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# The Pollution Status of Some Selected Rivers in Ado-Ekiti, Nigeria

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**Abstract.** The pollution status of three rivers (Ureje, Awedale and Ologan) in Ado-Ekiti, Ekiti State, Nigeria was investigated by carrying out necessary physicochemical, microbiological and heavy metal (elemental) analyses on them. Twenty physicochemical parameters were determined, notable results were as follows; Temperature ranged from 25.01-26.01 °C; Colour, 29.30 - 35.16 true colour units (TCU), pH 6.15 - 6.58; total suspended solids (TSS), 0.10 - 1.00 mg/l; total dissolved solids (TDS), 100 - 284 mg/l; total solids (TS), 156 - 394 mg/l; acidity, 1.08 - 1.32 mg/l $CaCO_3$; total hardness, 100.2 - 106.8 mg/l $CaCO_3$; chloride, 0.61 - 0.71 mg/l; nitrate, 2.00 - 7.55 mg/l; sulphate, 2.50 - 3.16 mg/l; dissolved oxygen (DO), 5.80 - 7.10 mg/l; biochemical oxygen demand (BOD), 12.5 - 111.85 mg/l and chemical oxygen demand (COD), 17.70 - 183.12 mg/l. River Ologan showed highest values for colour, turbidity, alkalinity as $HCO_3^-$, nitrate, chloride, BOD and COD. For river Ureje, temperature, pH, conductivity, TDS, TS and total alkalinity were the highest. River Awedale was high in total hardness and sulphate. The elemental analyses also revealed that Cu, Cr, Pb, Mn and Cd were significantly high in river Ologan. Pb, Cr and Cd were non detected in Ureje while Cr and Cd were also non detected in Awedale. Majority of the results obtained for the physicochemical and elemental analyses far exceeded the WHO recommended values. Similarly the bacteriological analysis indicated the presence of coliform bacteria in all the rivers above the WHO recommended values. It can be concluded that all the rivers are heavily polluted with the degree of pollution being Ologan > Awedale > Ureje.

**Keywords:** water pollution, contamination, heavy metals, physicochemical parameters, Ado-Ekiti, Nigeria

## Introduction

Water is undoubtedly the most precious natural resource over 70% of the earth's surface, that exist on our planet (Mackenzie, 1996). Although we as humans recognize this fact, we disregard it by polluting our rivers, lakes, oceans and underground water. Therefore, to combat water pollution, we must understand the problems and become part of the solution (Terry, 1996).

Contamination of water by foreign matter such as microorganisms, chemicals and industrial or other wastes, sewages are main causes of pollution. Such matter deteriorates the quality of the water and renders it unfit for its intended uses. The major sources of water pollution in Nigeria can be classified as municipal, industrial and agricultural. Heat may also be considered a pollutant when increased temperature in bodies of water results from the discharge of cooling water by factories and power plants. Notable effects of water pollution include those involved in human health. Nitrates (the salts of nitric acid) in drinking water causes 'methemoglobinemia' a potential health problem primarily for infants. Babies consume large quantities of water related to their body weight, especially if the water is used to mix powdered or concentrated formulas or juices. In addition, their immature digestive systems are more likely than adults digestive tracts to allow the reduction of nitrate to nitrite (McCasland *et al.,* 2007). Crops can adsorb cadmium in sludge-derived fertilizers; if ingested in sufficient amounts, the metal can cause an acute diarrhoea disorder, liver, and kidney damage. The hazardous nature of inorganic substances such as mercury, arsenic and lead has long been known or strongly suspected (Encarta, 2002).

Lakes are especially vulnerable to pollution. One problem, eutrophication occurs when lake water becomes artificially enriched with nutrients, causing abnormal plant growth. Runoff of chemical fertilizers from cultivated fields may trigger eutrophication. The process can produce aesthetic problems such as bad taste, bad odours, unsightly green scum's of algae, dense growth of rooted plants, oxygen depletion in the deeper waters and bottom sediments of lakes and other chemical changes including precipitation of calcium carbonate in hard water (Anil, 1988). The level of water pollution tends to rise not only with the degree of industrialization of countries but also with the increasing human population densities. The effectiveness of treating wastes prior to their disposal or release into the environment determines the balance between potential and acute pollution (Lee and Jones-Lee, 1994).

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The main aim of this study was to determine the pollution level of some selected rivers in Ado-Ekiti, Ekiti State, Nigeria. This involves the assessments of the physicochemical and bacterial parameters (Pollution index parameters) of the three rivers. Sampling was carried out in a manner to obtain a representative fraction of the volume of the rivers. The data thus obtained was compared with standard values of some international bodies and organizations concerned with water bodies throughout the world (WHO, 1993) and the conclusion made on the status of these rivers as regards pollution and contamination.

## Materials and Methods

**Sample collection.** The samplings of the rivers were carried out between the hours 08:00 and 11:30 am on Wednesday 15th 2004. The day was clear (no rain) and had a bright weather. Water samples were collected from the three (3) rivers at different locations (6 points in all). Ureje River along the Federal Polytechnic, Ado-Ekiti; Awedale River around the textile area while Ologan River (Omikududu) is situated behind Similoluwa and flows to dental centre along Adebayo Estate, Ado-Ekiti. Water samples were collected in a clean amber (colour) 1 liter sample bottles that were previously rinsed out thrice with distilled water. Sampling on each river was done at about a distance of approximately 1 km intervals. This makes it possible to collect samples from upstream and downstream. Sampling at each point was duplicated for better precision.

**Sample treatment.** Analytical methods were used according to "Standard Methods for Examination of Water and Wastewater" (APHA, 1998). Suspended solids and turbidity were determined using a portable data logging spectrophotometer, dialing (650 and 580 nm) in respective stored programs and the results expressed in mg/l and nephelometric turbidity units (NTU).

Lovibond colour comparator was used to determined colour; pH was determine by the glass in glass electrode method using calibrated pH. The conductivity meter bridge was used for measuring the electrical conductivity in μmΩ. Temperature was measured *in situ* using the thermometer. Atomic absorption spectrophotometer was used for metal analyses after samples were digested using $HNO_3$ (trioxonitrate (V) acid). The volume was made up to 50 ml in a standard flask using deionized water.

Dissolved oxygen (DO) was determined by azide modification of Winkler's method. Open reflux method utilizing potassium tetra-oxo chromate (VI) in boiling concentrated tetra-oxo sulphate(VI) solution in the presence of silver catalysts were used to determine chemical oxygen demand (COD), while Nessler's method was used for ammonia determination. Nitrate was determined by the colorimetric method using suitable spectrophotometer while the titrimetric method adopted by Jenkinson (1968) and Tabatabai (1974) using $BaCl_2$ as precipitant was used for sulphate determination. The molar method was used for determining Chloride (AOAC, 1995). Plate counting of coliform population was done on MacConkey agar.

## Results and Discussion

Tables 1-3 showed the physicochemical and mineral (elemental) data along with the standard values. Physical examination of water sample from the three rivers namely Ureje, Awedale and Ologan (Table 1) showed that they were odourless with an average temperature of 26.0, 25.10 and 25.54 °C respectively. The water samples showed average colour units ranging from 29.30 to 35.16 on Pt Co/Hazen scale. Ologan represented the highest value of 35.16 units followed by Awedale 30.05 units and the least figure was represented by Ureje. The values are greater than the WHO recommended value (5 NTU) for drinking water (Harrison, 1996; Sridhar and Omisakin, 1985). The observed higher values might be due to the persistent disturbance of the rivers and the water dumped into them.

**Table 1.** Physicochemical and bacteriological parameters* of three rivers

| Parameters | Ureje | Awedale | Ologan |
|---|---|---|---|
| Temperature (°C) | 26.01 | 25.10 | 25.52 |
| Colour Pt Co Hazen unit (TCU) | 29.30 | 30.05 | 35.16 |
| Turbidity (NTU) | 10.60 | 10.00 | 11.75 |
| pH | 6.58 | 6.15 | 6.32 |
| Conductivity (μs/cm) | 4 x 100 | 2.5 x 100 | 2.4 x 100 |
| TSS (mg/l) | 0.110 | 1.00 | 0.68 |
| TDS (mg/l) | 284 | 100 | 105 |
| TS (mg/l) | 394 | 165 | 156 |
| Acidity (mg/l $CaCO_3$) | 1.08 | 1.32 | 1.15 |
| Alkalinity as $CO_3^{-2}$ (mg/l) | Nd | Nd | Nd |
| Alkalinity as $HCO_3^-$ | 30.55 | 28.00 | 30.69 |
| T. Alkalinity (mg/l $CaCO_3$) | 36.84 | 31.15 | 36.00 |
| Total Hardness (mg/l $CaCO_3$) | 100.2 | 106.8 | 102.9 |
| Chloride (mg/l) | 0.61 | 0.71 | 216 |
| Nitrate (mg/l) | 55.00 | 62.00 | 80.44 |
| Sulphate (mg/l) | 2.5 | 3.16 | 300 |
| Dissolved oxygen (mg/l) | 7.10 | 5.80 | 6.00 |
| BOD (mg/l) | 20.25 | 12.5 | 111.85 |
| COD (mg/l) | 60.66 | 17.70 | 183.2 |
| Total viable count (cfu/ml) | $0.65 \times 10^2$ | $1.62 \times 10^2$ | $1.85 \times 10^2$ |
| Coliform count (cfu/ml) | $0.03 \times 10^2$ | $1.11 \times 10^2$ | $1.08 \times 10^2$ |

* = values are means of duplicate analysis; nd = non detected; TCU = true colour units; NTU = nephelometric turbidity units

Total suspended solids (TSS), total dissolved solid (TDS) and Total solids (TS) measured ranged from 0.11 to 1.00 g/l, 100 to 284 mg/l and 156 to 394 mg/l respectively for the river samples. These values are however lower than the WHO limits for drinking water. Conductivity, which is a measure of dissolved solids ranged between 240-400 µs/cm with highest value recorded for Ureje and the lowest for Ologan.

The pH value of Ureje water sample (6.58) was within the WHO permissible limit. Those of the other two rivers were lower than the acceptable limits (6.15, 6.32). The corresponding acidity values ranged from 1.08 to 1.32 mg/l $CaCO_3$. The slightly acidic conditions may be caused by the presence of organic acids. Low pH enhances the solubility of substances like metals in water, some of which are toxic to humans (Watras *et al.*, 1994). Carbonate alkalinity was non-detected, while bicarbonate ($HCO_3^-$) alkalinity ranged between 28.00 mg/l in Awedale and 30.69 mg/l in Ologan. Total alkalinity measured as mg/l $CaCO_3$ was found between 31.15 and 36.84 and were within the 30-500 mg/l $CaCO_3$ WHO limits.

Total hardness, which is mostly due to dissolved calcium and magnesium salts, ranged between 100.2-106.9 mg/l $CaCO_3$. These figures are also within the WHO range of 100-200 mg/l $CaCO_3$, moderately hard to hard water suitable for drinking (Harrison, 1996; Sridhar and Omisakin, 1985). The calcium and magnesium contents of the water samples and the controls were between 16.40 and 38.40 mg/l; 12.29 and 31.44 mg/l respectively.

Very low chloride values (between 0.61 and 0.71 mg/l) as compared with the 250 mg/l WHO limits were recorded in samples of Ureje and Awedale respectively. However, for Ologan River, 300 mg/l value exceeds the recommended range. High nitrate level ranging from 55 to 80.40 mg/l was recorded in all the water samples. This range is significantly higher than the 50.0 mg/l value of WHO. High nitrate level in water can also pose a health hazard because of its possible conversion to highly toxic nitrite by certain bacteria commonly found in the intestinal tract of infants leading to blue baby syndrome (Aiyesanmi *et al.*, 2004; Osibanjo *et al.*, 1998). The exceptionally high values of the chlorides and the nitrites in river Ologan might be due to the waste from the textile mill situated close to the river, since dyes and other chemicals used may contain much of nitroso, azo and chlorine. Low sulphate levels were measured in the water samples from Ureje and Awedale, 2.5 and 3.16 mg/l respectively. These values are very low as compared with the one obtained for Ologan 300 mg/l, a value significantly higher than the WHO values for drinking water. The dissolved oxygen (DO) level of the water sample ranged between 5.80 to 7.10 mg/l. High values of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were measured (12.5 to 111.8 mg/l and 17.70 to 183.12 mg/l respectively) for the samples. The highest values for Ologan River, the lowest for Ureje while Awedale's value is moderate. This implies that Ureje and Awedale have not been seriously afflicted with high oxygen depleting waste unlike Ologan whose values for BOD and COD are outrageous.

The total viable counts and the coliform count values obtained showed the presence of microorganisms. However, the values obtained are far higher than the WHO recommended values.

Table 2, shows the presence of Cd, Cu, Cr, Fe, Mn, Ni, Pb and Zn in varying concentrations in the three rivers analyzed. Generally, when the individual values were compared with the WHO standard only copper and manganese has values below the limits recommended for drinking water. Other elements appeared higher than the WHO recommended limits. However, cadmium and manganese were below the detection limits in both Ureje and Awedale river water samples. Lead (Pb) metal was also non-detected in Ureje river water.

**Table 2.** Mineral analysis of the three rivers

| Parameters (mg/l) | Ureje | Awedale | Ologan |
|---|---|---|---|
| Iron (Fe) | $7.1\pm1.97^a$ | $5.2\pm0.42^a$ | $7.00\pm0.71^a$ |
| Zinc (Zn) | $4.25\pm0.49^a$ | $5.80\pm0.42^b$ | $5.2\pm0.14^{ab}$ |
| Copper (Cu) | $0.25\pm0.07^a$ | $0.30\pm0.14^a$ | $0.50\pm0.14^a$ |
| Nickel (Ni) | $0.05\pm0.07^a$ | $0.15\pm0.07^a$ | $0.10\pm0.00^a$ |
| Lead (Pb) | Nd | $0.10\pm0.00^b$ | $0.20\pm0.07^c$ |
| Chromium (Cr) | Nd | Nd | $0.05\pm0.00$ |
| Manganese (Mn) | $0.25\pm0.00^a$ | $0.35\pm0.00^a$ | $0.45\pm0.00^a$ |
| Cadmium (Cd) | Nd | Nd | $0.05\pm0.01$ |

$^{a,\,b}$ = means denoted by the same superscripts are significantly the same $P < 0.05$ (Duncan Multiple Range Test)

All these metals with the exception of iron in most cases when present in high concentrations in drinking water are toxic to humans resulting into different ailments and in several cases leads to death (Packham, 1990). High iron and manganese content in water can cause brown coloration and impact unaesthetic and cosmetic effects (Ademoroti, 1996). Compared with WHO limits, low concentration of copper were measured. The presence of chromium and cadmium metals only in Ologan River further substantiate the argument that the textile mill effluents discharge into the river contributes immensely to its pollution as these metals are good associates of textile manufacturing process chemicals.

Figure 1, depicts the various relationships between the metals in the three rivers considered and reflects the status of the

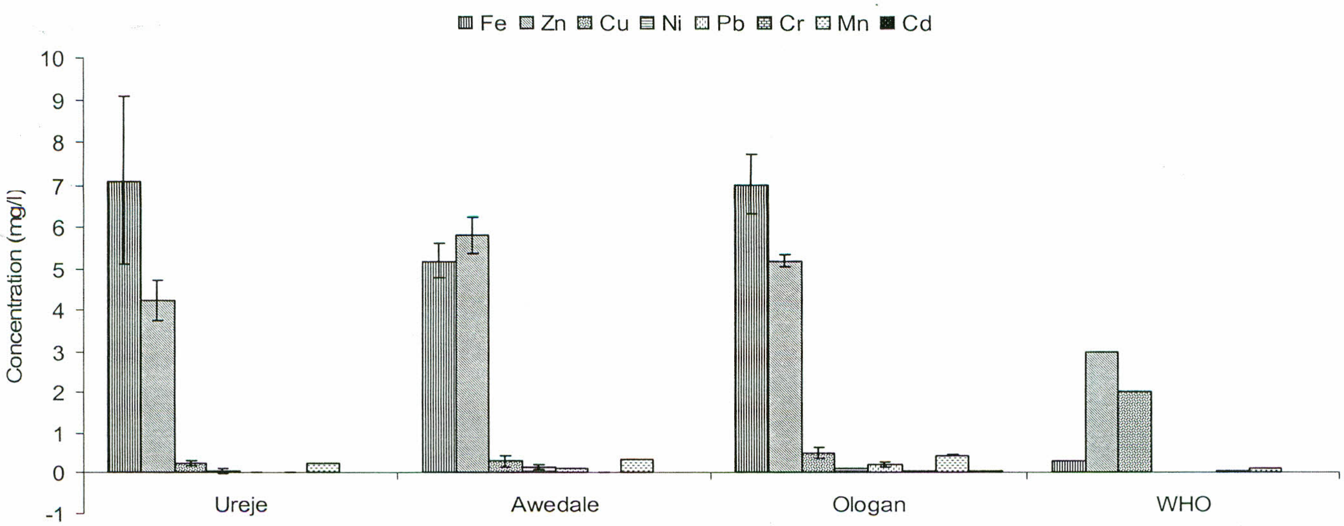


**Fig. 1.** Heavy metal status of Ureje, Awadale and Ologan rivers.

**Table 3.** Quality criteria of drinking water

| Quality characteristics | WHO guideline values 1993 |
|---|---|
| pH | 6.5-9.0, 8.0 (p) |
| Total Dissolved solids | 500 mg/l |
| Total Alkalinity as $CaCO_3$ | 30-500 mg/l |
| Total Hardness as $CaCO_3$ | 100-200 mg/l |
| Chloride (Cl) | 250 mg/l |
| Cyanide ($CN^-$) | 0.07 mg/l |
| Nitrate ($NO_3^-$) | 50.0 mg/l |
| Nitrite ($NO_2^-$) | 3.0 mg/l (p) |
| Sulphate ($SO_4^{2-}$) | 250 mg/l |
| Arsenic (As) | 0.01 mg/l (p) |
| Barium (Ba) | 0.7 mg/l |
| Cadmium (Cd) | 0.003 mg/l |
| Chromium (Cr) | 0.05 mg/l (p) |
| Copper (Cu) | 2.0 mg/l (p) |
| Iron (Fe) | 0.3 mg/l |
| Lead (Pb) | 0.01 mg/l |
| Manganese (Mn) | 0.1 mg/l, 0.5 mg/l (p) |
| Mercury (Hg) | 0.001 mg/l |
| Nickel (Ni) | 0.02 mg/l |
| Zinc (Zn) | 3.0 mg/l |

p = health based provisional value; source : NEMA (2003)

heavy metal loadings in the water samples in relation to the WHO standards for drinking water (WHO, 1993).

## References

Ademoroti, C.M.A. 1996. Toxicity and hazards of heavy metals. *Environmental Chemistry and Toxicology*, pp. 186-204, Foludex Press Ltd, Ibadan, Nigeria.

Aiyesanmi, A.F., Ipinmoroti, K.O., Adeeyinwo, C.E. 2004. Baseline geochemical characteristics of groundwater within Okitipupa south-east belt of the bitumen sand fields of Nigeria. *Intern. J. Environ. Studies* **61:** 49-57.

Anil Kurma De, 1988. *Environmental Chemistry*, 2nd edition, John Wiley & Sons (Asia) Pvt. Ltd., New Delhi, India.

AOAC 1995. *Official Methods of Analysis,* AOAC International 973.51 Chloride in Water, Mercuric Nitrate Method. Chapter 11, p. 11 (11.1.14).

APHA 1998. *Standard Methods for Examination of Water and Wastewater*, 19th edition, American Public Health Association, Washington, DC, USA.

Encarta 2002. Microsoft® Encarta® Encyclopedia 2002®, 1993-2001 Microsoft Corporation, USA.

Harrison, S.E. 1996. Morphology and Evolution of a Holocene Carbonate/Siliciclastic Sand Ridge Field, West-Central Florida Inner Shelf. *MS Thesis*. p. 211, University of South Florida, St. Petersburg, FL, USA.

Jenkinson, D.S. 1968. A titrimetric method for determining total sulphur in mineral soils. *Analyst* (London), **93:** 535-539.

Lee, F.G., Jones-Lee, A. 1994. *Impact of Municipal and Industrial Non-Hazardous Waste Landfills on Public Health and the Environment*. An overview prepared for California Environmental Protection Agency's Comparative Risk Project, USA.

MacKenzie, S.H. 1996. *The Ecosystem*, p. 240, Island Press, CA, USA.

McCasland, M., Nancy, M.T., Keith, S.P., Robert, J.W. 2007. Natural Resources Cornell Cooperative Extension "Nitrate: health effects in drinking water". http://pmep.cce.cornell.edu/facts.

NEMA 2003. *Environmental Standards and Preliminary,* *Environment Impact Assessment for Water Quality and Discharge of Effluent into Water/Land.* vol. **1**, Prepared for the Ministry of Natural Resources, National Environment Management Authority, Nigeria.

Osibanjo, O., Ajayi, S.O., Adebiyi, F.S., Akinyanju. 1998. Public analysts reporting system as applied to environmental issues (Water, liquid, effluent, gaseous emission and solid waste), p. 19, Institute of Public Analysts of Nigeria. Inaugural Mandatory Continuing Refresher Seminar Paper.

Sridhar, M.K., Omishakin, M.A. 1985. An evaluation of the water supply and sanitation problems in Nigeria. *J. R. Soc. Health* **105:** 68-72.

Packham, F. 1990. Drinking water quality and health, In: *Pollution, Causes, Effects and Control.* R.M. Harrison (ed.), pp. 52-65, 3rd edition, Royal Society of Chemistry, Cambridge, UK.

Tabatabai, M.A.J. 1974. Determination of sulphate in water samples. *Sulphur Inst. J.* **10:** 11-13.

Terry, L.A. 1996. Water pollution. *J. Environ. Law Prac.* **4:** 19-29.

Watras, C.J., Bloom, N.S., Hudson, R.J.M., Gherini, S., Munson, R., Claas, S.A., Morrison, K.A., Hurley, J.P., Wiener, J.G., Fitzgerald, W.F., Mason, R., Vandal, G., Powell, D., Rada, R., Rislove, L., Winfrey, M., Krabbenhoft, J.D., Andren, A.W., Babiarz, C., Porcella, D.B., Huckabee, J.W. 1994. Sources and fates of mercury and methylmercury in Wisconsin lakes, In: *Mercury Pollution Integration and Synthesis*. C. Watras, J. Huckabee (eds.), pp. 153-177, Boca Ratun Publishers, Lewis, USA.

World Health Organization 1993. Guidelines for Drinking-Water Quality, 3rd edition, www.who.int/water_sanitation_health/GDWQ/draftchemicals/list.htm. Last accessed June 2003. Geneva, Switzerland.