COMPARATIVE QUALITY ASSESSMENT OF INACHALO AND OFIAYI STREAMS IN IDAH KOGI STATE NIGERIA

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ABSTRACT

Inachalo and Ofiayi streams were compared with a view to finding out which is most suitable for drinking as most residents use it as their source of drinking water. Three samples were collected from each stream and analysed for physical, chemical, and bacteriological impurities in comparison with WHO Standards for drinking water. The results revealed that suspended solids, 10.3mg/l for Inachalo and 12mg/l for Ofiayi as against the permissible limit of 5 mg/l by WHO. Iron, o.47mg/l for Inachalo and 0.38mg/l for Ofiayi as against the permissible limit of 0.3mg/l, turbidity, 10.29 NTU for Inachalo and 13.26 NTU for Ofiayias against the permissible limit of 5 NTU by WHO. E-coli X 10^5, 89 cfu for Inachalo and 75 cfu for Ofiayi as against the 0 cfu permissible limit by WHO. The authors therefore conclude that the streams need to be treated before human consumption.

Keywords: Stream, analysis, quality assessment, WHO permissible limit.

1.0 INTRODUCTION

Water is among the major essentials that nature provides to sustain life for plants, animals, and humans. Water is undoubtedly the most precious natural resources that exist on our planet. The total quantity of fresh water on earth could satisfy all the needs of the human population if it were evenly distributed and accessible (Davie, 2008). Without water, life on earth would be non-existent. It is essential for everything on the planet to grow.

Water pollution manifests itself in form of impairment of the quality of the water. The pollution of water directly or indirectly affects public health. Various studies have shown that some chemicals are so harmful that even trace amounts consumed in water can cause illness or even death in humans (Förstner & Wittmann, 2012). Water quality can be negatively impacted by anthropogenic activities (agricultural and industrial practices, urban development and expansion), natural processes (sediment transport, weathering processes, and precipitation rate), stream processes (precipitation, metal release and adsorption from sediments, and dilution), and hydrologic inputs (from subsurface flow through shallow soils, direct overland flow, and precipitation) (Qadir, Malik, & Husain, 2008).

It has been realized that the development of water supply system results in an improved socio-economic benefits and public health improvement. Population growth, rapid urbanization and industrialization are imposing rapid growing demand of water supply and it pressurizes the government for the development of water resources. Those who do not have access and cannot afford rely on other sources of water with questionable quality. Globally, it is reported that 663 million people lack improved drinking water sources and 159 million people use surface water (WHO, 2015). Poor water supply has given rise to water borne diseases such as dysentery, hepatitis, cholera and other parasitic diseases and these water borne diseases cause low productivity in our country (WHO, 2015).

Surface water is the most easily (readily) available source of water. The analysis of its quality and possible treatment will help solve the problem of poor drinking water and combat water borne disease. In Idah, there is no functional government or elaborate private facility for the supply of pipe borne water and as a result, consumers get their drinking water from sources such as wells, streams, rivers, household boreholes, and rain water. The safety of the water obtained from these sources cannot be ascertained. As stated by Woutersen, Belkin, Brouwer, van Wezel, and Heringa (2011), to ensure the quality and safety of drinking water, it is essential to monitor the surface water sources as well as critical points in the distribution network.

Inachalo and Ofiayi streams are two of the major streams used by most rural dwellers as their main sources of drinking water. The high rate of untreated effluent discharged into these two streams is alarming and call for attention. This is because some rural dwellers use the streams as their toilets and dumping places for refuses, which supposedly expose the water in these streams to high pollution which may render them unfit for drinking. This work aims at ascertaining the suitability of water from three sampling points (upstream, midstream and downstream) of these two streams as drinking water. Physico–chemical and biological qualities of the water samples at the stated points from streams were studied and the results compared with standards from World Health Organization (WHO). Recommends were made of the safest points on either of the streams that is fit for consumption.

2.0 MATERIALS AND METHODS

Water samples of approximately one litre each were collected at three different points on the two streams - Inachalo and Ofaiyi streams. The samples were labelled as upstream, midstream and downstream.
The following physico-chemical properties of each water sample was investigated using relevant equipment - Hatch COISO, Hatch DR 2000 spectrophotometer, HA-4P-MGI, Model 9071 DO_2meter. Temperature, turbidity, conductivity, colour, total dissolved solids, suspended solids, PH, phosphate, sulphides, total hardness, Magnesium hardness, calcium hardness. The water quality based biological parameters tested were biological oxygen demand, chemical oxygen demand, total coliform bacteria, and E-coli-$X10^5$.

3.0 RESULTS AND DISCUSSION

In an attempt to determine the quality of inachalo, and Ofiayi streams the following results were obtained from the laboratory tests. The parameters tested which are here reported and discussed are primarily physical, chemical and biological.

3.1 Physical Parameters

3.1.1 Odour and Taste

The results of the odour and taste carried out in the work were unobjectionable, meaning that they are acceptable based on WHO standard. These results by implication proved that the level of complex organic compounds, generated usually from biodegradation of organic materials discharged directly into the streams, such as runoff, falling leaves etc. is low.

3.1.2 Temperature

The temperature of water at three sample points from Inachalo and Ofiayi streams are plotted in Fig. 1.

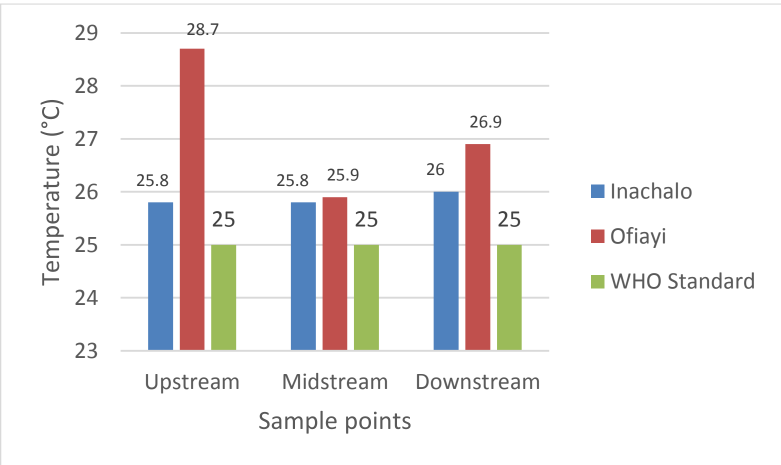

Fig. 1. Plot of Temperature against sample points

The values for Inachalo streams were slightly higher than the WHO standard while those from Ofiayi streams are reasonably higher, especially at the upstream. The higher temperature of samples from the two streams indicate presence of impurities and insufficient shading probably from poor vegetation around their headwater streams. The pronouncedly higher value at the upstream of Ofiayi stream implies significantly higher level of impurities due to anthropogenic factor (busy human activities such as fetching of water, laundry, and bathing), organic pollution from agricultural activities, and more exposure of the headwater stream to heating by sunlight compared to Inachalo stream. Water from the two streams will require purification before being used as drinking water.

3.1.3 Turbidity

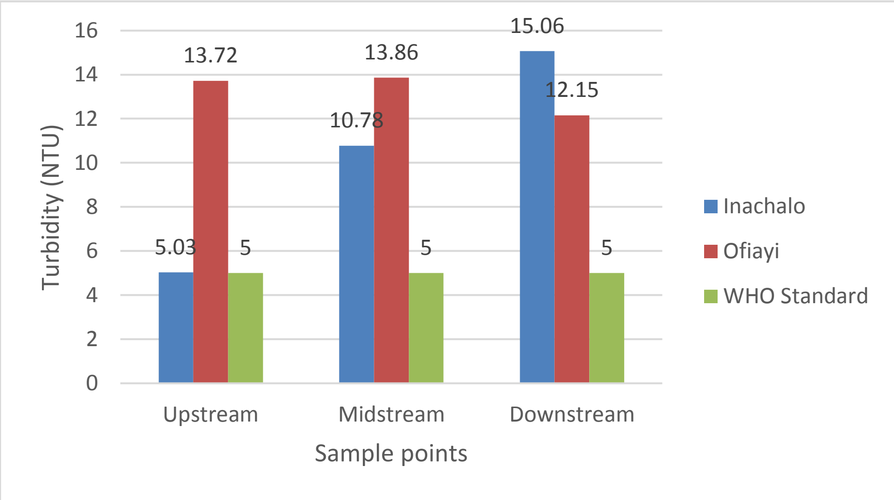

Fig. 2. Plot of Turbidity against sample points

As can be seen in Fig. 2, water upstream of Inachalo has insignificant amount of turbid colloidal particles above the WHO acceptable standard of 5 NTU. By this, the water at the said point may be recommended for drinking. However, the turbid colloidal particles were found to rise to prohibitive values at midstream and worst still at downstream. This could be due to the presence of disease causing microorganism such as bacteria and other parasites (Shittu, Olaitan, & Amusa, 2008) developed by high contaminants from human and fauna activities, and flora and/or agricultural runoff (Singh, Malik, & Sinha, 2005) as the water flow down the stream.

In the case of Ofiayi stream, turbid colloidal particles are very high at the upstream yet increased at midstream. However, the test in this work revealed that the turbid particles, though still quite higher than the WHO acceptable standard, are lower at downstream. This occurrence should be due to the phenomenon of self-purification (Wei et al., 2009).

3.1.4 Suspended Solid

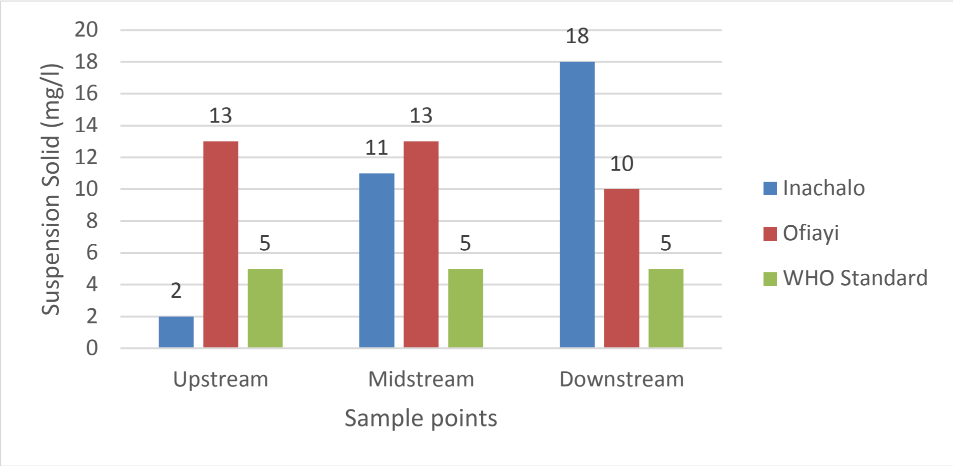

Fig. 3. Plot of suspended solid against sample points

Except upstream of Inachalo where the suspension solid being 2 mg/l fall within the WHO value for good quality drinking water, all other points sampled on both Inachalo and Ofaiyi stream have very high and unacceptable level of suspension solid, with the downstream of Inachalo at the worst level. The high level of suspension solids at these points can be traceable to activities such as logging and conversion of forest to agriculture land. These activities are believed to be strong contributors to total suspension solids in the literature (Shuhaimi-Othman, Lim, & Mushrifah, 2007).

3.1.5 Colour

Inachalo stream has better colour regime upstream compared to Ofiayi stream. Unfortunately, the colour of Inachalo stream increased to astronomical TCU values at midstream and downstream, while Ofiayi stream experience slight increase in TCU at midstream and reduced to a value lower than the upstream TCU. It can be convincingly infer that Inachalo stream have lower humic compounds (the cause of coloration in surface water (Eden, Weppling, & Jokela, 1999)) than Ofaiyi stream at their upstreams, but the said compound increased rapidly at the mid and downstream of Inachalo than the corresponding locations for Ofiayi stream. At every location of the two streams, the colour could not meet the acceptable value for drinking water as specified by WHO standard.

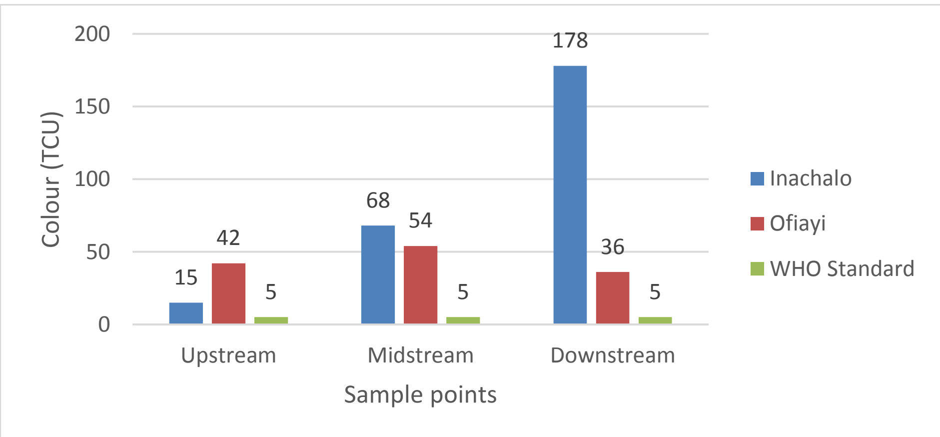

Fig.4. Plot of colour against sample points

3.2 Chemical Parameters

3.2.1 PH

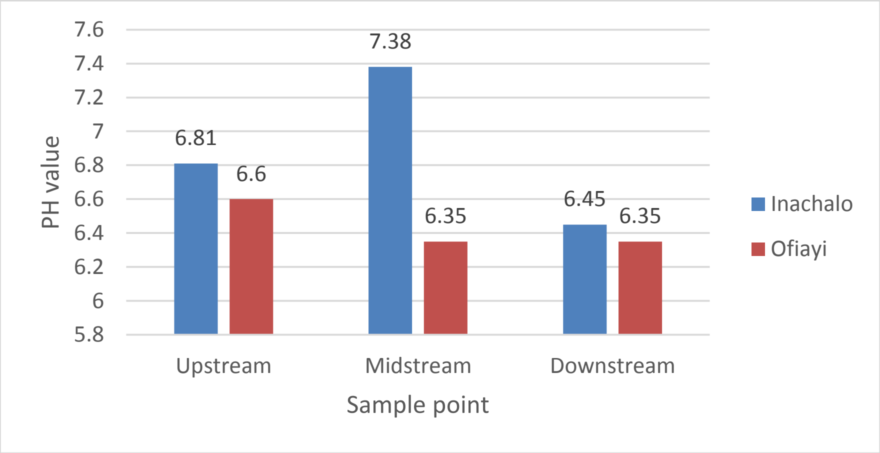

Fig.5. Plot of PH against sample points

The PH values at upstream and midstream of Inachalo stream fall within the accepted range (6.8 to 8.4) for drinking water as stipulated by the WHO standard. The PH values at the downstream of Inachalo and all the sampled points in Ofiayi stream fall below the limit, indicating high and unacceptable levels of acidity. These low PH is due to humic compounds, likely from agricultural surface drains (Eden et al., 1999), and human activities.

3.2.2 Hardness

Total hardness of water which is due to the presence of compounds like nitrates, chloride, sulphates, and bicarbonate of Mg and Ca has no adverse effect on human health, but when it is over 200 mg/l, it can cause scale deposits in the water containers and also make the water consumes more soap (Kumar, Bisht, Joshi, Singh, & Talwar, 2010). The acceptable total hardness of drinkable water by WHO standard is 100mg/l. For the studied streams, the total hardness of water from all their sampled points as represented in Fig. 6 are suitable for drinking.

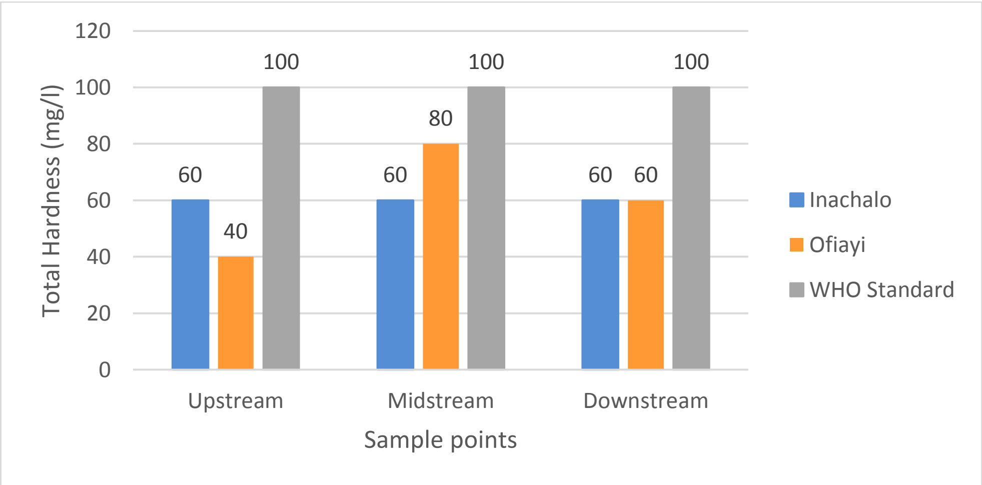

Fig.6. Plot of Hardness against sample points

3.2.3 Calcium

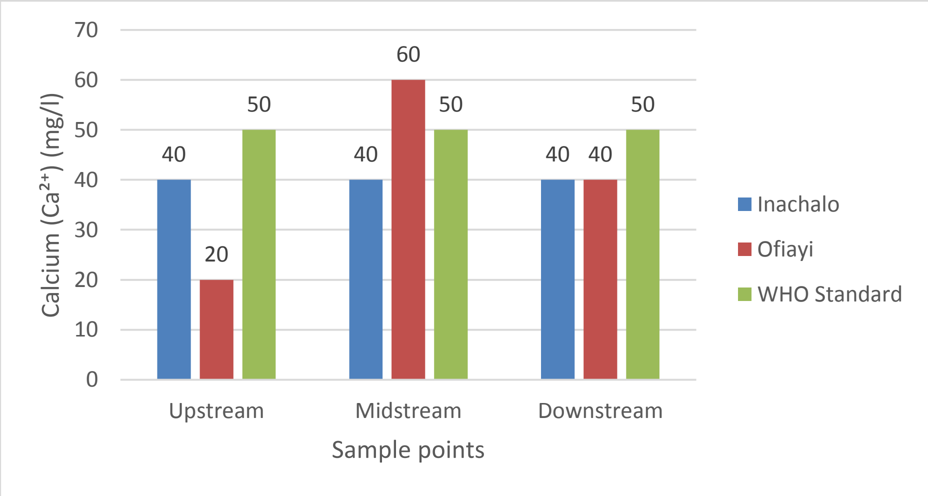

Fig.7. Plot of Calcium against sample points

Calcium is essential to coagulation, nerve impulse and muscular contraction, in particular for the cardiac muscle. It has been studied to protect against cardiovascular mortality. Owing to lactose intolerance, drinking water have been considered as the major source of calcium for elderly people (Marque, Jacqmin-Gadda, Dartigues, & Commenges, 2003). However, the need to study the calcium content of drinking water as done in this work arises from the fact that excess calcium causes hardness in water and also antagonize magnesium ions in the water (Marque et al., 2003). The safe limit of calcium from much studies have been set by WHO as 50mg/l. In the current study, all the water samples from Inachalo stream have the same calcium value of 40 mg/l throughout from upstream through to the downstream which is favorably comparable to the WHO standard of 50mg/l (Fig. 7). In the case of Ofaiyi stream, the calcium level is higher than the WHO acceptable standard only at midstream (Fig. 7). This may be from agricultural runoff, disposed waste from micro industries, leaching from soil, and municipal effluents (Singh et al., 2005).

3.2.4 Chloride

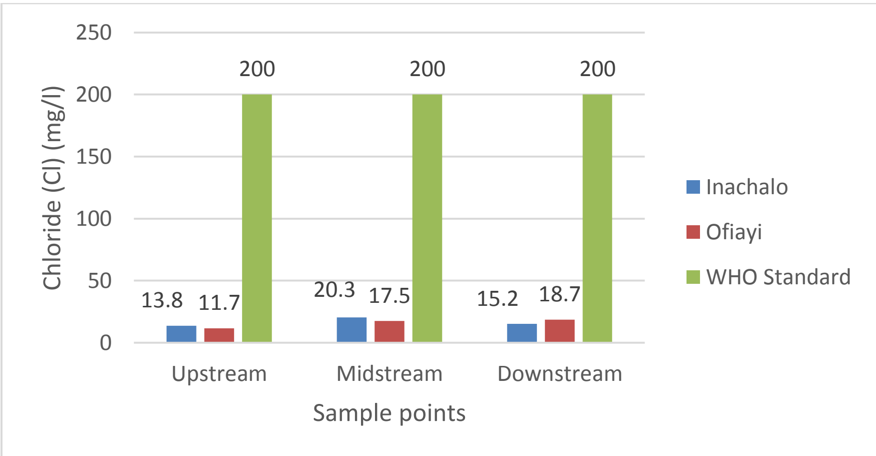

Fig.8. Plot of Chloride against sample points

Fig.8 shows the concentration of chloride from the water samples taken from the stated points of the studied streams and the WHO recommended concentration limit of the compound in drinking water. Quality of water get worse after increasing in the concentration of the chlorides anions (Cl-), limiting the suitability of using most surface water for drinking purposes (http://bit.ly/2uKQPtR). The streams investigated showed no chloride anion problem.

3.2.5 Nitrate

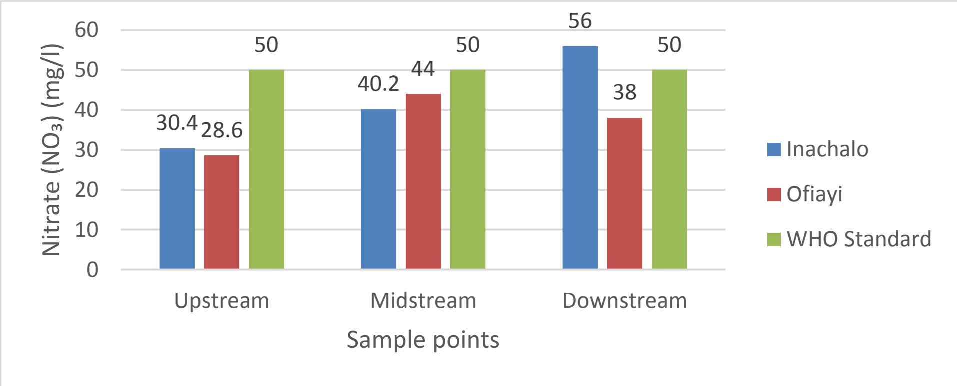

Fig.9. Plot of Nitrate against sample points

Presence of nitrate ion in a reasonable quantity makes the water toxic and not recommended for drinking. The recommendation of WHO is that nitrate ion in drinking water should not exceed 50 mg/l. In this investigation, only water sample at the downstream of Inachalo stream have nitrate ion concentration beyond the recommended value (see Fig.9.). The rise in the nitrate at this point may be due to the presence of high inorganic nitrogen from the aquatic ecosystem, runoff from irrigated cropland treated with commercial fertilizer and manure (Spalding & Exner, 1993). Rural dwellers at this location should not drink water from this stream as Ingested nitrites and nitrates from polluted drinking waters can cause birth defects, teratogenicity, mutagenicity, cancer of the digestive tract, ovary and bladder, blockage of the oxygen-carrying capacity of hemoglobin resulting in methemoglobinemia in infants, and other diseases reported in literature (Camargo & Alonso, 2006). Water at all the sampled points from Ofiayi stream are safe for drinking from the nitrate ion concentration point of view.

3.2.6 Sulphate (SO_4^{-2})

The leaching and dissolution of sulphide and carbonate containing mineral mostly from substrates of plants and animals leads to formation of sulphate anions in surface water (Lee, Choi, & Lee, 2005). Increasing concentration of the sulphates anions (SO42-), negatively impact the physical characteristics of water (such as odour, colour and taste) and also make the water destructive to human health upon consumption (http://bit.ly/2uKQPtR).

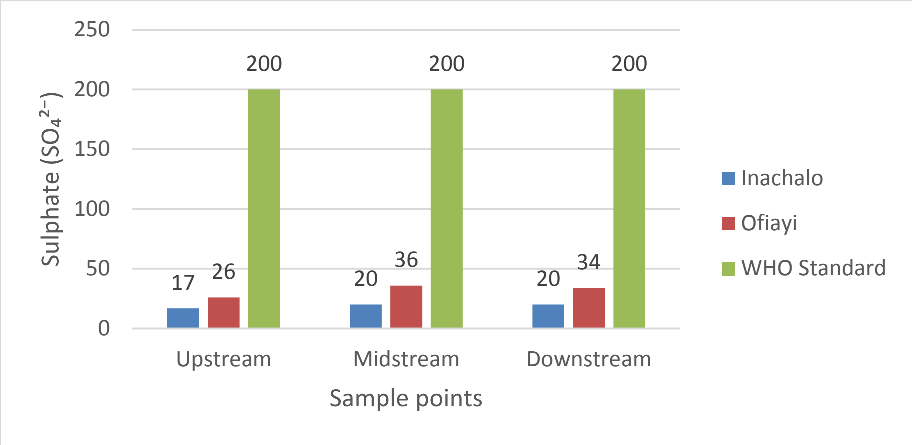

Fig.10. Plot of Sulphate against sample points

The Sulphate values of both Inachalo and Ofiayi streams vary from 17mg/l to 36mg/l. The highest value being 36mg/l is obtained from the sample taken at mid-region of Ofiayi stream. These values are within the maximum permissible limit of 200mg/l by WHO.

3.2.7 Magnesium

Magnesium is an important electrolytic constituent of the blood, present in the blood plasma and body fluids, viz; interstitial and cell fluids (Pandey et al.). It is involved in the transfer and the release of energy and takes part in cardiac physiology (Marque et al., 2003). Magnesium in drinking water is in ionized form, it might be more bioavailable than that provided by solid food (Marque et al., 2003). However, the limiting value of Magnesium concentration in drinking water is 50 mg/l, according to WHO (2015). As can be seen from the test results reported in Fig.11, the magnesium ion concentrates at all the sampled points in both Inachalo and Ofiayi streams are acceptable, presenting the water from both streams suitable for human consumption from this perspective.

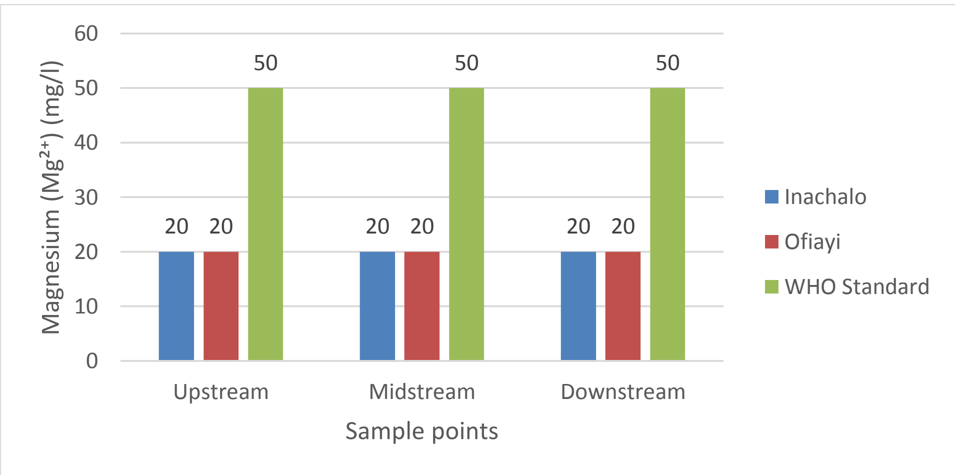

Fig.11. Plot of Magnesium against sample points

3.2.7 Dissolved Oxygen (DO_2)

Dissolved oxygen concentration (DO_2) in water determines the formation of reduced compounds, such as hydrogen sulphide, whose presence in substantial quantity have adverse (toxic) effects on aquatic animals (Camargo & Alonso, 2006). Anoxic conditions referring to 0 mg/l of DO_2 in water is not healthy for a stream as all aquatic lives will not exist and there is predominance of oxidized forms of constituents and formation of reduced forms of chemical species which leads to undesirable odour. On the other hand a condition in which the DO_2 is in excess of 4 mg/l in the water makes the water not fit for drinking, as specified by WHO. This study showed that the initial DO_2 of both Ofiayi and Inachalo streams are higher than the WHO recommended standard (Fig. 12) making water in the streams at all sampled points capable of sustaining excessive population of living organisms resulting in unhealthy water conditions (http://bit.ly/2uKQPtR).

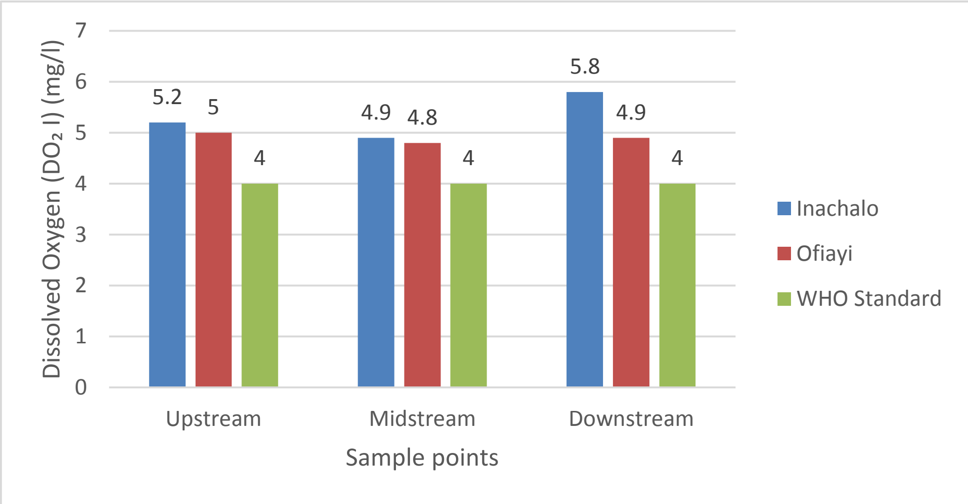

Fig.12. Plot of DO_2 initial against sample points

Fig. 13 shows unacceptably higher levels of the final DO_2 at the sources of the two streams but reduced to a an acceptable level midstream in the case of Ofiayi stream and near acceptable level in the case of Inachalo stream. While the final DO_2 downstream Inachalo further reduced to an acceptable level, that of Ofiayi stream strangely increased to an unacceptable level.

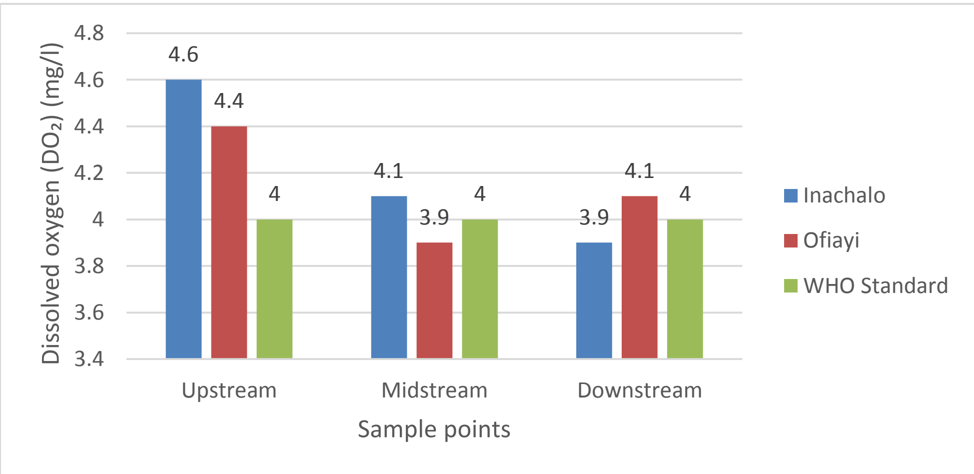

Fig.13. Plot of DO_2 final against sample points

3.3 Biological Parameters

3.3.1 Biological Oxygen Demand (BOD)

BOD is a measure of oxygen demand of bacteria or bio-degradable pollutants. It expresses the relative oxygen-depletion effect of a waste contaminant (Kumar et al., 2010). All things being equal, water having BOD up to 50 mg/l is acceptable for drinking purpose by WHO standard. From Fig.14, only water samples at midstream and downstream of Ofiayi and inachalo stream respectively have unacceptable levels of BOD. These are indications that biological contaminants at these locations are higher than the safe population for healthy water.

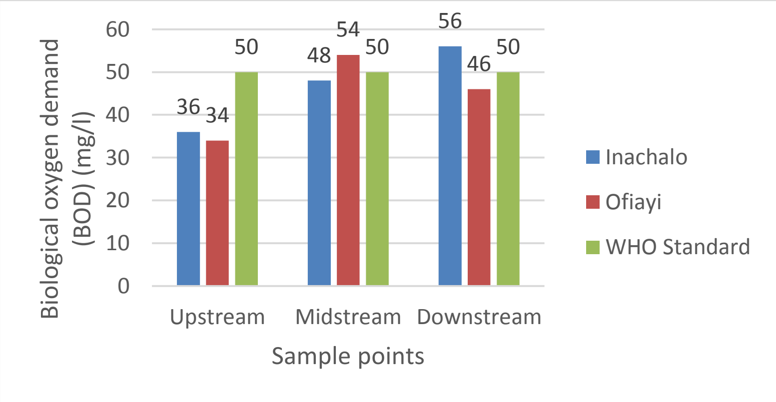

Fig.14. Plot of BOD against sample points

3.3.2 Chemical Oxygen Demand

Chemical oxygen demand (COD) test measures the oxygen demand of oxidizable pollutants (Kumar et al., 2010)**.** The lower the COD of water the lower the oxidizable pollutants and by inference, the better its quality for drinking purpose. The results for the two streams investigated in this work as reported in Fig.15 showed that the levels of oxidizable pollutants are lower (below 100 mg/l – WHO limit for drinking water) at upstream (acceptable COD). These contaminants builds up along both streams such that the COD level of Ofiayi stream shut up above the WHO limit at midstream while that of Inachalo stream when above the WHO limit at the downstream. There is a reduction in COD of Ofiayi stream to an acceptable level at down. These results imply that Inacholo stream in not drinkable at downstream while Ofiayi stream is not drinkable at midstream.

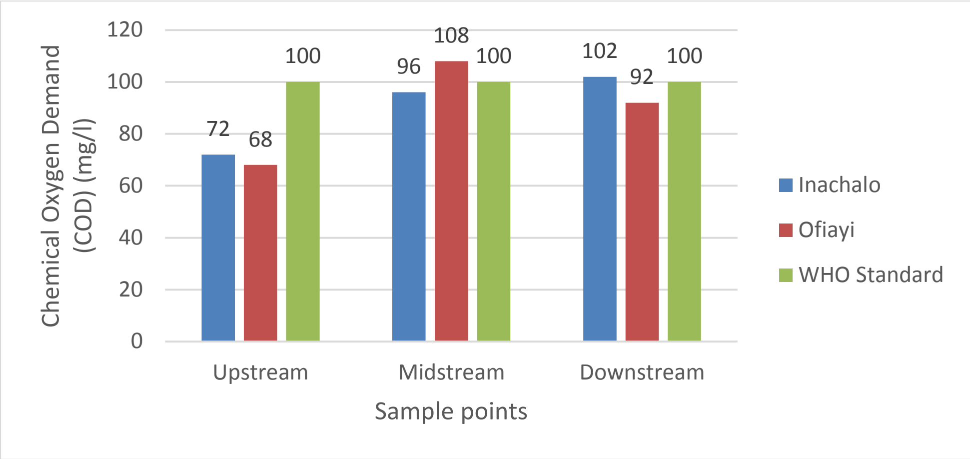

Fig.15. Plot of COD against sample points

3.3.3 Total Coliform Bacteria

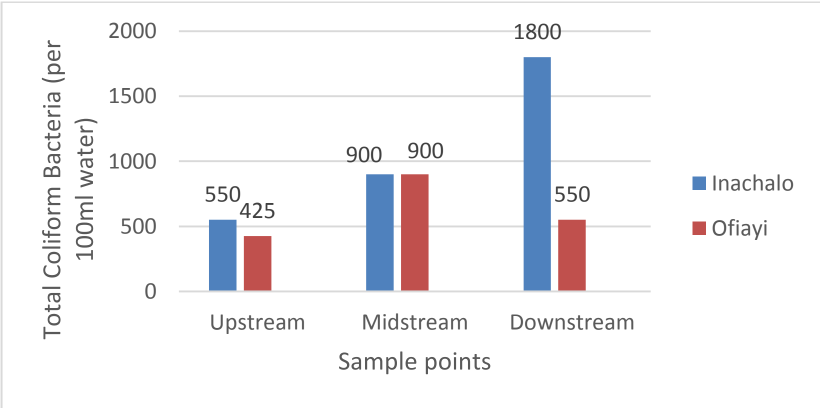

Fig.16. Plot of Total Coliform against sample points

Total coliforms, E. coli, and fecal coliform, limit the levels of contaminants in drinking water to protect public health (Shittu et al., 2008). All water samples tested from the two streams under the current investigation displayed unpleasantly high values of total coliform (see Fig.16.) compared to the WHO upper limit of 100 mg/l (WHO, 2015).

3.3.4 E-coli-X10^5

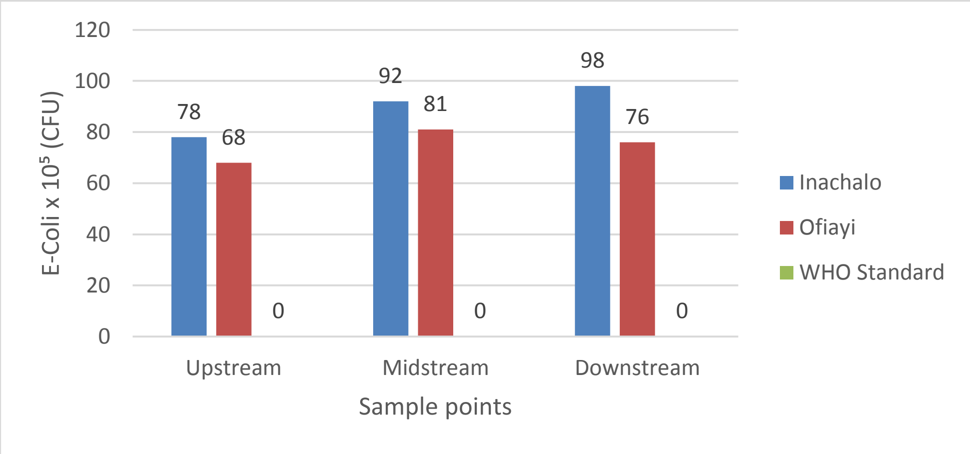

Fig.17. Plot of E-Coli against sample points

All the water samples tested from the two streams indicated reasonable values of E-coli-X105 which attested to high presence of organisms in the streams, well above the accepted WHO standard of 0 (10^{-5}c fu). This should be due to contamination by human and animal faeces and fermentation of waste from agricultural activities as reported in literature (Organization, 2003).

CONCLUSIONS

This study has provided data on the level of physico-chemical and micro-biological properties of water from (2) different streams (Inachalo and Ofiayi streams) in Idah metropolis. The study was set out to compare the quality assessments of these streams from the various sources with WHO standards for drinking water.

The results show that majority of the parameters are within the limit of WHO standard for safe drinking waters and few were found to be above WHO standards for instances Suspended Solids for (Inachaolo 10.3mg/l, and Ofiaiyi 12mg/l,) as against 5mg/l, Turbidity for (Inachalo10.29NTU and Ofiaiyi 13.26NTU) as against 5NTU, colour for (Inachalo 87pt co colour and Ofiayi 44pt co colour), as against 5pt co colour, DO_2 for (Inachalo 4.2mg/l and Ofiaiyi 4.1mg/l) as against 4.0mg/l, E-coli x10^5 for (Inachalo 89 cfu and Ofiaiyi 75cfu) as against Ocfu max. With these data, there is need for treatment before any of the streams will be safe for drinking purpose.

Hygienically approved method for waste disposal (both solid & liquid) should be explored and adopted to check the possibility of indiscriminate land dumping of potentially hazardous waste materials. Water users should also be on watch and to report every high level of any physical or chemical properties to the appropriate authorities in order to sustain water quality for consumption.

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