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Assessment of the presence of metals and quality of water used for irrigation in Kwara State, Nigeria

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ABSTRACT: In Nigeria irrigated agriculture is an important tool for economic growth, food security, and poverty reduction during dry periods of rain-fed agriculture. The concentration and composition of dissolved constituents in water determines its quality for irrigation use. Water quality studies strongly suggest that agriculture is a leading source of water quality problems, due to pesticides and other agro-inputs, widely used by farmers to improve agricultural productivity. Poor quality irrigation water would therefore obviously affect soil quality and crop productivity. This study was carried out in 2015 to assess the presence of metals and physical properties of water, used for irrigation in Kwara state, Nigeria. Samples were randomly collected from thirty irrigation sources in three senatorial zones of Kwara State. The samples were analyzed for the presence of metals and water quality parameters, using standard procedures. Results showed that the highest concentration of Sulphate (7.0mg/L), Nitrate (8.9mg/L), Sodium (31.6mg/L), Calcium (3.1mg/L), and Magnesium (0.7) ions were within acceptable limits. The Sodium Adsorption Ratio, an indicator for water suitability in agricultural irrigation as well as a standard diagnostic parameter for the sodicity hazard of a soil, was significantly the highest (22.7) in Kwara North. Results of the study point to the need for an effective irrigation water quality assessment to curb nonpoint source pollution that could be caused by improper use of chemicals and pesticides by farmers.

Keywords: agroecology, effluent flow, extension agents, irrigation, pollution.

INTRODUCTION

The importance of water for human and other biological systems cannot be over emphasized (Suresh et al., 1991). Agriculture is the major consumer of water, as irrigation uses more than two-thirds of the World's available freshwater resources (Shady, 1998). It is often assumed that water supply constitutes the primary limiting constraint to production (Doorenbos & Pruitt, 1976). Pollution is caused when a change in the physical, chemical, or biological condition of the environment harmfully affects the quality of human life, including other animals' lives and plants (Okoye et al., 2002). Water pollution occurs when unwanted materials, potential to threaten human and other natural

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system, find their ways into rivers, lakes, walls, streams, boreholes, or even reserved fresh water in homes and industries (Naseem et al., 2010). The pollution of water bodies transport from surface run off and uncontrolled discharge of untreated and partially-treated sewage and domestic wastes is a major source of water pollution (Izonfuo & Bariweni, 2001). The contamination of the environment, food, and water by pesticides has become a considerable concern, leading researchers to investigate their occurrence, distribution, and concentration in several ecosystems (Shankar et al., 2004). Discharge of heavy metals into irrigation water, due to fertilizer and pesticide use by farmers can result in the accumulation of certain heavy metals and other dangerous substances (Ghafoor et al., 1999). The yield of salt sensitive plant is negatively affected by heavy metals accumulation in soils, thus posing serious risks to human health, when consumed (Misra & Mani, 1991; Wenzel & Jackner, 1999).

Toxicity in plants normally results when certain ions are taken up with the soil-water and accumulate in the leaves, during water transpiration to an extent that damages the plant. The usual toxic ions in irrigation water are chloride, sodium, and boron; their damage, depending on time, concentration, crop sensitivity, and crop water use (Eckenfelder, 1980).

Toxic metals are known to have serious health implications, including carcinogenesis-induced tumor promotion, hence the growing consciousness about health risks, associated with environmental chemicals has brought a major shift in global concern towards the prevention of heavy metal accumulation in soil, water, and vegetables (Ahmed et al., 2009). Excessive accumulation of trace elements in agricultural soils through irrigation will affect food quality and safety by constraining important plants growth nutrients like Potassium, Zinc, Phosphorus, and Nitrogen (Gibbs et al., 2006; Sharma et al., 2008). In irrigation pollution studies, water evaluation emphasis is on chemical and physical characteristics (Ayers & Westott, 1994). The quality of irrigation water is generally judged by its total salt concentration or Electrical Conductivity (EC), relative proportion of cations or Sodium Absorption Ratio (SAR), and bicarbonate and boron content of water (Michael, 1999). The quality evaluation of irrigation water for metal presence is, therefore, a critical management tool, necessary to increase agricultural production, decrease pollution, and improve food safety.

MATERIALS AND METHODS

Kwara State lies between latitudes 7°45 N and 9°30 N and longitudes 2°30 E and 6°25 E of Greenwich Meridian (KWSMI, 2002). The State falls under the tropical climate of distinct wet and dry seasons. The former lasts from late March/ April to late October/ early November with a mean annual rainfall of 1318 mm. The latter commences in October through December and ends in late March (Oyegun, 1983). The larger proportion of Kwara State belongs to dry sub-humid, while its north-western fringe belongs to semi-arid climatic regions (Olaniran, 1988). The mainstay of the state's economy is agriculture and farmers specialize in arable crops such as groundnut, sorghum, cassava, yam, cowpea, maize, yam, and rice (KWADP, 2010).

Thirty locations in Kwara State were randomly selected for the collection of water samples. The locations were from Kwara North, Kwara Central and Kwara South senatorial districts. Figure 1 illustrates the location and positions of the sample collection points.

The samples were collected from September 2015 to November 2015, from rivers, ponds, and streams that served as irrigation sources for agricultural production. Replicate water samples were collected from five different points in each location, being poured into 2-litre plastic

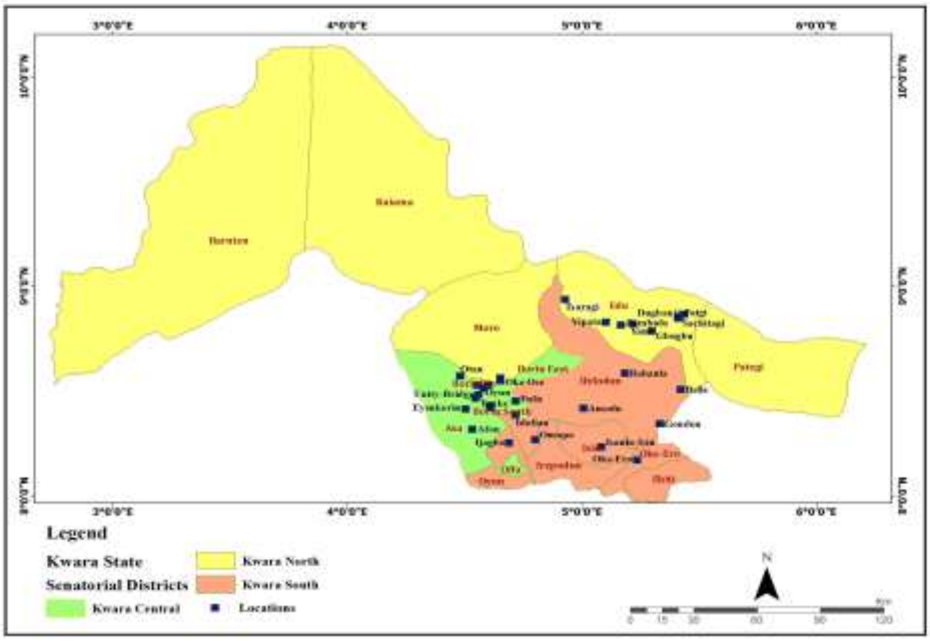

Fig. 1. Location and positions of sample collection points in Kwara State

containers as well as 200 cm^3 reagent bottles. The bottles were properly cleansed with distilled deionised water, beforehand. Collection was carried out by careful immersion of the sample containers deep inside the water, next to be sealed with tight fitting corks and stoppers, in order to avoid air bubbles. Samples were transported to a refrigerator (4°C) in the laboratory for chemical analysis, according to the standard tests (APHA, AWWA and WPCF, 1975). The sodium adsorption Ratio (SAR) was calculated using the formulae, according to Michael et al. (2008).

$$S.A.R = \frac{Na^{+}}{\sqrt{\frac{1}{2}\left(Ca^{2+} + Mg^{2+}\right)}}$$

The ata collected from each parameter were subject to analysis of variance (ANOVA), via the Statistical Package for Social Sciences (SPSS) version 15.0. The locations within a senatorial district were treated as replicates for that zone. The significant treatment means were separated using the Duncan's New Multiple Range Test at 5% level of probability.

RESULTS AND DISCUSSION

Table 1 shows results from the analysis of some chemical properties and metal concentration in the water samples. The analyzed parameters were Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical oxygen demand, Sulphate ion concentration, Nitrate ion concentration, and Chloride ion concentration.

Total Suspended Solids (TSS) connote the presence of silt and other dissolved solutes that contribute to the turbidity of a water body and is considered a warning sign for pollution (Wilber and Clarke, 2001). TSS levels in the water samples were between 10.3 mg/L in Kwara North to 90.6 mg/L in Kwara South. One positive effect of the presence of suspended solids in water is that pesticides and metals tend to adsorb to them, thereby reducing toxicity effects. The observed levels were within TSS permissible limit of 30 mg/L, set by Federal Environmental protection Agency (FEPA, 1991). This implies that there was reduced incidence of pathogens in the irrigation waters, which is in agreement with Gray et al. (2000), who are also of the opinion that a TSS value above the permissible limit is an indication of the high presence of pathogenic organisms in the waters.

The Total Dissolved Solids (TDS) value of 70.3 mg/L was significantly the highest in Kwara North, compared to 80.4 mg/L in Kwara South and 30.6 mg/L in Kwara Central. The TDS value is a measure of the amount of mobile charged ions and minerals salts in a given volume of water. An elevated TDS value beyond the optimum level can induce toxicity in plants and possibly increase the osmotic potential of the soil water, the consequence of which is an increase in the amount of energy plants that must be expended to take up water from the soil. The TDS range (30.6-80.4 mg/L), obtained in the study, was far below the permissible range of 450-200 mg/L for irrigation water by FAO (1985). Mustapha (2008) obtained similar high TDS values while assessing the Water Quality of Oyun Reservoir in Offa, Kwara State, Nigeria.

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen in water samples, being an effective indicator of organic quality of water that determines pollution levels (Clair et al., 2003). Results from the study showed that highest BOD levels were recorded significantly in Kwara South (31.4 mg/L) and Kwara Central (30.9 mg/L), with the lowest value belonging to Kwara North (13.2 mg/L). These values were far above the European Union value of 3.0-6.0 mg/L for safe BOD values for irrigation water (Chapman, 1996), indicating that the waters were highly polluted, possibly by pesticides and other pollutants. This was similar to the results of Adebayo and Usman (2009), who detected BOD values between 10 and 20 mg/L in Asa-River in Ilorin-Nigeria.

The Chemical Oxygen Demand (COD) is the amount of dissolved oxygen, a measure of the content of oxidizable organic as well as inorganic matter of the given water sample. Tepe et al. (2004) linked higher COD values to the possibility of water pollution. The values of the COD in the present study oscillated between 45 mg/L in Kwara South, 36.4 mg/L in Kwara Central, and 23.2 mg/L in Kwara North. They were above the limits of 20 mg/L for water bodies and, therefore, could be classified within the range of polluted waters, according to Chapman (1996). Kolawole et al. (2011), while assessing the water quality in Asa River in Kwara State-Nigeria also found a mean COD value between 5.0-58.4 mg/L. This was attributed, among other things, to be due to poorly-executed agricultural activities near the river banks.

Sulphate ion concentration was significantly the highest in Kwara South (7.0 mg/L) and Kwara Central (6.8 mg/L). Shinde et al. (2011) reported that sulfate ion is a major contributor to salinity in many irrigation waters and though it is rarely a problem, at very high concentrations it is leached into water sources, interfering with uptake of other nutrients in the soil. The concentration of sulphur, detected in this study, was below 250.00 mg/L, i.e. the recommended value set by FAO (2005). This could indicate that the farmer's use of fertilizers was restricted and that there were no industries around the study area to use sulphates that can pollute the water sources.

Nitrate ion concentration was also significantly the highest in Kwara Central (8.9 mg/L) and Kwara South (8.7 mg/L), while it was the lowest in Kwara North (6.4 mg/L). These values were below 50.00 mg/L, i.e. the maximum limit recommended as standard for good water quality for irrigation by FAO (2005). Nitrogen has been proven to stimulate crop growth and its presence in irrigation water is most frequently in the form of nitrate ions. It is likely that nitrate ions, present in irrigation water, will have the same effect as soil-applied fertilizer nitrogen. It is, therefore, assumed that the irrigated plant optimum fertilizer requirement should be observed to obtain expected crop yield. In a similar study, Ogidiaka et al. (2012) also detected low nitrate ion concentration in surface waters of Ogunpa River at Bodija- Nigeria.

The lowest Chloride ion concentration was recorded in Kwara South (31.2 mg/L), while the highest values belonged to Kwara Central (67.0 mg/L) and Kwara North (65.2 mg/L). Chlorides are the most stable components in water; their concentration, largely unaffected by most natural physicochemical and biochemical processes (Aremu et al., 2011). Water, containing chloride concentration below 150 mg/L, is considered safe and can support healthy plant growth for most crops, provided that proper irrigation management practices are taken (Landon, 1991). The chloride concentration in the water samples analyzed stayed within the safe limits of 250 mg/L for irrigation water set by World Health Organization (2006).

Table 1. Chemical properties and metal concentration in water samples from Kwara State

Senatorial District	Total Suspended Solids (TSS) (mg/L)	Total Dissolved Solids (TDS) (mg/L)	Biochemical Oxygen Demand (BOD) (mg/L)	Chemical Oxygen Demand (COD) (mg/L)	Estimation of Sulphate ions (mg/L)	Estimation of Nitrate ions (mg/L)	Estimation of Chloride ions (mg/L)
Kwara North	10.3a	70.3b	13.2a	23.2a	4.3a	6.4a	65.2b
Kwara Central	60.5b	30.6a	30.9b	36.4b	6.8b	8.9b	67.0b
Kwara South	90.6c	80.4c	31.4b	45.0c	7.0b	8.7b	31.2a

Means within a column followed by the same letter(s) are not significantly different using New Duncan Multiple Range Test at P=0.05

Table 2 shows the concentration of some other ion nutrients and metals. Calcium ion concentration was significantly the lowest in Kwara South (1.9 mg/L), the highest in Kwara South (3.1 mg/L) and intermediate in Kwara central (2.41 mg/L). Sodium concentration was the lowest in Kwara South (8.4 mg/L) and differed significantly from Kwara central (12.4 mg/L) and Kwara North (31.6 mg/L). Magnesium concentration was not significantly different in Kwara South (0.67 mg/L) and Kwara Central (0.68 mg/L), but was significantly the lowest in Kwara North (0.77 mg/L). The average values of the major ions determined fell below the FAO (2005) permissible limits for irrigation water of 25, 200, and 150 mg/L for Calcium, Sodium, and Magnesium, respectively.

Phosphate concentration was also below FAO's permissible limits (2005), being significantly the highest at Kwara North (0.011 mg/L) and the lowest at Kwara Central (0.006 mg/L). The low concentrations of this element implied an additional cost of inorganic fertilizer in phosphate-deficient soils. Akpan-Idiok et al. (2012) obtained similar results while assessing water quality of a river source in Nigeria.

Iron concentration did not vary significantly among the locations. Kwara North recorded a mean value of 0.26 mg/L, followed by Kwara Central (0.23 mg/L), and Kwara South (0.17 mg/L). These values were, however, marginally lower than 0.3 mg/L, being FAO (2005) threshold value of Manganese concentration, adopted for waters used for irrigation. The Manganese concentration differed significantly in Kwara North (0.017 mg/L) and Kwara Central and Kwara South senatorial districts with similar values (0.01 mg/L). The benchmark set by WHO (2006), for Iron concentration in irrigation water for wholesome agricultural purposes is 0.10 mg/L. Braul

(1998) believes that irrigation water with Iron levels above the optimum recommendation may cause discoloration on foliage plants, particularly at the substrate pH below 5.5.

The Boron ion concentration was not significantly different for all the locations with the concentration values of 0.225, 0.194, and 0.231 mg/L for Kwara North, Kwara Central, and Kwara South, respectively. Boron is one of the important plant micronutrient elements and plays a significant role in physiological and biochemical processes. The obtained values satisfy the Boron limit of 1.0 Mg/L, set by Van Roojen et al. (2005), considered safe for agricultural purposes.

Table 5 shows the Sodium Adsorption Satio (SAR) for the three senatorial zones. SAR is defined by US Salinity Laboratory Staff (1954), as Sodium rich water which may cause deterioration of the physical structure of the soil. SAR is therefore an index to determine sodicity hazard in irrigation water (Schwab et al., 1993). Sodium adsorption ratio (SAR) was the highest in Kwara North (22.7) and differed significantly from other locations of Kwara Central (10.0) and Kwara South (7.4). Usually a limit of 15 is considered safe for irrigation water quality standard by FAO (2005). The values obtained in this study fell beyond this value in Kwara North and could be detrimental for agricultural purposes. The higher values obtained could be a consequence of leaching inorganic fertilizers and plant protection products from soils into irrigation sources. The SAR values in this study were comparable to those of Ogunfowokan et al. (2013) and Talabi et al. (2014).

Table 2. Concentration of some other ion nutrients and metals in water samples from Kwara State

Senatorial District	Calcium (mg/L)	Sodium (mg/L)	Magnesium (mg/L)	Phosphate (mg/L)	Iron (mg/L)	Manganese (mg/L)	Boron (mg/L)	Sodium Adsorption Ratio (SAR)
Kwara North	3.11[c]	31.63[c]	0.772[b]	0.011[c]	0.261	0.017[b]	0.225	22.71[c]
Kwara Central	2.43[b]	12.45[b]	0.682[a]	0.006[a]	0.232	0.010[a]	0.194	10.03[b]
Kwara South	1.92[a]	8.46[a]	0.672[a]	0.008[b]	0.173 NS	0.010[a]	0.213 NS	7.49[a]

Means within a column followed by the same letter(s) are not significantly different using New Duncan Multiple Range Test at P=0.0

Table 3 shows the result of analysis of the physico-chemical properties of the samples for temperature, pH, alkalinity, turbidity, Conductivity, and total hardness.

The temperature values of the water samples showed a significant difference (P< 0.05) between the three senatorial zones. The values recorded were 23.3°C (Kwara South), 26.1°C (Kwara Central), and 28.2°C (Kwara North). These temperature values were within the range suitable for agricultural purposes in Nigeria, set by the Federal Ministry of Environment. Increased temperature normally facilitates the rate at which solutes dissolve, which improves mineral uptake and optimum plant growth (Xu et al., 2014). Brockwell and Gault (1976) had earlier confirmed a significant effect on growth of legumes by irrigation water temperature treatments below 20°C than above. This implies that irrigation water temperature in the study area was suitable for the optimum growth of arable crops.

The pH of the water samples was significantly the highest in Kwara South (7.2) and had an average value of 6.0 and 6.2 in Kwara Central and Kwara North senatorial zones, respectively. The pH characteristic of irrigation water has a significance influence on soil and plant reactions. According to Arimoro (2007), irrigation water outside the range of 4.5 to 8.5 may contain toxic ions and can cause nutritional imbalance. Bauder et al. (2010) believed that suitable water for irrigation should have a pH range between 6.5 and 8.4. The pH values, recorded in the present study, were within suitable limits for irrigation and agricultural production. The values were similar to those, reported by Morriso et al. (2001), but were lower than the range of 8.94 -10.34, reported by Akpan et al. (2008).

The alkalinity levels in the water samples were not significantly different in the senatorial zones and ranged from 729.3 to 752.1 mg/L. Alkalinity provides information on the natural salts, dissolved in the water samples, being a measure of the water's capacity to neutralize acids as well as an indicator of the productive potential of the irrigation water (Manahan, 1994). The values, obtained for this study, were far above WHO (2004) recommendation of standard of 80-120 mg/L. The high alkalinity observed in the samples may be due to agricultural and economic activities from overflow of industrial and agricultural wastes. Ogedengbe and Akinbile (2004) attributed high alkalinity levels to increases in the presence of bicarbonates and carbonates from effluents and leachates.

The turbidity value was significantly the highest in Kwara Central (22.1 NTU) and relatively the lowest in Kwara South (14.1 NTU). Turbidity is a measure of the quantity of solid matter, present in the suspended state of the water samples. The turbidity values reported in the study for the districts were far greater than 5.0 NTU, the limit given by WHO (2008), and this according to US EPA (2004), could cause pathogenic disease occurrence. Ololade and Ajayi (2009) in a similar study obtained high turbidity values in water samples obtained from major rivers along the highways in Ondo State, Nigeria, and attributed it to the presence of decaying organic matter. Adefemi et al. (2007) and Wakawa et al. (2008) had also reported very high turbidity values for some rivers in Nigeria as a result of runoff of pesticides into the water sources. The high values obtained in the present study could also be attributed to the same reason.

The highest conductivity value of 1174.7 µs/cm was measured in Kwara North, while the lowest value belonged to Kwara South (1157.8 µs/cm). These values fell below FAO's maximum acceptance level of 1200 µs/cm (1985) for irrigation water. This indicates that the water sources were not expected to have any salinity problems since the electrical conductivity is a parameter that summarizes the total dissolved solids, showing a correlation with higher alkalinity (Sandgren, 1993). The results found in this study, were similar to those, found by Igbinosa and Okoh (2009).

Kwara North presented the highest total hardness of 880 mg/L, followed by Kwara Central (640 mg/L), while the lowest value belonged to Kwara South (320 mg/L). Based on Tyson and Harrison (1990) classification of harness and softness in terms of mg/L (0-60 soft, 60-120 moderately soft, 121-180 moderately hard, and >180 hard), the water samples in this study could be classified as hard. Srinivasamoorthy et al. (2009) believe that hardness in water samples is mostly due to the leaching of Ca and Mg ions into the groundwater. Hardness does not affect plants directly, but has indirect impact on plant growth through the soil. It is assumed, therefore, that hardness observed in the study was caused by the leaching of ions into the water sources, used for irrigation. This assumption is in agreement with Nweke et al. (2013).

Table 3. Physico-chemical parameters in water samples collected from Kwara State

Senatorial District	Temperature	pH	Alkalinity (mg/L)	Turbidity (NTU)	Conductivity (µs/cm)	Total Hardness(mg/L)
Kwara North	28.2c	7.2b	742.7b	15.7a	1174.7	880.3c
Kwara Central	26.1b	6.0a	729.3a	22.1b	1171.7	640.4b
Kwara South	23.2a	6.2a	752.1b	14.1a	1157.8NS	320.7a

Means within a column followed by the same letter(s) are not significantly different using New Duncan Multiple Range Test at P=0.0

CONCLUSION

The study concludes that elements of water pollution varied with the collection site across Kwara State. While some of the analysed parameters, compared favourably with acceptable standards for safe use for irrigation purposes, others showed levels above tolerable limits. The values of water quality indices, particularly the sodium adsorption ratio, were intensely high for locations in the Kwara North senatorial district. It is, therefore, recommended that regular assessment of irrigation water quality should be carried out and non-point source pollution prevented by the regulated use of agro-chemicals and fertilizers by farmers in Kwara State, Nigeria.

REFERENCES

Adebayo, S.A. and Usman, L.A. (2009). Levels of ammonia-nitrogen, Carbon dioxide, dissolved oxygen and biochemical oxygen demand in Asa River in Ilorin-Nigeria. Science Focus, 14(4), 488-495.

Adefemi, O.S., Asaolu, S.S. and Olaofe, O. (2007). Assessment of the physicochemical Status of water samples from Major Dams in Ekiti State, Nigeria. Pakistan Nutrition, 6(6), 657-659.

Ahmed, G., Uddin, M.K., Khan, G.M., Rahman, M.S. and Chowdhury, D.A. (2009). Distribution of trace metal pollutants in surface water system connected to effluent disposal points of Dhaka Export Processing Zone (DEPZ), Bangladesh: A statistical approach. Journal of National Science and Sustainable Technology, 3, 293-304.

Akpan, J.C., Abdulrahaman, F.I., Damari, G.A. and Ogugbuaja, V.O. (2008). Physico- chemical determination of pollutants in waste water and vegetable samples along the Jakara wastewater channel Kano Metropolis, Kano state, Nigeria. European Journal of Scientific Research, 23(1), 122-133.

Akpan-Idiok, A.U., Ibrahim, A. and Udo. I.A. (2012). Water quality assessment of Okpauku River for drinking and irrigation uses in Yala, Cross-River state Nigeria. Research Journal of Environmental Sciences, 6(6), 210-221.

APHA, AWWA & WPCF. (1975). Standard Methods for the Examination of water and wastewater, 15th Ed., American Public Health Association, Washington.

Aremu, M.O., Ozonyia, G.N. and Ikokoh, P.P. (2011). Physicochemical properties of well, borehole and stream waters in Kubwa, Bwari Area Council., FCT Nigeria. Electronic Journal of Environmental, Agricultural and Food Chemistry, 10(6), 2296-2304.

Arimoro, F.O. (2007). Macro invertebrate functional feeding groups in River Orogodo, a second order stream in southern, Nigeria. Nigerian Journal of Environment and Science, 6, 45-57.

Ayers, R.S. and Westott, D.W. (1994). Water Quality for agriculture. FAO Irrigation and Drainage Paper. 29 Rev. 1, FAO, Rome.

Bauder, T.A., Waskom, R.M. and Davis, J.G. (2010). Irrigation water quality criteria. Colorado State University, United States Department of Agriculture.

Braul, L. (1998). Treating high Iron, Manganese, Sulfate, and Sodium Levels. Prairie Water News, 6(1).

Brockwell, J. and Gault, R.R. (1976). Effect of Irrigation water temperature on growth of some legume species in glassnhouses. Australian Journal of Experimental Agriculture, 16(81), 500-505.

Chapman, D. (1996). Water Quality Assessments: A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring. 2nd ed. Chapman and Hall; London, UK.

Clair, N.S., Perry, L.M. and Gene, F.P. (2003). Chemistry for Environmental Engineering and Science, 5th Ed., 233.

Doorenbos, J. and Pruitt, W.O. (1976). Guidelines for predicting crop water requirements. Irrigation and Drainage. Food and Agriculture Organization (FAO) Rome., 24, 144.

Eckenfelder, W.W. (1980). Principles of water quality management. CBI Pub. Co., Massachusetts.

Food and Agriculture Organization (FAO). (2005). FAOSTAT <http: // faosata.fao.org/default. Htmm

Food and Agriculture Organization (FAO) (1985). Water quality for Agriculture. FAO Irrigation and Drainage Paper No. 29 Rev. 1.

Federal Environmental Protection Agency (FEPA) (1991). Guidelines and standard for industrial effluents, gaseous emissions and hazardous wastes management in Nigeria.

Ghafoor, A., Ahmad, S., Qadir, M., Hussain, S.I. and Murtaza, G. (1999). Formation and leaching of lead species from a sandy loam alluvial soil as related to $_{p}$H and Cl: SO4 ratio of leachate. International Journal of Agriculture and Biology, 1(3), 82-84.

Gibbs, P.A., Chambers, B.J., Chaudri, A.M., McGrath, S.P. and Carlton-Smith, C.H. (2006). Initial results from long-term Studies at three sites on the effect of heavy metals amended liquid sludges on soil microbial activity. Soil Use and Management, 22, 180-187.

Gray, J.R., Gylsson, G.D., Turcios, L.M. and Schwarz, G.E. (2000). Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data. USGS Water-Resources Investigations Report 00-4191. Reston, VA: U S Geological Survey.

Igbinosa, E.O. and Okoh, A.I. (2009). Impact of discharge waste water effluents on the physico-chemical qualities of a receiving watershed in a typical rural community. International Journal of Environment Science and Technology, 6(2), 175-182.

Izonfuo, L.W.A. and Bariweni, A.P. (2001). The effect of urban runoff water and human activities on some physico-chemical parameters of the Epie creek in the Niger-Delta. Journal of Applied Science and Environmental Management, 5, 47-55.

Kolawole, O.M., Ajayi, K.T., Olayemi, A.B. and Okoh, A.I. (2011). Assessment of water quality in Asa River (Nigeria) and its indigenous Clarias gariepinus fish. International Journal of Environment Research and Public Health, 8(11), 4332-4352.

Kwara State Agricultural Development Projects (KWADP) (2010). Kwara State Agricultural Development Projects. Annual Reports.

Kwara State Ministry of Information (KWSMI). (2002). Kwara State Dairy 2002. 1-10.

Landon, J.R. (1991). Booker Tropical Soil Manual. John Wiley and Sons Inc., New York.

Manahan, S.E. (1994). Environmental Chemistry. Lewis Publication/CRC Press, USA, 161-173.

Michael, A.M. (1999). Irrigation Theory and Practice. Vikas Publishing House, PVT Ltd New Delhi, 741-790.

Michael, A.M., Kherpar, S.D. and Sondhi, S.D. (2008). Water wells and pumps. McGraw-Hill, New Delhi.

Misra, S.G. and Mani, D. (1991). Soil pollution. Ashish publishing House, 8/81, Punjabi Bagh, New delhi, India.

Morrison, G., Fatoki, O.S. and Ekberg, A. (2001). Assessment of the impact of Point Source Pollution from Keiskammahoek Sewage treatment plant on the Keiskamma river- pH, electrical Conductivity, Oxygen Demanding Substances (COD) and nutrients. Water SA, 27, 475-480.

Mustapha, M.K. (2008). Assessment of the Water Quality of Oyun Reservoir, Offa, Nigeria, Using Selected Physico-Chemical Parameters. Turkish Journal of Fisheries and Aquatic Sciences, 8(1), 309-319.

Naseem, S., Hamza, S. and Bashur, E. (2010). Groundwater geochemistry of Winder agricultural farms, Balochistan Pakistan and assessment for irrigation water quality. European Water, 31, 21-32.

Nweke, O.M., Aghamelu, O.P. and Obasi, I.A. (2013). Hydro geochemical analysis and quality evaluation of groundwater from Onicha-Uburu, Southeastern Nigeria for irrigation purposes. African Journal of Environment Science and Technology, 7(5), 222-228.

Ogedengbe, K. and Akinbile, C.O. (2004). Impact of Industrial Pollutants on Quality of Ground and Surface waters at Oluyole Industrial Estate, Ibadan, Nigeria. Nigerian Journal of Technological Development, 4(2), 139-144.

Ogidiaka, E., Esenowo, I.K. and Ugwumba, A.A. (2012). Physico-chemical parameters and benthic macroinvertebrates of Ogunpa River at Bodija, Ibadan Oyo state. Environmental Journal of Science and Research, 85(1), 89-97.

Ogunfowokan, A.O., Obisanya, J.F. and Ogunkoya, O.O. (2013). Salinity and sodium hazards of three streams of different agricultural land use systems in Ile-Ife, Nigeria. Applied Water Science, 3, 19-28.

Okoye, P.A.C., Enemuoh, R.E. and Ogunjiofor, J.C. (2002). Traces of heavy metals in marine crabs. Journal of Chemical Society of Nigeria, 27(1), 76-77.

Olaniran, O.J. (1988). Climate and the planning of agriculture land use in Nigeria, The NRBDA area as a Case Study. Journal of Agriculture and Meteorology, 43(4), 285-294.

Ololade, I.A. and Ajayi, O.A. (2009). Contamination profile of major rivers along the highways in Ondo State. Nigeria Journal of Toxicology and Environmental Health Sciences, 1(3), 38-53.

Oyegun, R.O. (1983). Water Resources in Kwara State Ilorin: Matami and Sons.

Sandgren, P. (1993). Preliminary results and interpretation of mineral magnetic analyses of a Holocene Sediment Succession from lake Maardu near Tallinn, Estonia. Proceedings of Estonia Academy of Science and Geology, 42(2), 69-79.

Schwab, G.O., Fangmeier, D.D., Elliot, W.J., Frevert, R.K. (1993). Soil and water conservation Engineering. 4th Edn., John Wiley and Sons Inc., New-York, USA., 507.

Shady, A.M. (1998). To produce more food and fiber with less water is the challenge of the 21st century. Spore, 74, 1-16.

Shankar, M.V., Anandan, S., Venkatachalam, N., Arabindoo, B. and Murugesan, V. (2004). Novel thin-film reactor for photocatalytic degradation of pesticides in aqueous solutions. Journal of Chemical Technology and Biotechnology, 79(11), 1279-1285.

Sharma, R.K., Agrawal, M. and Marshall, F. (2008). Heavy metal (Cu, Zn, Cd and Pb) contamination of vegetables in urban India: A case study in Varanasi. Journal of Environmental Pollution, 154, 254-263.

Shinde, S.E., Pathan, T.S., Raut, K.S., More, P.R. and Sonawne, D.L. (2011). Studies on the physico-chemical parameters and correlation coefficient of Haesool-Savangi Dam, District Aurangabad, India. Middle-East Journal of Scientific Research, 8(3), 544-554.

Srinivasamoorthy, K.S., Chidambaram, V.S.M., Sarma, K., Vasanthavigar, R., Vijayaraghavan, P., Rajivgandhi, J., Anandhan, B. and Manivannan, R. (2009). Hydro-geochemical Characterization of Groundwater in Salem District of Tamilnadu. Indian Research Journal of Environment and Earth Sciences, 1(2), 22-33.

Suresh, T.S., Naganna, C. and Srinivas, G. (1991). Study of water quality for agricultural use in Hemavathyriver (Karnataka). Journal of Indian Association of Hydrologists, 14(4), 247-254.

Talabi, A.O., Afolagboye, O.L., Tijani, M.N., Aladejana, J.A. and Ogundana, A.K. (2014). Hydro geochemistry of some selected springs waters in Ekiti Basement Complex Area, Southwestern Nigeria. International Journal of Engineering Science, 3, 19-30.

Tepe, Y.I., Akyurt, C., Ciminli, E., Mutlu, C. and Caliskan, M. (2004). Protective effect of Clinoptilolite on lead toxicity in common carp *Cyprinus carpio*. Fresenius Environment and Bulletin, 13(7), 639-642.

Tyson, A. and Harrison, K. (1990). Water quality for private water systems. Georgia Cooperative Extension Service. The University of Georgia: Athens, GA.

United States Environmental Protection Agency (USEPA) (2004). Wade able Streams Assessment. EPA/841-B-06-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

United States Salinity Laboratory Staff (U.S. S L S) (1954). Diagnosis and improvement of saline and alkali soils. Agricultural handbook, No. 60, USDA, US Government Printing Office, Washington, DC.

Van Roojen, D., Turra, H. and Biggs, T.W. (2005). Sponge city. Water balance of mega-city. Water use and Waste water use in Hyderabad, India. Irrigation and Drainage, 54, 581-591.

Wakawa, R.J., Uzairu, A., Kagbu, J.A. and Balarabe, M.L. (2008). Impact assessment of effluent discharge on physico-chemical parameters and some heavy metal concentrations in surface water of River Challawa Kano, Nigeria. African Journal of Pure and Applied Chemistry, 2(9), 100-106.

Wenzel, W. and Jackner, F. (1999). Accumulation of heavy metals in plants grown on mineralized soils of the Australian Alps. Environment and Pollution, 104, 145-155.

World Health Organization (WHO) (2004). The Prevention of Mental Disorders: Effective Interventions and Policy Options. Geneva.

World Health Organization (WHO) (2008). Guideline for Drinking Water quality (electronic Resource). Incorporating first Addendum 1, Recommendations-3rd retrieved September 19, 2015 from http://www.whglibdoc.who.int/publications/2006/924 1546- 964.eng.pd.

World Health Organization (WHO) (2006). Global Strategy for Food Safety: Safer Food for better Health. Geneva: World Health Organization.

Wilber, D.H. and Clarke, D.G. (2001). Biological effects of suspended sediments: a review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. North American Journal of Fisheries Management, 21(1), 855-875.

Xu, P., Cai, X.T., Wang, Y., Xing, L., Chen, Q. and Xiang, C.B. (2014). HDG11 upregulates cell-wall-loosening protein genes to promote root elongation in *Arabidopsis*. Journal of Experimental Botany, 65, 4285-4295.