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ASSESMENT OF POTENTIAL HEALTH IMPACTS ON SURFACE WATER SOURCES IN NORTHERN NIGERIA

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Abstract

Northern Nigeria represents the most populous region in Nigeria and adequate water supply and sanitation typically leaves a lot to be desired in the region in order to prevent water related diseases to the vulnerable communities of the region. This research work was carried out in Kano state with specific emphasis on Tomas dam which is one of the largest dams established for multipurpose use in Nigeria. The research was aimed at evaluating Physico-chemical and Bacteriological quality of Tomas Dam in Kano State. 240 water samples from 5 sampling stations within eight months were analyzed for bacteriological and physico-chemical quality. The physico-chemical parameters indicated Biochemical Oxygen Demand (BOD) and Water Current Speed results were not significantly different ($P>0.05$), while other physico-chemical parameters analyzed varied significantly ($P<0.05$). The study also revealed that Dissolved Oxygen (DO), BOD, Turbidity, and Nitrates recorded higher values than WHO and Federal Environmental Protection Agency, Nigeria (FEPA) limits. Total aerobic bacterial counts (TBC) and total coliform counts (TCC) were determined using pour plate and Most Probable Number (MPN) techniques. TBC and TCC were high and exceeded acceptable limits. Faecal coliforms, faecal *Streptococci*and *Klebsiella* species constituted 25% of the indicator organisms identified.The observed parameters indicated the Dam was contaminated with pathogenic bacteria. Variations in the weather conditions, animal and anthropogenic interferences were all directly or indirectly related to faecal contamination in the dam. Preventing indiscriminate faecal discharge close to the Dam and sufficient water treatment before consumption are of prime importance to public health as the dam was established for agricultural purposes.

Keywords: Physico-chemical quality, Bacteriological quality, Tomas dam water, Kano

Introduction

Water is a natural resource which presents us numerous challenges at global, national and local levels ranging from water shortages, droughts, to floods and declining water quality; these contribute to increased malnutrition and diseases, loss of biodiversity, loss of agricultural production and reduced economic growth and social stability (Leens, *et al.,* 2007). Various human activities consume or pollute a lot of water, the consequences of water shortages are experienced most acutely at the river basin and local levels (Leens, *et al.,* 2007).

Water supply and sanitation leaves a lot to be desired in northern Nigeria. Poorly functioning systems and low coverage inconvenience the inhabitants and allow infectious diseases to spread. Women bear a disproportionate share of the inconveniences, while infants and small children bear a disproportionate share of the burden of diseases (World Water Assessment Programme, 2003). The reasons for this problematic situation are many: Poverty is of course an underlying problem in virtually all urban areas where water and sanitation inadequacies are severe, poor governance is an increasingly popular explanation for bad water management (W.W.A.P, 2003).

Water plays a key role in prevention of diseases to human as drinking eight glasses of water daily can decrease the risk of colon cancer by 45% and bladder cancer by 50% as well as reducing the risk of other cancers (APEC, 1999).Water is an essential element in the maintenance of all forms of life, and most living organisms can survive only for short periods without water (Kegley and Andrews, 1998).

Water related diseases are the most common causes of illness and death, affecting mainly poor inhabitants in the local communities, several cases has been reported in Nigeria. In October 2010, about 29,115 cases involving 1,191 deaths of cholera have been reported in just 15 out of the 36 states and Federal Capital Territory. The figure increased from 1,616 and 126 deaths in 2004. It was observed that the outbreak is still in existence in new areas due to continuous water pollution. In May 2009, the Society for Gastroenterology and Herpetology in Nigeria (SOGHIN) revealed very high prevalence rate of Hepatitis with 19 million people, mostly poor, being infected. Hepatitis B and C remains the silent killer and dominant hepatitis infections that are lately diagnosed in Nigeria (Galadima *et al*., 2011).This study aimed at assessing physico-chemical and bacteriological quality parameters of Tomas dam water and compared it with national and international standards.

Materials and methods

Sampling sites

Five sampling stations were chosen for the study along longitudinal stretch of Tomas dam and designated as Water Sampling Points A, B, C, D and E (WSP A,B,C,D and E). Three sets of containers were used twice on monthly basis in each of the sampling station. 240 water samples were collected and analyzed in sterile dark brown bottles (250ml capacity) from July, 2011 to February, 2012. Periodic samplings were carried out during morning hours (Adnan *et al.,* 2010). Physico-chemical and bacteriological parameters were determined using accepted

procedures (APHA, 1998; WHO, 2006).The Samples were appropriately labelled and transported to the laboratory in ice packs for analysis the same day as described in Obire, *et al.*, 2005.

Physico-chemical analysis of the water samples

All meters and equipments used were checked and calibrated according to the manufactures specification. Temperature and water current speed were determined on site while nitrogen and phosphate were determined using potable data logging Spectrophotometer (DR/2010 HACH). pH also was determined using pH meter (Suntex TS-2), Dissolved Oxygen (DO) was determined using DO meter (Jenway model-9071, England) while Biochemical Oxygen Demand (BOD) was determined from the collected and preserved sample after 5 days of incubation in a cupboard, where another DO was determined as the final DO. The final DO was subtracted from the initial DO which gave BOD reading. TDS was determined after conductivity measurement was determined using conductivity meter (Hanna HI 98303).

Bacteriological analysis of the water samples

All the media, chemicals and reagents used were prepared according to manufacturer's specifications. The culture media used were sterilized using an autoclave at 121°C for 15 minutes, while glassware was sterilized in a hot air oven at 160°C for 1 hour. Total aerobic bacterial count was determined using standard plate count adopted from FAO, 1979. In this method, serial dilution was first carried out, where 1ml of the sample collected was transferred into a test tube containing 9.0ml of sterile distilled water and the tube was shaken and labelled 1: 10. From this tube 1.0ml was then transferred into another tube containing 9.0 ml of sterile distilled water and labelled as 1: 100. This was also agitated and the procedure was repeated up to 1: 10^6 using sterile syringes. 1.0ml from the dilution factor of 1:10^5 were transferred into appropriately labelled triplicate sterile petri dishes. This was followed by pouring a cooled molten prepared nutrient agar. The dishes were gently rocked, allowed to solidify and incubated at 37°C for 24hours. After 24 hours incubation, plates showing less than 300 colonies were counted and the average was computed which was multiplied by the reciprocal of the dilution factor to get the actual number of organisms. The result was finally expressed in colony forming unit per ml (cfu/ml) of the sample. Bacterial identification was done using separate inoculated and incubated plates based on morphological appearance, gram staining and biochemical characterizations (FAO, 2007). Total Coliform Counts (TCC) was carried out using Most Probable Number (MPN) Technique adopted from Richard, 1954. In this method each sample was inoculated into 3 sets of five (5) test tubes containing prepared lactose broth with durham tubes: to the first set of tubes l0ml of the collected sample was introduced, after thorough shaking into five test tubes containing 40m1 of lactose broth and designated as double strength lactose broth (DSLB); to the second set of tubes 1.0ml of the same sample was introduced into 20m1 of the prepared lactose broth and designated as single strength lactose broth one (SSLB1); to the third set of tubes 0.lml of the same sample was also introduced into another 20m1 prepared

lactose broth and designated as single strength lactose broth two (SSLB2). All the inoculated tubes were incubated at 35°C for 48 hrs. After the incubation tubes showing gas production in the durrham tube of at least 10% were counted, recorded and compared with MPN table adapted from APHA, 1998 for the determination of most probable number (MPN) of coliforms per 100mls of water. Indicator organisms were identified based on colony appearance, gram staining and relevant biochemical characterizations.

Statistical analysis

The data obtained were subjected to descriptive statistical analysis (95% confidence limit). The computation were achieved with the use of statistical package for social sciences (SPSS) to determine the mean, standard deviation and coefficient of variation and range values. Correlation was performed using simple Pearson correlation method.

Results and discussion

The pH values obtained during the study were within WHO and FEPA normal standards (Table 1,2,3 and 4). DO results recorded during the study were above WHO limit and lower than FEPA limit (Table 1,2,3 and 4). This may be attributed to low temperature experienced which direct effect to DO during January and December samplings (Table 4). Biochemical Oxygen Demand (BOD) recorded low result during July and August, 2011 in all the sampling stations (Table 1), and increases during September and October samplings (Table 2). This could be due to the concentration of organic load from surface run off into the Dam during July and August which decreases towards October due to high level of dilution effect from rain water and all the BOD results were lower than FEPA standards while WSP D (July, 2011) and WSP A, C, D and E (October, 2011) recorded normal WHO limits for DO. All the remaining sampling sites recorded higher DO results than WHO limit.

Turbidity measurements during the study recorded higher values than WHO limit (<5mg/l) with the highest value recorded in WSP A (July and August) (Table 1). This may be attributed to agricultural, fishing and other human activities such as washing, bathing and other domestic effluents reaching the dam especially on the dam sites (WSP A and E). The Turbidity measurement is considered significantly different ($P<0.05$) (Appendix 1). Similar pattern was recorded for TDS and Conductivity results in all the sampling sites which were within WHO limits. TDS and Conductivity varied significantly ($P<0.05$) (Appendix 1).Suspended Solids for both seasons were higher than normal standards for both FEPA and WHO limits and is considered significantly different ($P<0.05$) (Appendix 1).

Nitrogen result during the study recorded higher values especially during December, January and February where only WSP C and D recorded lower values than FEPA limit for January and February, 2012. This could also be attributed to the overall surface run off experienced during rainy season and the evaporation effect during dry season especially in January and February (2012). However it is only WSP A during February (2012) recorded the highest value of 20.19mg/l among all during dry season which is higher than FEPA standard but

lower than WHO limit. The statistical analysis shows the result of Nitrogen was significantly different ($P<0.05$) (Appendix 1).

In both seasons the temperature ranges falls within WHO and FEPA limits which may be attributed to the seasons experienced during the study. The temperature value is considered significantly different ($P<0.05$) (Appendix 1).The result of water current speed shows variable trends during the study which shows similar pattern. Using a paired t-test for seasonal compares, the current speed values were not significantly different ($P>0.05$) (Appendix 1). The total aerobic bacteria counts result had a range of 0.7×10^6 - 9.0×10^6 cfu/ml (Table 5) during the study, while total c*oliform* counts had a range of 2 - 350 MPN index per 100ml (Table 6) during the study. These counts were generally higher in WSP A, B and E during the study whereas WSP C and D recorded lower values during the study.

Of the four bacterial species isolated; only *E. coli* and *E. aerogenes* occurred in all the months (Table 7). The remaining species occurred in some months during the study. *Klebsiella* species were not isolated during July and September while S*treptococcus faecalis* were also not isolated during December and February respectively (Table 7). The relationship between environmental factors and natural microbial populations are fairly complex and could lead to variations in bacterial numbers and types. Bacterial species isolated in this investigation varied in different sampling stations (Table 7 and 8). Atlas (1988) reported that the population of any aquatic system is to a large extent influenced by the water body. Establishing the presence of bacteria in water bodies is important, as they have been identified as the major organisms which initiate the breakdown of introduced wastes including hydrocarbons to various metabolic intermediates (Hollaway *et al.*, 1980).

TBC and TCC were high with the TBC being higher during the study. These high counts might have arisen due to the poor level of hygiene and sanitation observed at the dam sites. Also, the layout of the houses in the study area are not well planned such that the distances between Agricultural land neighbouring the dam, Houses and even refuse dumps are very minimal. In some studies conducted within the country(Ifabiyi, 2008; Akinbile and Yusoff, 2011;Shittu *et al.*, 2008; Akahaan *et al.*, 2010; Orebiyi *et al.*, 2010; Adejuwon and Mbuk, 2011) recorded higher values of bacteria which poses serious public concern. The presence of coliform in water is an indication of faecal contamination and has been associated with waterborne epidemic (Mackenzie *et al*., 1995). Any water source used for drinking or cleaning purposes should not contain organisms of faecal origin (Akeredolu, 1991).

Table 1: Monthly variations of physico-chemical parameters in relation to sampling sites during July and August (2011) samplings.

S/N	PARAMETERS	JULY					AUGUST				
		A	B	C	D	E	A	B	C	D	E
1	pH	8.60	8.13	7.69	8.20	8.21	8.30	8.14	7.89	8.21	8.52
2	Conductivity (μScm^{-1})	401.31	368.11	326.00	412.33	376.11	266.15	301.31	251.30	270.19	296.16
3	TDS (mg/l)	268.88	246.13	218.42	276.26	252.00	178.32	201.88	168.37	181.02	198.43
4	DO (mg/l)	8.9	10.0	6.8	7.2	9.6	16.9	11.2	18.2	16.0	13.2
5	BOD (mg/l)	5.2	4.1	3.4	3.6	6.7	9.6	10.0	12.1	8.7	9.3
6	Turbidity (mg/l)	82.0	61.0	43.0	57.0	49.0	86.0	44.0	43.0	49.0	56.0
7	Phosphate (mg/l)	0.19	0.31	0.26	0.67	0.11	6.21	4.31	4.20	5.10	6.00
8	Nitrate (mg/l)	24.63	14.90	13.21	12.52	23.20	22.62	13.93	14.28	12.81	23.86
9	SS (mg/l)	66.0	29.0	21.0	53.0	42.0	79.0	34.0	32.0	53.0	29.0
10	Temperature(°C)	22	21	20	22	20	22	20	21	21	23
11	Current Speed (m/s)			1.2					0.8		

Key: A,B,C,D and E = Water sample A,B,C,D and E

Table 2: Monthly variations of physico-chemical parameters in relation to sampling sites during September and October (2011) samplings.

S/N	PARAMETERS	SEPTEMBER					OCTOBER				
		A	B	C	D	E	A	B	C	D	E
1	pH	8.50	8.40	8.58	8.44	8.40	8.57	8.84	8.33	8.90	8.75
2	Conductivity (μScm^{-1})	392.86	378.57	377.14	371.00	378.57	397.00	358.57	855.71	358.54	357.14
3	TDS (mg/l)	263.22	253.64	252.68	248.86	253.64	260.22	240.14	573.33	240.24	239.28
4	DO (mg/l)	17.2	18.1	18.6	14.3	17.0	6.7	8.2	3.3	2.1	5.0
5	BOD (mg/l)	12.0	16.9	7.8	10.2	8.1	4.2	7.1	2.1	1.0	2.1
6	Turbidity (mg/l)	66.0	57.0	67.0	66.0	47.0	63.0	46.0	39.0	39.0	57.0
7	Phosphate (mg/l)	4.19	3.16	3.18	6.33	5.37	5.20	6.72	6.01	5.53	5.67
8	Nitrate (mg/l)	22.20	12.31	11.62	15.71	23.00	21.21	10.93	10.11	10.98	24.00
9	SS (mg/l)	60.0	46.0	67.0	34.0	41.0	44.0	13.0	17.0	11.0	16.0

10	Temperature (°C)	22	20	23	20	22	25	24	24	23	24
11	Current Speed (m/s)			1.8					1.5		

Key: A,B,C,D and E = Water sample A,B,C,D and E

Table 3: Monthly variations of physico-chemical parameters in relation to sampling sites during November and December (2011) samplings.

S/N	PARAMETERS	NOVEMBER					DECEMBER				
		A	B	C	D	E	A	B	C	D	E
1	pH	8.10	8.00	7.90	8.03	8.14	7.82	7.69	7.90	8.01	7.64
2	Conductivity (μScm^{-1})	318.16	279.11	288.20	219.16	298.00	118.60	256.10	318.00	271.00	270.00
3	TDS (mg/l)	213.17	187.00	193.09	146.84	199.66	79.46	171.59	213.06	181.57	180.90
4	DO (mg/l)	22.1	17.6	14.0	18.0	16.2	14.2	16.	13.3	14.7	14.0
5	BOD (mg/l)	5.1	4.3	1.1	2.8	4.9	10.0	8.9	11.2	8.1	7.8
6	Turbidity (mg/l)	69.0	42.0	38.0	56.0	63.0	46.0	52.0	69.0	56.0	62.0
7	Phosphate (mg/l)	3.42	2.31	2.81	3.61	4.20	2.60	2.72	1.81	1.62	1.93
8	Nitrate (mg/l)	30.01	19.42	6.10	13.00	20.52	47.11	26.20	22.10	12.91	25.00
9	SS (mg/l)	38.0	20.0	17.0	19.0	23.0	35.0	44.0	18.0	26.0	32.0
10	Temperature (°C)	26	24	24	25	23	22	21	21	23	22
11	Water Current Speed (m/s)			2.0					0.4		

Key: A,B,C,D and E = Water sample A,B,C,D and E

Table 4: Monthly variations in relation to sampling sites of physico-chemical parameters during January and February (2012) samplings.

S/N	PARAMETERS	JANUARY					FEBRUARY				
		A	B	C	D	E	A	B	C	D	E
1	Ph	7.61	7.49	7.53	7.31	7.44	6.90	6.81	7.21	6.60	6.90
2	Conductivity(µScm^{-1})	98.31	161.23	111.00	126.11	187.00	110.00	63.97	72.62	63.00	66.17
3	TDS (mg/l)	65.87	108.02	74.37	84.49	172.86	73.70	40.88	48.25	42.21	44.22
4	DO (mg/l)	18.0	20.0	19.0	20.5	21.0	11.6	12.4	13.4	12.7	12.8
5	BOD (mg/l)	12.8	13.5	12.9	14.5	14.0	3.3	3.9	5.9	5.3	5.6
6	Turbidity (mg/l)	38.0	32.0	35.0	42.0	46.0	32.0	31.0	35.0	33.0	38.0
7	Phosphate (mg/l)	2.51	1.67	1.09	0.82	0.68	0.39	0.28	0.16	0.40	0.52
8	Nitrate (mg/l)	56.21	24.13	14.10	16.15	28.25	44.87	29.04	18.41	19.30	27.98
9	SS (mg/l)	27.0	29.0	17.0	11.0	19.0	16.0	29.0	16.0	14.0	23.0
10	Temperature (°C)	24	23	25	24	22	24	25	26	26	24
11	Current Speed (m/s)			1.2					0.2		

Key: A,B,C,D and E = Water sample A,B,C,D and E

TABLE 5: Monthly variations of total aerobic Bacterial Counts in relation to sampling sites (X 10^6 cfu/ml)

	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	WET SEASON	DRY SEASON
A	7	8.3	2	3.3	2	4.3	3.3	2	5.15	2.9
B	2	4	4	2.3	2.3	2.3	2	4	3.08	2.65
C	0.7	2	2.3	2	0.7	1.3	2.3	7	1.75	2.83
D	3.3	4	9	5	3.3	2.3	1.3	2	5.33	2.23
E	9	6	8	6	4	2	1	0.7	7.25	1.93

Key: A,B,C,D and E = Water sample A,B,C,D and E

TABLE 6: Monthly variations of Total Coliform Counts in relation to sampling sites (MPN index per 100ml)

	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	FEPA limit	WHO limit
A	220	50	26	17	17	30	11	17		**<10**
B	110	350	17	11	7	23	30	13		
C	13	50	9	2	11	7	21	7		
D	11	110	12	4	2	4	4	4		
E	13	110	50	14	17	13	4	8		

Key: A,B,C,D and E = Water sample A,B,C,D and E

TABLE 7: Frequency of occurrence percentage of indicator organisms

	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	TOTAL
E. coli(n=35)	4 (11.4%)	3 (8.6%)	5 (14.3%)	3 (8.6%)	1 (2.9%)	6 (17.1%)	7 (20%)	6 (17.1%)	**35**
E. aerogenes(n= 113)	18 (15.9%)	21 (18.6%)	12 (10.6%)	9 (8.0%)	16 (14.2%)	8 (7.1%)	16 (14.2%)	13 (11.5%)	**113**
Klebsiella sp.(n=14)	0	2 (14.3%)	0	1 (7.1%)	3 (21.4%)	3 (21.4%)	1 (7.1%)	4 (28.6)	**14**
Streptococcus faecalis(n=23)	6 (26.1%)	7 (30.4%)	1 (4.3%)	4 (17.4%)	3 (13.0%)	0	2 (8.7%)	0	**23**

TABLE 8: FREQUENCY OF OCCURRENCE PERCENTAGE OF FAECAL COLIFORMS AND FAECAL STREPTOCOCCI

	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	TOTAL
E. coli	7 (13%)	8 (14.8%)	7 (13%)	10 (18.5%)	6 (11.1%)	4 (7.4%)	5 (9.3%)	7 (13%)	54
Strept. Faecalis	2 (28.6%)	0	1 (14.3%)	1 (14.3%)	0	0	1 (14.3%)	2 (28.6%)	7
Klebsiella sp.	0	1 (33.3%)	0	0	0	2 (66.7%)	0	0	3

APPENDIX 1: SEASONAL COMPARISM (PHYSICO-CHEMICAL ANALYSIS) USING PAIRED t TEST

	RAINY SEASON			DRY SEASON						
	MEAN	**SD**	**SEM**	**MEAN**	**SD**	**SEM**	**P-value**	**t-value**	**df**	**Corr.**
pH	8.380	0.301	0.067	7.552	0.466	0.104	< 0.0001	5.196	19	-0.7166
Conductivity	374.70	122.93	27.48	184.79	95.113	21.268	0.0002	4.690	19	-0.3695
TDS (mg/l)	250.75	82.318	18.40	126.06	64.834	14.497	0.0002	4.579	19	-0.3606
DO (mg/l)	11.425	5.364	1.199	16.075	3.231	0.723	0.0004	4.302	19	0.4572
BOD (mg/l)	7.210	4.054	0.907	7.795	4.183	0.936	0.371	0.916	19	0.7601
Turbidity (mg/l)	55.850	13.204	2.952	45.750	12.752	2.851	0.0177	2.597	19	0.1026
Phosphate (mg/l)	3.936	2.353	0.526	1.778	1.220	0.273	0.01	2.860	19	-0.7606
Nitrate (mg/l)	16.902	5.386	1.204	25.041	12.356	2.763	0.002	3.577	19	0.5871
Suspended Solids (mg/l)	39.350	19.367	4.331	23.650	8.707	1.947	0.0012	3.817	19	0.3338
Temperature (°C)	21.950	1.572	0.352	23.700	1.559	0.349	0.0001	4.742	19	0.4445
Current Speed	1.325	0.427	0.214	0.950	0.823	0.411	0.4535	0.859	3	0.1375

Conclusion

The present study revealed that Dissolved Oxygen, BOD, Turbidity, and Nitrates (physico-chemical parameters) and bacteria were present in relatively higher concentrations. Although, there were variations in some sampling sites in terms of physico-chemical parameters and bacterial counts, the observed high coliform counts and presence of *Escherichia coli* showed that the water may be contaminated with pathogenic bacteria and possible public health risk to end users. The water from Tomas dam required suitable treatments such as filtration, chlorination, alum treatment, aeration, neutralization, softening and chemical precipitation, to minimize contamination and make it fit for drinking. The dam sites were excessively polluted and were not potable for drinking. This study suggests that, it is important to monitor the activities taking place in and around the dam with the aim of controlling the possible sources of contamination. Local citizens can be enlisted to watch for and report the status of changes especially in sampling stations A and E.

References

Adejuwon, J.O., and Mbuk, C.J., 2011. Biological and physico-chemical properties of shallow wells in Ikorodu town, Lagos Nigeria. *Journal of Geology and Mining Research 3(6), 161-168.*

Adnan, A., Taufeeq, A., Malik, E., Irfanullah., Muhammad, M.K., and Muhammad, A.K., 2010. Evaluation of Industrial and City Effluents Quality using physicochemical and Biological parameters; *Journal of Environmental, Agricultural and Food Chemical. 1579-4377.*

Akaahan, T.J., Oluma, H.O.A., and Sha'Ato, R., 2010. Physico-chemical and bacteriological quality of water from shallow wells in two rural communities of Benue state, Nigeria. *Pakistan Journal of Analytical and Environmental Chemistry* 11(1), 73-78.

Akeredolu, F.A., 1991. Setting water quality standards for Nigeria. *In:* Proceedings of first national conference on water quality monitoring and status in Nigeria pp. 216-224.

Akinbile, C.O., and Yusoff, M.S., 2011. Environmental impact of leachate pollution on groundwater supplies in Akure, Nigeria. *International Journal of Environmental Science and Development* 2(1), 81-86.

American Public Health Association (APHA). 1998. "Standard Methods for the examination of water and wastewater." 20th edition; APHA: Washington, DC, USA. Pp 608.

Asia-Pacific Economic Cooperation (APEC). 1999. Health Information Importance of Water and Human Health, retrieved from http://www.freedrinkingwater.xom/water_education.

Atlas, R.M., 1988. Influence of environmental factors on the growth and distribution of microorganisms. Microbiology: fundamentals and Application. 2nd edition.Pp 347-356.

FAO. 1979. Methods of microbiological analysis of food and water. Manual of food and agricultural organization of the United Nations (FAO) Ec/microbiol./75/Report1/Annex/.

FAO. 2007. Coping with water scarcity, 2007 World Water Day, retrieved from http://www.fao.org/nr/water7docs/wwd07brochure.pdf.

Galadima, A., Garba, Z.N., Leke, L., Almustapha, M.N. and Adam, I.K., 2011. Domestic Water Pollution among Local Communities in Nigeria; Causes and Consequences.*European Journal of Scientific Research, 52,4, 592-603.*

Hollaway, S.L., Gray, M.F., Sizemore, R.K., 1980. The bacterial community composition of an active oil field in the North Western Gulf of Mexico. *Marine Pollution Bulletin* 11: 153-156.

Ifabiyi, I.P., 2008. Depth of hand dug wells and water chemistry: Example from Ibadan Northeast Local Government Area (L.G.A.), Oyo-state, Nigeria. *Journal of Social Sciences* 17(3), 261-266.

Kegley, E.S., and Andrew, J., 1998. The Chemistry of Water. 2nd ed., California: University Science books publisher USA. Pp: 13-162.

Leenes, W.G., Hoekstra, A., Richard, H., Greg, K.I., Jack, M., Pancho, N., Stuart, O., Mariska, R., and Eric, R., 2007. WATER NEUTRALITY: a concept paper, retrieved on 20th November, 2007 from www.waterneutral.org.

Mackenzie, W.R., Schell, W.L., Blair, K.A. and Addiss, D.G., 1995. Massive outbreak of waterborne cryptosporidium infection in Milwaukee, Wiscousin: recurrence of illness and risk of secondary transmission. *Clinical Infectious Diseases* 1, 57-62.

Obire, O., Tamuno, D.C., Wemedo, S.A., 2005. Bacteriological Water Quality of Elechi Creek in Port Harcourt, Nigeria;*Journal of Applied Science and Environmental Management.* 9 (1) 79 – 84.

Orebiyi, E.O., Awomeso, J.A., Idowu, O.A., Martins, O., Oguntoke, O. and Taiwo, A.M., 2010. Assessment of pollution hazards of shallow well water in Abeokuta and Environs, Southwest, Nigeria. *American Journal of Environmental S*ciences 6(1), 50-56.

Shittu, O.B., Olaitan, J.O., and Amusa, T.S., 2008. Physico-chemical and bacteriological analyses of water used for drinking and swimming purposes in Abeokuta, Nigeria. *African Journal of Biomedical Research.* 11, 285- 290.

WHO, 2006. Guidelines for Drinking-water Quality: Incorporating First Addendum (3rd edition), *Recommendations*vol. 1 retrieved fromhttp://www.who.int/water_sanitation.

World Water Assessment Programme (WWAP), 2003. Water for People; Water for Life. Joint Report by UN Agencies concerned with Freshwater. UNESCO and Berghahn Books, retrieved from http://unesdoc.unesco.org.