Asian Journal of Applied Chemistry Research

4(2): 1-9, 2019; Article no.AJACR.52206
ISSN: 2582-0273

Monitoring the Physicochemical Properties of Water Used for Irrigation in Gwagwalada Area Council of FCT Abuja, Nigeria

Chime Maureen Oby[1*], Dauda Mary Sunday[1], Useh Mercy Uwem[1,2] and Rosemary Okoh Esene[2]

[1]Department of Chemistry, University of Abuja, Abuja, Nigeria.
[2]Chemistry Advanced Research Center, Sheda Science and Technology Complex (SHESTCO), Kwali, Abuja, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJACR/2019/v4i3-430106
Editor(s):
(1) Dr. Azhari Hamid Nour, Associate Professor, Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang, Malaysia.
Reviewers:
(1) Antipas T. S. Massawe, University of Dar es Salaam, Tanzania.
(2) A. E. Adeleke, Federal University, Otuoke, Nigeria.
(3) M. K. N. Kumari, Rajarata University of Sri Lanka, Sri Lanka.
Complete Peer review History: http://www.sdiarticle4.com/review-history/52206

Original Research Article

Received 11 August 2019
Accepted 21 October 2019
Published 04 November 2019

ABSTRACT

Water is one of the most important global requirements for every activity in life including agricultural irrigation. Water if polluted, creates direct problems of alkalinity/salinity/toxicity to agricultural farms, thereby negatively affecting the quality and nutritional value of cultivated crops. This study was carried out to evaluate the physicochemical parameters of river water from eight different rivers within Gwagwalada Area Council of the FCT, using standard methods. These parameters were determined during wet and dry seasons and the results showed seasonal variations of all the parameters. Means of seasonal values of pH ranged between 6.37 - 7.95, temperature 22.40 – 27.100°C and electrical conductivity 124.55 µS/cm – 312.32 µS/cm. The mean values of Dissolve oxygen (DO) and Dissolved solid (DS) in the two seasons (wet and dry) were 3.37 mg/l – 9.39 mg/l and 67.76 mg/l - 151.23 mg/l respectively. For sulphate, phosphate, nitrate and turbidity, the mean values for wet and dry seasons ranged between 42.94 – 98.98 mg/l, 0.98 – 3.56 mg/l, 4.98 – 11.94 and 4.90 – 47.32 NTU respectively. Other parameters are

**Corresponding author: Email: chukwudi666@yahoo.com;*

potassium 3.12-6.56 mg/l, sodium 13.78 -24.33 mg/l, magnesium 3.76 – 8.90 mg/l and calcium 9.78 – 19.87 mg/l. These chemical parameters also showed significant seasonal variation. The results of the analyses indicated that some of the parameters fall within the recommended limits and thus largely suitable for irrigation and domestic purposes.

Keywords: Water quality; physicochemical; irrigation; seasonal variation.

1. INTRODUCTION

Water is essential to living organisms, agricultural production, industrial processes and domestic use for humans [1]. Water quality is defined in terms of its chemical, physical and biological characteristics, usually in respect to its suitability for an intended purpose [2]. No single measure constitutes good water quality, this is because the quality of water appropriate for recreational purposes differs from that used for industrial purposes [1,2]. Also water suitable for drinking can be used for irrigation, but water used for irrigation may not be fit for drinking. Population growth, urbanization and industrialization have led to the decline in the quality of surface water globally [3].

Pollution from natural and anthropogenic sources also threatens available fresh water [4]. Water quality monitoring is essential for identifying sources of pollutants. The quality of water bodies is determined by its physicochemical features. Water quality monitoring methods include biological indicators, physicochemical parameters and the use of remote sensing [5]. Irrigation is a basic determinant of agriculture because of its inadequacies which is one of the most powerful constraints on the increase of agricultural production [6,7].

Irrigation can have adverse effect on soil properties as well which causes soil degradation, thus it should be regularly monitored. The effect of irrigation on soil physicochemical properties in arid and semi arid environment were well documented [8]. It is important to have a good understanding of agricultural practices in order to maintain the soil structure [9]. It is a fact which cannot be disputed that irrigation is an essential and indispensible practice in dry land agriculture. There is a huge competition for the use of fresh water in the development of urbanization, industry, leisure and other fields which provokes a net decline of fresh water for irrigation [10,11].

Water quality would be determined by weathering of bedrock minerals, by the atmospheric processes of evapo-transpiration and by the deposition of dust and silt by wind, by natural leaching of organic matter and nutrient from soil, by hydrological factor that leads to runoffs, and by biological processes within the aquatic environment that can alter the physical and chemical composition of water [12]. There is no other resource that affects so many areas of the economy or of human and environmental health like water. In view of this fact, there is need for proper use of the water resource. It has been suggested that water pollution is the leading worldwide cause of deaths and disease and that it accounts for the deaths of more than 14,000 people daily [13,14]. An estimated 700 million Indians have no access to a proper toilet, and 1,000 Indian children die of diarrhea every day [15]. Some 90% of China's cities suffer from some degree of water pollution, and nearly 500 million people lack access to safe drinking water [15]. In addition to the acute problems of water pollution in developing countries, industrialized countries continue to struggle with pollution problems as well [16]. In the most recent national report on water quality in the United States, 45 % of assessed stream miles, 47% of assessed lake acres, and 32% of assessed bay and estuarine square miles were classified as polluted [17]. Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support human use, such as drinking, and/or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish [18]. The primary objective of irrigation is to provide crops with adequate and timely amounts of water, thus avoiding yield loss caused by extended periods of water stress during stages of crop growth that are sensitive to water shortages.[2,19]. Thus, this study was carried out to evaluate the physicochemical parameters of river water from eight different rivers within Gwagwalada Area Council of the FCT, Abuja, Nigeria using standard methods.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Abuja, the Federal capital Territory is located in the North central region of Nigeria. Its geographic coordinates are 9°10[1]32[11] N and 70°10[1]50[11]E [20]. There are six area councils that make up the Federal Capital Territory namely: Abuja Municipal Area Council, Abaji Area Council, Bwari Area Council, Gwagwalada Area. Council, Kuje Area Council and Kwali Area Council. Gwagwalada Area Council has a land mass of 1,043 km^2 and population density of over 157,770 (2006 National Population Census). It is one of the major agricultural zones of FCT with predominant dry season agricultural activities, most likely because of the presence of Gwagwalada River that traversed most of the communities. The huge agricultural activities can also be attributed to the presence of the headquarters of FCT Agricultural Development Project (ADP). Samples of water were collected from the following points.

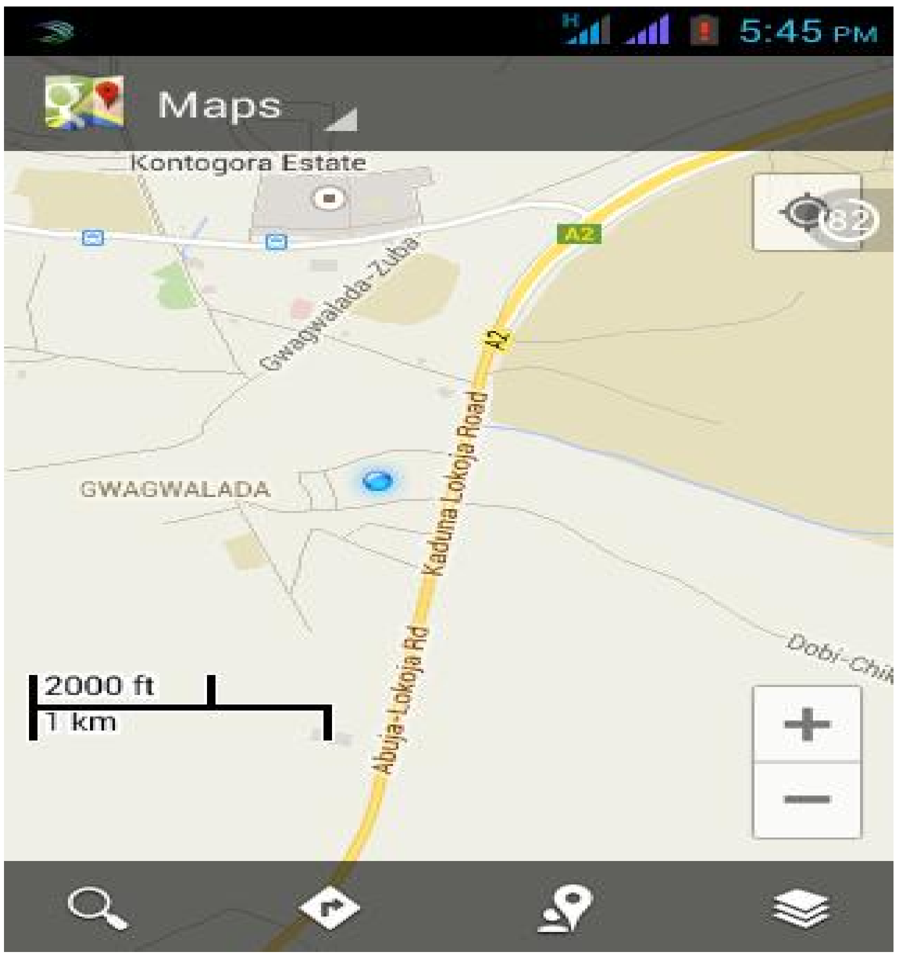

Fig. 1. Map of Gwagwalada area council

Table 1. Sampling stations and their coordinates

Code	Name of river	Coordinates
S1	Gwagwalada	Lat. 9.03584, Long. 7.000365,
S2	Ibuwa 1	Lat. 9.180608, Long.7.128494
S3	Ibuwa 2	Lat.9.19208, Long.7.120907
S4	Paiko	Lat. 8.99338, Long.7.051869
S5	Old Kutunku	Lat. 9.002643, Long.7.026527
S6	Rafinzurufi	Lat.8.975912, Long.7.04764
S7	Dobi	Lat.8.963288, Long.7.082378
S8	Sabodupaso	Lat.9.019241, Long.7.013446

2.2 Sample Collection

A total of twenty four samples (24) were used for the present study. Three samples each from different sample point were collected from the period of June to August for wet season and October to December for dry season 2018 with pre-washed 2 litres keg respectively, at areas where activity takes place and a point of high turbulence flow to ensure good mixing. Temperature, pH, DO and colour were determined insitu. The samples were placed in a cooler to prevent increase in bacterial load and also to avoid depletion of the contamination due to oxidation and direct sunlight. The sampling for different parameters were taken and preserved [21,22]. All samples were properly labeled and kept in ice chest in cooler prior to laboratory analysis. The temperature readings of the samples were taken at the sampling point by placing a clean thermometer vertically into the water sample and allowed to stand till the temperature reading was steady. Turbidity was determined using turbidimeter [23,24]. The pH was measured with a pH meter by inserting the probe into the samples and values were read from the LCD screen. Total Solid was determined gravimetrically by evaporating a known volume of the water samples to dryness and further drying to constant weight in the oven at 105°C. Total Suspended Solid of the water samples was determined gravimetrically after filtering a known volume of the sample through a glass fibre (glass filter paper). Total dissolved solid was obtained by difference between total solids and total suspended solids (TDS = TS – TSS) [25,26]. Total hardness in the water samples was determined titrimetrically using the sodium salt of ethylene-diamine-tetra-acetic acid (EDTA) as titrant. Titrimetric method was used for the determination of dissolved oxygen. This was determined insitu by adding 2 ml of manganous sulphate and 2 ml of alkalin iodide azide solution, then with conc HNO3 and 30 ml of sample was titrated against a standard of 0.012 M of sodium thiosulphate until the b[ueblack colouration disappeared. COD in the water samples was determined titrimetrically, the process being achieved by using a strong oxidizing agent (potassium dichromate) under acidic condition. Chloride ion in water samples was measured titrimetrically using the Mohr's method. Nitrate concentrations in water samples were determined by the phenol disulphonic acid method. Sulphate in the water samples was determined by turbidimetric method. Phosphate concentrations in water samples were determined using the phosphate Vanadomolybdate colorimetric method [27].

All mean values were calculated using statistical analysis:

$$\overline{X} = \sum x_i/n$$

Where

X = Sample mean
x_i = Individual sample
N= Total number of samples

Sodium Adsorption Ratio (SAR), was one of the parameters used to assess the suitability of water for irrigation purposes. According to Jain, [27], SAR is expressed as:

$$SAR= \frac{Na^{+}}{\sqrt{1/2(Ca^{2+} + Mg^{2+})}}$$

3. RESULTS AND DISCUSSION

pH value of water is important because many biological activities can occur only within a narrow range. Thus any variation beyond acceptable range could be fatal to a particular organism [28]. pH was highest (7.95) at sampling station 8 during the dry season and lowest (6.37) at sampling location during the raining season. The pH range observed during the study period was 6.37-7.95 for both seasons, and it was within the range for inland waters (pH 6.5 - 8.5). The pH range obtained in this study is within the acceptable level of 6.0 to 8.5 for culturing tropical fish species and, for the recommended levels for drinking water. pH recorded during raining season could be due to combined effects of run-off from agricultural lands. pH value of water is important because many biological activities can occur only within a narrow range [29,30,31]. Thus any variation beyond acceptable range could be fatal to a particular organism. The pH is an important parameter required for maintenance and promotion of both biotic and abiotic ecological system [32]. pH of any water body can be changed with the change of season as there are several factors which govern it [33]. High electrical conductivity (EC) values were observed during the dry season and low values in the raining season. High EC values during dry season are due to evaporation resulting in high concentration of ions. The situation in the present study was such that increased conductivity during the dry season was enhanced by increased water evaporation and upwelling from wind [34].

The highest value for turbidity was measured at sampling location 6 with a value of 47.32 NTU during the raining season when the highest rainfall was being experienced. During rainy season silt, clay and other suspended particles contribute towards high turbidity values, while during dry season settlement of silt, clay results in low turbidity [35,36]. Higher turbidity values were observed during the rainy season period due to increased in suspended solids loads laden from run-offs while the mean value increased between sampling sites; this could be attributable to the level of human activity in the river systems. The highest (27.10°C) mean temperature was recorded at sampling location 2 and the lowest (21.90°C) was recorded at sampling station 5 during the dry season and raining season respectively. The lowest water temperature recorded during dry season coincided with the period of harmattan and samples were collected very early in the morning. In this study, the high water volume which increases wave action, and decrease surface water temperature might have contributed to the increased oxygen concentration during the raining season.

However, low Dissolved Oxygen (DO) was recorded during the dry season, this could be attributed to the extent of flora composition, organic pollution and population density of fauna. DO in water affects the oxidation-reduction state of many of the chemical compounds such as nitrate and ammonia, sulphate and sulphite and ferrous and ferric ions. It is extremely useful in self-purification of water bodies. The high oxygen value for the raining season coincides with periods of lower temperature and high turbulence. The amount of dissolved oxygen in water has been reported not to be constant but fluctuates, depending on temperature, depth, wind and amount of biological activities such as degradation. The carbonate system is the sum of all inorganic forms of carbon, which represents the most important component of the total budget and turnover of carbon i.e., one of the main cycles of the turnover of substances in nature. The carbonates and bicarbonates are the major components of alkalinity of surface water Carbonates showed significant variations with the seasonal variation during the entire study period, while the a maximum value of 96.28 mg/L was observed at sampling location 8 during the raining season, a minimum value of 46.44 mg/l was observed at location 1 during the dry season. The higher values of hydrogen bicarbonates during the raining season may be attributed to the decomposition in the dead phytoplankton leading to liberation of CO_2 which dissolves in water and increase in the formation of HCO^-_3.

Table 2. Physical parameter of water during rainy season

Sampling stations	Temperature (°C)	PH	TDS (mg/L)	Turbidity (NTU)	EC (µS/cm)
1	22.40	6.45	67.76	36.80	124.55
2	21.90	6.87	89.65	41.87	154.98
3	23.10	6.66	102.87	36.85	197.87
4	23.10	6.87	106.78	42.98	199.78
5	23.50	6.37	123.98	45.22	265.87
6	22.90	6.39	121.55	47.32	255.54
7	23.20	6.78	109.99	38.55	198.87
8	22.60	6.70	91.11	39.65	193.98

Table 3. Mean physical parameter of water during dry season

Sampling stations	Temperature (°C)	Ph	TDS (mg/L)	Turbidity (NTU)	EC (µS/cm)
1	26.20	7.45	95.87	9.65	191.87
2	26.60	7.31	84.43	11.98	195.54
3	26.90	7.72	132.83	6.87	253.98
4	26.60	7.66	111.43	4.90	233.65
5	27.10	6.99	151.23	13.78	312.32
6	26.70	6.60	142.23	13.90	265.87
7	26.90	7.21	101.33	9.78	212.87
8	25.90	7.95	109.38	13.16	209.76

Phosphate concentration was highest (3.56 mg/l) at sampling location 7 during the dry season and lowest (0.98 mg/l) at sampling location 6 during the raining season. Phosphate and nitrate levels are a measure of level of eutrophication of a given lake. Phosphate levels in the present study were significantly higher during dry season. High values of phosphate and nitrate support algal growth and Phosphate levels in the present study were significantly higher during dry season. High values of phosphate and nitrate support algal growth and hence good plankton bloom. The phosphate level in the sampled rivers may be a result of release from disturbed sediment, anoxic conditions as a result of decaying macrophytes and washing of phosphate fertilizer from nearby farmlands. The reason for the decreased phosphate value, compared to the other aquatic systems, may involve heterotrophic uptake by micro-organisms, sediment adsorption and removal by the currents. Seasonal data showed that, during the study period the chloride content was higher in the dry season (54.44 mg/l) at station 2 which was probably due to the sewage waste.

The presence of nitrate and nitrite in water may result from the excessive application of fertilizers or from leaching of wastewater or other organic waste into surface water and ground water. Nitrate concentration was highest (11.94 mg/l) at location 4 during the raining season and lowest (4.98 mg/l) at location 8 during the dry season. Nitrate is found in little amounts in natural waters and mostly it is of mineral origin, while most coming from organic and inorganic sources, such as effluent discharges and fertilizer runoff. Sulphates concentrations in all seasons at all stations were within the permissible limits. Sulphate concentrations in the sampling stations were highest (98.98 mg/l) at location 6 during the dry season and lowest (42.94 mg/l) at location 5 during the raining season.

Sulphates naturally occur in surface water which arises from the leaching of sulphur compounds either as sulphate minerals such as gypsum or sulphite as pyrite or from sedimentary rocks. Also, the variation in concentration of sulphate at different locations could be due to the fact that the sulphate discharged to the rivers was used up as a source of oxygen by bacteria and was converted entirely to H_2S under anaerobic conditions.

The sodium adsorption ratio is used to predict the potential for sodium to accumulate in the soil. U.S salinity Lab. Proposed sodium Adsorption Ratio (SAR) as more reliable criteria for evaluating Na hazard in irrigation water [27].

Table 4. Mean chemical parameters of water during raining season

	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	HCO_3^- (mg/l)	DO (mg/l)	NO_3^- (mg/l)	SO_4^{2-} (mg/l)	PO_4^{3-} (mg/l)	Cl^- (mg/l)
1	16.87	7.45	21.43	4.93	78.98	7.61	11.23	55.44	1.09	40.19
2	19.87	7.22	18.29	4.89	86.21	7.82	9.23	69.34	1.23	39.29
3	17.45	7.01	18.32	4.09	84.12	9.32	8.29	55.93	1.22	31.84
4	14.65	8.90	24.33	5.38	85.55	9.39	11.94	50.98	1.09	22.83
5	13.43	6.23	19.43	5.02	90.01	6.42	8.66	42.94	1.32	34.76
6	16.76	6.32	14.98	4.54	87.10	6.29	8.84	81.23	0.98	29.54
7	14.11	6.02	15.43	3.12	83.29	7.93	8.45	61.20	2.22	30.28
8	15.76	5.98	13.78	5.55	96.28	8.11	7.44	49.03	2.01	40.29

Table 5. Means chemical parameters of water during dry season

	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	HCO_3^- (mg/l)	DO (mg/l)	NO_3^- (mg/l)	SO_4^{2-} (mg/l)	PO_4^{3-} (mg/l)	Cl^- (mg/l)
1	10.43	5.87	23.87	5.55	46.44	4.44	9.87	76.98	1.89	45.39
2	12.65	5.89	21.43	5.34	54.34	4.57	8.67	89.45	1.98	54.44
3	11.98	5.54	20.45	4.87	51.23	6.44	7.54	56.93	2.56	35.65
4	15.76	6.01	22.34	6.56	49.04	6.45	8.98	66.95	2.12	41.09
5	10.78	4.45	17.24	5.03	63.23	3.43	10.67	69.87	1.87	37.56
6	12.65	4.87	15.34	4.34	51.23	3.37	6.98	98.98	2.54	53.03
7	9.78	3.96	13.84	3.48	50.23	4.65	8.01	65.12	3.56	36.76
8	12.21	4.65	15.84	5.01	68.97	4.53	4.98	54.86	2.73	42.21

Table 6. Contains U.S salinity classes of sodium hazard

Water class	SAR	Suitability for irrigation
Excellent	<10	Can be used on all soils
Good	10 – 18	Can be used on textured soils
Doubtful	18 – 26	Ordinary unsuitable water
Unsuitable	>26	Ordinary unsuitable water

Table 7. Guidelines for interpretation of water quality for irrigation (FAO, 1994)

Potential irrigation problems	Units	None	Degree of restriction slight-moderate	Severe
Salinity				
EC_w^{l}	dS/m	<0.7	0.7-3.0	>3.0
TDS	mg/l	<450	450-2000	>2000
Infiltration				
SAR2 = 0-3 & EC_w	>0.7		0.7-0.2	>0.2
3-6	>1.2		1.2-0.3	>0.3
6-2	>1.9		1.9-0.5	>0.5
12-20	>2.9		2.9-1.3	>1.3
20-40	>5.0		5.0-2.9	>2.9
Specific ion toxicity				
Sodium (Na)	SAR	<3	3-9	>9
Chloride (Cl^{-1})	mg/l	<4	4-10	>10
Boron (B)	mg/l	<0.7	0.7-3.0	>3.0
Miscellaneous effecs				
Nitrogen $(NO_3\text{-}N)^3$	mg/l	<5	5-30	>30
Bicarbonate (HCO_3^-)	mg/l	<1.5	1.5-8.5	>8.5
pH	normal	Range =	6.5-8.4	

The SAR values varied from 4.18 – 7.09 for raining season and 5.18 – 8.36 for the dry season with higher values recorded during the dry season. The data revealed that all of the water samples fell in the low sodium class (excellent) Table 6. If the SAR values are greater than 6 to 9, the irrigation water will cause permeability problems.

4. CONCLUSION

The physico-chemical parameters of the studied rivers in Gwagwalada area council of FCT were optimal for aquatic organisms within the study period, however the nitrate concentration of 4.98 – 11.94 mg/l raised concern on accumulation of this parameter that can posed threat of pollution to the rivers. Furthermore, the concentrations of the elements were generally higher in dry season than in raining season probably due to water dilution during the raining season. Finally, the sampled water quality of Gwagwalada Area Council of FCT was assessed for its irrigational and domestic suitability. The values of total dissolved solids (<250 mg/L), electrical conductivity (<300 µS/cm), and sodium adsorption ratio (<9) obtained for all the rivers were found to be within the safe limits. In addition, most of the other irrigation indices of the sampled water also fall within the permissible level indicating low solid waters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Chapman D. Water quality assessment: A guide to the use of biota, sediments and water in environmental monitoring. 2nd Edition. Taylor and Francis, London and New York. 1996;626.
2. Bartram J. Water quality monitoring - A practical guide to the design and implementation of freshwater quality studies and monitoring programmes; 1996.
3. Gordon J. Classifications of Irrigation Water Quality. Oklahoma Cooperative Extension Fact Sheets; 2007.

4. Müller K, Magesan GN, Bolan NS. A critical review of the influence of effluent irrigation on the fate of pesticides in soil. Agriculture, Ecosystems and Environment. 2007;120:93-116.
5. Mustapha MK. Assessment of the water quality of Oyun reservoir, Offa, Nigeria, using selected physico-chemical parameters. Turkish Journal of Fisheries and Aquatic Sciences. 2008;309:3-19.
6. Tele OE, Ugwumba OA. Seasonal variation in the physico-chemistry of a small tropical reservoir (Aiba Reservoir, Iwo, Osun, Nigeria). African Journal of Biotechnology. 2008;7:62-171.
7. Augustin M. The costs of water pollution in India. 60 Bd St Michel, 75006 PARIS Paper Presented at the conference on Market Development of Water & Waste Technologies through Environmental Economics; 2003.
8. Acharaya A, Princic A, Mahne I, Megasus F, Paul EA, Tidje JM. Effects of Ph and oxygen and ammonium concentrations on the community structure of nitrifying bacteria from wastewater. Applied and Environmental Microbiology. 2008;64(10): 3584-3590.
9. Adebayo WO. Weather and climate in: Ado-Ekitiregion, A Geographical Analysis and Master Plan (Ed. Ebisemiju F.S.). Alpha Printers Lagos. 1993;11-14.
10. Chapman D. Water quality assessment: A guide to the use of biota, sediments and water in environmental monitoring. 2nd Edition. Taylor and Francis, London and New York. 1996;626.
11. Corcoran E, Nellemann C, Baker E, Bos R, Osborn D. Savelli H (eds). Sick water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal; 2010.
12. Egborge ABM. Salinity and the distribution of rotifers in the Lagos Harbour Badagry Creek system, Nigeria. Hydrobiologia. 1994;272:95-104.
13. LaDon S. A fish farmer's guide to understanding water quality. Department of Animal Sciences, Illinois-Indiana Sea Grant Program Purdue University; 2007. Available:aquanic.org/publicat/state/il-in/as-503.htm - 60k. (02/12/2007)
14. Ayers RS, Westcot DW. Water quality for agriculture, irrigation and drainage Paper; 1994. Available:Http://www.Fao.org/DOCREP/003/TO234E/T0234E00.htm.
15. Bartram J. Water quality monitoring - A practical guide to the design and implementation of freshwater quality studies and monitoring programmes; 1996.
16. Boyd CE, Tucker CS. Pond aquaculture water quality management lower acadshers. London. 1998;15-20.
17. Boyles W. The science of chemical oxygen demand. Technical Information Series, Booklet, 1997;9:24. Available:http://www.hach.com/asset-
18. Chapman D. Water quality assessment: A guide to the use of biota, sediments and water in environmental monitoring. 2nd edition. Taylor and Francis, London and New York. 1996;626.
19. Corcoran E, Nellemann C, Baker E, Bos R, Osborn D, Savelli H. (eds). Sick water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal; 2010.
20. Dladla B. The impact of sub-catchment activity on river water quality: A case study of Mbabane River in the Ezulwini Valley. Unpublished MSc Thesis; 2009.
21. FEPA. Federal Environmental Protection Agency. S.1.9 National Interim Guidelines and Standard for Industrial Effluents, Gaseous Emission and Hazardous Waste Management in Nigeria; 1991.
22. Gordon J. Classifications of irrigation water quality. Oklahoma Cooperative Extension Fact Sheets; 2007. Available:http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2223/F-2401web.pdf. (25/11/2007)
23. Hammer MJ. Laboratory chemical analysis in water and wastewater technology. 2nd Edition, John Willey and Sons, New York; 1986.
24. Hem. Concentration of surface water. 1992 (Cd pdf Weppi.gtk.f1-published-foregsatles-text)
25. Hillel D, Vlek P. The sustainability of irrigation. Advances in Agronomy. 2005;87: 55-84.
26. Irenosen OG. Water quality assessment of the owena multi-purpose dam, Ondo State, Southwestern Nigeria. Journal of Environmental Protection. 2012;03:14–25.

27. Jain CK, Bhatia KKS, Vijay T. Ground water quality monitoring and evaluation; 1995.
28. Kannel PR, Lee S, Lee Y, Kanel S, Khan P. Application of water quality indices and dissolved oxygen as indicators for river water classification and urban impact assessment. Environmental Monitoring and Assessment. 2007;132:93-110.
29. Kolo RJ. The assessment of physico-chemical characteristics parameters of shiroro lake and its major tributaries. Proceeding of the Conference of Fisheries Society of Nigeria (FISON), 13th Annual Report. 1996;260-268.
30. Masamba WRL, Mazvimavi D. Impact on water quality of land uses along Thamalakane-Boteti River: An outlet of the Okavango Delta. Physical and Chemistry of the Earth. 2008;33:687-94.
31. Massoud MA. Assessment of water quality along a recreational section of the Damour River in Lebanon using the water quality index. Environmental Monitoring and Assessment. 2012;184:4151-4160.
32. Matta G. A study on physico-chemical characteristics to assess the pollution status of river Ganga in Uttarakhand. Journal of Chemical and Pharmaceutical Sciences. 2014;7:210–217.
33. Maya RS. Perspectives on water quality and conservation in Zimbabwe"s Urban Centres Southern Centre, Natural Resource Programme, Phase 1 report, Urban Water Quality and Conservation Project. Mediterranean Journal of Social Sciences. 1996;4:65–68.
34. Mero R. Assessment of water quality and spatial distribution of the major pollutants in Ngerengere River Catchment, Tanzania. MSc. Thesis, University of Zimbabwe, Harare; 2011. Available:www.ir.uz.ac.zw/jspui/bitstream/10646/789/1/Rose%20thesis-27.7.11.pdf
35. Muhmmad A, Salam A, Azeem A, Shafiq M, Khan BA. Studies on the effect of seasonal variations on physical and chemical characteristics of mixed water from rivers Ravi and Chenab at union site in Pakistan. Journal of Research Science. 2000;11:11-17.
36. Müller K. Magesan GN, Bolan NS. A critical review of the influence of effluent irrigation on the fate of pesticides in soil. Agriculture, Ecosystems and Environment. 2007;120:93-116.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/52206