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IMPACT OF SELECTED LANDUSE TYPES ON SURFACE WATER QUALITY DOWNSTREAM OF ASA DAM IN KWARA STATE, NIGERIA

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ABSTRACT

This study examines the impact of selected land use types on surface water quality downstream of Asa dam in Ilorin, Southwestern Nigeria. Water samples were collected at seven points (including a control, 0.50 km from Asa dam). Four-sampling points fall within agricultural land use area, two within light industrial/residential area, and the control was within an undisturbed natural environment. The level/concentration of 10 physico-chemical parameters, color, total dissolved solids, dissolved oxygen, biochemical oxygen demand, total hardness ($CaCO_3$), calcium hardness, magnesium hardness, chloride, calcium, and nitrate were determined using standard procedures. GIS was used to determine the extent of land cover by Asa dam and its downstream environment including the length of River Asa in respect to sampling points. This was achieved through the map generated from satellite imageries and the use of GPS. This article presents and discusses the results of laboratory analyses undertaken, spatial variability in the level/concentration of the water quality parameters, as well as the consequences of sustained use of River Asa water without treatment for domestic purposes. The results show that the quality of River Asa downstream of the dam was impaired to different degrees using WHO standards for the selected parameters and land use types. Consequently, using the water for domestic purposes, in particular as currently obtained in the area, portends grave danger to human health and the situation will be worse in the near future if necessary control is not put in place.

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INTRODUCTION

The past decade has seen remarkable impact of man on the environment due to unprecedented increase in population and rapid rate of urbanization as well as the intensification of the use of fragile and marginal ecosystems. This has led to progressive land and other vital resources degradation and continued desertification of marginal agricultural lands.

Understanding and monitoring the land use/land cover of a region remains a better tool toward promoting sustainable development of our land resources within the societal economic and conservational contextual need. The assessment of the impact of such land uses on the available surface water resources is also of importance. This is necessary since per capita water demand is increasing while accessibility to available freshwater is on the decrease.

In order to achieve a sustainable and friendly land use practice within a river catchment in an urban setting, there is the need to examine the impact of such practices on the available surface water (Ofoezie, 2003). Cases of impaired surface water quality always result in an unhealthy socio-economic environment (Bullard, 1972; Ojekunle, 2000).

Hence, this study examines the impact of urban land use along the downstream of River Asa floodplain (Ilorin, Southwestern, Nigeria) and its effect on surface water quality. This is necessary in order to harmonize human development and land use within the sustenance of surface water resources quality within River Asa floodplain.

THE STUDY AREA

The study area is located in northern part of Kwara State, Southwestern, and lies between latitude 8°24^1 to 8°32^{1}N and longitude 4°29^1 to 4°35^{1}E (Figure 1). Estimated population of the area was about 640,988 in 1997 (Abdulrasaq, 1998). Generally, the topography is undulating with noticeable isolated hills such as Sobi. Average elevation within the area is about 300 m above sea level and the main river draining the area is the River Asa, which occupies a fairly wide valley and flows in the south-north direction (Aderamo, 1997). The geological formation of the area is basically crystalline rocks of the Precambrian age.

Asa area is under the influence of the dry north easterlies and the moist south westerlies. This has resulted into the emergence of two well-marked seasons (the dry and wet seasons). The dry season starts in November and ends in March while the wet season starts in April and ends in October. Also, the region experiences a mean annual rainfall which ranges between 1000–1250 mm (Barbour, Oguntoyinbo, Onyemelukwe, & Nwafor, 1982; Iloeje, 1977; Uluocha & Ekop, 2002). The temperature is constantly high and ranges between 26° to 28°C (Oyegun, 1985; Uluocha & Ekop, 2002).

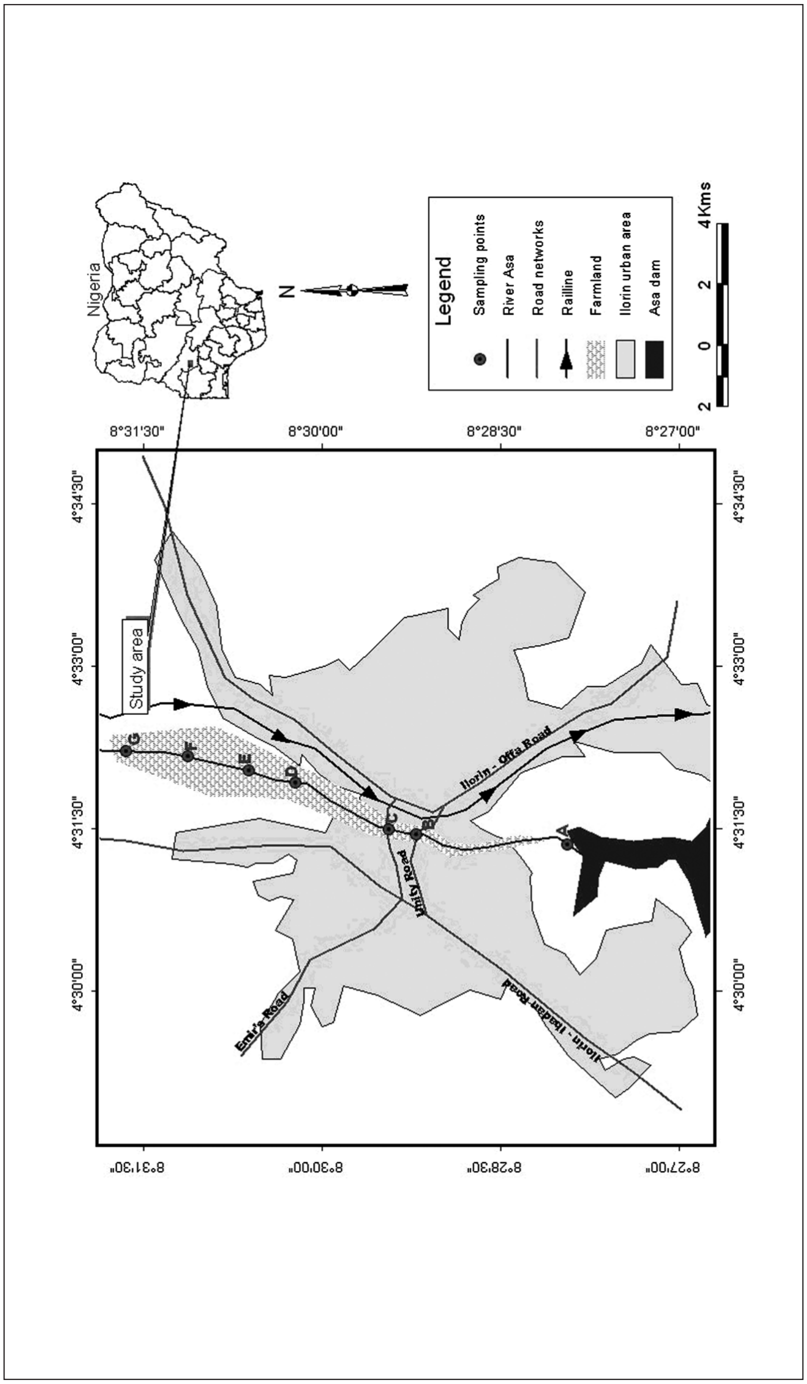

Figure 1. Nigeria showing location of study area.

Table 1. Map attributes

Map attributes	Area covered km^2/length km
Ilorin urban area	40.82 km^2
Farm land	4.21 km^2
Dam area	2.48 km^2
River length within the mapp area	9.95 km

The vegetation is predominantly of Guinea savanna, which degenerates with increasing aridity (Barbour et al., 1982; Uluocha & Ekop, 2002). The economic activities of the people within Asa area are mostly farming. See Table 1 for data generated from the satellite imagery on the study area through the use Geographic information system tool (Arcview version 3.3).

METHODOLOGY

Data Collection

The water sampling method entails division of the study area into three zones. Zone 1 has only one sampling point, Zone 2 has two while Zone 3 has four points. At each sampling point, 6 water samples were collected during the onset of raining season (April/June), 2005. Factors responsible for the zoning and sampling points are provided in Table 2. Global Positioning System was used in the collection of sampling points coordinate which was later overlaid on digitized satellite imagery map. The satellite imagery was processed, digitized, and edited in the Arcview 3.3 environment.

GPS Specification

Projection: Universal Traverse Mercator (UTM)
Datum: Minna
Zone: 31
Units: Meters

Laboratory Analysis of Water Samples

The water collected from sampling points were analyzed for the following properties, namely: appearance (color), total dissolved solid (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), total hardness as $CaCO_3$, calcium hardness (Ca^{2+}), magnesium hardness (Mg^{2+}), chloride (Cl^-), calcium (Ca^+), and nitrate ($N0_3^-$).

Table 2. Sampling Points Distribution

S/n	Sampling points	Distance from Asa Dam	Criteria
1	A	0.50 km	This area served as control point because it is free from all sorts of pollutional activities.
2	B and C (Taiwo Isale and Unity areas respectively)	3.06 km and 3.56 km respectively	These regions fall within the center of Ilorin metropolis and attract major pollution activities from the dwellers both domestic and industrial waste.
3	D, E, F, and G	5.43 km, 6.35 km, 7.51 km, and 8.62 km respectively	These areas are agricultural land use. Tomatoes, vegetables, maize, rice, and pepper are the major crops in this area.

Source: Author field survey (2005).

Also, the physical appearance of water was analyzed after the suspended matter was removed. This was determined by comparison with an arbitrary yellow standard of cobalt chloride and potassium chloroplatinate. Dissolve oxygen (DO) was analyzed using portable DO meter. Biochemical oxygen demand (BOD) was also analyzed by titration using standard akali azide methods. In addition, total water hardness was analyzed volumetrically with soap solution. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were analyzed by atomic absorption spectrometer. Nitrate on the other hand was analyzed by chlorimetric method using phenol disulphoric acid.

Hypothesis

H0: Physiochemical parameters of River Asa water downstream Asa Dam, Ilorin, meet the WHO standard.

H1: Physiochemical parameters of River Asa water downstream Asa Dam, Ilorin, do not meet the WHO standard

Analysis of Data

The result of the sampled water was analyzed and compared with the WHO standard (see Table 3 for the result of sampled water and WHO standard).

Table 3. Water Samples Result

Parameters	Distance from the Asa Dam							
	A (Control point) 0.50 km	B 3.06 km	C 3.56 km	D 5.43 km	E 6.35 km	F 7.51 km	G 8.62 km	WHO (Highest permissible)
Appearance	Clear	Slightly colored	Slightly colored	Deeply colored	Slightly colored	Colored	Colored	Clear
Total Dissolved Solid (ppm)	792	356	432	476	472	538	467	500 ppm
Dissolved Oxygen (ppm)	2.25	1.36	1.16	2.38	2.18	1.02	1.70	N.V.
Biochemical Oxygen Demand (ppm)	N.D.	15.00	6.00	35.00		35.00	13.00	6 ppm
Total Hardness as $CaCO_3$ (ppm)	26.00	90.00	114.00	124.00	126.00	130.00	138.00	250 ppm
Calcium Hardness (ppm)	16.13	51.61	64.52	70.97	74.19	77.42	83.87	200 ppm
Magnesium Hardness (ppm)	9.87	38.39	49.48	53.03	51.81	52.58	54.13	150 ppm
Chloride (ppm)	7.10	24.85	35.50	39.05	39.05	39.05	40.80	250 ppm
Calcium as Ca^{+} (ppm)	6.45	20.64	25.81	28.39	29.68	30.97	33.55	200 ppm
Nitrate (ppm)	0.96	12.00	7.86	23.92	28.61	27.72	20.64	50 ppm

Description of Analyzed Chemical Parameters

Color—It should be noted that WHO recommends 15 TCU (True Color Unit) as the standard value for clear water appearance. Although, in this study, the color of the water samples was not measured in terms of TCU; rather, it was described as clear, colored, slightly colored, and deeply colored. Table 3 shows the variance between measured parameters within the sampled points. These parameter values were compared with the WHO (1993) drinking water standard. From the table, it is obvious that only sample point "A" meets the WHO (1993) drinking water standard while sampled points "B," "C," and "E" were slightly colored, point "D" was deeply colored, while "F" and "G" appeared colored. The colors of sampled points "B" and "C" might be associated with different effluent from the urban center (e.g., Taiwo, Sabo-Oke, Maraba among others). Points "D," "E," "F," and "G" constitute the agricultural land use area. It can be said that agricultural waste is responsible for the colored appearances of water within these points. Point "A" appeared clear due to the fact that the area is free from large-scale agricultural, industrial, and residential waste disposal.

Total Dissolved Solid (TDS)—TDS is highest in the sampled water at point "A" with a value of 792 ppm. This is followed by point "F" value of 538 ppm while Points "C," "D," "E," and "G" are homogeneous with values, of 432 ppm, 486 ppm, 472 ppm, and 467 ppm respectively. Point "B" has the lowest TDS value of 356 ppm; this shows that TDS values at points point "A" and "F" are higher than the WHO (1993) highest permissible limit but, on the average, TDS in this river is less than the WHO permissible limit (500 ppm), see Table 3 and Figure 2a). TDS influences other qualities of water such as taste, hardness, corrosion properties, and encrustation in drinking water system (Mendie, 2005; WHO, 1993, 2006). Water becomes unpalatable, becoming salty and losing its taste at values >1000 mg/l while low and high TDS arising from useful ions (e.g., Ca, Mg) and salt, respectively, are injurious to health (Mendie, 2005). Akinwumi (2000) observed that low TDS may result in gastrointestinal irritation.

Dissolved Oxygen (DO)—DO provides valuable information about the biological reactions taking place in the water and gives an assessment of the ability of water to receive organic matter (WHO, 1993, 2006). The DO values in sampled water varied from one point to another as a result of pollutant activities at the various sampling points due to the various land uses. For example, at points "B," "C," "G," and "F" the DO values are 1.36 ppm, 1.16 ppm, 1.70 ppm, and 1.02 ppm, respectively. Hence, Ilorin falls within the highly oxygen demanding zone along River Asa channel. This might be due to depletion being observed in the DO content. Meanwhile, sampled points "E," "A," and "D" are low DO regions (Table 3 and Figure 2b).

Biochemical Oxygen Demand (BOD)—BOD is useful in evaluating the pollutional strength of water and it also gives a measure of the amount of oxygen

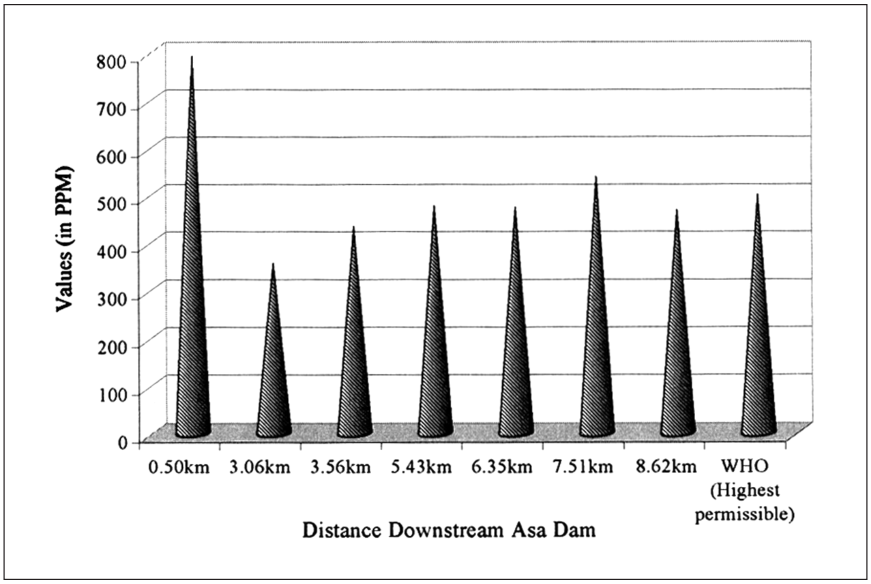

Figure 2a. Total dissolved solid (TDS).

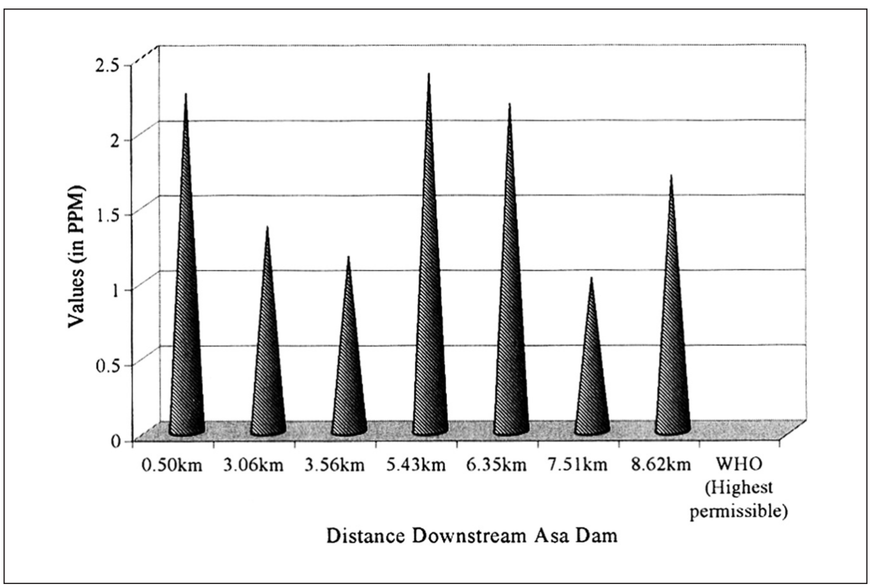

Figure 2b. Dissolved oxygen (DO).

required by microorganisms to decompose an organic matter in sampled water under specific set of conditions (Akinwumi, 2000).

The sampled water taken from points "D" and "F" are homogeneous with BOD value of 35 ppm. Sampled "B," "G," and "C" BOD values are 15 ppm, 13 ppm, and 6 ppm, respectively. The BOD values for sampled points "A" and "E" were not determined. From Table 3 and Figure 2c there might be high oxidizing compounds in the two points ("A" and "E") than the others except at point "C" which meets the WHO standard. The high value can be attributed to high percentage of organic matter in the water.

Total Hardness ($CaC0_3$)—The results of this parameter show that the total hardness increases downstream from point "A" which has the lowest value (26 ppm) to point "G" with the 138 ppm. From this value only point "A" is soft, since soft waters have total hardness that equal or are less than 50 ppm $CaC0_3$ equivalent (Table 3 and Figure 2d). The hardness can be attributed to the geological composition of the rock on which the river flows (Ogunkoya & Adejuwon, 1990). Principally, soluble salts of calcium and magnesium and the presence of inorganic salts are also contributory to this total hardness contents (Perlman, 2006). The implication of this in drinking water will cause impaired health since the water is hard on the average. The water within the sampled

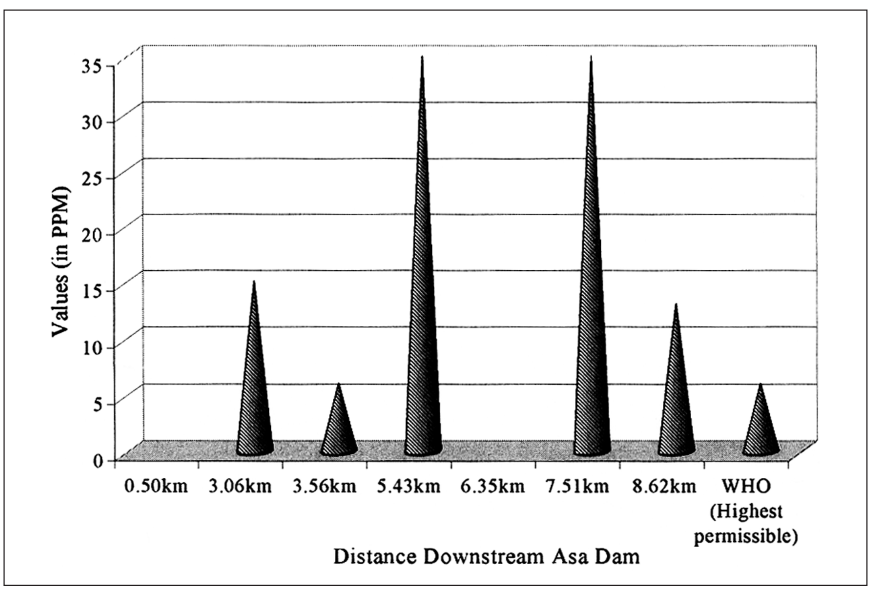

Figure 2c. Biochemical oxygen demand (BOD).

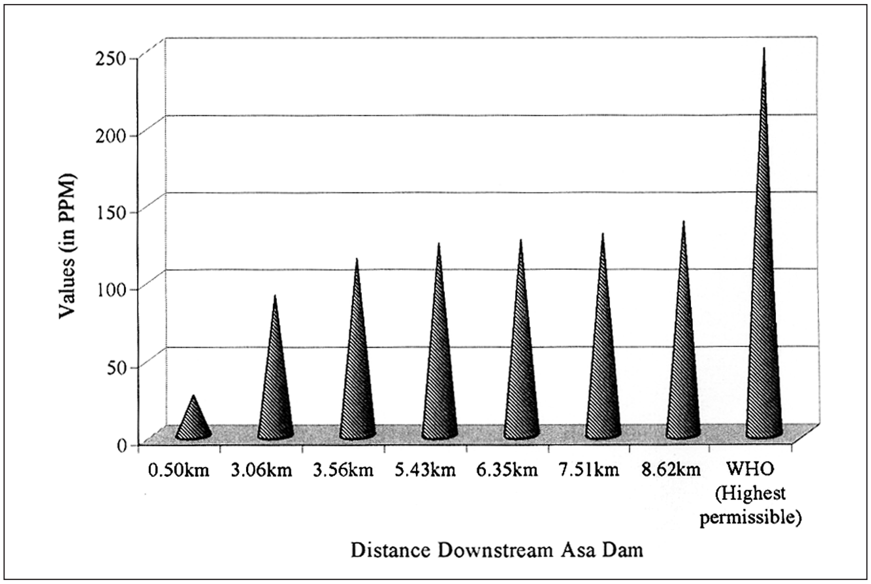

Figure 2d. Total hardness as $CaCO_3$.

points therefore needs a comprehensive treatment scheme before it can satisfy the WHO portable water requirement.

Calcium Hardness (Ca^{2+})—The result of Ca^{2+} shows that the values increase downstream from point "A" (16.13 ppm) to point "G" (83.87 ppm). The chemistry of this can also be attributed to the geological composition of the rock on which the river flows (Ogunkoya & Adejuwon, 1990). Principally, soluble salts of Calcium will cause impaired health precisely tooth disease (Table 3 and Figure 2e).

Magnesium Hardness (Mg^{2+})—As shown in Table 3 the Mg^{2+} values increases downstream from sampled point "A" to "G." The chemistry of this can also be attributed to the geological composition of the River bed-rock (Ogunkoya & Adejuwon, 1990). The implication of this is that if the water is drank without treatment it might impair human health and lead to heart and kidney diseases (see also Figure 2f).

Chloride (Cl^-)—The result of samples shows that the Cl^- is generally low while compared to the WHO standard. The lowest is recorded at sampled point "A" (control point) with 7.10 ppm and the highest is recorded at point "G" (extreme point of agricultural area) with 40.80 ppm (Table 3 and Figure 2g). The low content of Cl^- may arise as a result of various soluble salts and animal

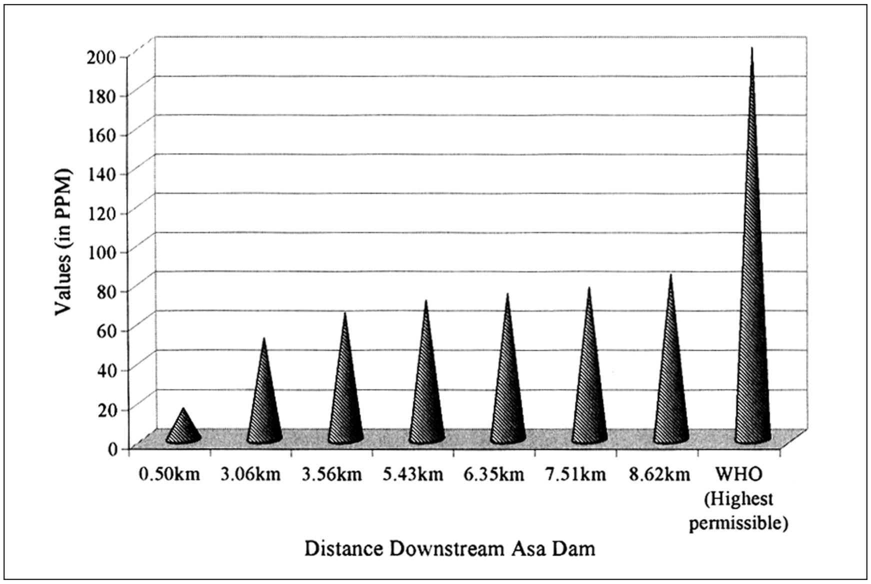

Figure 2e. Calcium hardness (Ca^{2+}).

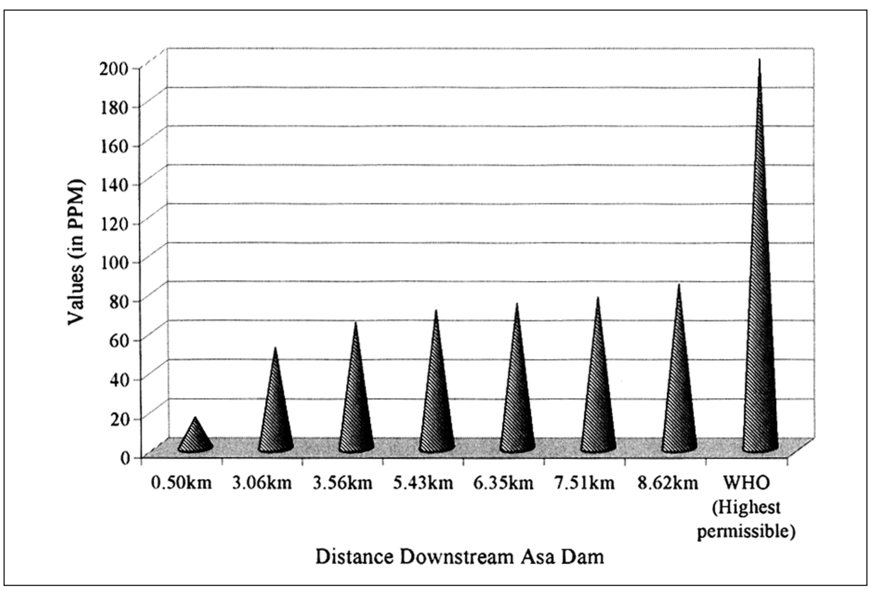

Figure 2f. Magnesium hardness (Mg^{2+}).

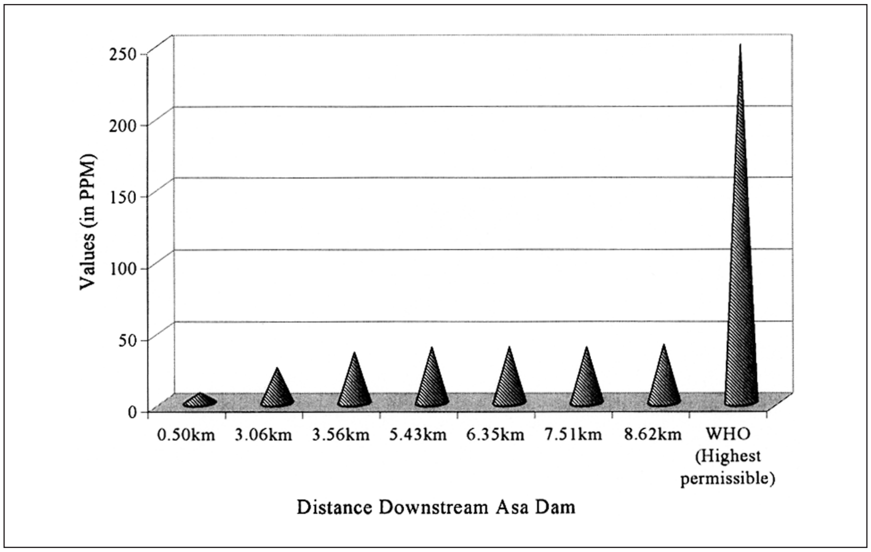

Figure 2g. Chloride (Cl^-).

manure, which is a potential source of sulphate. The implication of this in drinking water will lead to heart and kidney diseases and cause impaired health (Paul, 2000).

Calcium Ca^+—The Ca^+ of the sampled water at the various points was generally lower than that of WHO standard. Also, the value increases downstream from 6.45 ppm at point "A" to 33.55 ppm at point "G" (Table 3 and Figure 2h). The self-purifications process, which normally include complex physico-chemical and biological processes such as sedimentation of suspended matter, coagulation of colloid, and absorption of dissolved substances, may be attributed to the increases and general reduction in values when compare with WHO standard. The implication of excess and deficiency of calcium in drinking water will cause kidney and bladder disease (Mendie, 2005).

Nitrate ($N0_3$)—The sampled water collected from point "D," "E", "F," and "G" have the highest $N0_3$. Point "E" recorded the highest with 28.61 ppm followed by "F," "D," and "G" with values of 27.72 ppm, 23.92 ppm, and 20.64 ppm, respectively (Table 3 and Figure 2i). Although these values are less than the WHO highest permissible limits, $N0_3$ in water is attributed to the contents of fertilizer load in the agricultural land use region. The increasing output of nitrate (i.e., dissolved nitrogenous compounds) in natural water is a serious problem, higher nitrogen increases the rate of eutrophication in water bodies and conflicts with health standards (Ifabiyi, 1997). The amount of nitrate in these samples

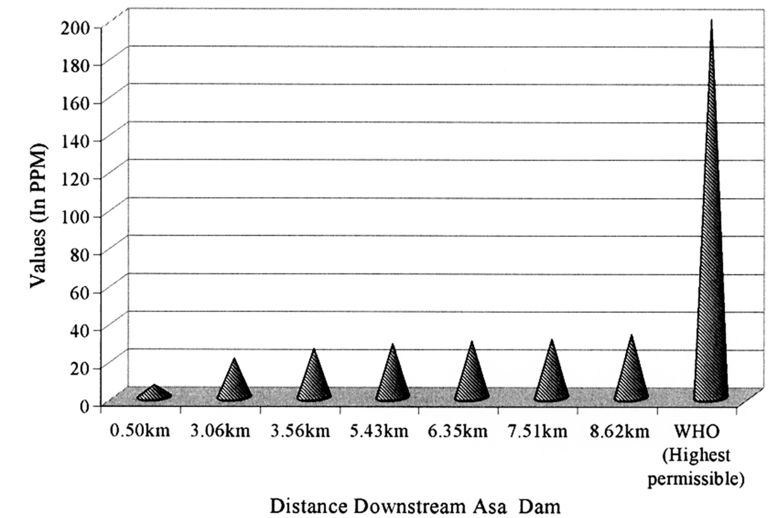

Figure 2h. Calcium (Ca).

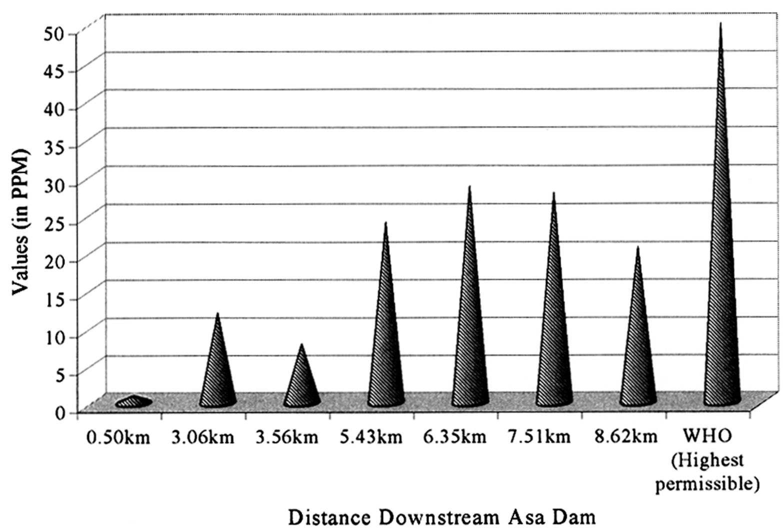

Figure 2i. Nitrate (NO_3).

is a result of natural watershed for agricultural activities. The implication of this in drinking water will cause methemoglobinemia (an infant illness) and retard growth.

Generally speaking, organic acids resulting from decaying plant are also part of the causes of variation in the values of these parameters (TDS, DO, BOD, Total hardness as $CaCO_3$, Ca^{2+}, Mg^{2+}, Cl, Ca^{+}, and NO_3) in the sampled points. Although, the downstream reduction in values can be attributed to self-purification of the river as it flows downstream. Apart from the extent of some pollutants such as synthetic detergent chemicals, heavy metals, oil and salt, which are discharged into the river by Global soap and detergent industry in Ilorin metropolis, also contributed to the variation in the sampled values in points "B" and "C."

As shown in Figure 3, the values of TDS in points B, C, D, E, F, and G were generally lower than the control point and varied from one point to another. It also indicates that indirect relationship exists between control point and the sampled points. Also, since the value of DO is less than 1, while compared to control point, the sampling points will be highly oxygen demanding. Also, the values of total hardness in the sampling points were higher than the control point.

On the other hand, the value of Ca^{++}, Mg^{++}, Cl^{-}, Ca^{+}, and NO_3^{-} in the sampled points is also higher and this can be attributed to pollutional free activities in the control point and presence of various organic salts and sort of pollution in the other points.

Figure 4 shows the comparison between WHO permissible limit and sampled points with TDS at points A and F, and BOD at points B, D, F, and G being above the WHO highest permissible. This shows that the water quality at the sampled points along River Asa is generally low and does not meet WHO permissible limit for drinking water.

Table 4. Chi-Square Test Analysis for the Hypothesis Formulated

Parameters	TDS	DO	BOD	Total hardness as $CaCO_3$	CA^{2+}	Mg^{2+}	Cl^{-}	Ca	NO_3
Mean of the sampled parameters (Observed)	456.83	25.2	1.63	120.33	70.4	49.90	36.3	28.1	20.1
WHO standard (Expected)	500	6	0	250	200	150	250	200	50

Significant at 0.01 level (1-tail).

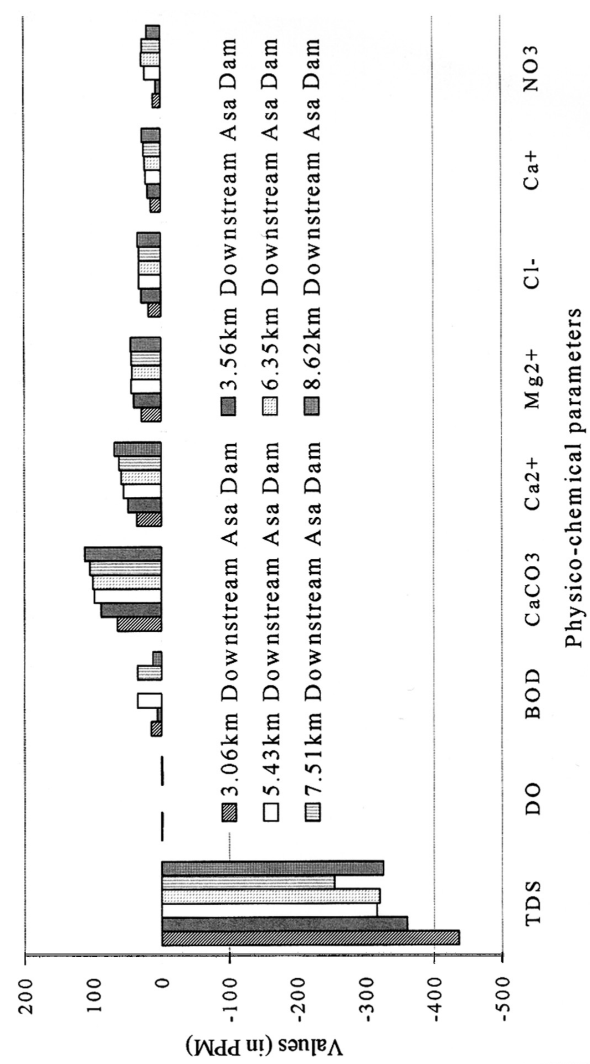

Figure 3. Deviations of concentration of sampled water from control point.

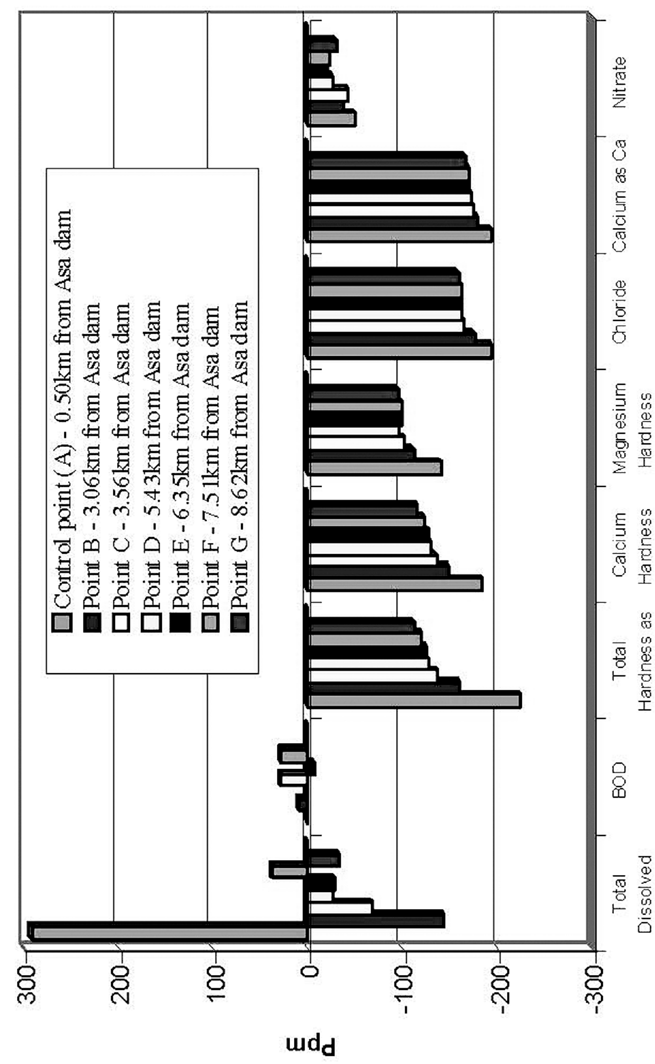

Figure 4. Deviations of concentration of sampled water from WHO regulatory limit.

From the Table 4:

Degree of freedom = 8
χ^2 calculated = 238.12
χ^2 tabulated = 20.09

Since χ^2 calculated greater is than χ^2 tabulated, H_O is rejected. Hence, H_1 is accepted (i.e., the physico-chemical parameters of Asa water downstream Asa Dam, Ilorin, do not meet the WHO standard).

CONCLUSION

Based on the analysis of water parameters using the various analytical techniques, it can be concluded that the quality of River Asa downstream Asa Dam, Ilorin, Nigeria has degraded beyond reasonable doubt. The research, therefore, recommends the treatment of runoff being generated from the agricultural land, industries as well as the urban wastewater from Ilorin metropolis. Waste should be disposed and/or managed properly instead of discharging to River Asa. Also, the government should inaugurate various enlightenment and/or environmental awareness programs such as Environmental education, Seminars, and Workshops among others. This will go a long way in ensuring sustainable fresh water availability for domestic consumption.

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