THE EFFECT OF INDUSTRIAL EFFLUENTS ON THE QUALITY OF GURAH-LOH-MANCHA STREAM WATER IN JOS, NIGERIA

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Abstract: This study was conducted to evaluate the effect of industrial effluents on Gurah-Loh-Mancha stream water, Jos, Nigeria. Water samples were collected from four sampling points along the length of the Gurah-Loh-Mancha stream that serves as the Industrial waste effluents dump sites. The Samples were analyzed for physicochemical parameters by classical methods and heavy metal concentrations were determined by Spectrophotometric method using Agilent MP-AES 4210 Spectrometer. The result of the study was analyzed using ANOVA. The study revealed that the industrial effluent discharge into the stream water has a high degree of physicochemical parameters; Color (393.0 ±4.24 mg/l) and Turbidity (20.33± 1.53 NTU) maximum values were found to be above WHO/FEPA health-based permissible standard of 15 TCU and 5 NTU, respectively. But in heavy metals, Cd (0.07±0.01 mg/l), Pb (0.135±0.148 mg/l) maximum values were > WHO limit 0.003 and 0.01 mg/l respectively and Mo (0.015±0.070 mg/l) maximum value > FEPA/WHO (0.01 mg/l). Gurah-Loh-Mancha stream water quality became deteriorated due to the high degree of pollutants discharged into it which makes it unfit for human use, hence the need for treatment before discharge.

Keywords: Industrial effluents, heavy metals, physicochemical parameters, stream water

Introduction

Water is a precious natural resource that exists on earth, thus the current concern to quality environment that focused on water quality due to its significant role to human and ecosystem (Mahananda *et al*., 2010 and Yusif *et al.*, 2018). Availability of sufficient drinking water continues to be a major problem in the public health, because of its importance to the environment, which is also essential for the survival of all living things such as plants and animals, hence the need to maintain it clean and unpolluted (USEPA, 1991; Postel, 1997; Yusif *et al*. 2018). Drinking water is the water that it's organoleptic, physicochemical, and biological properties that meet human biological needs and have neither color nor smell. Drinking water taste is determined by the presence of physiologically necessary salts of calcium, magnesium, sodium, and potassium in corresponding concentrations without which metabolism in the human organism is impossible (Goncharuk, 2013).

Wastewater is any water that has been adversely contaminated by organic pollutants, bacteria and microorganisms, industrial effluent or any compound that deteriorated its initial quality (Ellis, 2004**)**. Therefore, WHO/EPA health guidelines and legislation stated that water suitable for drinking should contain some parameters such as microorganisms in low amount such that the risk of acquiring waterborne infection should be below acceptable limit (Zan *et al*., 2011). In industrialized nations, high standards of drinking water are set for its quality and safety (Bishnoi and Arora 2007; Akoto and Adiyiah, 2007). Rapid urbanization of rural areas, industrialization and population growth have been the major causes of stress on the environment leading to serious problems to human being and climatic changes as reported by Bay *et al*. (2003). WHO estimates that more than 20% of the world population has no access to safe drinking water and that more than 40% of all population lack adequate sanitation (Oastridge *et al.*, 1999; Ogwu and Ogu, 2014). Poor water quality is still a significant problem in many parts of the world.

Wastewater from industries and sewage spillages from burst pipes in urban areas in Nigeria are released into water bodies. With the prevailing hard economic situation in the Country, most of the effluents are released into the water environment untreated or partially treated. Most Industrialists in Nigeria have adopted the use of substandard treatment methods that partially treat and, in most cases, forgo the effluent treatment process in their bid to minimize cost and maximize profit. Several industries are located in close proximity to the river and some of them do not have well-established sewage treatment facilities, therefore effluents from these industries are directly discharged in the river exclusively without adequate treatment which results in nutrient enrichment, the accumulation of toxic compounds in biomass and sediments (Ogwu and Ogu, 2014).

Nigeria being one of the most populous and industrialized country in West Africa has been facing water-borne related diseases. Jos the State capital of Plateau State has a land mass of 26,899 square kilometers located at North Central Geopolitical Zone of Nigeria with an estimated population of about 3.5 million people. This population is not stagnant but is growing daily which leads to the high demand for portable drinking water, which is very significant for the health of the populace.

From the afore mentioned background, the main aim of the study is to investigate the effect of industrial effluent on the quality of Gurah-Loh-Mancha stream water. Specifically. The sought to

1. Determine the physicochemical parameters of industrial Effluent and Gurah-Loh-Mancha stream water.
2. Determine heavy metalsfrom industrial Effluent and Gurah-Loh-Mancha stream water.

Materials and Methods

Sampling sites

The Gura-Loh-Mancha wastewater sampling stream is located at Latitude $9^0 52' 30''$ North and at Longitude $8^0 52' 30'$ East (Fig. 1). The industrial effluent from chemical industrythat produces detergents, and the stream water samples were sampled and collected at four different locations of the stream using the method that was used by Danazumi and Bichi (2010). The sampling Points are: (1) the industrial effluent outlet, (2) the upper part of the stream, (3) the industrial effluent-stream water junction and (4) stream water lower part of the stream.

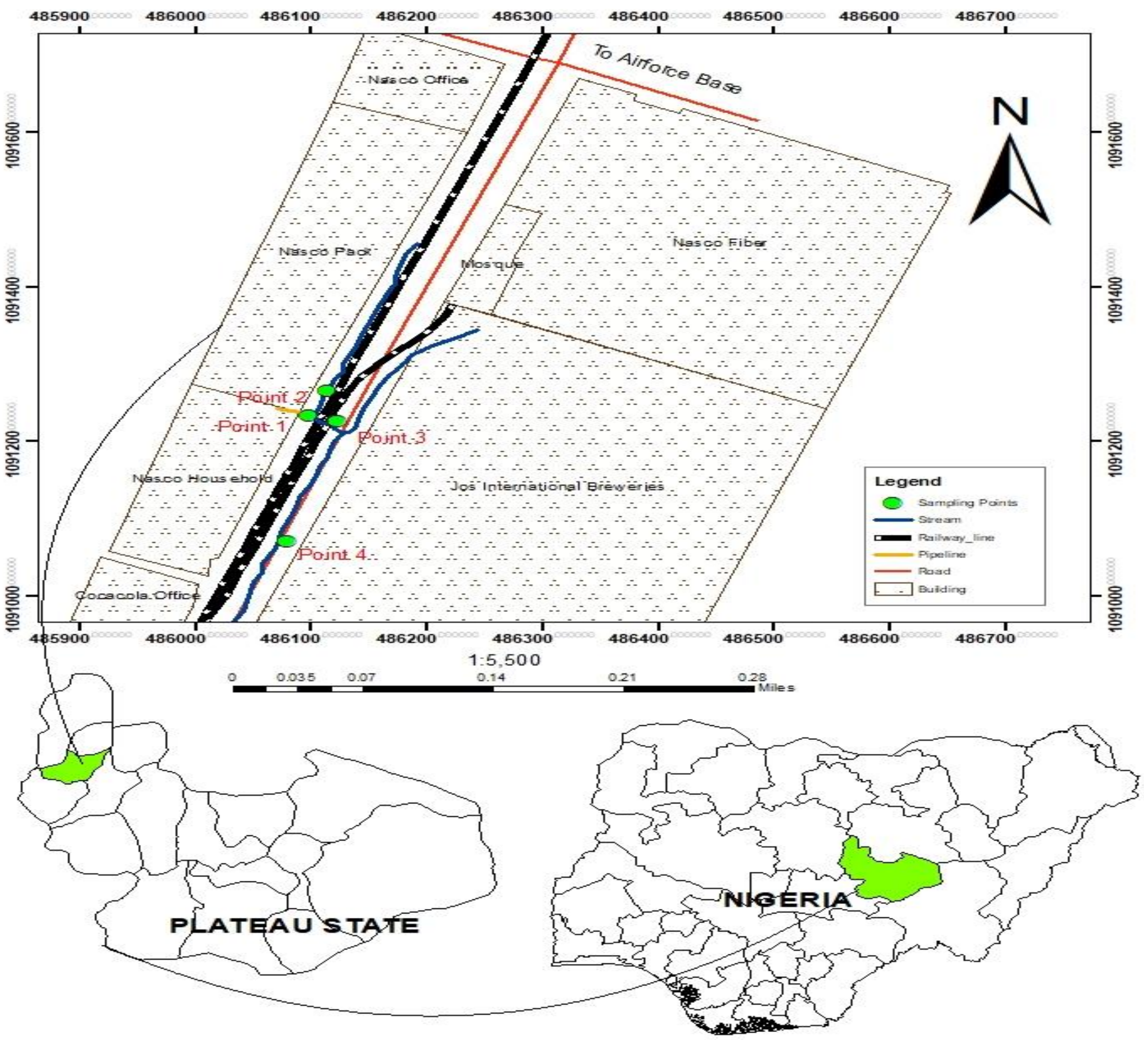

Fig. 1: Industrial effluent sampling site on Gurah-Loh-Mancha Stream in Jos, Nigeria

Sample collection

Water samples were collected from four different points along Gurah-Loh-Mancha stream in Jos, Plateau state.In each sampling point 4L in triplicate of water samples were collected inside plastic gallons and composite samples were made and labeled before being stored in a deep freezer for analysis.

Sample pre-treatment and preservation

One-liter sample was collected and mixed to form a composite from each point within and outside the premises of the industry. Polyethylene bottles were used for the sample collection. The containers used was carefully washed with 1% HNO_3 acid and rinsed with tap water and distilled water. The samples weredrained and collected after rinsing. Temperature, pH, and conductivity were measured immediately after sample collection. The samples were labeled appropriately and transported to the laboratory where it was refrigerated at 4^oC prior to analysis (Olaniyi *et al.,* 2012).

Analytical methods

Physicochemical parameters

The physicochemical parameters of Gura-Loh-Mancha stream water samples were analyzed using standard methods. Temperature and DO were determined by using HANNA meter model HI 9146, TDS, pH, and EC were analyzed using HANNA Meter Model HI 9813-5.TSS of the samples was analyzed by filtration method. PO_4, P_2O_5 and SO_4 were analyzedusing Spectrum Lab 23A spectrophotometer, while Chlorine,Turbidity andColor was analyzed using DR/890 Colorimeter.Carbonates andCOD of the samples was analyzed using titrimetric method, and BOD_5 of the sample was determined by incubation method.

Determination of heavy metals

The method that was outlined by Balaram *et al*. (2014) was adopted for the analysis of Cd, Co, Cr, Fe, Li, Mn, Mo, Ni, Pb and Zn in the samples using Agilent Microwave Plasma Atomic Emission Spectrometer (MP-AES 4210).

Results and Discussion

The results of the physicochemical analysis of the industrial effluent and the stream water obtained from Gura-Loh-Mancha stream are presented in Table 1. The concentrations of heavy metals in the different samples are given in Table 2.

Table 1: Physicochemical parameters of industrial effluent and Gura-Loh-Mancha stream water, Jos

Parameter	Samples			
	Point 1	**Point 2**	**Point 3**	**Point 4**
pH	6.23 ± 0.06	5.17 ± 0.06	4.93 ± 0.06	4.97 ± 0.06
Col. NTU	393.0 ± 4.24	32.5 ± 3.54	64.00 ± 1.41	22.50 ± 0.71
TSS mg/l	102.5±3.50	107.5±10.61	197.0±4.24	299.0±1.41
TDS mg/l	333.0 ±4.24	91.5±2.12	128.0±1.41	45.0 ±0.71
SO_4 mg/l	11.075 ±1.24	8.365 ± 0.18	9.205 ± 0.035	5.48 ± 0.141
P mg/l	0.93±0.06	1.42± 0.42	0.905± 0.02	0.925±0.007
PO_4 mg/l	2.935±0.06	4.37±0.11	2.815±0.02	2.85 ±0.01
P_20_5 mg/l	2.215±0.02	3.17± 0.23	2.10± 0.014	2.11±0.014
Cl mg/l	0.70 ± 0.14	0.20 ± 0.00	0.20 ± 0.00	0.30 ± 0.00
CO_3 mg/l	218.0±1.41	71.50±0.71	106.05±0.21	50.1 ±0.42
COD, mg/l	40.53 ± 2.51	28.42 ± 2.10	27.91 ± 1.75	21.92 ± 0.80
Turb. NTU	20.33 ± 1.53	8.00 ± 1.00	7.67 ± 0.58	12.33 ± 0.58
DO mg/l	6.67 ± 0.15	6.83 ± 0.25	6.53 ± 0.06	7.20 ± 0.26
EC, µs/cm	1253.33 ± 5.77	353.33 ± 5.77	486.67 ± 5.77	173.00 ± 5.20
BOD5 mg/l	4.83 ± 0.15	2.47 ± 0.21	4.77 ± 0.06	2.97 ± 0.21

Table 2: Heavy metal concentration in Gura-Loh-Mancha stream water, Jos

Heavy metals	Samples			
	Point 1	**Point 2**	**Point 3**	**Point 4**
Cd	0.07 ± 0.01	0.04 ± 0.03	0.06 ± 0.01	0.055 ±0.06
Co	0.22 ± 0.310	0.005 ±0.007	0.005 ± .007	0.005 ±0.007
Cr	0.01 ± 0.000	0.01 ± 0.000	0.005 ±0.007	0.01 ± 0.000
Fe	0.31 ± 0.170	0.18 ± 0.084	0.215 ±0.050	0.24 ± 0.311
Li	0.255 ± 0.148	0.135 ± 0.190	0.145 ± 0.205	0.165 ± 0.233
Mn	0.04 ± 0.010	0.015 ± 0.020	0.015 ± 0.007	0.020 ± 0.028
Mo	0.015 ± 0.070	0.01 ± 0.000	0.01 ± 0.000	0.01 ± 0.014
Ni	0.000 ±0.000	0.000 ±0.000	0.005 ±0.007	0.000 ±0.000
Pb	0.135 ±0.148	0.05 ± 0.010	0.035 ±0.007	0.13 ± 0.184
Zn	0.110 ± 0.113	0.155 ± 0.040	0.170 ± 0.010	0.180 ± 0.060

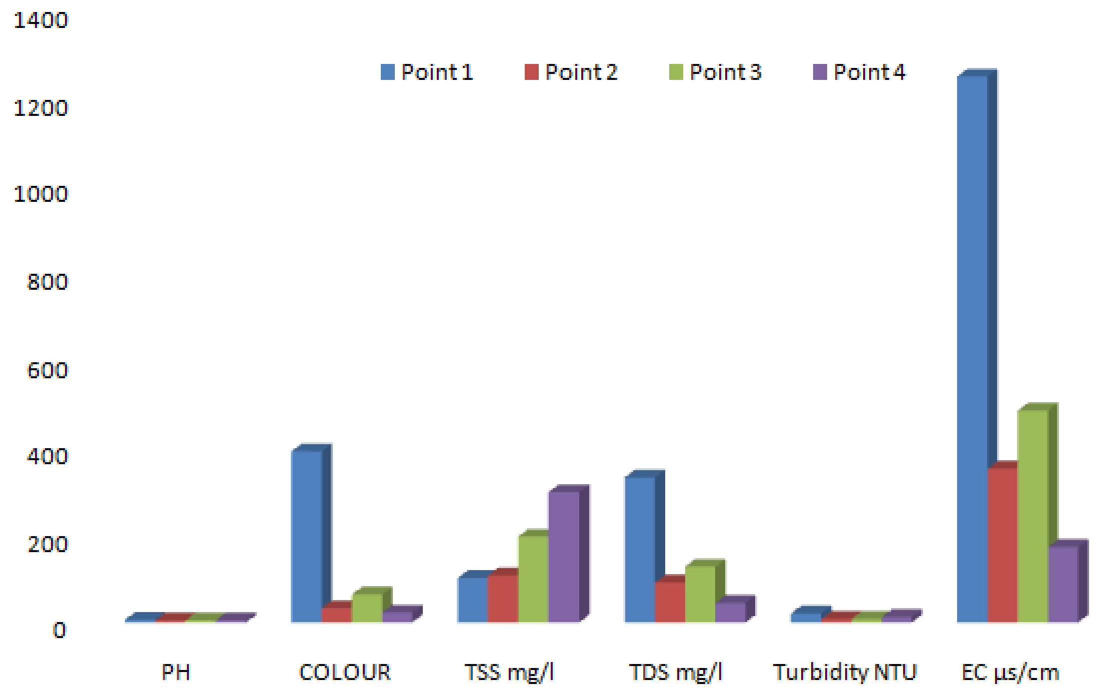

Fig. 1A: Physical parameters in Gura-Loh-Mancha stream water, Jos

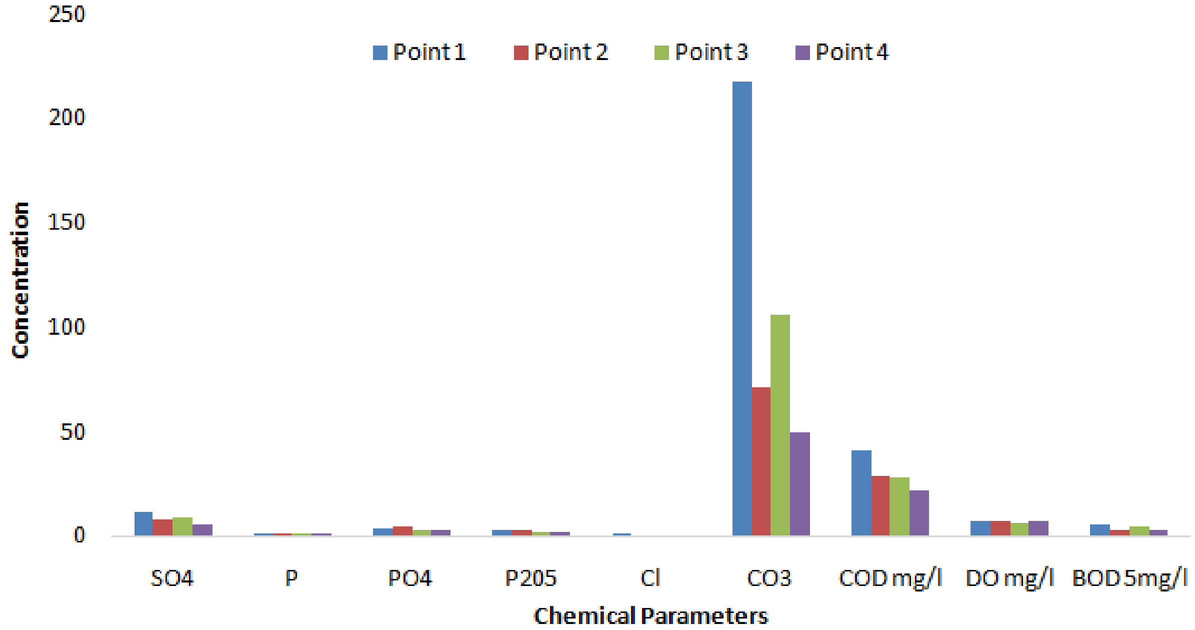

Fig. 1B: Distribution of chemical parameters in Gura-Loh-Mancha stream water in Jos

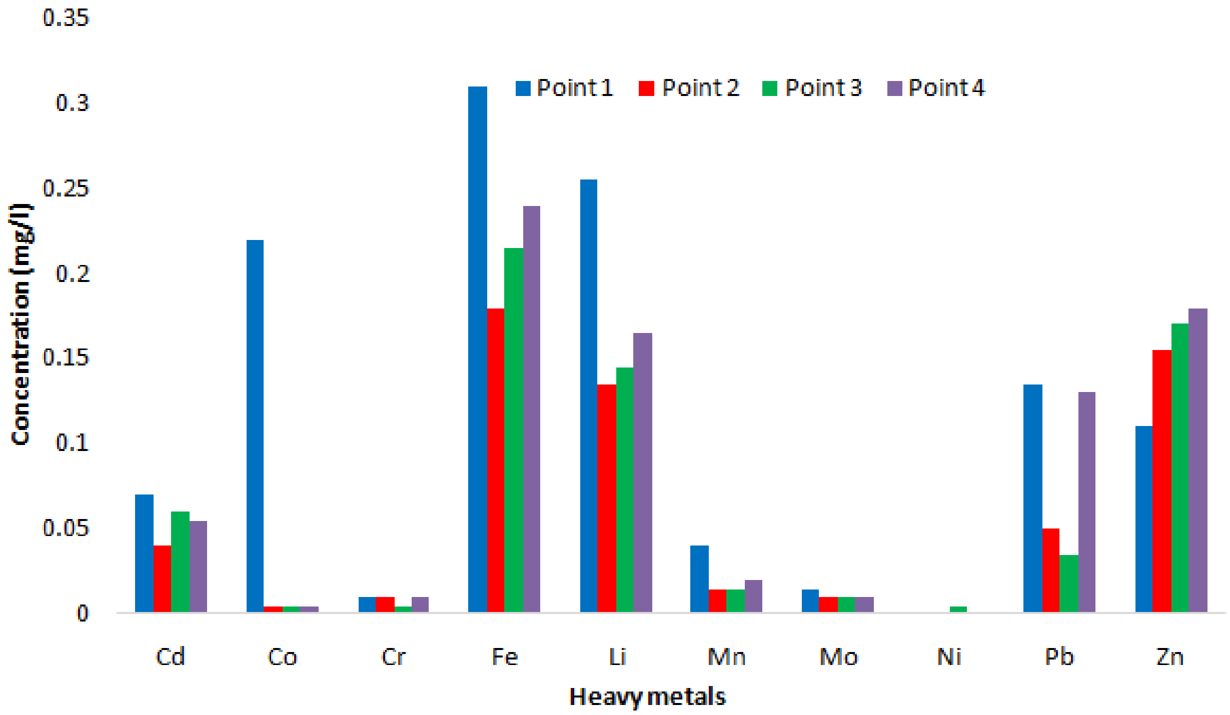

Fig. 2: Distribution of heavy metal concentrations in Gura-Loh-Mancha stream water, Jos

The results of physicochemical analysis were analyzed and presented by bar chart as shown in Figs. 1A and B and heavy metal analysis is presented in Fig. 2. These parameters can be discussed under the following.

pH: pH value is a very important determinant of water quality which denotes the presence of alkali or acid in water samples. Its high value affects chemical reactions such as metal toxicity and solubility as reported by Kataria *et al*. (2011 cited in Yusif *et al*., 2018). According to Wang *et al*. (2002), metabolic activities of ecological life depend on pH values. When pH of a stream water is too high it may be too acidic or basic, the H^+ or OH^- ion activity may disrupt aquatic organism biochemical reactions by harming or killing the stream organisms. Wastewater pH has been identified as one of the parameters that influence effective wastewater treatment as reported by Aboulhassan *et al*. (2006 cited in Mandal, 2014). The result of the analysis showed that the pH values of the samples were recorded as 6.23±0.06, 5.17±0.06, 4.93±0.06 and 4.97±0.06 in samples from Points 1, 2, 3 and 4, respectively, with a maximum and minimum values of 6.23±0.06 and 4.93±0.06 that were observed in samples from Points 1 and 4, respectively. The pH values in all the samples were found to be below EPA/WHO permissible limit of 6.5-8.5 which will cause acidosis as confirmed by the reports of WHO (2008, 2011) and Amorin (2011).

Color: in drinking water is a sign of the presence of colored organic matter. Color property was analyzed, and its value was recorded as 393.0±4.24, 32.5±3.54, 64.0±1.41 and 22.50±0.71 mg/l in sample from Point 1, Point 2, Point 3 and Point 4, respectively, with a maximum and minimum values of 393.0±4.24 mg/l and Color 22.50±0.71 mg/l in samples from Points 1 and 4, respectively. Most people can detect color above 15 TCU (True Color Unit). The values of Color in the result are all above WHO/FEPA permissible limit of 15 TCU which makes water to be unappealing to drink.

Total suspended solids (TSS): TSS was analyzed, and values recorded as 102.5±3.50, 107.5±10.61, 197.0±4.24 and 299.0±0.71 mg/l in samples from Points 1,2, 3 and 4, respectively. The maximum and minimum TSS values of 299.0±0.71 mg/l and 102.5±3.50 mg/lwere observed in samplesfrom Points 4 and 1 respectively, which can be due to the discharge of industrial effluent into the stream. The results of the analysis showed that all the values of TSS in all the samples were found to be within WHO and FEPA permissible limit of 500 mg/l and 1000 mg/l respectively, which means that when the effluent is discharged into the stream it will not constitute danger to both the environment and humanity.

Total dissolved solids (TDS): The palatability ofwater with total dissolved solids level of less than 600 mg/l is generally considered to be good and unpalatable at TDS level greater than 1000 mg/l. High level of TDS in water causes excessive scaling of pipes, heaters, boilers, and household appliances.The values of TDS in the study were recorded as 333.0±4.24, 91.5±2.12, 128.0±1.41 and 450.0±0.71 mg/l in samples from Points 1,2, 3 and 4 respectively, with a maximum and minimum values of 450.0±0.71 and 91.5±2.12 mg/l observed in samples from Points 4 and 2, respectively. The result of the study revealed thatall theTDS values were found to be below WHO and FEPA acceptable limit of 1000 and 500 mg/l, respectively which means that the effluent is safe to be discharged into the environment, which also agreed with the report of Ogwo and Ogu (2014).

Sulphate (SO_4): The presence of SO_4 in drinking water can bring noticeable taste and very high level can cause laxative effect particularly for those that are unaccustomed customers (who are not used to it). Taste impairment varies with the associated cation and its threshold ranges from 250-1000 mg/l but generally taste impairment is minimal below 250 mg/l. The result showed the values of SO_4 to be 11.075±1.24, 8.385±0.18, 9.205 ±0.035 and 5.48±0.141 mg/l in samples from Point 1, Point 2, Point 3 and Point 4, respectively, whereby maximum and minimum values of 11.075±1.24 and 5.48±0.141 mg/l were observed in samples from Points 1 and 4, respectively. The SO_4 values in all the samples were found to be below WHO and FEPA acceptable limit of 250-500 and 400 mg /l, respectively; hence, the discharge of the effluent to the environment will not be dangerous to the ecological life as confirmed by the report of Adekola *et al*. (2015) and WHO (2017).

Phosphorus (P): Phosphorus values were recorded as 0.93±0.06, 1.42±0.42, 0.905±0.02 and 0.925±0.007 mg/l in samples from Points 1, 2 and 3 respectively, which showed a maximum and minimum values of 1.42±0.42 mg/l and 0.905±0.02 in samples from Point 2 and Point 3. The values of the Phosphorus result in all the samples were found to be below FEPA acceptable limit of < 5 mg/l but are all significantly above WHO maximum permissible limit of 0.5 mg/l which will cause eutrophication effect on ecology (overgrowth of vegetation) due to high concentration of plant nutrients in the bodies of water that may end up releasing toxins(cyanotoxins) by blue-green algae. The high value of phosphorus that was discovered in the study can be due to the discharge of industrial effluent coupled with other waste of diverse compositions into the stream which also agreed with the report of Ogwo and Ogu (2014).

Phosphate (PO_4): Phosphate value in the result was recorded as 2.935±0.06, 4.37±0.11, 2.815±0.29 and 2.85±0.01 mg/l in samples from Points 1, 2, 3 and 4, respectively. But maximum and minimum sample values of 4.37±0.11 and 2.815±0.2 mg/l was observed in samples from Points 2 and 3, respectively. The concentration values of Phosphate in all the samples in the result were found to be below FEPA acceptable limit of < 5 mg/l but were above WHO health-based permissible limit of 0.5 mg/l which will cause the same danger as reported of Phosphorus above (eutrophication and the release of toxins by blue-green algae).

Peroxide (P_2O_5): The results of the analysis showed that P_2O_5values were recorded as 2.215±0.02, 3.17±0.23, 2.10±0.014 and 2.11±0.014 mg/l in samples from Point 1, Point 2, Point 3 and Point 4, respectively. Maximum and minimum values of 3.17±0.23 and 2.10±0.014 mg/l were observed in samples from Point 2 and Point 3, respectively. The result also revealed that the P_2O_5 values in all the samples are within the safe limit of 35 mg/l which means if discharge to the environment it will not be harmful to both humans and aquatic life.

Chlorine (Cl): The values of Chlorine revealed in the study was recorded as 0.70±0.14, 0.20±0.00, 0.20±0.00 and 0.30±0.00 mg/l in samples from Points 1, 2, Point 3 and 4 respectively, with samples from Point 1 and (Points 2 and 3) having maximum and minimum values of 0.70±0.14 and 0.20±0.00 mg/l, respectively. The values of Clin all the samples are below WHO and FEPA health-based permissible limit of 250 mg/l which is safe to be discharged into the eco system without any treatment.

Carbonates (CO_3): The result of the study showed that the concentration values of Carbonate were recorded as 218.0±1.141, 71.50±0.71, 106.05±0.21 and 50.1± 0.42 mg/l in samples from Points 1, 2, 3 and 4, respectively. Maximum and minimum concentration values of 218.0±1.141 mg/l and 50.1± 0.42 mg/l were observed in samplesfrom Point 1 and Point 4. The values ofCO_3in all the samples were found to be below WHO acceptable limit of 125-350 mg/l except that from Point 1 whereby the value was above WHO acceptable lower limit which may cause hardness of water by endangering the ecological life except if properly treated before discharge which agreed with the report of WHO (2017).

Chemical oxygen demand (COD): The chemical oxygen demand (COD) is a measure of water and is an integral part of wastewater management quality. The COD test is used to monitor water treatment plant efficiency. The COD is the amount of oxygen consumed to chemical oxidize organic water contaminants to inorganic end products. In addition, it is used to estimate Biochemical Oxygen Demand (BOD) because of the strong correlation that exist between them, however, COD is much faster and more accurate. COD and BOD are both function of DO and decrease in DO leads to increase in both COD and BOD values (Siyambola *et al*., 2011). When COD is higher than the acceptable limit it will in the other hand also increase the amount of oxidizable organic material in the water thereby reducing the DO and then causing anaerobic conditions that will be harmful to aquatic life. The result of the analysis showed that COD values were recorded as 40.53±2.51, 28.42±2.10, 27.91±1.75 and 21.92±0.80 in samples from Points 1, 2, 3 and 4, respectively whereas maximum and minimum values of 40.53±2.51 and 21.92±0.80 were observed in samples from Points 1 and 4 respectively. The values of COD in all the samples were found to be below the FEPA permissible limit of 1000 mg/l as confirmed by the reports of FEPA (1991); WHO (2004); Ogwo and Ogu (2014).

Turbidity: It is an optical property that broadly describes the clarity or cloudiness of water. Turbidity is related to color but is more to do with loss of transparency which results from the effect of suspended particles and colloidal materials such as clay, silt, finely organic and inorganic matter, soluble colored organic compounds, plankton, and other microscopic organisms. Turbid water has muddy or cloudy appearance that looks unattractive, and turbidity increases as sewage becomes stronger as reported by Mandal (2014). The result of the study revealed that turbidity values were recorded as 20.33±1.53 NTU, 8.00±1.00 NTU, 7.67±0.58 NTU and 12.33±0.58 NTU in samples from Points 1, 2, 3 and 4 respectively. Maximum and minimum values of 20.33±1.53 NTU and 7.67±0.58 NTU were observed in samples from Points 1 and 3 respectively, and turbidity values in the samples were found to be above WHO permissible limit of 5 NTU, hence, the need to properly treat the effluent water before discharging into the stream in order not to endanger the aquatic life which agreed with the report of WHO, 2008 and 2011**.**

Dissolved oxygen (DO): It is a measure of the amount of oxygen (O_2) dissolved in water for living aquatic organisms. Oxygen gets into the water by diffusion from atmosphere, aeration of the water as it tumbles over rocks and waterfalls and as a product of photosynthesis. The result of the analysis revealed that the DO values were recorded as 6.67±0.15, 6.83±0.06, 6.53±0.06 and 7.20±0.26 for samples from Points 1, 2, 3 and 4, respectively. The maximum and minimum values of 7.20±0.26 and 6.53±0.06 were observed in samples from Points 4 and 3 respectively. The result showed that all the value of DO are within FEPA minimum level of not less than 2 Mg/l and WHO permissible limit of 5.0 mg/l as confirmed by the reports of FEPA (1991), Ogwo and Ogu (2014).

Electric conductivity (EC): This is a measure of water ability to conduct an electric current which depend on the amount of dissolved minerals in the water (Pandey *et al*., 20100). Electrical conductivity is a good and rapid method for measuring the amount of total dissolved ions as it is related to total solids found in water sample as reported by Singh *et al*.2010. The results of the study showed that the values of EC were recorded as 1253.33±5.77, 353.33±5.77, 486.67±5.77 and 173.00±5.20 µs/cm in samples Point 1, Point 2, Point 3 and Point 4 respectively. But maximum and minimum values of 1253.33±5.77 and 173.00±5.20 µs/cm were observed in samples from Points 1 and 4, respectively. The values of EC determined in all the samples were found to be below WHO permissible limit of 600 µs/cm except sample from Point 1 which may be attributed to the high level of total solids found in the waster sample due to impurities thereby making the water unfit drinking except if treated which confirmed by the report of Yusif *et al.* (2018).

Biochemical oxygen demand (BOD): It is the amount of oxygen required to decompose the organic matter in one litre of polluted water. Therefore, low BOD is an indicator of good quality water while a high BOD indicates polluted water. According to Central Pollution Control Board the limit of BOD in industrial and municipal wastewater to be discharged into the body of natural water is less than 10 ppm. (10 mg/l). The results of the study revealed that BOD values were recorded as 4.83±0.15, 2.47±0.21, 4.77±0.06 and 2.97±0.0.21 mg/l in samples Point 1, Point 2, Point 3 and Point 4, respectively. Maximum and minimum BOD values of 4.83±0.15 and 2.47±0.21 mg/l were observed in samples from Points 1 and 2, respectively. The values of BOD in all the samples were found to be below FEPA maximum permissible limit of 30 mg/l and above WHO permissible limit of 0.0 mg/l which agreed with the reports of the research conducted by Chukwu (2008), Ogwo and Ogu (2014).

Cadmium (Cd): In the result of the analysis obtainedthe concentrations values of Cd were recorded as 0.07±0.01 Mg/l, 0.04±0.03 Mg/l, 0.06±0.01 Mg/l and 0.055±0.06 Mg/l in samples from Points 1,2, 3 and 4, respectively. Maximum and minimum values of 0.07±0.01 Mg/l and 0.04±0.03 Mg/l in samples from Points 1 and 2, respectively. The values of Cd in all the samples were found to be above WHO health-based guideline permissible limit of 0.003 Mg/l (3 µg) thereby inflicting carcinogenic effect and kidney damage over people and the aquatic life which agreed with the report of WHO (2008 and 2011) guideline.

Cobalt (Co): The concentrations of Co from the result obtained were recorded as 0.22±0.310, 0.005±0.007, 0.005±0.007 and 0.005±0.007 Mg/l in samples fromPoints 1, 2, 3 and 4 respectively, whereas maximum and minimum values of 0.22±0.310 and 0.005±0.007 Mg/l were observed in samples from Points 1 and (2, 3, 4) respectively. The concentration values of Coin samples from Points 2, 3 and 4 were below WHO/FAO permissible limit of 0.05 Mg /l, whereas sample from Point 1 which was collected at industrial effluent discharge Point 1was found above. This then has the tendency to bring about chronic inflammatory or metallosis that will result in early prosthesis and tissue damage on public health and the ecological life.

Chromium (Cr): Chromium is an essential micronutrient for plants and animals. It is considered as a biological pollutant because it is toxic at high concentration especially when in the hexavalent form. Sub chronic and chronicexposure to chromic acid can cause ulceration of the skin and dermatitis, while long-term exposure can lead to liver, kidney, circulatory and nerve tissue damages. Chromium often accumulates in aquatic life, which adds to the danger of eating fish that may have been exposed to high level of chromium (Salem *et al*., 2000; Oyeku and Eludoyin 2010). The results of the analysis obtained showed that Cr concentrations were recorded as 0.01±0.000, 0.01±0.000, 0.005±0.007 and 0.01±0.000 Mg/l in samples from Points 1, 2, 3 and 4 respectively, and maximum and minimum values of 0.01±0.000 and 0.005±0.007 in samples from Points (1, 2 and 4) and 3 respectively. The values of Cr in the samples were found to be below the WHO health-based guideline allowable value of 0.05 Mg/l hence it's safe to be discharged into the environment which corresponded with the report of WHO (2008 & 2011).

Iron (Fe): Iron occurs mainly in water as ferric or ferrous state (Pandey *et al*., 2010) in suspended form which causes staining of clothes and imparts bitter taste. Excess amount of iron of more than 10 mg/kg causes rapid increase in pulse rate and coagulation of blood in blood vessels, hypertension and drowsiness. It comes into water from natural geological sources, industrial wastes, and domestic discharge and also from byproducts. It is one of the essential trace elements found insignificant concentration in drinking water because of its abundance. The deficiency of iron causesdisease such as anemia, while at high concentration it is associated with liver disease called haemosiderosi as reported by Oyeku and Eludoyin (2010). High concentration of iron in water imparts taste and promotes growth of iron bacteria that accelerate rusting process of ferrous metals that are exposed to water as reported by Rajappa *et al*. (2010) and also cited by Yusif *et al.* (2018). The concentration of Fe obtained in the study was recorded as 0.31±0.170, 0.18±0.084, 0.215±0.050 and 0.24±0.311 Mg/l in samples NH1, NH2, NH3 and NH4 respectively and maximum and minimum values of 0.31±0.170 and 0.18±0.084 Mg/l in samples from Points 1 and 2, respectively. The Fe values in allthe sample were below both FEPA and WHO acceptable limit of 20 and 1.0 Mg/l respectively in drinking water which also agreed with the report of Patil and Ahmad (2011).

Lithium (Li): Lithium from electronic waste, batteries and the earth crust can contaminate water supply. Lithium levels in water may be associated with population density, and that wastewater treatment plants aren`t currently effective at removing it from drinking water. Contamination from lithium ion batteries might come from wastewater released at industrial sites, incineration systems, illegal landfills or storage of old batteries. Lithium is prescribed to cause psychiatric disorders. The concentration values of Li found in the study were recorded as 0.255±0.148, 0.135±0.190, 0.145±0.205 and 0.165±0.233 Mg/l in samples from Points 1, 2, 3 and 4 respectively, and maximum and minimum values of 0.255±0.148 and 0.135±0.190 Mg/l in samples from Points 1 and 2, respectively. The values of Li in all the samples were found to be below FEPA/WHO permissible levels of 0.7 Mg/l.

Manganese (Mn): WHO acceptable guideline concentration of Mn for consumers is 0.1 mg/l and even at concentration of 0.2 mg/l Mn forms black precipitate coating on pipes. The concentrations of Mn from the result obtained were recorded as 0.04±0.010, 0.015±0.020, 0.015±0.007 and 0.020±0.28 Mg/l in samples from Points 1, 2, 3 and 4 respectively but maximum and minimum values of 0.04±0.010 Mg/l and 0.015±0.007 were observed in samples from Points 1 and 4, respectively. The values of Mn in all the samples were found to be below FEPA/WHO acceptable limit value of 0.1 Mg/l. Excess manganese can interfere with absorption of dietary iron, which can result in iron deficiency such as anemia. It also increases bacterial growth, and excess manganese intake can lead to hypertension in people above 40 yearswhich coincided with the report of Adewoye *et al*. (2013).

Molybdenum (Mo): The concentrations values of Mo were recorded as 0.015±0.070, 0.01±0.000, 0.01±0.000 and 0.01±0.014 Mg/l in samples from Points 1, 2, 3 and 4 respectively, with maximum and minimum values of 0.015±0.070 and 0.01±0.000 Mg/l were observed in samples from Points 1 and 3, respectively. The values of Mo in all the samples were found to be below the FEPA/WHO acceptable limit of 0.01 Mg/l except the sample from Point 1which is slightly above FEPA/WHO permissible limit of 0.01 Mg/l, meaning that the industrial effluent sample must be treated before discharging it into the environment else it will constitute danger to the environment and humanity especially those living around the industry.

Nickel (Ni): Nickel has been considered to be an essential trace element for human and animal health. The permissible limit of Nickel in plants recommended by WHO is 10 mg/kg. The maximum permissible limit for Ni in water is 0.2 mg/l Concentration of. The result of the analysis showed that the concentration of Ni was not detected in samples from Points 1, 2, and 4 except in sample from Point 3 of 0.005±0.007 mg/l which was below WHO health-based guideline permissible limit of 0.2 Mg/l which agreed with the report of Zaigham *et al*. (2012)

Lead (Pb): Lead is one of the harmful heavy metals due to its common toxicity which is very harmful even in small concentration as reported by Greoriadou *et al.* (2001). The result of the study showed that the concentration of Pb was recorded as 0.135±0.148, 0.05±0.010, 0.035±0.007 and 0.13±0.184 Mg/l in samples from Points 1, 2, 3 and 4 respectively, whereas maximum and minimum values of 0.135±0.148 Mg/l, and 0.035±0.007 Mg/l were observed in samples from Points 1 and 3, respectively. The results of the study revealed that the values of Pb in all the samples were all above WHO health-based acceptable limit of 0.01 mg/l, which then means that the industrial effluent sample must be treated before discharging it to the environment because it can enter the body through many routes such asby the uptake of food in both humanity and aquatic life and can be removed mostly through urine. It's high concentration in the body can cause permanent damage to central nervous system, or cardiovascular disease, brain, impaired renal function, hypertension, impaired fertility, accumulates in bones, kidney, lungs and spleen as confirmed by the reports of the research conducted by Salem *et al*. (2000); Akinyemi *et al*. (2019), Debnath *et al*. (2019)

Zinc (Zn): It imparts an undesirable a stringent taste to water at a threshold concentration of about 4 NTU wastewater containing Zn at a concentration above 3- mg/l opalescent develop greasy film on boiling. The accumulation of Zn that results from the collection of rain water from house roof leads to acute harm in people involves nausea, lack of moisture, tiredness, weariness, abdominal pain, inability to coordinates the muscles and kidney malfunction, Chronic doses of Zn increases the risk of developing deformation of blood cells and can damage pancreas (Varshaly *et al*., 2015). The values of Zn in the result obtained were recorded as 0.110±0.113, 0.155±0.040, 0.170±0.010 and 0.80±0.060 Mg/l in samples from Points 1, 2, 3 and 4, respectively. Maximum and minimum values of 0.80±0.060 and 0.110±0.113 mg/l were observed in samples from Points 4 and 1, respectively. The result of the study showed that the values of Zn in all the samples were found to be below EPA/WHO health- based guideline value of 5 Mg/l, hence, the effluent needs no treatment before discharge into the stream/environment as confirmed by the report of the research report conducted by Sha *et al.* (2013) as also cited by Nazir *et al.* (2015).

Conclusion

The study was conducted to analyze the effect of industrial effluentson the quality of stream water in Gura-Loh-Mancha, and to also compared their conformity with World Health Organization health-based standard set by National and International Regulatory Agencies (FEPA and WHO). The study concluded that the industry discharge effluent with a high degree of physicochemical parameters such as Color and Turbiditymaximum values were found to be above WHO/FEPA health-based permissible standard of 15 TCU and 5 NTU respectively while pH, TDS, Cl, EC, COD, BOD, Co and PO_4 were found to be within WHO/FEPA acceptable limit and in heavy metals, Cd, Pb and Mo maximum values were > WHO limit but heavy metals such asCr, Ni and Fe were found to be within WHO/FEPA acceptable limit and in heavy metals, Cd, Pb and Mo maximum values were > WHO limit. Therefore, the study revealed that Gura-Loh-Mancha stream water quality is poor due these high degrees of pollutants that were being discharged into the stream thereby deteriorating its quality which makes it unfit for human use.

Conflict of Interest

The authors declare that there is no conflict of interest related to this work.

References

Aboulhassan MA, Souabi S, Yaacoubi A & Bauda M 2006. Removal of surfactant from industrial wastewater by coagulation flocculation process. *Int. J. Envtal. Sci. Techn.*, 3(4): 327-336.

Akoto O & Adiyiah J 2007. Chemical analysis of drinking water from some communities in the Brongahafo Region. *Int. J. Envtal. Sci. and Techn.*, 4(2): 211-214.

Alhibshi E, Albriky K & Bushita A 2014. Concentration of heavy metals in underground water wells in Gharian, District, Libya. *Int. Conf. on Agric., Ecol. and Med. Sci.* (AEMS) February 6-7th, 2014, Bali (Indonesia) 35-39.

Akinyemi AJ, Miah MR, Ijomone OM, Tsatsakis A, Soares FAA, Tinkov AA, Skalny AV, Venkataramani V & Aschner M 2019. Exposure Indices Dopaminergic

Neurotoxicity in Caenorhabditis Elegance: Involvement of Dopamine Transporter. *Elsevier Toxicology Reports*. 6: 833-840.

Amorin R 2011. Assessment of the quality of bottled/sachet water in the Tarkwansuaem Municipality (TM) of Ghana. *Res. J. Appl. Sci. and Engr. Techn.*, 3: 337-385.

Balaram, V., Vummiti, D., Roy, P & Kamala, CT 2014 Micro Plasma Atomic Emission Spectrometry (MP-AES): Anew Analytical Tool for Geochemical Studies. *Article in Atomic Spectroscopy-Norwalk Connecticut*, pp. 1-15.

Bay SM, Zeng EY, Lorenson TD, Tran K & Alexander C 2003. Temporal and spatial distributions of contaminants in sediments of Santa Monica Bay, California. *Marine Environmental Research*, 56(1-2): 255 – 276.

Danzumi S & Bichi MH 2010. Industrial pollution and implication on source of water supply in Kano, Nigeria. *Int. J. Engr. & Techn., JET-IJENS*, 10(01): 76-81.

Bishnoi M & Arora S 2007. Potable ground water quality in some villages of Haryana, India: focus on fluoride. *J. Envtal. Bio.*, 28(2): 291-294.

Chukwu O 2008. Analysis of groundwater pollution from abattoir waste in Minna, Nigeria. *Res. J. Diary Sci.*, 2(4): 74-77.

Debnath B, Singh WS & Manna K 2019. Sources and toxicological effects of lead (Pb) on human health. *Indian J. Med. Specialties*, 10: 66-71.

Ellis TG 2004. Chemistry of wastewater: Encyclopedia of life support system (EOLSS). *Envtal. and Ecol. Chem.: Chemistry of Wastewater*, 2: 1-10.

FEPA 1991 National Guidelines and Standards for Industrial Effluents, Gaseous Emissions and Hazardous Waste Management in Nigeria. Government Notice (S.1.8 OF 1991) Under section 40: 21-153.

Gregoriadou A, Dedou K, Dermosonoglou D, Tsoumparis P, Edipidi C & Katsougiannopoulos B 2001. Heavy Metals in Drinking Water in Thessaloniki Area, Greece Proceedings of the 7th International Conference on Environmental Science and Technology, Greece Aristotle University,

Kataria HC, Gupta M, Kumar M, Kushwala S, Kashyap S, Trivedi S, Bhadoriaya R & Badewar K 2011. Study of physico-chemical parameters of drinking water of Bhopal city with reference to health impacts. *Current World Environment*, 6(1): 95-99.

Mahananda MR, Mohanty BP & Behera NR 2010. Physicochemical analysis of surface and ground water of Bargarh district, Orissa, India. *Int. J. Res. and Rev. in Appl. Sci.*, 2(3): 284-295.

Mandal HK 2014. Influence of wastewater pH on turbidity. *Int. J. Envtal. Res. Devt.*, 4(2): 105-114.

Nazir R, Khan M, Masab M, Ur Rehman H, Ur Rauf N, Shahab S, Ameer N, Sajed M, Ullah M, Rafeeq M & Shaheen Z 2015. Accumulation of heavy metals (Ni, Cu, Cd, Cr, Pb, Zn, Fe) in the soil, water and plants and analysis of physico-chemical parameters of soil and water collected from Tanda Dam Kohat. *J. Pharmac. Sci. Res.*, 7(3): 89–97.

Oastridge JW & Trent R 1999. Why is Freshwater an Issue for Business? Background Paper. Can 176-oatr. United Nations.CDS,9

Ogwu PA & Ogu OG 2014. Impact of industrial effluents discharge on the quality of Nwiyi River, Enugu, South Eastern Nigeria. *J. Envtal. Sci. Toxicol. and Food Sci. Techn.* (IOSR- JESTFT), 8(11): 22-27.

Oyeku OT & Eludoyin AO 2010. Heavy metal contamination of ground water resources in a Nigerian Urban Settlement. *Afri. J. Sci. and Techn.*, 4(4): 201-214.

Patil G & Ahmad I 2011. Heavy metals contamination assessment of Kanhargaon Dam Water Near Chindwara City, India. *Acta Chimica & Parmaceautica Indica*, 1(1): 7-9.

Pandey J, Shubhashish K & Pandey R 2010. Heavy metal contamination of Ganga River at Varanasi in relation to Atmospheric Deposition. *Tropical Ecology*, 51(2): 365-373.

Postel 1997 Last Oasis: Facing Water Security. New York, Norton, pp. 17-191.

Rajappa B, Manjappa S & Puttaiah ET 2010. Monitoring of heavy metal concentration in ground water of Hakinaka Taluk, India. *Contemporary Engineering Sciences*, 3(4): 183-190.

Rao CS, Rao BS & Hariharan 2010. Determination of water quality index of some areas in Guntur District Andhra Pradesh. *Int. J. Appl. Bio. and Pharmac. Techn.*, 1(1): 79-86.

Sha A, Niaz A, Ullah N, Rehman A, Akhlaq M, Zakir M, Khan MS *et al*. 2013. Comparative study of heavy metals in soil and selected medicinal plants. *Journal of Chemistry*, 5.

Salem HN, Eweida EA & Farag A 2000. Heavy metals in drinking water and their environmental impact on human health. *Int. Center of Envtal. Hazard Mitigation* (ICEHM), 542-556.

Singh MR, Asha G & Beeteswari KH 2010. Physicochemical properties of water samples from Manipur River System, India. *J. Appl. Sci. and Envtal. Mgt.*, 14(4): 85-89.

Siyambola TO, Ajanku KO, James OO, Olugbuyiro JAO & Adekoya JO 2011. Physico-chemical characteristics of industrial effluents in Lagos State, Nigeria. *Global J. Pure and Appl. Sci. and Techn.*, 1: 49-54.

USEPA 1991 Is Your Drining Water Safe? Office of Water (WH-550), EPA 570/ 9-91-005, Washington DC.

Varshaly AG, Mathew BB & Kirshnamurthy NB 2015. Health effects caused by metal contaminated groundwater. *Int. J. Advan. Sci. Res.*, 1(2): 60-64.

Wang W, Wang A, Chen L, Liu Y & Sun R 2002. Effect of pH on survival, phosphorus concentration, adenylate energy charge and Na+ - K+ ATPase activity of Penaeuschinensis Osbeck Juveniles. *Aquatic Toxicology*, 60: 75-83.

Yusif BB, Anteyi A, Bichi KA, Mu'azu AB & Chutiyami M 2018. Determination of physicochemical parameters and heavy metal levels in some well water of Gwaram Town, Jigawa, Northwest, Nigeria. *Int. J. Trend in Scient. Res. and Devt.* (IJTSRD), 2(2): 278-682.

WHO 2008 & 2011. Drinking –Water Quality 3rd and 4th Editions: Chemicals of Health Significance as Described by World Health Organization Guidelines. Appendix 2.2, 1-4.

WHO 2004. Guideline for Drinking Water Quality, 3rd Edition. World Health Organization, Geneva, 515.

Zan F, Huo S, Xi B, Li Q, Liao H & Zhang J 2011. Phosphorus distribution in the sediments of a shallow Eutrophic Lake, Lake Chaohu, China. *Environmental Earth Science*, 62: 1643-1653.