09.30.2019 BERKELEY PUBLICATION AND RESEARCH INTERNATIONAL

Journal of Env. Design & Construction Mgt Vol. 10 No.4

ENVIRONMENTAL EFFECT OF ARTISANAL AND SMALL SCALE MINING ACTIVITIES ON WATER QUALITY IN GURARA LOCAL GOVERNMENT AREA, NIGER STATE, NIGERIA

USMAN, U.S., SULEIMAN, Y.M AND YUNUSA, M.B
Department of Geography, Federal University of Technology Minna, Niger State, Nigeria

ABSTRACT

Artisanal and Small Scale Mining (ASM) activities have been identified as a major economic activity in Gurara Local Government Area of Niger State, Nigeria. This study evaluated the environmental effect of ASM activities on the environment, of Gurara LGA. The study utilized data from the ASM sites especially the soil and water samples to ascertain physicochemical parameters and heavy metal in waters. The result obtained were compared to the WHO acceptable standards. The results indicated that most of the water samples were polluted with lead, Aluminum, Zinc, among others and thus, unsafe for domestic use and aquatic life. Also, the concentration of the Lead, Aluminum and Zinc in the water sample was found to be higher than that of the control sample especially during the wet season. It has, thus, been discovered that ASM activities have significant effects on the water quality of the study area, because the water in the area. Therefore, there is the need for urgent

Introduction:

Over the years, water has been considered a vital raw material of social development and organization (Sabhapandit et al., 2010).Water has much broader influences on health and wellbeing and issues such as the quantity and quality of the water are important in determining the health of individuals and whole communities (WHO, 2011). The inadequacy of water in both quality and quantity can be intensified through pollution by effluents from anthropogenic sources such as industrial, mining activities, domestic sewage, waste water treatment plant and agricultural land which

BERKELEY RESEARCH & PUBLICATIONS INTERNATIONAL
Bayero University, Kano, PMB 3011, Kano State, Nigeria. +234 (0) 802 881 6063,
Website: www.berkeleypublications.com

ISSN: 1933-5948

measures to monitor and regulate the mining activities in the area, in order to reduce the effects on environmental quality especially the water.

Keywords: *Mining, environment, standards, physicochemical parameters.*

are directly or indirectly discharged into the aquatic environment, is a significant problem in some countries in the world (Manickum et al., 2014;Fosso-Kankeuet al., 2011).

Mining refers to the practice of extraction of mineral deposits from the surface of the earth or from beneath the surface (Ako et al., 2014). Though mining can only take place wherever minerals are present and economically feasible. The broad significance of the mining sector has been known to include foreign exchange, employment and economic development (Obaje et al., 2005). An artisanal and small-scale miner (ASM) is a subsistence miner who is not officially employed by a mining company, but works independently, mining various minerals or panning for gold using their own resources (Macdonald et al., 2014).

In Nigeria, most of the mining operations are carried out by artisanal and small scale miners which are usually surface mining carried out with little or no advanced technology to manage the ecological damages of the mining operations (Oladipo, 2006).

Artisanal and Small-Scale Mining is a means of livelihood adopted primarily in rural areas (Veiga, 2003). This is sometimes called informal sector, which is outside the legal and regulatory framework (Azubike, 2011). When not formalized, organized, planned and controlled, Artisanal and Small-Scale Mining can be viewed to be harmful by governments and environmentalists, because of its potential for environmental damage, social disruption and conflicts (Opafunso, 2010). Some of these menaces are; depletion of the environment such as land degradation, devegetation, loss of aquatic animals, water pollution and air pollution. Most artisanal and small scale miners work in difficult and often very hazardous conditions in the absence of the required safe mining regulations to safeguard the operations (Veiga, 2003).

Artisanal and Small Scale Mining operations continue to spread due to; rise in the demand for gold and unattractive nature of other means of livelihoods such as farming in the rural areas where the mineral is substantially available. Despite serious dangers posed by this activity, impact of small scale mining activities in

Nigeria economy cannot be over exaggerated. Besides minning's direct contribution to Gross Domestic Product (GDP), its activities can attract land, capital and labour, all of which are indispensable for industrialisation and economic development, particularly in developing countries.

However noxious materials are released into the environment, posing large health risk to the miners, their families and surrounding communities (Azubike, 2011). Thus, gold mining operations are particularly dangerous, as they often use mercury amalgamation process to extract gold from ores (CDC, 2010). In March 2010, Medecins Sans Frontieres (MSF) discovered an epidemy of lead poisoning in Zamfara state in North–Western Nigeria particularly in Anka and Bukkuyum Local Government Areas of the state (MSF, 2010). Subsequent investigations by the Centre for Disease Control (CDC), the World Health Organization (WHO) and the Zamfara State Ministry of Health (ZMOH) confirmed that hundreds of children under ages of five were at risk of death or serious acute and chronic health effects due to extremely high levels of lead and mercury (WHO, 2011). At least 10,000 people were estimated to be affected overall (MSF, 2010).The source of the outbreak was associated with artisanal gold ore processing that occurs in the villages (Azubike, 2011).

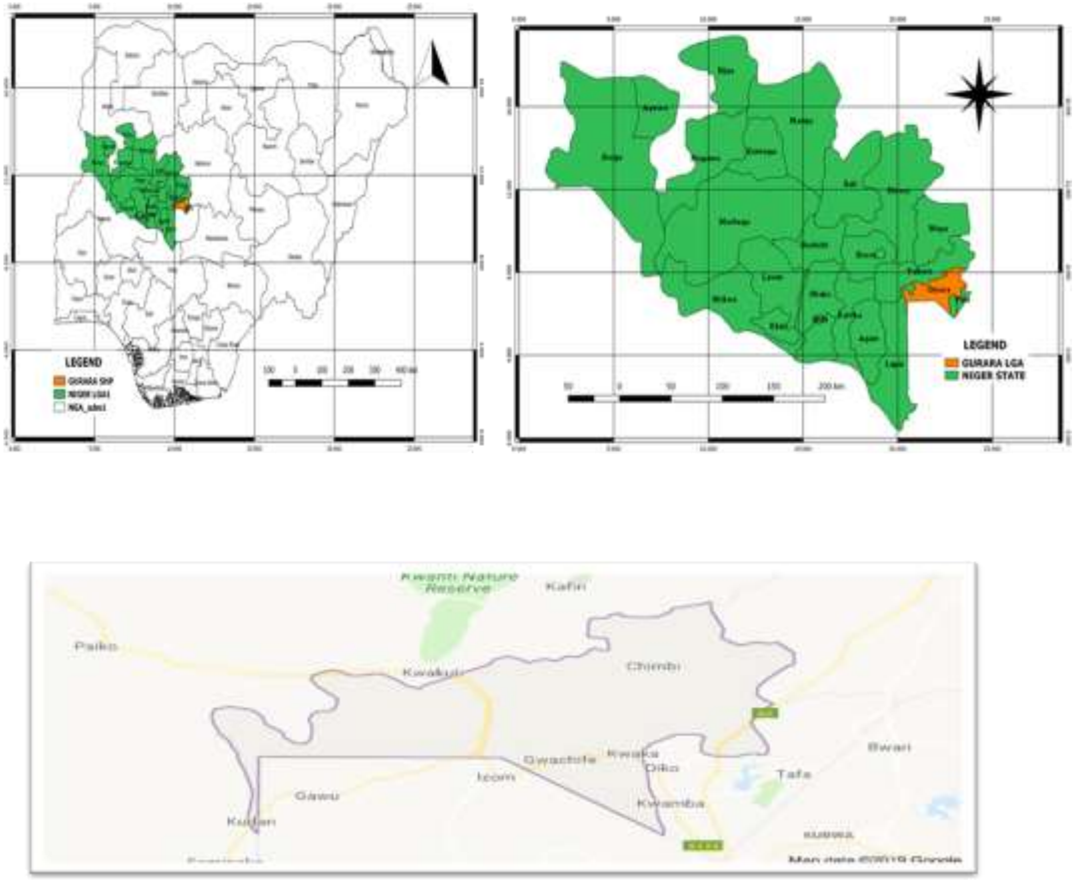
Numerous research have been conducted locally to checkmate the environmental effect of Artisanal and Small Scale Mining in Nigeria, Nganje et al., (2010) evaluated the influence of mine drainage on water quality along River Nyaba in Enugu South-Eastern Nigeria, as drainage from underground coal mines, surface mines and coal refuse piles is the oldest industrial pollution in the Enugu coal area. Ahmed, Bashir and Okafo (2011) also looked into the impacts of local gold mining on drinking water quality in Zamfara State.

Gurara and its' environs is a major lead and gold field and therefore suffer in the hands of artisanal miners. There is no substantial and detailed research work available as it relates to water quality and ASM in Gurara Local Government. The present study therefore investigates the effect of artisanal small scale mining activities on water quality in Gurara Local Government, Niger State.

Study Area

Gurara is a Local Government Area in Niger State, Nigeria, adjoining the Federal Capital Territory. Its headquarters are in the town of Gawu. Major inhabitants are the Gwari people. Gurara is home to the famous tourist recreation center: Gurara

Waterfalls, named after the Gurara River, on whose course the fall is situated. Gurara has an area of 954km2 and a population of 90,974 at the 2006 census with a coordinate of 9021'n 7005'E/ 7.3500N 7.0830E. It is known with Mineral Raw Materials: Marble, Dolomite, Silica sand, Clay, granite, Galena. (RMRDC, 2012).Gurara currently hosts a number of very active Artisanal precious and base metal mining activities.



(Source: Department of Geography, Federal University of Technology Minna Niger State)

Figure 1: The Study Area (Parts of Gurara Local Government Area, Niger State, Nigeria)

Literature Review

Hydrosphere consists of sea (97.2%) and freshwater (2.8%), including oceans, seas, rivers, lakes and underground waters (Sinha et. al., 2011). Quality of freshwaters, being small part of it is a global problem nowadays, because of thought that the water quality is a major factor affecting both humans and animals. When the parameters of water quality are enough and in tight amount, health of plants, animals and humans increase in parallel. Surface water quality of an area affects usually both natural events (such as climatic changes) and anthropogenic sources such as artisanal mining is stable pollutant sources (Wu and Wang, 2007).

Retaining water for agricultural or other purposes; increasing organic materials together with urbanizing (Mutlu, et al., 2016) and especially over increasing of phosphorus and other nutrients with use of fertilizers in agriculture causes water pollution (Easton et al., 2007). This leads to negative effects on fish sources, mortality in communities of benthic organisms, decreasing in species number and microbial growth with decrease in oxygen supply due to increase in nutrients and impaired water quality (Treseder, 2008).

The general desire to protect fresh water fisheries has led to an expansion of research into their habitat requirements, in terms of their physicochemical parameters such PH, temperature, dissolve oxygen, transparency, total alkalinity, total hardness, electrical conductivity, total dissolved solid, Biological Oxygen Demand e.t.c. The physical and chemical properties of water immensely influenced its uses, distribution and productivity of the biota (Unanam and Akpan, 2006).

Metal released from processing, dewatering or acid rock drainage can further degrade river water quality. Particularly concerning in ASGM is the widespread use of mercury amalgamation techniques in processing, although cyanide processing is increasingly being used in reprocessing of tailings (de Andrade Lima et al., 2008; Velásquez-López et al. 2011). Mercury processing emits toxic vapours, with predicted global mercury emission by ASGM to be 727 tonnes:35% of the total world anthropogenic emission of mercury (UNEP 2013). The toxicity of mercury derived from ASGM operations to people and, to a lesser extent, the environment, has been well studied (Bose-O'Reilly et al. 2010). However, the impact of AGSM operations on the broader water quality of these river and streams has been largely overlooked.

Hydrological changes in rivers can alter available hydrological habitat for aquatic biota (Blanchette and Pearson 2013), and increased turbidity may lead to smothering of aquatic plants, habitats, and biota.

To protect fresh water fisheries has led to an expansion of research into their water in terms of their physicochemical parameters such as total alkalinity, total hardness, electrical conductivity, and serve as a basis for the richness or otherwise biological productivity of the environment.

The chloride is found to be most predominating. The groundwater in Balochistan has high concentrations of fluoride, iron and nitrate in many districts. The pH part of the Durov diagram reveals that groundwater in study area is alkaline and electrical conductivity of most of samples lies in the range of drinking water standards adapted (Prabaharan et al., 2010).

From the SAR and conductivity plot it was found that most of groundwater cannot be used on soil without restricted drainage and special requirement of Management for salinity control. Comparison of data with WHO(2011) standards for drinking water indicate that the groundwater in the most of study area are suitable for drinking purpose except some few places. The ground water recorded a wide range in TDS.

A joint CDC and WHO investigation on the outbreak of acute lead poisoning in Zamfara State reported illness and deaths among children mostly under 5 years old in some communities in Bukkuyum and Anka LGAs (CDC, 2010). Based on the findings of this report and consultations with UNICEF and Zamfara State Ministry of Water Resources, the National Water Resources Institute (NWRI) deployed a technical team to carryout comprehensive assessment of the situation consisting of four (4) key components that included: (i) socio-economic assessment, (ii) water quality assessment (both physico-chemical and microbiological), (iii) sanitary inspection and hygiene practices assessment, and (iv) geochemical assessment of the processed rock and inspection of mines. This paper highlights the findings of the drinking water quality assessment. Detailed results of all the components of the assessment are given elsewhere (NWRI, 2010).

Ako et *al.,*(2014), the evaluation of environmental impact of artisanal gold mining was carried out in Luku, North Central Nigeria. During the field work, observations of the whole mining site were made so as to evaluate the physical impact of mining and representative soil samples were randomly collected from the surface from mined and un-mined areas within the mining sites. Results from the laboratory analyses show that soils are contaminated with elements such as Pb, Cu, Zn etc. These elements in the soil get accumulated in plants and animals, and are passed on to human through the food chain. Also, these elements can find their way to surface and ground water making the water unsuitable for human consumption. It may cause slow growth rate in plants and respiratory problem, liver and kidney damage in man.

Joseph et *al.,* (2013), in his study specifically, looks into how mining activities affect water resources and therefore water access in the mining communities of Konongo and Odumasi based on the perception, opinions and practices of selected households. Through the use of the fish bowl probability sampling, a total of 107 households were selected from the mining communities of Konongo and Odumasi to respond to interviews.

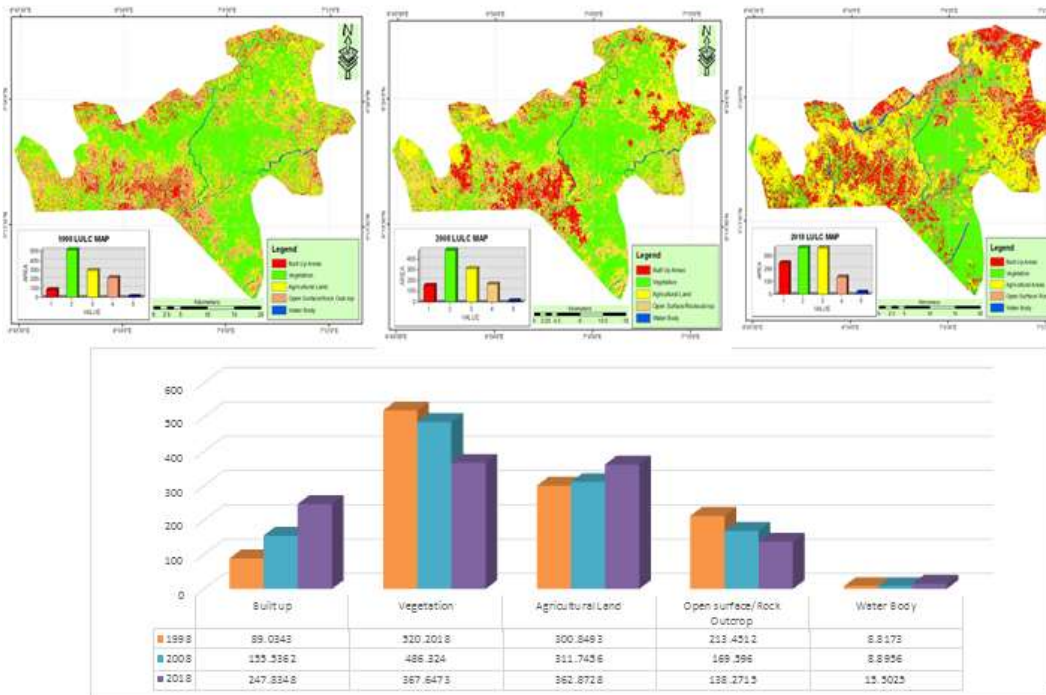
Ibrahim et al., (2013) also study the impact of Lead mining activities in Tunga Tsauni, Gurara Local Government Area of Niger State, Nigeria. The major materials used in this work include samples of water and crop plants obtained from the study site and its vicinity. The study site is a lead mining site located at Tunga Tsauni in Gurara Local Government Area (LGA) of Niger State, Nigeria. Major chemicals used during the experimental work include nitric acid (HNO3-96% purity), hydrochloric acid (HCl- 95% purity) and lead nitrate (PbNO3- 95 % purity. From the analysis samples taken at varying distances from the mining site, the effects of the mining activities on water and crop plant sat the mining environs was conducted in their investigation by testing for the presence as well as the concentration of lead. Furthermore, it was reported that the values of the lead concentrations obtained were compared with the set limits (standard) of World Health Organization. It was discovered from the results obtained that most of the water samples were polluted with lead and, thus, unsafe for domestic use and aquatic life. Also, discovered the concentration of the lead in the crop plants was found to be higher than that of the control sample. It has, thus, been discovered that the mining activities of lead have significant effects on the crop plants and the water in the mining area (Tunga Tsauni) of Niger State because the soil and the water in the area were found to be contaminated with lead, which is toxic and dangerous. Therefore, there is the need for urgent and serious measures to regulate the mining activities at the site in order to significantly reduce the effects of this poisonous substance (lead) on the crop plants and the water of the area.

Materials and Methods

Since the target of this study is to investigate the Environmental Effect of Artisanal and Small Scale Mining Activities On Water Quality. Collection and handling of samples was polypropylene (PP) plastic bottles at five different stations along Gurara River. Sample collection was done twice a month, for about eight months (four (4) months of Wet Season and four (4) months of dry season)and subjected to laboratory analysis.

Observations method and questionnaire were administered to the target population of the study, to obtain the required information to achieve the objectives of the study. As well as Landsat image (Landsat ETM 1998, Landsat ETM 2008, Landsat ETM 2018) of the study location was utilised, to determine the trend of the land use and land cover in the study area.

RESULTS AND DISCUSSIONS



(Source: Research Compilation, 2019)

Figure 2 show the Land use Land cover change of the study area in 1998, 2008 and 2018.

Figure 2 shows the Land use Land cover change of the study area in 1998. It reveals that vegetation is the dominant land cover features covering about 520.2018 square kilometer (45.94%) of the area. This can be found on every section of the study area but more concentration is at the central part. This is followed by farmland which covers an area of 300.8493 square kilometer

(26.57%) of the total land mass of the area. Most of the farmland lands were located majorly in the northern and southern fringes of the study area.

Also, open surface/rock crop accounted for 213.4512 square kilometer (18.85%) were typical found across the north western, north eastern, and south western section of the study area. In addition, built up areas cover an area of 89.0343 square kilometer (7.86%). This is found majorly in the southern part of the map and in small patches at other section of the area, this land use indicates that in 1998 they were only few settlements in the study. Finally, water body covers a total land area of 8.8173 square kilometer (0.78%) and these rivers start flowing from the northern to southern section of the study area. The total land area of the study area is 1132.354 square kilometer.

The LULC of the study area in 2008 which indicates that built up areas has increased within the ten –years (10) time period from 89.0343 square kilometer (7.86%) in 1998 and now accounted for about 155.5362 (Km2) (13.74%) this increase can be attributed to influx of people to the area as well as increase in population due to the presence of large markets where agricultural products are sold at a very reduced price. vegetation on the other hand decreased from 520.2018 square kilometer (45.94%) to 486.324 (Km2) (42.96 %) which indicates that expansion in built up and other developmental activities has reduced vegetation cover. In addition, farmland increase from of 300.8493 square kilometer (26.57%) in 1998 to 311.7456 (Km2) (27.54 %). This increase can be attributed to increase demand for food. In addition, open surface/ rock out crop decreased from 213.4512 square kilometer (18.85%) in 1998 to 169.596 (Km2) (14.98%) in 2008. Finally, water body remains relatively stable at 8.8956 (Km2) (0.79%).

The analysis of 2018 satellite image of the study areas reveals that there was continuous expansion of built up area in the study area. The expansion encroached on other land use category mostly towards eastern and southern section of the area. Figure 4.3 reveals that in 2018 Settlement areas covered a total of 247.8348 (Km2) (21.89%) of the total area which is made up both residential, commercial, and other land use areas. There was an increase of built up areas by 92.2986 (Km2) (8.06%) in the ten years' period.

Similarly, vegetation land also decreases from 486.324 (Km2) (42.96 %) in 2008 to 367.6473 (Km2) (32.47%) in 2018 which may be attribute to the influx of people leading to increased deforestation activities as well as pressure on other available vegetation resources. Agricultural land on the other hand has increased further to 362.8728 (Km2) (32.05%), in 2018 from 311.7456 (Km2) (27.54 %) in 2008, which can be attribute to the conversion of vegetation, open surface as well as other land uses to agricultural land to meet the increase demand for food supply in the area as well as other people coming to the area, also with the present government encouragement to farming. Furthermore, open surface/ rock outcrop covers an area of 138.2715 (Km2) (12.21%) in 2018 while Water body increase from 8.8956 (Km2) (0.79%) in 2008 to 15.5025 (Km2) (1.37%) due to various mining activities going in the study area.

Table 1: Effects of mining Activities on the Study Area

Purpose	Strongly Agree		Agree		Don't know		Disagree		Strongly Disagree	
	Frq.	(%)	Frq.	(%)	Frq.	(%)	Frq.	(%)	Frq.	(%)
Source of drinking water	25	41.67	30	50	1	1.67	1	1.67	3	5
Sedimentation of water	28	46.67	22	36.67	2	3.33	2	3.33	1	1.67
Pollution of water	32	53.33	18	30	5	8.33	3	5	2	3.33
Waterborne diseases	17	28.33	25	41.67	15	25	2	3.33	1	1.67
Land degradation	23	38.33	32	53.33	2	3.33	2	3.33	1	1.67

(Source: Research Compilation, 2019)

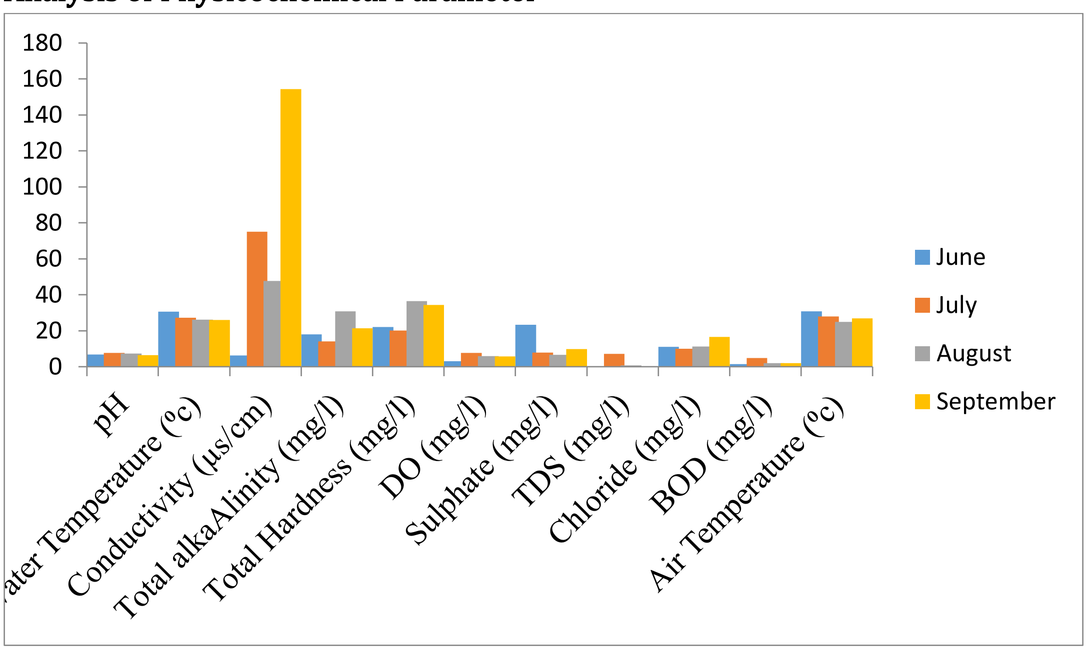
Table 4.3 shows that 50% of the participants agree that mining activities affect their various source of water majorly at the downstream while 5% strongly disagree to the same effect on source of drinking water. On the other hand, 28 (46.67%) strongly agree that mining result to sedimentation of the river while 2(3.33%) disagree to the presence of sedimentation Furthermore, 32 (53.33%) strongly agree that mining in the area result to pollution of the water in the area by contaminating the water and making it unsafe for domestic consumption while 3(5%) disagree.

In addition, 25 (41.67%) agree that there is emergence water related diseases such as malaria because of the waterlog resulting to breeding place of mosquitoes while 2(3.33%) disagree. Finally, 32 (53.33%) agree that there is problem of land degradation on the area and 2 (3.33%) disagree. Plate I shows pictures of land degradation on the study area.

(Source: Research Compilation, 2019)

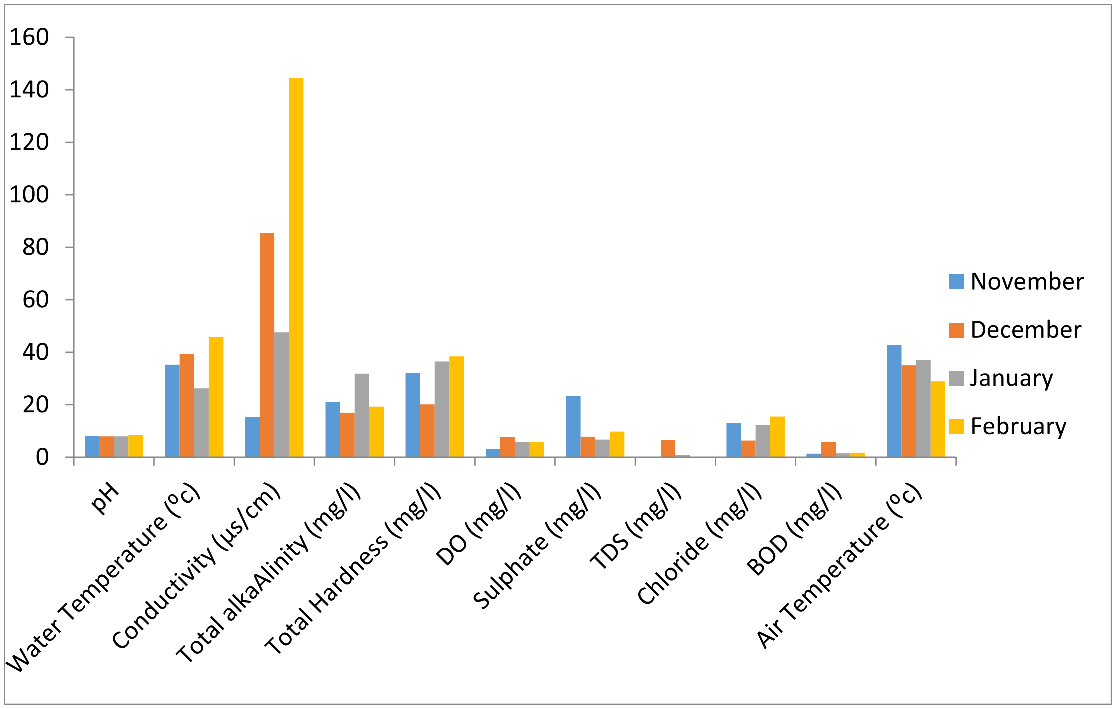
Plate I: Land degradation in the Study Area due to ASM activities

Analysis of Physicochemical Parameter



(Source: Research Compilation, 2019)

Figure 3: Wet Season Monthly Variation of Physicochemical Parameter



(Source: Research Compilation, 2019)

Figure 4: Dry Season Monthly Variation of Physicochemical Parameter

Figure 3 shows that the water temperature value of the water sample during the wet season was highest in the month of June (30.60°C) and lowest in the month of September (25.90 °C)). Also Table 3 and Figure reveals the water temperature value for Dry season, was highest in the month of December (39.20 °C) and lowest in the month of November (35.20°C)), the total alkalinity value of the water sample during the wet season was highest in the month of August (30.80 mg/l) and lowest in the month of July (14.00mg/l). Also Figure 4 reveals the total alkalinity value for Dry season, was highest in the month of January (31.80 mg/l) and lowest in the month of December (17.00 mg/l), the total hardness value of the water sample during the wet season was highest in the month of August (36.50 mg/l) and lowest in the month of July (20.10mg/l).

Figure 4 reveals the total hardness value for Dry season, was highest in the month of February (38.40 mg/l) and lowest in the month of December (20.10 mg/l), the dissolve oxygen value of the water sample during the wet season was highest in the month of July (7.70 mg/l) and lowest in the month of June (3.00 mg/l). Also

Table 2 reveals the dissolve oxygen value for Dry season, was highest in the month of December (7.70 mg/l) and lowest in the month of November (3.00 mg/l), the sulphate value of the water sample during the wet season was highest in the month of June (23.35 mg/l) and lowest in the month of June (6.69 mg/l). The sulphate value for Dry season, was highest in the month of November (23.35 mg/l) and lowest in the month of January (6.69 mg/l), the chloride value of the water sample during the wet season was highest in the month of September (16.59 mg/l) and lowest in the month of July (9.95 mg/l). Also the chloride value for Dry season, was highest in the month of February (15.47 mg/l) and lowest in the month of December (6.33 mg/l), the biological oxygen demand value of the water sample during the wet season was highest in the month of July (4.74mg/l) and lowest in the month of June (1.46 mg/l). the biological oxygen demand value for Dry season, was highest in the month of December (5.74 mg/l) and lowest in the month of November (1.36 mg/l).

Analysis of Heavy Metal

The contents of heavy metals, especially Cu, Zn, Ni, Cd, and Co, were elevated in this section of the stations.

Table 2: Average Mean Variation of Heavy Metals For Wet and Dry Season

Station	Ni Month /year	Sampling	Al	Cu	Fe	Mn	Zn	Pb	Cd	Co	Cr	Mo
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	Nov	0.2	1.85	0.02	0.048	2.49	0.42	0.005	1.8	0.05	0.08	0.02
	Dec	0.2	1.50	0.04	0.267	2.61	0.32	0.006	1.7	0.043	0.06	0.02
	Jan	0.19	2.62	0.04	0.332	2.42	0.02	0.015	1.9	0.07	0.07	0.02
	Feb	0.3	2.5	0.01	0.54	2.76	0.00	0.010	2.0	0.08	0.07	0.02
2	Nov	0.3	1.5	0.47	0.198	3.13	0.21	0.005	1.0	0.02	0.07	0.03
	Dec	0.32	2.01	0.23	0.229	3.89	0.25	0.005	2.0	0.07	0.09	0.02
	Jan	0.2	0.95	0.38	0.249	12.9	0.22	0.009	1.0	0.04	0.05	0.04
	Feb	1.26	2.00	0.06	0.2	5.41	0.00	0.005	3.0	0.05	0.06	0.02
3	Nov	0.18	2.96	0.6	0.681	7.43	0.39	0.005	1.0	0.07	0.08	0.02
	Dec	0.41	1.30	0.2	1.239	5.27	0.44	0.002	2.0	0.01	0.04	0.02
	Jan	0.51	1.50	0.17	0.340	2.24	0.70	0.005	2.1	0.08	0.05	0.02
	Feb	0.19	1.25	0.35	0.2	3.51	1.25	0.005	2.3	0.08	0.05	0.02
4	Nov	0.02	2.02	0.04	0.54	3.00	0.00	0.005	2.3	0.16	0.05	0.03
	Dec	0.03	2.03	0.22	0.373	3.01	0.67	0.007	2.7	0.04	0.07	0.02

	Jan	0.2	0.26	0.04	0.608	2.96	0.21	0.005	2.1	0.05	0.07	0.02
	Feb	0.15	2.1	0.04	0.227	2.8	0.01	0.005	2.1	0.06	0.05	0.03
5	Nov	0.16	1.93	0.06	0.62	3.1	0.01	0.005	2.1	0.08	0.07	0.02
	Dec	0.02	2.04	0.04	0.159	3.3	0.03	0.004	2.1	0.15	0.07	0.03
	Jan	0.19	1.1	0.04	0.104	3.1	0.05	0.008	2.2	0.05	0.05	0.02
	Feb	0.20	1.99	0.02	0.209	2.9	0.01	0.005	2.1	0.15	0.07	0.03

(Source: Research Compilation, 2019)

Table 2 shows that the Aluminum level in the water had its highest value in the month of February (1.26mg/L) in station two and its lowest value in the month of November (0.02mg/L) in station four. However, there was no significant differences (p>0.05) among the stations except in station three, Copper (Cu), the Copper level in the water had its highest value in the month of November (2.96mg/L) in station three and its lowest value in the month of (0.26mg/L) in January in station four. However, there was no significant differences (p>0.05) among the stations and months (Table 4.8, the Iron level in the water had its highest value in the month of November (0.47mg/L) in station two and its lowest value in the month of February (0.01mg/L) in station one. However, there was no significant differences (p>0.05) among the stations and months, the water had its highest value in the month of November (0.681mg/L) in station three and its lowest value in the month of November (0.048mg/L) in station one. However, there was no significant differences (p>0.05) among the stations and months, the water had its highest value in the month of February (5.41mg/L) in station two and its lowest value in the month of January (2.24mg/L) in station three. However, there was no significant differences (p>0.05) among the stations and months, Lead level in the water had its highest value in the month of February (1.25mg/L) in station three and its lowest value in the month of November (0.00mg/L) in station four. However, there was no significant differences (p>0.05) among the stations and months, the water had its highest value in the month of January (0.015mg/L) in station one and its lowest value in the month of December (0.002mg/L) in station three. However, there was no significant differences (p>0.05) among the stations, the Cobalt level in the water had its highest value in the month of December (2.7mg/L) in station four and its lowest value in the month of November and January (1.0mg/L) in station two and three respectively. However, there was no significant differences (p>0.05) among the stations and months, the Chromium level in the water had its highest value in the month of November (0.16mg/L) in station four and its lowest value in the month of December (0.01mg/L) in station three. However, there was no significant differences ($p>0.05$) among the stations and months, the Molybdenum level in the water had its highest value in the month of December (0.09mg/L) in station two and its lowest value in the month of December (0.04mg/L) in station three, the water had its highest value in the month of January (0.04mg/L) in station two and its lowest value (0.02mg/L) in all the stations.

Comparison of water quality from Artisanal and Small Scale Mining areas to the acceptable National Standard for drinking, water quality

Table 3 Comparison between the Physicochemical Parameters of Recommended Range of Some Organization and the Result of the Present Study

S/N	Names of Organization	Parameters	Recommended Range	Months	Stations
1	WHO (2017)	pH	6.5 – 8.5	6.48 – 7.73	6.81 -7.15
2	WHO(2017)	Water Temperature	< 40 ^{0}C	25.90 – 3.60	27.00 – 27.75
3	WHO(2017)	Conductivity	2000 maximum	6.30 – 154.40	59.50– 145.63
4	WHO(2017)	Total Alkalinity	<50mg/L as alkalinity >250mg/L as $CaCO_3$	14.00 - 30.80	15.43 - 28.93
5	BIS	Total Hardness	300mg/L maximum	20.10 – 36.50	20.03 – 38.90
6	WHO(2017)	Dissolve Oxygen	3.9 – 7.6mg/L	3.00 – 7.70	5.03 – 6.48
7	WHO(2017)	Total Dissolve Solid	<500mg/L	0.08 – 7.12	0.70 – 4.93
8	BIS	BiologicalOxygen Demand	2 – 3mg/L	1.46 – 4.74	2.15 – 2.63
9	WHO(2017)	Sulphate	2 – 80mg/L	6.69 – 23.35	10.20 – 13.68
10	BIS	Chloride	250mg/L maximum	9.95 – 16.59	8.76 – 21.76
11	WHO(2017)	Air temperature	< 40 ^{0}C	25.00 – 30.70	27.13 – 28.25

(Source: Research Compilation, 2019)

Table 4: WHO Drinking Water Standards for Heavy Metal

Metal	WHO (2017)	mg/L
Al	0.2	0.02 – 1.26
Cu	2.0	0.26 – 2.96
Fe	0.5	0.01 –0.46
Mn	0.5	0.048 – 0681
Zn	3	2.24 – 5.41
Pb	0.01	0.000 – 1.25
Cd	0.003	0.000 – 0.015
Co	2	1.0 – 2.7
Cr	0.05	0.01 – 0.16
Mo	0.07	0.04 -0.09
Nickel	0.02	0.02 – 0.04

(Source: Research Compilation, 2019)

Discussion of Findings

The range of pH observed was within the range of (6.5) to (4.5) as suggested by world health organization (WHO) as guideline value for pH of water. World Health Organization (WHO) suggested a guideline value of low alkalinity to be <50mg/L as alkalinity > 250mg/L as $CaCO_3$. The highest value of total alkalinity was recorded in the month of January (36.50 mg/L), this was higher any other month between the period of study and thus, in agreement with the findings of W.H.O, for low alkalinity. Temperature changes and it effect are as a result of light penetration, wind action and sediment particles which reduced the temperature of the water and dissolve oxygen (Ovie and Adeniji, 1993). The result is in agreement with the findings of some previous researchers who reported that the temperature range is between 24.0 – 30.7^{0}C Adeosun *et al*., (2009). The result is also in line with the recommended range of water temperature and air temperature of < 400C W.H.O (1999).

The result of the biological oxygen demand agrees with some previous researchers who reported that biological oxygen demand range between (0.06 to 5.46 Mg/L) by Saksena et al, (2008). The present research shows that the dam water was fairly clean, the BOD value was higher in the month of December than any other month during the study, this can be attributed to higher organic matter, water washed into the dam due to runoff from the surrounding in the raining season. A high biological oxygen demand indicates the presence of a large number of microorganisms., The result of sulphate agrees with (WHO 2006) in natural water, SO_4 level should range generally between 2mg/L to 80mg/L, the sulphate value was higher in the month of November than any other months in the present study with a value of (23.35mg/L).

There were no significant differences between the month ($\rho > 0.05$) in the total hardness. The highest value was recorded in the month of January (36.50 mg/L), the lowest value was recorded in the month of December (20.10mg/L), which is in line with BIS recommended range of (300 mg/L) maximum.

Fresh water usually has TDS level between 0 and 1000mg/L depending on the geology of the region, climate and weathering and other environmental features that affects source of dissolved material and its transport to a water system. High level of TDS and conductivity render the water less fit for drinking and irrigation (Adams, 2001), the conductivity of the water varies significantly with months and stations, the range obtained from this study for month was (6.30 – 154.40 µs/cm), while the station range between (59.50 – 145.63µs/cm) W.H.O (1999) reported that the recommended range for conductivity of water at maximum is 2000mg/L, the variation in the conductivity range for months could be as a result of water runoff while the total dissolve solid for the month range between (0.08 – 7.12mg/L) and for station range between (0.70 – 4.93mg/L) which is in-line with the recommended range of W.H.O (1999).

A maximum of 250 mg/L of chloride is allowable in surface water as per EPA 2001. The highest value of chloride was recorded in station 3 (21.76 mg/L) with the lowest in station 4 (8.76mg/L) which is in agreement with BIS recommended range of (250 mg/L) maximum, Aluminum (Al) level in the water ranges from 0.02mg/L - 1.26mg/L, which is on average moderate to the 0.2 standard level of the WHO, 2017. Hence it is then concluded that there is few impact of Artisanal and Small Scale Mining activities on the concentration of aluminum in stream water, also Cu level ranges from 0.26mg/L - 2.96mg/L) as compared to the WHO standard of 2.0, this reveals that there is significant variation in the Cu level in the stations, which could be concluded there is a significant effect of ASM on the water content. The Iron (Fe) ranges from 0.01 - 0.47mg/L, which is low as compared with value of the WHO standard, indicating that there is no significant effect of mining activities on Fe level of the water in the study area, however the low level may be as a result imbalance of other constituent element as a result of mining activities going on in the study. The concentration of manganese level in the water falls within the range of 0.048 – 0681mg/L, is approximately moderate on average to the required standard by (WHO, 2017). Hence there is no significant effect of mining on the concentration of Manganese (Mn) in the water of the study area, the Zinc level in the water takes the range between 2.24mg/L - 5.41mg/L, the result reveals that there is significant effect of mining activities as its highest value is far greater than the 3.0 (WHO, 2017), this assertion is also made by (Ibrahim et al., 2013).

It was also discovered from the findings that Cadmium level in the water had its highest value in the month of January (0.015mg/L) in station one and its lowest value in the month of December (0.00mg/L), However, there was no significant effect as there is no consistency in the variation of the Cadmium level in water as shown in Table 2.

Cobalt level in the water ranges from 1.0 – 2.7mg/L compared to the National Standard by (WHO, 2017) is 2.0, hence there is no significant effect of ASM on concentration of cobalt in water level.

The Chromium level in the water ranges from 0.01mg/L - 0.16mg/L in the station. However, there was no significant effect as there is no consistency in the variation of the chromium level months (table 4.6). The Molybdenum level in the also ranges from the 0.04 - 0.09mg/L which also shows that there is no significant effect of ASM among the stations and months (table 4.6). The standard of Nickel level of water is 0.02 and the obtained range is 0.02 – 0.04mg/L thus there is no significant effect of ASM on the nickel concentration in water.

Conclusion and Recommendations

The result obtained from the analysis of Land use Land covers shows the presence of Artisanal and Small Scale Mining in the study location. Likewise, the analysis of physicochemical parameters and heavy metal in Gurara dam downstream is essential to know the status of the water since people around the community depend on the water for their activities and it also supports fish farming practices by the local people. The differences observed between some months and stations in the physicochemical parameters and heavy metals of Gurara dam downstream can be attributed to the location of the dam, amount of rain fall obtained annually, as well as human activities going on around the dam.

The result of water quality assessment shows that some of the water quality parameters are within the permissible limit with slight variation in some parameters. And also lead, zinc, aluminum and chromium are above the standard requirement.

Recommendations in includes Enlightening programme on proper mining activities as well as risk involved in wrong mining practices. Monitoring of the water for testing physicochemical parameters of the dam regularly to ensure effective conservation and licensing should be made available for any miner who meets the regulation requirements of the Mining authorities

REFERENCES

Ako T.A, Onoduku U.S, Oke S.A, Adamu IA, Ali S.E, Mamodu A, Ibrahim A.T (2014). "Environmental Impact of Artisanal Gold Mining in Luku, Minna, Niger State, North Central Nigeria". Journal of Geosciences and Geomatics 2(1): 28-37.

Azubike A L (2011). The Technology of peaty soils in Mozambique and Angola. Transactions of the 5th International Congress of Soil Science, Leopoldville 3: 398-401.

Blanchette, M., Pearson, R. (2013). Dynamics of habitats and macroinvertebrate assemblages in rivers of the Australian dry tropics. Freshwater Biology, 58(4), 742-757.

Bose-O'Reilly, S., Drasch, G., Beinhoff, C., Rodrigues-Filho, S., Roider, G., Lettmeier, B., et al. (2010). Health assessment of artisanal gold miners in Indonesia. Science Total Environment, 408(4), 713-725.

CDC (2010). Outbreak of Acute Lead Poisoning in Zamfara State, Nigeria. Executive Summary of Zamfara State, CDC and WHO investigation May 22-June 4, 2010.

de Andrade Lima, L. R., Bernardez, L. A., Barbosa, L. A. (2008). Characterization and treatment of artisanal gold mine tailings. Journal of Hazard Mater, 150(3), 747-753.

Devangee ShuklaKinjal BhadreshaN K JainH A Modi (2013). "Physicochemical Analysis of Water from Various Sources and Their Comparative Studies " IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399. Volume 5, Issue 3 (Jul. - Aug. 2013), PP 89-92 www.Iosrjournals.Org.

Easton, D., C. Trasar-Cepeda, M.C. Leiro & F. Gil-Sotres, (2007). “Evaluation of various tests for the diagnosis of soil contamination by 2, 4, 5-trichlorophenol (2, 4, 5-TCP)”, Journal of Environmental Pollution, 156: 611.

Fosso-Kankeu E, Mulaba-Bafubiandi AF, Mamba BB and Barnard TG. (2011). Prediction of metal-adsorption behaviour in the remediation of water contamination using indigenous microorganisms. Journal of Environmental Management, 92 (10), pp 2786-2793. http://dx.doi.org/10.1016/j.jenvman.2011.06.025.

Ibrahim, A. A., Jimoh, A, Okafor, J.O. Abdulkareem, A.S. and Giwa, A. (2013), “Effect of Lead Mining Activities on Crop Plants and Water: A Case Study of Tunga Tsauni, Gurara, Niger State, Nigeria”. International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181Vol. 2 Issue 12.

Joseph O. A., Justice B. O. Alexander A. (2013). “Effects of mining activities on access to potable water: households’ perception and practices at Konongo and Odumasi communities in Ghana.”, Civil and Environmental Research, ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.3, No.12.

Macdonald, K. F., Lund, M., Blanchette, M., McCullough, C. (2014). “Regulation of Artisanal Small Scale Gold Mining (ASGM) in Ghana and Indonesia as Currently Implemented Fails to Adequately Protect Aquatic Ecosystems”. Paper presented at the 12th International Mine Water Association, China.

Manickum, T., John, W., Terry, S. & Hodgson, K. (2014). “Preliminary study on the radiological and physicochemical quality of the Umgeni Water catchments and drinking water sources in KwaZulu-Natal, South Africa”. Journal Environment Radioactive, 137:227-240, Nov. http://dx.doi.org/10.1016/j.jenvrad.2014.07.015.

Mutlu, M. B., Kazi, T. G. Jamali,M. K. Afridi, H. I., Baig, J. A.., (2016). “Study on water quality of Wanparakalpa Reservoir Nagpur, Near Parli Vaijnath, District Beed. Marathwada region” Journal of Analysis. Environmental Chemistry, 9(2), 101.

Nganje T. N., Adamu C. I., Ntekim E. E. U., Ugbaja A. N, Neji P. and Nfor E. N. (2011) “Influence of mine drainage on water quality along River Nyaba in Enugu South-Eastern Nigeria” African Journal of Environmental Science and Technology Vol. 4(3), pp. 132-144, March, 2010 Available online at http://www.academicjournals.org/AJEST ISSN 1991-637X © 2010 Academic Journals Nigerian Minerals and Mining Regulations.

Obaje, N.G., Nzegbuna, A.I., Moumouni A., Ukaonu, C.E. (2005). Geology and Mineral Resources of Nasarawa State, Nigeria. A preliminary Investigation. Paper presented at the 4th Nasarawa State Agricultural and Solid Minerals Exposition held at Agyaragu, Nasarawa State, Nigeria, 21-23 March, pp. 1-27.

Okafo C.N., Hassan S. and Ahmed, D.B. (2011) "Impacts of Local Gold Mining on Drinking Water Quality" National Water Resources Institute, Kaduna Paper presented at the 2nd National Water and Sanitation Conference held at the Conference Centre, National Water Resources Institute, Kaduna, Nigeria.

Opafunso, Z. O. (2011). Overview of Artisanal and Small Scale Mining of Gold Operations in Nigeria. Lecture at Federal University of Technology, Akure, Ondo State, Nigeria.

Prabaharan S., Manonmani R., Ramalingam M. and T. Subramani, (2010) "Groundwater Contamination due to Municipal Solid Waste Disposal in Salem City using GIS", International Journal of Earth Science and Engineering, Volume 05, No. 04, pp- 696-702.

Sabhapandit, P., Saikia, P. & Mishra, A.K. (2010). "Statistical analysis of heavy metals from water samples of Tezpur sub-division in Sonitpur district, Assam, India". International Journal of Applied Biology and Pharmaceutical Technology, 1 (3).

Sinha, S. K., M. S. Deepak, R. V. Rao & H. P. Borgaonkar. (2011). Dendroclimatic analysis of teak (Tectona grandis L.f.) annual rings from two locations of peninsular India. Current Science100: 84–88.

Treseder,V. T (2008),. "Investigation of soil characters and Azospirillum isolated from paddy soils of Thanjavur district, East Coast of Tamilnadu, India", Archives of Applied Science Research, 3(2): 525.

Veiga, M. M (2003). Mercury in artisanal gold mining in Latin America: facts, fantasies and solutions, UNIDO Expert Group Meeting - Introducing new technologies for abatement of global mercury pollution deriving from artisanal gold mining, Vienna, Austria.

Velásquez-López, P. C., Veiga, M. M., Klein, B., Shandro, J. A., Hall, K. (2011). Cyanidation of mercury-rich tailings in artisanal and small-scale gold mining: identifying strategies to manage environmental risks in Southern Ecuador. Journal of Cleaner Production, 19(9-10), 1125-1133.

WHO, (2011) Guidelines for Drinking-Water Quality–Recommendations, 4th Edition, Volume 1: WHO, Geneva.

http://apps.who.int/iris/bitstream/10665/44584/1/9789241548151_eng. pdf Date of access 20 October 2018.

Wu, M.L., Wang, Y.S., (2007). Using chemometrics to evaluate anthropogenic effects in Daya Bay, China. Estuarine, Coastal and Shelf Science 72, 732–742.