analysis for water quality met the accepted standard values in colour and turbidity whereas temperature above ambient measure of NSDWQ in the lower Usuma dam treatment domestic water supply. In investigation of chemical parameters (properties), almost all parameters met standard except Mangesse at sample S4 that was above required standard with 0.4. Bacteriological parameters were total aerobic bacteria and presumptive coliform were tested, total aerobic bacteria met required standard guidelines set by NSDWQ but for presumptive coliform some sample points were above limit, only sample S3 and S8 (Treatment plant and in-house tap) were screen clean for domestic water supply. The Lower Usuma Dam water project have to some extend met required standard for water quality in physical and chemical parameter but for bacteria parameters, present of high concentration total aerobic bacteria and presumptive colifrom. The high microbial load particularly in Lower Usuma dam makes the water unsuitable for drinking purposes, although it can be use for others purposes. This is also similar with the higher bacterial load in the bottled water from Benin,Port Harcourt and Onitsha may be due to the structural integrity of the bottle/container. The Benin, Port Harcourt and Onitsha bottled water is ordinary polyethylene (Anochie, Onyeozirila and Onyeneke, 2018). However, based on observation, rearing of animals and human activities such as fishing, swimming, and some recreational sport contribute immensely to the rate of contamination in lower Usman dam. This was substantiated by the site Engineers that women fetching firewood close to the saddle dam at Ushapa where there is Poultry Industry and some Quarry activities by Chinese Company and SCC Israelis Quarrying Industry were the factors that contributed towards bacteriological contamination. Varieties of microorganisms continue living in water including bacteria, fungi, protozoa, algae and viruses, where they form a complex ecosystem whose dynamics are usually difficult to understand (Chrsanthus, 2014) that could result in illness, diseases and outbreak of communicable diseases experience in some areas of Abuja that solidly depend on Lower Usuma Dam their main source of drinking water and other domestic activities.

REFERENCES

[1] Akbarzadeh, A., Jamshidi, S., Vakhshouri, M. (2015) Nutrient uptake rateand removal efficiency of Vetiveriazizanioides in contaminated waters Pollution 1(1):1–8.

[2] Amos H. and Nwagilari, J. E. (2014). Assessment of Drinking Water Quality of Alau DamMaiduguri, Borno State, Nigeria. International Journal of Scientific and Research Publications,4, (10) 1 – 6.

[3] Arumugam, K. and Elangovan, K., (2009). Hydrochemical characteristics and groundwaterquality assessment in Tirupur region, Coimbatore district, Tamil Nadu, India.Environ. Geol. 58 (7) 1509.

[4] Bakobie, N., Sukairazu, I., and Duwiejuah, A. B. (2015). Assessment of dam water quality in threeselected communities in Savelugu-Nanton municipality, Ghana. Int. Res. J. Public Environ. Health,2 (12), 225-231.

[5] Chrysanthus, N. (2014). Bacteriological Quality of Alternative Water Sources in Bambui and Bambili residential areas, North-West Region, Cameroon.Open Access Libr. J. 1 (5) 1–6.

[6] Darko G., Ansah E., Faanu A. and Azanu D. (2017) Natural radioactivity andheavy metal distribution in reservoirs in Ghana. Pollution 3(2):225–241.

[7] Diersing N (2009) Water Quality: Frequently Asked Questions. FloridaBrooksNational Marine Sanctuary, Key West, FL.

[8] Ding, S., Chen, M., Gong, M., Fan, X., Qin, B., Xu, H., Gao, S., Jin, Z., Tsang, D.C.W. and Zhang, C. (2018). Internal phosphorus loading from sedimentscauses seasonal nitrogen limitation for harmful algal blooms. Sci Total Environ 625(1):872–884.

[9] Ibrahim A. Q, Onyenekwe P. C and Nwaedozie I. M (2014). An Efficiency Assessment of LowerUsuma Water Treatment Plant in Abuja Metropolis, Nigeria. Journal of Environmental Science,Toxicology and Food Technology (IOSR-JESTFT) 8 (12) II, 46-53.

[10] Karami, J., Alimohammadi, A. andModabberi, S. (2012) Analysis of thespatiotemporalpatterns of water pollution and source contribution usingthe MODIS sensor products and multivariate statistical techniques.Journal of Selected Topics in Applied Earth Observations andRemote Sensing 5(4):1243–1255.

[11] Karamouz, M., Zahraie, B., Araghi-Nejhad, S,,Shahsavari, M. andTorabi, S. (2001). An integratedapproach to water resources development ofthe Tehran region in Iran. J Am Water ResourAssoc 37(5):1301–1311.

[12] Lukubye,B.,Andama,M. (2017). Bacterial analysis of selected drinking water sources in Mbarara municipality, Uganda. J. Water Resour. Prot. 9, 999–1013.

[13] Narendra, P. and Sharma, H. (1993).African Water Resources, World Bank Publications, Washington DC.

[14] Ojutiku, R. O.,Kolo, R.J. and Mananaso,C. A.(2014). Composition and Dynamics of Some Nutrient and Physico0chemical Parameters in LowerCourseof Gwagwalada River in Federal Capital Territory, Abuja, Nigeria. American Journal ofAgriculture, 4(12), 1480-1491.

[15] Razmkhah, H., Abrishamchi, A. and Torkian, A. (2010) Evaluation of spatial andtemporal variation in water quality by pattern recognition techniques:a case study on Jajrood River (Tehran, Iran). J Environ Manag. 91(4):852–860.

[16] Saadatpour, M., Afshar, A., Edinger, J. E. (2017) Meta-model assisted 2nd hydrodynamic and thermal simulation model (ce-qual-w2) in derivingoptimal reservoir operational strategy in selective withdrawalscheme. Water ResourManag 31(9):2729–2744.

[17] Tajziehchi, S. (2014) A critical look at social impact evaluation of damconstruction by revised SIMPACTS software-a case study of Alborzdam in Northern Iran. International Journal of Environmental Research 8(2):329–334.

[18] Temgoua,E. (2011) Chemical and bacteriological analysis of drinking water from alternative sources in theDschang municipality, Cameroon. J. Environ. Prot. 2, 620–628.

[19] Ugwu,A. I. and Wakawa R.J. (2012): A study of Seasonal physico-chemical parameters in River Usman.American Journal of Environmental Science,8(5) 569-576.

[20] Ujoh, F., Ikyernum, J. and Ifatimehin, O. O. (2012). Socio-Environmental Considerations at theUsuma Reservoir in Abuja, Nigeria. Frontiers in Science, 2(6): 169-174.

[21] WHO, Guidelines for Drinking Water Quality, 1, second ed., World Health Organization, Geneva, 1996, p. 173. pp. 14–22.

[22] World Commission on Dams [WCD] (2000). 'Dams and Development: A New Framework forDecisions-Making'.Earthscan Publications, London.