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PHYSICO-CHEMICAL CHARACTERISTICS AND HEAVY METAL CONCENTRATIONS OF ALETO STREAM, ELEME, RIVERS STATE, NIGERIA

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ABSTRACT

Aim: The physico-chemical properties and heavy metal concentrations of Aleto stream were investigated to determine its status.
Research Design: Samples were collected randomly from four points; upstream, outfall, downstream of Aleto stream with Agbonchia stream serving as control.
Methodology: The physico-chemical parameters: temperature, pH, EC, turbidity, TSS, TDS, total hardness, calcium hardness, alkalinity, nitrate, phosphate, chloride, COD, BOD, DO, color, odor, and taste were determined using standard methods. Heavy metal levels were determined using AAS.
Results: The physico-chemical characteristics revealed range values of EC (5400-5600 µs/cm), turbidity (39-90NTU), TDS (2780-3020 mg/L), Total Hardness (550-600 mg/L), calcium hardness (500-550 mg/L), chloride (1798-2043 mg/L), COD (50-115 mg/L), BOD (12-23 mg/L) and DO (12-15 mg/L) were above WHO permissible limits for upstream, outfall and downstream while alkalinity, nitrate, phosphate, and temperature ranges of 22-23 mg/L, 3.7-4.7 mg/L, 0.6 -1.9 mg/L and 26-26.3^{0}C respectively were within maximum allowable limit of WHO. The pH was slightly alkaline for Aleto Stream. Color and taste for the water samples were above recommended limits. The heavy metal levels were Fe: 0.488, 0.499, 0.499 and 0.142; Zn: 0.094, 0.094, 0.095 and 0.061; Cd: 0.055, 0.053, 0.051 and 0.022; Pd: 0.358, 0.386, 0.419 and 0.110; Cr: 0.131, 0.141, 0.152 and 0.018; As: <0.01, <0.01. <0.01 and <0.01 for downstream, upstream, outfall and control samples respectively. The result suggests that there is significant difference in the mean values of the parameters in the water sources considered.
Conclusion: Thus, regular surveillance should be carried out on the stream to detect any alteration in the water quality in order to avert any outbreak of health disorders.

Keywords: Physico-Chemical Characteristics, Heavy Metals, Aleto Stream, Water Pollution, Water Sample

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1. INTRODUCTION

Water is abundantly found in nature, and it forms an essential component of the environment, housing about 75% of the earth's surface Yadav and Kumar (2011) All forms of life depend on it for survival. It can be used for cooking, drinking, washing, bathing, and other numerous industrial processes Akhilesh et al. (2009) Water is found as surface water in the form of lakes, streams, rivers, ponds, shallow aquifers, oceans, seas, ice caps, glaciers, etc. It is also present in the ground and appears as spring water, well water, and borehole water Chandra et al. (2012). Water, a universal solvent Aremu et al. (2014) has the tendency to absorb heat and it functions in the lives of both flora and fauna including their metabolic processes Golterman (2015)

Water is so important that life cannot exist without it and even most factories cannot carry out their routine activities in its absence. Thus, a safe and reliable source of water remains a prior condition for establishing a stable community Erah et al. (2013)

Anthropogenic activities have often resulted in polluting the water bodies thereby rendering such waters unsafe for human consumption. Water is polluted when there is an alteration in the water quality which makes it unsafe or dangerous for man and animal as well as, industrial, agricultural, and fishing activities. Water pollution is caused primarily by anthropogenic activities Gebreyohannes et al. (2015) poor land use system, agricultural activities, population growth and industrialization Aremu et al. (2014) Lokhande et al. (2011) stated that pollution of the aquatic ecosystem is caused by the activities of certain industries such as petrochemical, paper mill, dyes, paint, pharmaceutical and textile industries. Thus, the consequences of pollution cannot be over-emphasized. It results to indiscriminate circulation of diseases and ultimately death Egboh and Emeshili (2007) Aremu et al. (2014) However, before transition from pre-industrial to industrial state, there was low level of contamination of water by pollution. Recent technological development including manufacturing process contributed to contamination of service water source. For instance, most chemical companies are cited at riverbanks with concomitant release of effluent into the river. Okonkwo et al. (2009) noted that sewage is consistently discharged into Lagos lagoon, leaving the water bodies polluted. Pollution alters the physico-chemical properties of water bodies. Water pollution has been identified as one of the areas of major concern to environmentalists Yadav and Kumar (2011) and is an important global environmental challenge Mathuthu et al. (1997) Aremu et al. (2014) Gbarakoro et al. (2020) One major problem in the world today is the discharge of industrial effluents directly or indirectly into aquatic environment without adequate treatment Aremu et al. (2014) and this is being experienced worldwide irrespective of countries Gbarakoro et al. (2020) In Nigeria, most of the water systems serve as receptacles or reservoirs for the effluents expelled from industries Otokunefor and Obiukwu (2005) Water quality is related to water use and to the state of economic development Walakiri and Okot-Okumu (2011) The poor water quality has negatively impacted the ecosystem balance, causing pollution of both ground and surface water resources Gebreyohannes et al. (2015)

Heavy metal is an element having a somewhat high density relative to water Kinuthia et al. (2020) Even though, the word "heavy metal" is a broad name used for metals and metalloids linked with the term's contamination and toxicity Duffus (2002) they have been recently described as metals that occur in nature with atomic number greater than 20 and an elemental density greater than 5g/cm3 Ali and Khan (2018). Heavy metals are environmental pollutants found mostly in waters and biota owing to natural or anthropogenic sources El-Bouraie et al. (2010). Contamination of the aquatic environments by heavy metals has led to serious threats to plant and animal lives and is of great concern El-Bouraie et al. (2010) Hashem et al. (2017) Ali et al. (2019) since most heavy metals have industrial applications Kinuthia et al. (2020) Rout et al. (2003) identified monsoon run-off from the highly urbanized and industrialized areas as the main source of heavy metal in water bodies. These metals eventually end up in our aquatic ecosystems where they are highly soluble and can easily be assimilated by living organisms. Hence, they act as pollutants when present above allowable limits and affect virtually everything in the environment, including humans and organisms. Mansourri and Madani (2016) Metals cannot be gradually broken down or degraded biologically as most organic pollutants do and they are likely piled up in the ecosystem Gbarakoro et al. (2014)

The work on the physico-chemical parameters of water (including heavy metals) is of essence in order to know the present condition of the water which can be compared to standard values Chaiudani and Premazzi (2006) Raji et al. (2015) carried out an investigation on the physico-chemical characteristics of River Sokoto, northern Nigeria. The work was done during rainy and dry season periods of August and January respectively. Their study concluded that seasonal variation occurred significantly in some physico-chemical parameters while some fell within allowable limits. Gbarakoro et al. (2020) studied the impact effluent discharged from industries have on the physico-chemical properties of Aleto stream, Rivers State, Nigeria. Their results show low levels of samples at downstream than upstream. Some of the parameters analysed were above the permissible limits. Adebisi and Fayemiwo (2011) studied the physico-chemical properties of industrial effluents and receiving water from six major industries in Ibadan, Nigeria and found that the receiving water, soil quality and even groundwater of the surrounding environments were significantly influenced by untreated effluents discharged from the industries. Specifically, DO was high in effluents from the industries. The physico-chemical characteristics of industrial effluents in Lagos state, Nigeria was carried out by Siyanbola et al. (2011)They recorded high levels of acidity, BOD and COD contrary to Federal Environmental Protection Agency (FEPA) set standards. However, the heavy metals in the effluents found in their study were within the permissible limits required by FEPA.

Sorsa et al. (2015) assessed the physico-chemical properties and heavy metals present in wastewater close to a biological treatment lagoon of the Hawassa textile factory, Ethiopia, which empties virtually treated effluents into the nearby environment. Their results showed higher values of pH, PO4, conductivity, and total dissolved solid which were above the discharge limits provided by national/or international organisations. Therefore, the presence of such high parameters in the effluent after treatment calls for concern as to whether the treatment plant is really functioning or not. Yadav and Kumar (2011) also carried out a research work on the impact of industrial effluents on water quality of Kosi River in Rampur district, India and their results showed that the parameters investigated were more than the tolerable limits. However, the results recorded by Ewere et al. (2014) who analysed the physico-chemical parameters of industrial effluents in parts of Edo state, Nigeria indicated that the industrial effluents were relatively treated as the parameters examined were within regulated limits.

Gbarakoro et al. (2014) investigated the levels of heavy metals as well as the physico-chemical characteristics of Luubara creek, Rivers State for wet and dry seasons and reported that some of the physico-chemical parameters analysed showed significant differences in the stations and seasons ($P>0.001$) contrary to others with no significant differences ($P<0.001$). There were no significant differences ($P<0.001$) in the Analysis of Variance (ANOVA) results of the heavy metals and the creek was said to be polluted to a moderate extent.

El-Bouraie et al. (2010) measured and monitor how the heavy metals were distributed in surface river water and bed sediments of Rosetta Branch of river Nile in Egypt. From their results, elevated levels of metals in the bed sediments were recorded. Although, the results showed variations in the sampling points, the contaminants analysed in water were wiyhin tolerable limits. In a related study, Shanbehzadeh et al. (2014) analysed heavy metals in water and sediment in Tembi River, Iran, and concluded that the water and sediments were contaminated by heavy metals.

In another study, six heavy metals in the effluents and receiving water of Ikpoba River in Benin City, Nigeria were analysed using AAS and the results indicated higher concentrations of heavy metals in the effluents as compared to the ones found in the receiving water. Oguzie and Okhagbuzo (2010) The X-Ray florescence (XRF) has also been used for detecting heavy metals in water. Abubakar et al. (2015) used XRF to determine heavy metals in surface water in Kaduna metropolis, Nigeria and the results showed higher concentrations of heavy metals when compared to World Health Organization (2011) permissible limits. Evidently, the water from the river was polluted.

Eleme, a famous local government area in Rivers State, Nigeria houses several companies and seaports, two of Nigeria's four oil refineries including Indorama Petrochemicals company, and as a result effluent is generated in large quantity and if untreated impacts the surrounding freshwater quality. Run-offs from diverse activities within the vicinity along the stream banks like sand mining, roasting of cattle skins, automobile repairs, oil spillage, and catchments areas also find their ways into the stream. Hence, Aleto stream in Eleme, being one of the most stressed streams in the Eastern Niger Delta region of Nigeria, is of considerable importance industrially, economically, agriculturally, and culturally. The outcome of these activities affect biological, physical, and chemical characteristics of this water body, hence the evaluation of the physico-chemical characteristics and heavy metal concentrations of Aleto stream, Eleme, Rivers State.

2. MATERIALS AND METHODS

2.1. DESCRIPTION OF STUDY AREA

Eleme Local Government Area, River's state, Nigeria can be found between the coordinates 7E and 8E, 4N and 5N on the South-eastern map of Nigeria. It is bounded in the northern side by Obio/Akpor and Oyigbo, in the southern side by Okrika and Ogu/Bolo, in the east by Tai and the west by Okrika and Port Harcourt local government areas. Aleto stream is a stream that flows into Imo River and is located in Eleme and situated between latitude 50 04' 60.00'' North of the equator and longitude 60 38' 55.99'' East of the Greenwich meridian Figure 1 Eleme has distinct weather conditions consisting of alternate rainy and dry seasons with mean annual rainfall ranging from 160mm and 298mm, relative humidity of over 90% and means temperature of 270C Udom et al. (2002) The period of the rainy season is usually from April to October, with convectional rains witnessed in the dry season months of November to March NMA (2009). The Imo River section of the river flows through Oyigbo and discharges into Agbonchia stream which is fresh water consisting of various palms and diverse aquatic macrophytes such as Raffia. The other end of the river is linked to Akpajo and Okrika rivers which consist of tropical evergreen plants of the Rhizophoraceae family Gbarakoro et al. (2020) The upper reaches of the stream which experiences high tide is fresh water while the lower reaches consisting of saltwater experiences low tide.

Figure 1

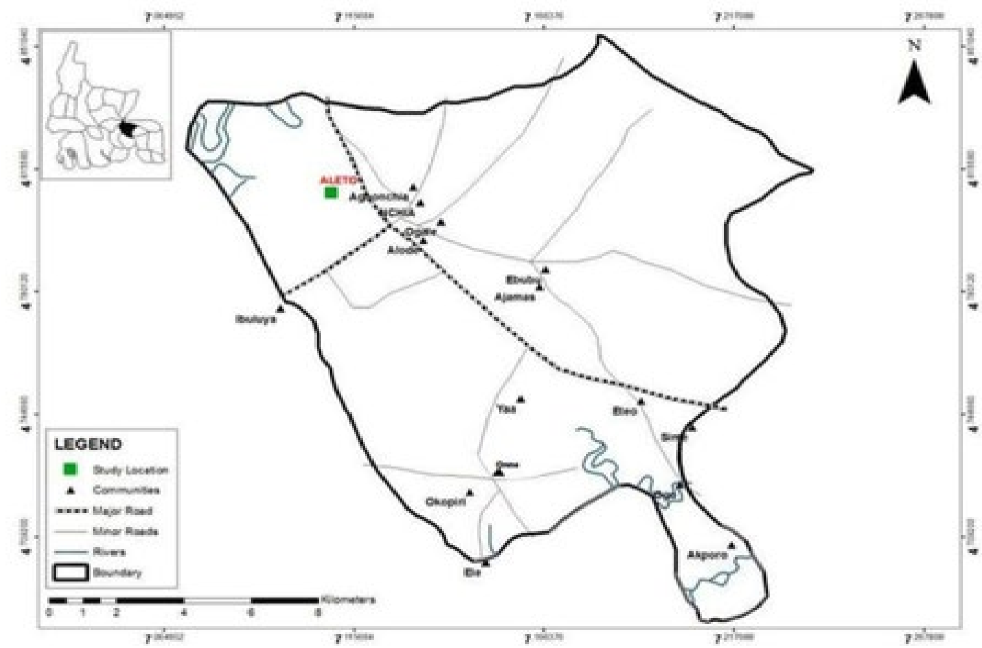

Figure 1 Map of Eleme showing study areas

2.2. STUDY DESIGN

The study was conducted in four stations: upstream, downstream and outfall of Aleto stream and downstream of Agbonchia stream as the control sample. Water samples for eighteen physico- chemical parameters and six heavy metals were obtained in a Completely Randomized Design.

2.3. SAMPLE COLLECTION AND PREPARATION

The water samples to be analysed were collected from Aleto and Agbonchia streams manually and randomly from the four study sites into pre-cleaned 1-litre plastic containers, apart from samples for DO and BOD which were collected using special DO and BOD bottles of 100-150ml. The sensitive water parameters such as temperature, pH, taste, and odor were analysed insitu because of their unstable nature, whereas samples for the estimation of other parameters were brought to the laboratory for analysis.

Samples were analysed for the following physico-chemical parameters; pH, temperature, turbidity, colour, odor, taste, electrical conductivity, total suspended solids, total dissolved solids, total hardness, calcium hardness, alkalinity, nitrate, phosphate, chloride, dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The heavy metals analysed were iron, zinc, cadmium, lead, chromium, and arsenic.

2.4. PHYSICO-CHEMICAL AND HEAVY METAL ANALYSES

The standard analytical methods were followed for the analysis of each parameter APHA (2010) The physico-chemical parameters analysed included temperature using mercury-in-glass thermometer, pH using a pH meter, electrical conductivity using a conductivity meter, turbidity using calibrated turbidity meter, total suspended solids and total dissolved solids using gravimetric method, total hardness, calcium hardness, alkalinity, chloride, and nitrate and dissolved oxygen by titrimetric method. Biochemical oxygen demand and chemical oxygen demand using standard methods. Colour, odor, taste was by sensory technique. The heavy metals were analysed by Flame Atomic Absorption Spectrophotometer (FAAS) as described by APHA (2010).

2.5. STATISTICAL ANALYSIS

The statistical analyses carried out in this work are descriptive analysis and ANOVA using all the parameters, water sources, control and WHO data.

3. RESULTS AND DISCUSSION

The physico-chemical characteristics of the analysed samples from Aleto stream are presented in Table 1 The COD, BOD, DO, and alkalinity recorded for each study site are presented in Figure 2 while the mean concentration of heavy metals is shown in Table 2

Table 1

Table 1 Physico-chemical parameters of Aleto Stream

Parameter	Upstream Sample A	Downstream Sample B	Outfall Aleto stream mean Sample C	Agbonchia Control	WHO limit
Temperature (^{0}C)	26	26.3	26.1 26.13333333	25	15-30
pH	8.3	8.4	8.3 8.333333333	6.5	6.5-8.5
EC (µs/cm)	5400	5600	5500 5500	215	400
Turbidity (NTU)	39	90	60 63	7	25-May
TSS (mg/L)	55	100	60 71.66666667	7	-
TDS (mg/L)	2780	3020	2950 2916.666667	102	500
Total hardness (mg/L)	550	600	550 566.6666667	55	500
Calcium hardness (mg/L)	500	550	500 516.6666667	50	500
Alkalinity(mg/L)	22	23	22 22.33333333	15	200
Nitrate (mg/L)	4.7	3.7	3.8 4.0666666667	1.5	45
Phosphate (mg/L)	0.6	1.9	1.1 1.2	< 0.01	2
Chloride (mg/L)	1798	2043	2010 1950.333333	74	600

COD (mg/L)	50	115	100 88.33333333	30	5
BOD (mg/L)	12	23	20 18.33333333	6	5
DO (mg/L)	15	12	13 13.33333333	18	6
Colour	Clear	Turbid	Clear	Clear	-
Odour	Chocking	Not offensive	Not offensive	Odourless	-
Taste	Sour	Salty	Tasteless	Tasteless	-

Figure 2

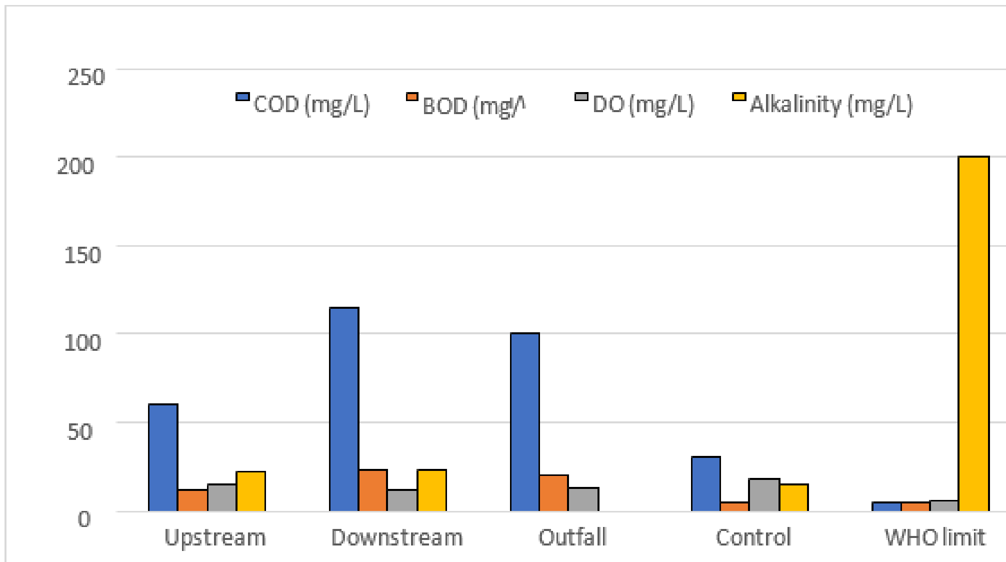

Figure 2 COD, BOD, DO and Alkalinity of Aleto Stream

Table 2

Table 2 Mean concentration of heavy metals in Aleto stream

Parameters (mg/L)	Upstream Sample A	Downstream Sample B	Outfall Sample C	Aleto stream mean	Agbonchia Control	WHO limit
Iron (Fe)	0.488	0.499	0.49	0.495333333	0.142	1.0
Zinc (Zn)	0.094	0.094	0.095	0.094333333	0.061	15.0
Cadmium (Cd)	0.055	0.053	0.051	0.053	0.022	0.01
Lead (Pb)	0.358	0.386	0.419	0.387666667	0.11	0.05
Chromium (Cr)	0.131	0.141	0.152	0.141333333	0.018	0.05
Arsenic (As)	<0.01	<0.01	<0.01	<0.01	<0.01	0.5

Figure 3

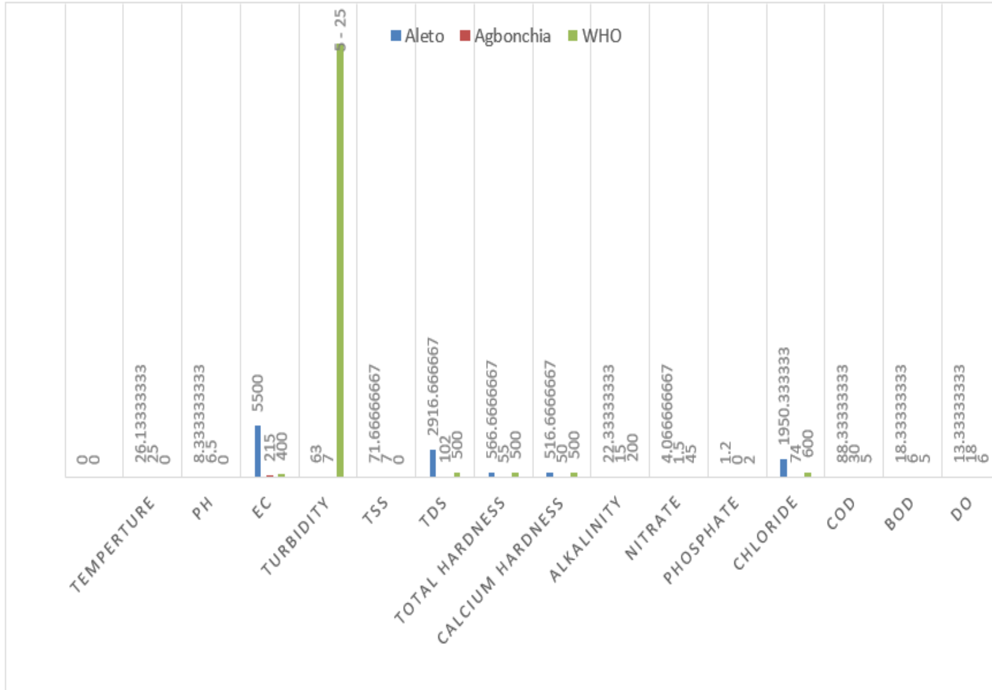

Figure 3 Physico-chemical parameters of Aleto Stream

Figure 4

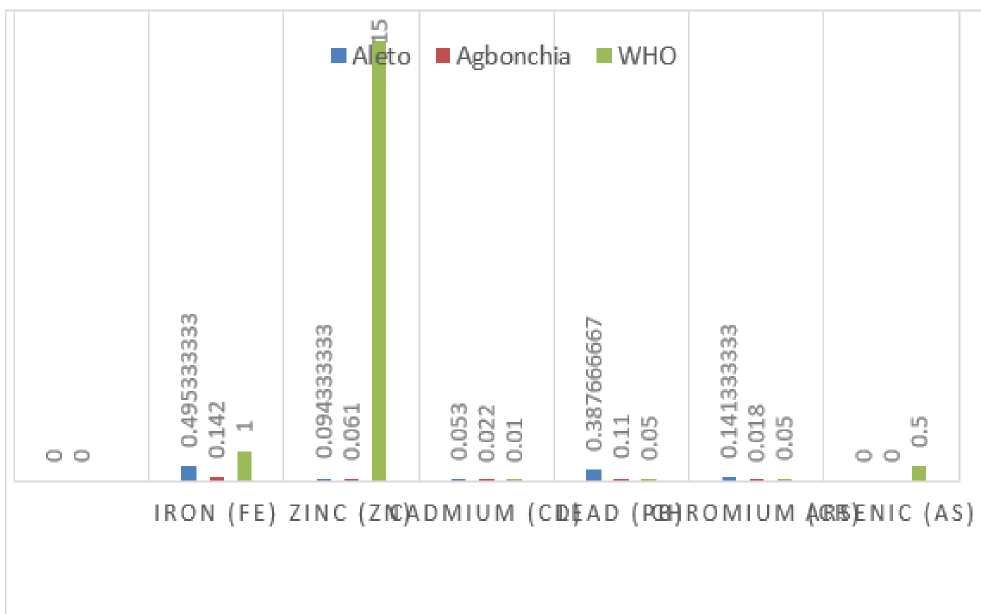

Figure 4 Heavy Metal Concentrations of Aleto Stream

Figure 5

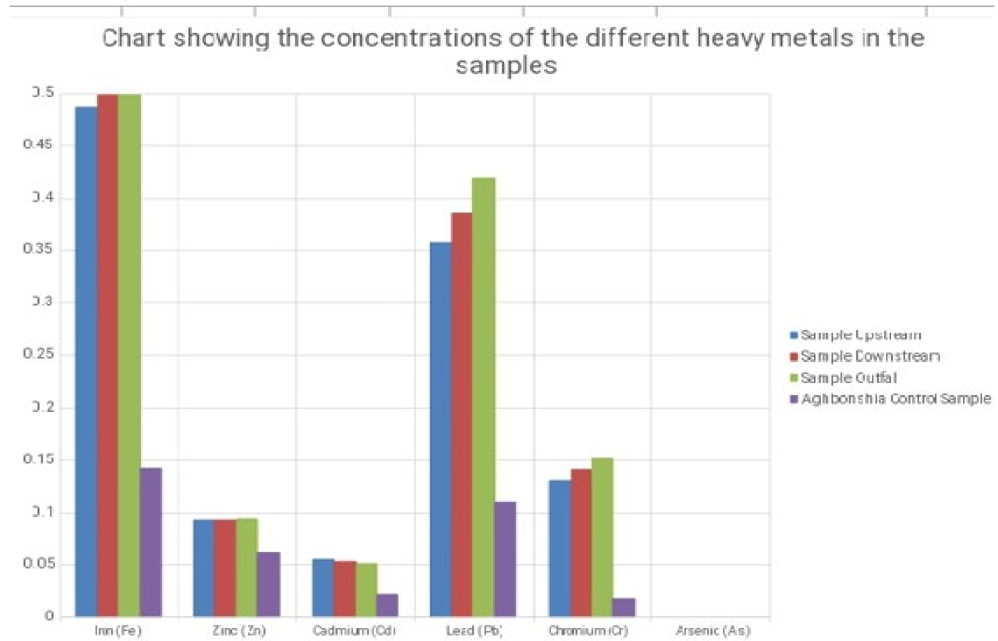

Figure 5 Concentrations of heavy metals in the samples

The temperature of water samples was in the range of 25.0-26.3oC. The temperature values were however lower than 29.27-29.87oC recorded by Sorsa et al. (2015) The values of temperature obtained from all the studied sites were within WHO maximum value Table 1 pH indicates deterioration of water quality. The pH values ranged between 6.5 – 8.4. The pH of the upstream, downstream and outfall were 8.3, 8.4 and 8.3 respectively indicating that the samples were slightly alkaline. The pH of the control was found to be 6.5 which are slightly acidic. Similar results were obtained by Gbarakoro et al. (2020) but lower than 9.88 and 9.87 values documented by Sorsa et al. (2015) The slight variation in the pH can be attributed to industrial effluent received by the stream and it could be a threat to downstream users since the stream is used by inhabitants in the area.

Electrical conductivity (EC) of Aleto stream ranged from 5400µs/cm to 5600 µs/cm. The EC shows higher values in the upstream, downstream and outfall. The higher amounts of EC could be attributed to high amount of dissolved solids in ionized form as cations and anions. The high values may be due to discharge of effluent into the stream. The EC in all the samples except control was noticeably higher than the WHO tolerable limit and the values recorded by Otokunefor and Obiukwu (2005) Sorsa et al. (2015) and Gbarakoro et al. (2020).

Turbidity is the cloudiness in water. In the analysed samples, turbidity was found to range from 39-90 NTU. The turbidity was generally high likely as a result of elevated dissolved solids and suspended matters due to abattoir activities and dumping of waste. The turbidity values of Aleto stream were far lower than the values reported by Wakawa et al. (2008) but exceeded the values reported by Rout et al. (2003) and maximum turbidity values by WHO.

A total dissolved solid is an indication of the amount of inorganic substance dissolved in water. The values ranged between 2780 mg/L - 3020 mg/L, far above the values obtained by Otokunefor and Obiukwu (2005) Siyanbola et al. (2011) and

Sorsa et al. (2015) who worked on industrial effluents. Any water which contains values greater than 1200 Mg/L of the total dissolved solids is not potable and more than 500mg/L of TDS causes cancer Otokunefor and Obiukwu (2005) The values of TDS in samples A, B, and C were above WHO maximum allowable limit and values reported by Rout et al. (2003)

The value of total suspended solid (TSS) of Aleto stream ranged from 55-100 mg/l in samples A, B and C. They were slightly higher than that of Gbarakoro et al. (2020)

The total hardness values for all the sites apart from the control ranged from 550-600 mg/L and were higher than WHO limit, and the ones recorded by Rout et al. (2003) The total hardness may be due to dissolve minerals such as Ca2+, Fe2+, and Mg2+ and anions such as CO3- and HCO3- Chandan et al. (2017)

The calcium hardness in samples A and C were within WHO permissible limit while sample B was slightly above the WHO permissible limit Figure 1. The values were generally less than the ones reported by Gbarakoro et al. (2020) The presence of calcium ions in the study area could be ascribed to geology of the area as calcium occurs as a result of leaching of rocks containing limestone Chandan et al. (2017).

The alkalinities of samples A, B, C, and control were within WHO maximum allowable limit but slightly below the values obtained by Gbarakoro et al. (2020). However, the results are not in line with Rout et al. (2003) who had elevated levels of alkalinity.

The nitrate was generally higher than the phosphate. However, the values fell within the maximum permissible limits by WHO. The nitrate values are very close to 4.87 and 3.97 reported by Sorsa et al. (2015) for the two sites but below the ones documented by Gbarakoro et al. (2014) for Luubara creek. Nitrate concentrations in the stream could be due to dumping of effluents and run-off from agricultural lands. The concentration of phosphate ranged from 0.6-1.9 mg/L. These levels were within WHO maximum allowable limits. The low phosphate level could be as a result of the geology of the area. This is in line with similar work carried out by Adeyemo et al. (2008)

The chloride level recorded for Aleto stream is in the range of 1798 mg/L – 2043 mg/L. All values were higher than that of control (74 mg/L) and WHO maximum allowable limit. The high presence of chloride in the downstream could be attributed to the discharge of household waste which might contain a large amount of chlorides Addo et al. (2013) Gebreyohannes et al. (2015) Bohlke (2002) enumerated how chloride gets into natural water to include chloride in solution with minerals and rocks and pollution from waste waters which emanate from the industries, houses, and agricultural activities.

In Aleto stream, the COD and BOD parameters are not in agreement with standard data as stipulated by WHO (5 mg/L). The COD ranged from 50-100 mg/L for the water samples while BOD ranged between 12-23 mg/l for the water samples. The high COD in this study is in agreement with Gbarakoro et al. (2020) indicating that organic and inorganic matters are present in the water. This could be an indication of organic pollution since run-off from catchments areas washed fertilizers from agricultural landsinto the stream. Generally, the COD values are higher than the BOD in the stream. Elevated levels of COD and BOD lower the DO content in river waters Gebreyohannes et al. (2015)

The level of dissolved oxygen (DO) in water samples was found to be in the range of 12-15 mg/L. The DO in the sample was found to be lower than the control (18 mg/L) but far above WHO permissible limit and the values obtained by Wakawa et al. (2008) Ewere et al. (2014) Gbarakoro et al. (2014) and Raji et al. (2015) A Moving stream is supposed to have high DO as it provides river water with natural self-purification capacity. Lower levels of Oxygen in water are an indication of microbial contamination or corrosion of chemical substance in the aquifer Olumuyiwa et al. (2012)

From sensory test, sample A, C and control were clear and sample B was turbid. The turbidity of sample B could be caused by suspended or dissolved materials and organic matters associated with human activities in the stream.

The results of the AAS showed the presence and concentrations of heavy metals and followed the order of Fe>Pb>Cr>Zn>Cd>As in all the study sites Table 2 and Figure 3 The results are generally lower than the values documented by Abubakar et al. (2015) who worked on same heavy metals. From Table 2 it may be observed that the values for Cd, Pb and Cr are far above the W.H.O maximum allowable concentration. The other metals (Fe and Zn) have values below the maximum allowable limit recommended by W.H.O and above values reported by Rout et al. (2003) The results did not however, agree with Shanbehzadeh et al. (2014) and Oguzie and Okhagbuzo (2010) Arsenic was virtually absent in the stream. The results indicated that the stream is polluted with heavy metals. These pollutants could be as a result of urban, agricultural, and industrial effluents and other anthropogenic sources which are discharged into the stream.

Table 3

Table 3 Oneway ANOVA for Physico-Chemical Properties

		Sum of Squares	df	Mean Square	F	Sig.
Values	Between Groups	101809701.5	14	7272121.538	2319.125	.000
	Within Groups	94071.52	30	3135.717		
	Total	101903773.1	44			
Samples	Between Groups	.000	14	.000	.000	1.000
	Within Groups	30.000	30	1.000		
	Total	30.000	44			

Table 4

Table 4 Oneway ANOVA for Heavy Metals

		Sum of Squares	df	Mean Square	F	Sig.
Values	Between Groups	.596	5	.119	657.28	.000
	Within Groups	.002	12	.000		
	Total	.598	17			
Samples	Between Groups	.000	5	.000	.000	1.000
	Within Groups	12.000	12	1.000		
	Total	12.000	17			

The above ANOVA results suggest that there is statistically significant difference in the mean values of the parameters in the three different streams or water sources. The F-statistics value is very high, that is, 2319.125, with a probability value of 0.00 which is less than 0.05 and

657.280, with a probability value of 0.00 which is less than 0.05 respectively.

Ho is failed to be accepted in both. The hypothesis tested is that: there is no significant difference in the mean concentration of the parameters (physico-chemical properties and heavy metals).

4. CONCLUSION

The research work has shown that the upstream has low levels of samples analysed while the outfall and downstream have high values. Physico-chemical parameters such as EC, turbidity, COD, BOD, TDS, DO, total hardness, colour, taste, and odour were above the W.H.O permissible limit. This suggests that the effluent discharged from nearby companies and abattoirs into Aleto stream could be responsible for the deterioration of the stream as it affects both human and aquatic dwellers, thereby causing undue stress on the stream. Therefore, the stream should be monitored regularly to keep record of any changed condition of the quality of the stream so as to avert any outbreak of health disorders. Also, abattoir activities at the bank of the stream should be discouraged.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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