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Assessment of Physiochemical Properties of Lakpah Stream, for Domestic use in Nasarawa Eggon, Nasarawa State, Nigeria

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Abstract

Streams can be utilized for beneficial purposes such as domestic, recreation and irrigation especially in this era of endemic water scarcity. This study assessed the physiochemical properties of Lakpah stream for domestic use in Nasarawa Eggon. A total of six (6) water samples were collected from the stream. The water samples were collected mostly for upper, mid and lower stream on which the water is perennial and offer ample opportunity for a variety of uses such as irrigation and domestic. The water samples were taken for laboratory analyses for properties affecting the use of water for domestic purposes. Properties of water such as; temperature, turbidity, electrical conductivity and total dissolved solids chlorides, nitrates, calcium, magnesium, sodium, potassium, iron, zinc, manganese and lead were analyzed using standard laboratory techniques. Results from this study showed the means concentration of the properties of water was high for most of the variables. Temperature was 25.5^0c, pH 8.48, total dissolved solids 1324 mg/l, turbidity 20.8 NTU, iron 3.2 mg/l and zinc 0.1mg/l. The spatial distribution of the variables showed that pH was between 7.32 and 10.2, $CaCO_3$ 125 and 382 mg/l, TDS 400 to 2004 mg/l, phosphates 0.4 to 0.8 mg/l, turbidity 5 to 44Ntu and iron 1.18 to 5.7 mg/l. Analysis of variance carried out showed that there was significant difference in the distribution of the properties within the stream. The evaluation of the suitability of the water for domestic use showed mean concentrations of variables such as pH 8.48, total dissolved solids 1324 mg/l, calcium carbonate 20.8 mg/l, iron 3.2 mg/l and magnesium 7.9 mg/l were all above the highest desirable limit considered for domestic water by WHO (2012). Results therefore show that water from the stream objectionable for domestic use within the study area. The study therefore recommends that the people around the stream should be cautious in the use of water for domestic purpose especially when treatment is

not done; water from the stream should be evaluated for other uses that require less stringent water quality such as recreation and irrigation and monitoring.

Keywords: Physiochemical, Properties, Lakpah Stream, Domestic Use, Nasarawa Eggon

Introduction

The most essential and abundant resources in the world today is water. All life on earth depends on the availability of water for their survival. There are several sources of water ranging from rain water, stream water, underground water, rivers, and oceans among many. Lager population in developing countries lack adequate potable water and are compelled by this unavailability to result to the use of marginally qualitative water from other sources like springs, streams, shallow well and boreholes for domestic and drinking purpose (Kolawale and Afolayan, 2017). Water is a function of both the natural and anthropogenic activities. The increasing population growth of the world and anthropogenic activities has led to an increase in the demand of water for domestic and industrial activities inevitable (Umeh, 2005).

However, the quality of water resources is a subject of ongoing concern and has resulted in fervent demand for monitoring water quality. These qualities described by its physical, chemical and microbiological characteristics (Basu and Lokesh, 2013).

Rivers and their catchments are highly important parts of the natural heritage and have been utilized by mankind for thousands of years to the extent that few of them are now in their natural condition (Ngoye*et al*, 2004). A regular monitoring of river water quality not only prevent the outbreak of diseases and check water from further deterioration, but also provide a scope to assess the current investment for pollution prevention and control (Basu and Lokesh, 2013). It is important to assess the health of a watershed and to make necessary management decisions to control current and future pollution of receiving water bodies (Khadam and Kaluarachchi, 2006; Behbahaninia *et al.,* 2009).

Mining refers to the extraction of useful or valuable minerals (geological materials) from the earth, normally from an ores body vein, reef or placer deposit (Agricola *et al*., 1950). Mining sector plays a very vital role in income generation, employment, development and also for economic growth of the nation.

Many metals are essential for life, in the right concentrations but beyond permissible limit are poisonous (Ombugadu *et al*., 2014). The total replenishable water resource in Nigeria is estimated at 319 billion cubic meters, while the groundwater component is estimated at 52 billion cubic meters, an indication that Nigeria has adequate groundwater resources to meet its current water demands. However, with all the efforts made by Governments and various agencies to improve the access to potable water supply to all Nigerians, it was estimated that only 58 % of the inhabitants of the urban and semi-urban areas and 39 % of rural areas have access to potable water supply (Tukura *et al.,* 2014). Mining activity usually create negative impacts on the

environment diverse ways. The major impact of mining process is the contamination of water sources within or close to the mining sites; this pollution is as a result of mining close to water sources (Prasad *et al.,* 2008). These mining activities percolates some of the mining elements which leaks or flow to water sources either through surface water body or near aquifer system. These might lead to the contamination of ground water sources and the run-offs may discharge directly into the streams or to land (Zare *et al*., 2011). The leach can be soluble salts, mostly likely chlorides and other soluble minerals which can result to various types of water pollution such as; acid mine drainage, heavy metal contamination and leaching, erosion and sedimentation (Abraham *et al.,* 2008).

The discharge of mining waste into the environment has led to serious destruction of ecosystems in severe cases, such destruction maybe difficult to be restored. The impact of discharge, containing metals and heavy metals in streams in most cases is unexpectedly broad to comprehend (Garizi *et al*., 2011).

Statement of Research Problem

Exploration in Nigeria for several solid minerals, such as, tin, niobium, lead, zinc and gold, goes back for more than 90 years with tin and niobium production have ranking high on a world-wide scale. While the major international exploration groups seldom paid more than a passing interest, there has been general exploration carried out by the tin mining companies especially the Nigerian Mining Corporation. Throughout its long history the Geological Survey of Nigeria Agency has played an active role in exploration for Mineral deposits many of which have been first reported by its officers. The Geological Survey of Nigeria Agency has also been responsible for the regional mapping, airborne magnetic and radiometric surveys which provide an invaluable base for more detailed exploration. There is at present an upsurge of interest in the development of solid mineral resources whose production in the last 30 years has been declining in every case. The privatization, commercialization and general reform exercises currently being undertaken by the government of Nigeria are expected to lead to an upsurge in the exploration and development of Nigeria's solid mineral resources.

In spite of the immense contributions the solid mineral exploitation often results to environmental degradation, most especially when the mining sites are located close to water bodies. Maina (2013).It is burdened with a lot of challenges. Lakpa Stream in Nasarawa Eggon LGA serves as a major source of water supply to the communities around it. The stream originates from Eggon hill down to the communities. However, there are mining activities carried on by artesian miner on the hill and this miners lack the knowledge and tool to observe safety and health regulations. The miners use the same water from the stream to process their mineral finding and this has led to the contamination of the water. Also waste deposit from the mining activities are not properly disposed, but rather disposed indiscriminately around the environment and most often washed into the stream during rainfall.

Thus, the need to investigate the pollution of the water in Lakpah stream is paramount, since the water might have adverse effect on the user either in a long or short run.

Research Questions

This study therefore addressed the following questions.

i. What are the physical and chemical properties of water at the Lakpah stream?

ii. What are the biological properties of water in the study area?
iii. To what extent is the distribution of physical and chemical properties of water within the study area?
iv. How suitable is the water for domestic use in the study area?

Aim and Objectives of the Study

The aim of this study is to assess the physiochemical properties of Lakpah stream for domestic use in Nasarawa Eggon. To achieve that, the following objectives are to:

i. Determine the physio-chemical properties of water in Lakpah stream.
ii. Determine the biological properties of water within the study area
iii. Determine the distribution of physical and chemical properties of water in the study area.
iv. Evaluate the suitability of water in the study area for domestic purpose.

Conceptual Framework

Concept of Water Quality

Water is one of the most abundant and essential resources of man, and occupies about 70% of the earth's surface. About 97% of this volume of earth's surface water is contained in the oceans, 21% in polar ice and glaciers, 0.3-0.8% underground, 0.009% in inland freshwaters such as lakes, while 0.00009% is contained in rivers (Eja, 2002). Water has been regarded as a universal solvent that can dissolve many chemicals which may or not be beneficial to man and its environment (Agbaire *et al*., 2014). It is however essential to all living things and its environment (Oluyemi *et al*., 2010).Ground water is the water beneath the surface where all the voids in the rocks and soil are filled. It is a source of water for wells, boreholes and springs. A borehole is a hydraulic structure which when properly designed and constructed, permits the economic withdrawal of water from an aquifer. It is a narrow well drilled with machine (Ukpong and Okon, 2013).

Apart from the essential role played by water in supporting human life, if polluted, it also has a great potential for transmitting a wide variety of diseases. Portable water for human consumption does not always occur in nature because of the presence of impurities in most natural water bodies (Goldface, 1999; Shrivastava and Sonawane, 2010), and this has been attributed to its high solvating capacity. Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life (Agbaire *et al*., 2014).

The composition of surface and underground waters is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal differences in runoff volumes, weather conditions and water levels (Karmakar *et al.,* 1987).

Large natural variations in water quality may, therefore, be observed even where only a single watercourse is involved. Human intervention also has significant effects on water quality. Some of these effects are the result of hydrological changes, such as the building of dams, draining of wetlands and diversion of flow (Rory 2004). More obvious are the polluting

activities, such as the discharge of domestic, industrial, urban and other wastewaters into the watercourse (whether intentional or accidental) and the spreading of chemicals on agricultural land in the drainage basin (Eggen *et al.,* 2010).

Water quality is affected by a wide range of natural and human influences. The most important of the natural influences are geological, hydrological and climatic, since these affect the quantity and the quality of water available. Their influence is generally greatest when available water quantities are low and maximum use must be made of the limited resource; for example, high salinity is a frequent problem in arid and coastal areas (WCW 1999). If the financial and technical resources are available, seawater or saline groundwater can be desalinated but in many circumstances this is not feasible. Thus, although water may be available in adequate quantities, its unsuitable quality limits the uses that can be made of it. Although the natural ecosystem is in harmony with natural water quality, any significant changes to water quality will usually be disruptive to the ecosystem (Ogunkoya 2000). The effects of human activities on water quality are both widespread and varied in the degree to which they disrupt the ecosystem and/or restrict water use. Pollution of water by human faeces, for example, is attributable to only one source, but the reasons for this type of pollution, its impacts on water quality and the necessary remedial or preventive measures are varied. Faecal pollution may occur because there are no community facilities for waste disposal, because collection and treatment facilities are inadequate or improperly operated, or because on-site sanitation facilities (such as latrines) drain directly into aquifers (Liu *et al.,* 2009). The effects of faecal pollution vary. In developing countries intestinal disease is the main problem, while organic load and eutrophication may be of greater concern in developed countries (in the rivers into which the sewage or effluent is discharged and in the sea into which the rivers flow or sewage sludge is dumped) (Mclure 2001). A single influence may, therefore, give rise to a number of water quality problems, just as a problem may have a number of contributing influences. Eutrophication results not only from point sources, such as wastewater discharges with high nutrient loads (principally nitrogen and phosphorus), but also from diffuse sources such as run-off from livestock feedlots or agricultural land fertilized with organic and inorganic fertilizers. Pollution from diffuse sources, such as agricultural runoff, or from numerous small inputs over a wide area, such as faecal pollution from unsewadged settlements, is particularly difficult to control (Agbaire *et al.,* 2014). The quality of water may be described in terms of the concentration and state (dissolved or particulate) of some or all of the organic and inorganic material present in the water, together with certain physical characteristics of the water. It is determined by *in situ* measurements and by examination of water samples on site or in the laboratory. The main elements of water quality monitoring are, therefore, on-site measurements, the collection and analysis of water samples, the study and evaluation of the analytical results, and the reporting of the findings. The results of analyses performed on a single water sample are only valid for the particular location and time at which that sample was taken (Ovrawah *et al.,* 2001). One purpose of a monitoring programme is, therefore, to gather sufficient data (by means of regular or intensive sampling and analysis) to assess spatial and/or temporal variations in water quality.

The quality of the aquatic environment is a broader issue which can be described in terms of:

- Water quality,
- The composition and state of the biological life present in the water body,
- The nature of the particulate matter present,

Review of Related Literature

Impact of Mining on Water

Mining can have harmful effects on surrounding surface and groundwater. If proper precautions are not taken, unnaturally high concentrations of chemicals, such as arsenic, sulfuric acid, and mercury over a significant area of surface water may cause a sever danger to organism in the water. With large amounts of water used for mine drainage, mine cooling, aqueous extraction and other mining processes, increases the potential for these chemicals to contaminate ground and surface water. As mining produces copious amounts of waste water, disposal methods are limited to contaminate within the waste water. Runoff containing these chemicals can lead to the devastation of the surrounding vegetation. The dumping of the runoff in surface waters is the worst option (Kangpe *et al.,* 2014). Therefore, submarine tailings disposal are regarded as a better option (if the waste is pumped to great depth). Land storage and refilling of the mine after it has been depleted is even better, if no forests need to be cleared for the storage of debris. The contamination of watersheds resulting from the leakage of chemicals also has an effect on the health of the local population.

In well-regulated mines, hydrologists and geologists take careful measurements of water to take precaution to exclude any type of water contamination that could be caused by the mine's operations (Ademola, 2008). The minimization of environmental degradation is enforced in America mining practices by federal and state law, by restricting operators to meet standards for the protection of surface and groundwater from contamination. This is best done through the use of non-toxic extraction processes as bioleaching

Mining contributes to water pollution in various ways and the most common and significant mining related processes, which result in water pollution, are discussed below:

Sources of Water Pollution

Drainage Water from mine site:

The water in the mines is contaminated due to the following reasons:

- During wet dust suppression where variety of dusts get mixed with water.
- During drilling, blasting, transportation, of different metals, minerals salts, sediments, that get mixed with water to be drained (Aremu *et al.,* 2008)

Coal Mines:

Mine drainage water is generally hard, alkaline, moderately saline, and ferruginous, with low oxygen demand but rich in suspended matters associated with most of coalmining. A high level of mineralisation was noticed via high values of electrical conductivity. Besides coal dust contain high level of Na, K salts, strontium and barium; If seam contains Fe, S then mine water will be acidic and very low pH (Roy *et al.,* 2003).

Discharge Mining Pit:

The physical changes such as de-lamination, bedding plane separation, fault reactivation and fissuring of rock masses during mining permit air to penetrate a much larger surface area than

the immediate boundaries of the working area and associated roadways. These physical changes alter the hydro-geological conditions within coalfield and allow wider movement of ground water through the rock masses than existed prior to mining. These factors mean that the ground water comes in contact with large surface area of rock and exposed to oxidation. Hence, ground water becomes contaminated, mine water or ground water which are exposed to mining have high salt content, and also high quantity of sulphates, iron, and other metals derived from natural resources or artificially introduced by mining equipment (Khadam *et al.,* 2006).

Water from Spoil Heaps and Spoil Heap Failures:

Surface water run-off can leach soluble salts, especially chlorides. These run-offs may discharge directly into drainage ditches and to land around periphery of the heap and infiltrate into aquifer (Umeh 2005).

Acid Mine Drainage:

It is most evident in seams with high Pyrite or Sulphur content. This is a type of drainage resulting from natural oxidation of sulphide minerals that occur in mine rock or waste that are exposed to air and water. This is a consequence of oxidation of Sulphur in the material to a higher state of oxidation and if aqueous iron is present and unstable, the precipitation of ferric iron with hydroxide occurs (Oluyemi *et al.,* 2010). The acidic ferruginous water may contain high concentration of aluminum that precipitates as hydroxide as the pH value rises on entering a receiving body of water, giving a milky appearance. Concentration of heavy metals may be high in some acid water. This phenomenon does not occur if the S is in nonreactive state and the rock has sufficient alkaline material to neutralise the acidity. But still it may contain high amount of Calcium/ Magnesium Sulphate (Mclure *et al*., 2001).

Materials and Method

Study Area

Location and size

Nasarawa state is one of the thirty-six (36) states including Abuja Federal Capital Territory (FCT); located centrally in the middle belt region of the country and lies between latitude 7º45' and 9º25N' of the equator and between longitude 7º and 9º37'E of the Greenwich meridian (Ayedemi *et al.,* 2007).

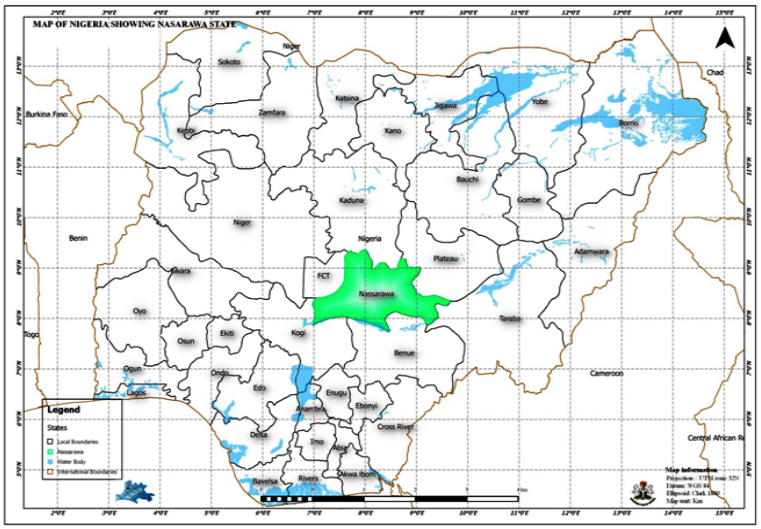


Figure 1: Nigeria showing Nasarawa State.
Source: Nasarawa geographic information service (NAGIS), 2019

Method of Data Collection

Type of data required for this study included data on the physical and chemical properties of water. It also involved data on standards from WHO and NSWQ for domestic water. The sources of the data were from both primary and secondary.

The primary data were sourced from the field through collection of water samples at the stream affected by tin mining in the study area. The water samples were analysed in the laboratory to give the concentrations of the properties covered by this study. The secondary source of data was obtained from documented materials of the WHO and the Federal Ministry of Water Resources. Data from these sources form the bulk of information required for this study.

Sample and sampling procedure

For the purpose of this study, samples were collected from six (6) points in Lakpah stream of Nasarawa Eggon Local Government Area. A reconnaissance survey was first undertaken to the study areas in Lakpah after which samples were taken in the stream at various locations, with two samples each collected of water in the stream affected by mining. The water samples were collected in two litres plastic containers labeled and preserved with four mills of nitric acid before they were taken for laboratory analysis. Further preservation was applied to the water samples by placing them in a pre-set refrigerator at 4^{o}c as laboratory analyses was in session.

At the point of sampling a hand held Global Positioning System model Garmin GPS 12 was used to geo-referenced the position at which the samples were taken. Photographs were also taken of these mining ponds to show there level of degradation on the landscapes of the adjoining communities.



Plate 1 Showing part of Lakpah Stream



Plate 2: Mining water close to Lakpah stream

Source: Field survey 2019

Laboratory Analyses

Water samples were subjected to laboratory investigation to determine the concentrations of both the physical and chemical properties.

Analysis of Water

Properties of water such as turbidity, pH, electrical conductivity and temperature were recorded in situ at point of sampling.

The physio-chemical properties of water analyzed for this study included: Temperature, Electrical Conductivity, Total Dissolved Solids; Total Suspended Solids; turbidity; Cl^-, $N0_3$, Po_3^{-4}, Pb^{2+}, Fe^{2+}, Ni^{2+}, Na^+, Ca^{2+}, Mg^{2+} and K^+. The standard methods for analysis of water were adopted for laboratory analyses of the parameters listed.



Plate 3during digestion of water samples



Plate 4: Physio-Chemical Analysis of Water

The analyses of water samples from the ponds covered by this study were carried out in the laboratory of the Agronomy Department, Nasarawa State University, Keffi.

Determination of physio-chemical properties of water

Temperature

Temperature readings were carried out in-situ at the site of sample collection, using Hanna instrument. , before taking the measurement, the probe of the electrode was sterilized using distilled water. The meter was calibrated by pressing the on mode button. The lower liquid crystal display (LCD) was then displayed, which displayed the normal default measurement mode, and then the temperature of the water read.

pH

The pH was determined with a pH meter which consisted of a potentiometer, a glass electrode, a reference electrode and temperature compensating device. The instrument was first calibrated with standard buffer solution of pH 4, pH 7, and pH 10. The electrodes were rinse in distilled water, then immersed in the test solution. The pH values were read directly on the pH meter.

Total Dissolved Solids (TDS)

A well-mixed sample was measured and filtered through a standard Millipore membrane filter. The filtrate was transferred to a weighed evaporating dish and evaporated to dryness on a stream bath. The filtrate was then dried for at least one hour in an oven at 180^0C, cooled in a desiccator and weighed. The cycle of drying, cooling, desiccating and weighing was repeated until a constant weight was obtained. The increase in dish weight represents the total dissolved solids. The formula for calculating TOS in as Follows:

$$\text{Total Dissolved solid} = \frac{A - B \times 1000}{\text{Sample volume (ml)}}$$

Where: A = weight of dried residue + dish (mg)

B = weight of dish (mg)



Plate 5 prepared nutrient agar and Eosin Methylene Blue

Total Suspended Solids (TSS)

A well-mixed sample was filtered through a weighed standard Millipore membrane filter. The residue retained on the filter was dried in an oven to a constant weight at a temperature of (103

– 105) ^{O}C for at least one hour. Then, it was cooled and weighed. The cycle of drying and weighing was repeated until a constant weight was obtained. The following formula is used to calculate TSS.

$$\text{Total suspended solid} = \frac{A - B \times 1000}{\text{Sample volume (ml)}}$$

Where: A = weight of filter + dried residue (mg)
B = weight of filter (mg)

Turbidity

Turbidity was measured with a turbid meter which consists of nephelometer with a light source for illuminating the sample. It is also made up of one or more photoelectric detectors with a read out device to indicate intensity of light scattered at 900nto the path of incident light. Calibration was carried out and its accuracy was checked by using appropriate standards. The sample was thoroughly shaken, poured into a turbidimeter tube already immersed in an ultrasonic bath. The turbidity was read directly from the instruments scale. The following formula is used to calculate Turbidity:

$$\text{Nephelometric Turbidity Unit (NTU)} = \frac{A \times (B-C)}{C}$$

Where: A = NTU found in diluted sample
B = Volume of dilution water (ml) and
C = Sample volume taken for dilution

Total Hardness ($CaCo_3$)

Total hardness was analyzed by using 25mL of the samples which was placed in different clean 250mL conical flask. To this were added 3mL of ammonium chloride in concentrated ammonia buffer (NH4CL/conc.NH3) and 2 drops of Ferrochrome Black T indicator. This was titrated against 0.01M EDTA solution until there was a color change from violet to blue. Total Hardness by Calculation: mg $CaCO_3$/ L = 2.497 [Ca mg/L]

Iron (Fe)

Methods for Detection of Iron and Manganese in Water include Atomic Absorption spectrophotometer (AAS), Inductively Coupled Plasma (ICP) and Colorimetric method. In colorimetric method iron is detected at wavelength 510 nm and manganese is detected at 525 nm. Iron is Phenanthroline method while Manganese is Persulphate method Periodate method

Lead (Pb)

Lead was determined by use of Hach's Spectrophotometers using the Reagent Set (p/n 2375000) for lead determination by the Leadtrak® Fast Column Extraction. Hach Method 8317. Range: 5 to 150 µg/L as Pb. Sample Size: 100 mL. 20 tests/reagent set.

Calcium (Ca)

Accurately weigh out about 0.252 g (to 0.001 g) of dry primary standard calcium carbonate (CaCO3, FW=100.087). Rinse into a 100 mL volumetric flask with a few milliliters of

deionized water. Dissolve in a minimum amount of 6 M HCI (a few mL) then dilute to the mark with deionized water and mix thoroughly. Concentrations of Ca were measured by digestion and filtration methods, through membrane filter papers. The digestion was made with potassium peroxosulfate. After the digestion and filtration through a<0.45-Am membrane filter, the totals were determined by continuous flow analyzer as suggested by WHO, (2011).

Sodium (Na^{+2})

Sodium was determined by the flame Atomic Absorption Spectrophotometer (Model: Buck Scientific-200A/210)

Magnesium (Mg)

Flame Atomic Spectrophotometry was used to determine Mg. Accurately weigh out about 0.101 g (to 0.001 g) of dry magnesium oxide (MgO, FW = 40.304). Rinse it into a 1000-mL volumetric flask with a few milliliters of deionized water. Dissolve in a minimum amount of 6 M HCI (a few mL) then dilute to the mark with deionized water.

Potassium (K)

The same method as in sodium was used in determining potassium in water samples. Standards of potassium chloride were prepared of 5, 10, 15, 20 and 25ppm. The concentration of potassium was then observed and recorded from the plotted graph of absorbance of potassium chloride.

Phosphorus (PO_3)

Phosphorus was measured by digestion and filtration methods through membrane filter papers. The digestion was made with potassium peroxo-sulfate. After the digestion and filtration through a<0.45-Ammembrane filter, the totals were determined by continuous flow analyzer.

Chloride (Cl_3)

Chloride was determined by Argentometric Method. Chloride is determined in a natural or slightly alkaline solution by titration with standard silver nitrate, using potassium chromate as an indicator. Silver chloride is quantitatively precipitated before red silver chromate is formed.

$$\text{Chloride mg/L} = \frac{(A-B) \times N \times 35.45 \times 1000}{\text{ml sample}}$$

Where A = ml AgNO3 required for sample
B= ml AgNO3 required for blank
N= Normality of AgNO3 used

Nitrates (NO_3)

The ultraviolet spectrophotometric screening after (Greenberg et.al, 1985) was used to determine nitrates. The filtrates of 250mls of each water sample was collected and measured at a. 200nm and b.275nm. For each sample a blank zeroing with twice distilled water was

used. Absorbers due to nitrates were calculated as a-b and multiplied 0.55 to get values of nitrate in mg/l.

Fluoride (F)

Fluoride was determine by the use of Colorimetry; EMSLC Method 340.1, Sample added to sulfuric acid and distilled to remove interferences; distilled sample treated with SPADNS reagent; color loss resulting from reaction of reagent with fluoride is determined at 570 nm and concentration read off standard curve.. EPA, (1998c).

Determination of Heavy metals

Determination of heavy metals was done based on method described by Tukura *et al*. (2014) and Dan'azumi and Bichi, (2010). Digestion of the sample is one of the storage steps taken to preserve the samples from bacterial activities and to release the metals into the analytical solution. 20mlof each water samples was measured into conical flask and; 5ml of concentrated HNO3 was added for preservation. The sample was then heated for 15minutes to evaporation point using digestion block in a fume chamber and each of the sample was allowed to cool before it was transferred into a clean 100cm3 volumetric flask which was filled to the mark with deionised water. It was then filtered and then the filtrate was then used for Atomic Absorption spectrophotometric analysis. Where the level (concentration) of each metal (copper, zinc, iron, lead, manganese, chromium, and nickel) present in the sample was determine with reference to the appropriate calibration curve that was obtained from the concentration of the standard solutions.



Plate 6: During digestion of water samples



Plate 7: Heating water samples containing nitric acid

Determination of Microbial Load

Sterilization of Glassware and Other Materials for Microbial Test:

All glassware were thoroughly washed with detergent, rinsed and allowed to dry. The glassware were wrapped with aluminum foil was sterilized in a hot air oven at about 170^{oc} for 60minutes.
The media and the distilled water that was used for serial dilution was autoclaved at 120^{oc} for 15minutes, the work bench was also swab with 70% alcohol frequently before and after every stage of the procedure.

Total Coliform Count
Method: The standard plate count technique was used as described by Idowu*et al*. (2011)
Reagent: Nutrient agar (Eosin Methylene Blue (EMB) and MacConkeybroth was used for determination of total colony and *E.coli* in the water samples. And each the media was prepared according to the manufacturer's specification and sterilized using autoclave to avoid external contamination.

Apparatus used:

- Incubator
- Autoclave
- Media preparation utensils (Borosilicate glass, stainless steel)
- Pipettes and its container
- Petri Dishes.

Media preparation:
37.5 gram of Eosin Methylene Blue Agar was weighed and dissolved in 1000ml of distilled water. This was heated on a hot plate with magnetic stirer to cook; it was then sterilized in an autoclave at 121^{o}c for 15minutes.

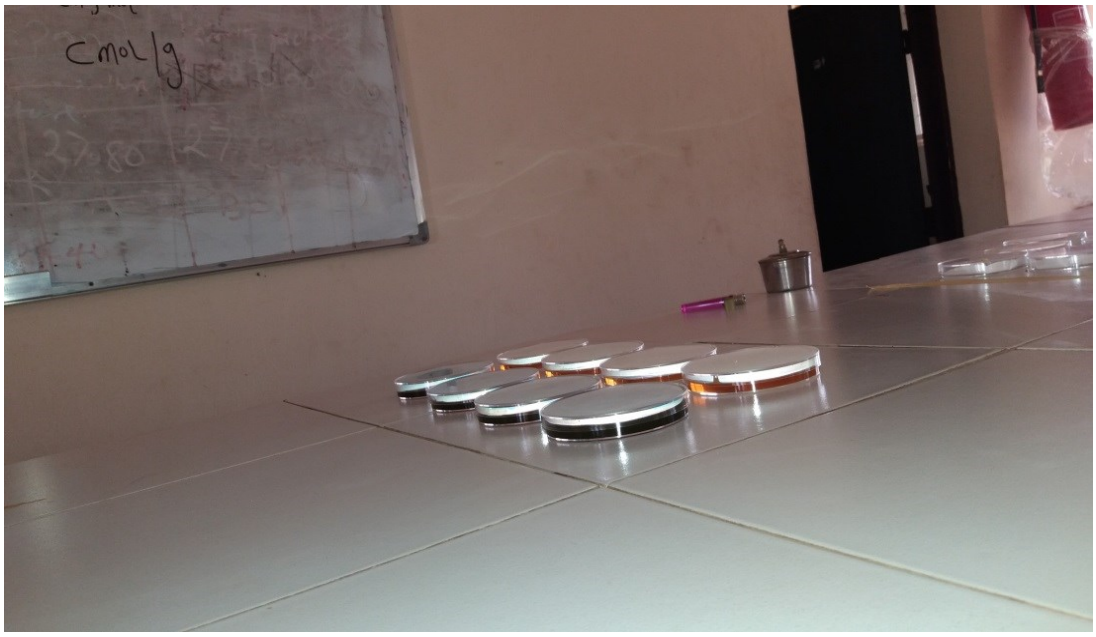


Plate 8 prepared nutrient agar and Eosin Methylene Blue

Statistical Analysis

The results of the water samples were summarized using simple descriptive statistics. These involved the computation of range, mean, standard deviation and coefficient of variation.

Correlation analysis was done to determine the relationship between the variables covered by this study by applying Pearson Product Moment correlation. The procedure indicated the degree to which pairs of variables are correlated (Blalock 1079).

The basic materials used for sampling was; one liter of plastic container, marker, camera, writing pad, masking tape and cooling box. One stream, two mining pits were collected in October 2019, the sampling point includes upstream, mid-stream, downstream, the first mining pit (pit1), and the second mining pit (pit2) in clean plastic bottles. All the sampling bottles were washed with sample water to reduce contamination. The samples were marked and labeled after the source of water, sampling location and date of water sample collection. The collected samples were preserved in ice-block containing plastic cooling box and transported to the laboratory after which was refrigerated for further analysis. The physio-chemical analysis of the water samples were determined using standard analytical methods.

Parameters with extremely low stability such as temperature was determined in the field using a mercury in glass thermometer, others parameters like TDS, Electrical conductivity and pH was determined immediately the samples were taken to the laboratory. The pH of water samples was measured using pH meter after the meter had been dully calibrated with standard buffers of pH 4.0, 7.0 and 9.0. Other metals were carried out using Atomic Absorption Spectrometric and digestion of water samples was carried out as explained below for heavy metal determination

Results and Discussion

The concentration of the physio-chemical properties of water in Lakpah Stream

Temp (^{0}C)

Table 4.1 gives the physical and chemical properties of water at Lakpah stream. The temperature of the water ranged between 22 to 26^{0}c and with a mean of 24^{0}c. The temperature showed little variation in distribution. Since the stream is not very far from mining areas, it is therefore not surprising that the temperature of the water showed slight variation as recorded by this study.

PH

The mean pH recorded of water was 7.7 for the Lakpah stream. The pH was highest for the pond at Lower stream which recorded 8.2. The distribution of pH within the stream showed slight variation and were all slightly alkaline as the values recorded for this study were not far from neutral. The pH of thestream implies that the water will not affect the solubility of the water for a variety of uses.

Electrical Conductivity (uS/cm)

The result in table 4.1 revealed that electrical conductivity ranged between 11 to 353 uS/cm. All the values were low for the water though slight variations were observed among the stream

however, the concentrations will not pose problem as it will not result in salinity built up at level to affect many uses of the water in the area. The low values of electrical conductivity observed for the water can be attributed to the low anthropogenic activities taken place and the fact that most of the mines have their water drained through the raining season causing dilution of the dissolved salts in the water thus reducing them to the barest minimum as observed by this study. In a study by Khadijat (2016) high electrical conductivity was observed for water in River Kurafe which she attributed to the human activities which increased the pollution load of the river.

Total Dissolved Solids (mg/l)

The result of TDS revealed that the range was between 400 to 2004 mg/l. The high values observed for within the river which could be attributed to the nature of rocks most of which are rich in primary elements. The total dissolved solids of the water vary in distribution. Three differences observed can be attributed to difference in sampling points and activities taking place. The total dissolved solids of the water however were at level that will impair the use of the water in the area. However, the use of water in the area if not properly managed may result in salinity in the long run.

Turbidity (NTU)

Table 1 revealed that turbidity was between 4.8 to 44 NTU within the river. The highest was recorded for the lower point while the lowest was at the highest point. The highest turbidity observed for the Lakpah River may be attributed to the decomposed leave falls and the stagnation of water that cause unsightly condition. Middle point showed little turbidity of their water, implying that the direct penetration of the rays of light into the river will not affect aquatic organisms. Similar finding was observed in a study by Shittu *et.al*. (2008)

Table 1 Physico-chemical properties of water In Lakpah Stream

Locations	Temp. ^0C	pH	TDS mg/l	Hardness mg/l	NO_3 Mg/l	Turbidity (NTU)	EC uS/cm	Cl_3 mg/l	PO_3 mg/l
Lakpah	23.8	7.76	400	286	0.04	44	80	1.5	0.5
Point 1	26.5	8.1	1800	382	0.03	32	11	0.97	0.8
Point 2	24	8.4	2,004	278	0.05	32	230	1.2	0.8
Point 3	24	9.1	1,600	146	0.08	6.8	240	2.2	0.4
Point 4	26.5	10.2	1682	125	0.05	4.8	.20	1.12	0.5
Point 5	28.3	7.32	462	300	0.07	5	352	0.26	0.6
Range	23.8-28.3	7.32-10.2	400-2004	125-382	0.04-0.08	5-44	11-352	0.26-2.2	04-0.8
Mean	25.5	8.48	1324	252.8	0.05	20.8	188	1.21	0.6

Source: Laboratory Analysis, 2019

Hardness mg/l (CaCO3)

The hardness of water was between 125 to 382mg/l and a mean of 252.8 mg/l. the result showed that hardness of the water was high. The result revealed a very high variation in the distribution. The high values observed of hardness in the study area may be attributed to the

nature of the rocks and the discharge of agricultural return flow into the river that enrich the water with calcium and probably with carbonate. The high hardness observed of water indicated that it can be used for washing a lot of detergents will be applied to produce foam. This implies that much money will be expended in the use of the water.

Chlorides (mg/l) (ClO_3)

The values of chloride were generally low for the water the river and ranged between 0.26 to 2.2 mg/l. The low chloride observed for the study implies toxicity likely to occur from chloride concentration will not pose serious problem in the use of water in the area.

Nitrates mg/l (NO_3)

The concentration of nitrates was between 0.04 to 0.08 and with a mean of 0.05 mg/l. The concentration of nitrates was generally within the stream as observed by the study. The low nitrates observed for the study area was likely as a result of the low application of it in the surrounding agricultural lands and the fact that nitrates is usually low for most soils. The nitrates observed for the water imply that the enrichment of the water with this element will not result to algal bloom in such a manner as to affect dissolved oxygen required for aquatic organisms in the area.

Phosphates mg/l (PO_3)

Phosphate just like nitrates is an important nutrient resulting in the enrichment of water in rivers and ponds. The results of phosphates of the river showed the concentration was between 0.4 to 0.8 and with a mean of 0.6 mg/l. The results have shown that the concentration was low. The low values observed just as observed for nitrates may be attributed to low use of organic and chemical fertilizers that will discharge water from agricultural return flow. The low human activities around most of this ponds and the nature of the rocks have all contributed in the low phosphates observed for the water. Low phosphates in the indicated that dissolved oxygen will not be affected to impair the oxygen demand of aquatic organisms in the river.

Calcium mg/l (Ca)

Table 2 shows the concentration of the chemical properties of water within the river. The result reveals that the distribution of calcium varies. The highest concentration of 36.2 mg/l was recorded for upper point while the lowest of 15.4 mg/l was recorded for lower point. A mean of 22.3 was however observed for calcium in the study area. The high calcium observed for upper point could be attributed to high application of calcium reach additives by farmers in the area and the subsequent discharge into the water to raise the concentration of calcium.

Magnesium mg/l (Mg)

The concentration of magnesium as indicated in table 4.2 just as calcium showed variations in distribution. The range of magnesium was 5.3-10.7 with a mean of 7.9mg/l. The variation observed for magnesium may be attributed to the nature of rocks and probably the

anthropogenic activities engaged in the area. A study by Samaila, (2015) also reported similar results of magnesium of soils on irrigated lands along Farin Ruwa River.

Table 2 Chemical properties of the stream water

Location Unit	Pb mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Fe mg/l	Zn mg/l	Mn mg/l
Lakpah	23.2	7.8	4.5	0.34	2.02	0.08	0.03	0.02
Point 1	32.6	10.3	2.7	0.12	1.18	0.12	0.01	0.01
Point 2	28.4	5.3	2.8	0.08	5.7	0.18	0.06	0.05
Point 3	15.4	5.8	0.8	0.56	4.2	0.04	0.03	0.02
Point 4	16.2	10.7	2.4	0.48	3.6	0.12	0.08	0.04
Point 5	18.0	7.2	7.2	0.21	2.6	0.08	0.05	0.02
Range	15.4-32.6	5.3-10.7	0.8-7.2	0.08-0.56	1.18-5.7	0.04-0.18	0.01-0.00	0.01-0.05
Mean	22.3	7.9	3.4	0.3	3.2	0.1	0.04	0.03

Source: Laboratory Analysis, 2019

Sodium mg/l (Na)

Sodium recorded for the study area was between 0.8 and 7.2 with a mean of 3.4 mg/l. The values of sodium recorded for this study though were low when compared with major cations of calcium and magnesium. The presence of sodium in combination with chloride may affect the taste of the water thus making it objectionable for drinking. Khadijat (2016) observed low concentration of sodium for water along River Kurafe and attributed this to the nature of the rock from which the water was flowing.

Potassium mg/l (K)

Potassium just like sodium was generally low the water of the river. The distribution of potassium was between 0.08-0.56 and with a mean of 0.3mg/l. The low potassium observed for the ponds was likely due to its low application in inorganic fertilizer and the nature of the rocks which do not yield high potassium.

Iron mg/l (Fe)

The concentration of iron was generally high. The range observed for the distribution was from 1.18 to 5.7 and a mean of 3.2 mg/l. High concentration of iron in water affect the taste and wholesomeness for a variety of uses. Study by Madu*et al* (2008) observed a lower mean value of 0.80 mg/l of iron for wet season water of River Antau.

Zing mg/l (Zn)

The presence of zinc in the ponds covered by this was traced, the concentration is however very low. The concentration was between 0.04 and 0.18 with a mean of 0.1 mg/l. Though the values of zinc were low however there is variation in the distribution.

Manganese mg/l (Mn)

The concentration of manganese for water was low. It ranged between 0.04-0.08 and a mean of 0.04 mg/l. slight variation was observed in the distribution of this metallic ion in the water of the ponds. Despite the low values observed for manganese however the concentration of this in some ponds could be lethal to human health.

Lead (Pb) mg/l

Lead like other trace metals covered by this study was traced for the water generally. The values of lead ranged from 0.01-0.05 and with a mean concentration of 0.3 mg/l .The result of lead in the study area was generally low within the river. The nature of the rocks and the low human activities at the ponds could have been responsible for the low lead recorded in the study area. In a similar study in Pakistan, Zaigham (2012) recorded high values of lead and attributed this to dissolved materials from rocks, waste water from streets or roof tops and pesticides from agricultural operations that end up into the natural drainage system.

Distribution of the physio-chemical properties in Lakpah Stream

The spatial distribution of the parameters covered by this study in some cases showed high variation while in others little variations were observed. The variation observed for some of the properties covered by this study may be attributed to the nature of rock and the low level of pollution from the absence of human activities within the river.

Temperature for water was highest (28.3^0c) at upper point and lowest at middle point (23.8^0c) while a mean of 25.5^0c was observed. The variation observed was due to the difference in time of sampling.

pH varied with the highest recorded (10.2) at lower point and lowest 7.32 at upper point. The mean distribution of pH was 8.48. This showed that pH varied in its distribution at the river. Total dissolved solids were highest (2004mg/l) at middle and dropped to 400 mg/l at lower part of the river. The mean of 1324 mg/l recorded of TDS indicate that there is high variation in the distribution amongst the ponds. Hardness as indicated by $CaCO_3$ was at every point in the river between 382 and 125mg/l respectively. A mean of 252.8 mg/l was observed. High calcium carbonates observed and may be attributed to the nature of the rocks and the applications of calcim rich fertilizers in adjoining farmlands.

Nitrates were generally low. However the highest value was recorded (0.08) and lowest (0.04 mg/l) within the river. A mean of 0.05 was observed. The result showed little variation in the distribution of nitrates. Turbidity was highest (44 NTU) at the upper point and lowest (5 NTU) at the lower point of the Lakpah river. A Mean of 20.8 NTU was observed across the river in the study area.

The highest (352 uS/cm) electrical conductivity of water was recorded while the lowest is at (11uS/cm). The mean of 188uS/cm recorded of EC showed that the distribution varied within the river. Chlorides were also low however, very slight variations were observed. Between 2.2 and 0.26mg/l was recorded. A mean value of 1.21 was observed for the river in the area. Phosphate just as in nitrates was low within the river. The highest value (0.8) was recorded at 0.4mg/l for with a mean of 0.6mg/l across the water.

Calcium and magnesium had means of 22.3 and 7.9 mg/l respectively. The highest calcium (32.6mg/l) was recorded and lowest (15.4mg/l). Magnesium (10.7 mg/l) was highest at the upper point and lowest (0.08 mg/l) at lower point of the river. The values of both calcium and magnesium were low and varied in distribution across the river. The variation observed of these cations was likely due to the low application of both organic and inorganic fertilizer and the low availability of these elements in the rocks overlain by surrounding mining activities. Sodium and potassium are also important primary elements of rocks. However their presence depends on the type of rocks. The concentrations of these cations were generally low when compared to those of calcium and magnesium. The mean concentrations of Na and K were 3.3 and 0.3 mg/l respectively. The highest concentrations of 7.2 and 0.56 were observed. While the lowest were of o.8 and 0.08 mg/l were recorded. The results of these elements also showed variation in distribution within the river. Iron had a mean value of 3.2 mg/l, zinc was 0.1mg/l, manganese 0.04mg/l and lead 0.03 mg/l. The concentrations of these trace elements varied. The lowest values of iron at (1.18 mg/l) were recorded, 11mg/l, zinc 0.04mg/l at, manganese 0.04 and lead 0.01mg/l. The highest values observed for iron 5.7 mg/l, zinc 0.18mg/l, manganese 0.08mg/l while 0.05mg/l was observed. Analysis of variance carried out to determine if there was significant difference in the distribution of the chemical properties of water at 0.05 significant level, showed that there is no significant difference in the distribution of the variables covered by this study. Though variations may exist however statistically there is no significant difference as ANOVA indicated.

Determination of the biological properties of water within the Lakpah stream

Table 3 Biological properties of water sampled along the gradients of Lakpah stream

S/N	Sample Name	Media	Total E coli	Media	Total coliform Count(CFU/100ml)
	Lakpah Stream				
1.	Point 1	EMB	21	NA	118
2.	Point 2	EMB	160	NA	123
3.	Point 3	EMB	269	NA	128
4.	Point 4	EMB	230	NA	90
5.	Point 5	EMB	91	NA	139
	Control	EMB	100	NA	20
	WHO limit = 0.00	CFU/100 Ml		0.00CFU/ 100ml	

Source: Laboratory Analysis, 2019

Key EMB = Eosin Metheylene Blue Agar, NA = Nutrient Agar, CFU= Coliform forming unit

Table 3 showed the results of the microbial load of the water samples. The total coliform count WHO standard is 0CFU/100ml, the results of this study provided imperative evidence that all

the water samples analyzed from the various sampling points were contaminated with total Coliform. The *E.coli* count standard according to WHO is 0CFU/100ml for drinking water. All the samples were above the standard and as such it is said to have been contaminated, diseases and illnesses that can be contracted in water with high fecal coliform counts include; typhoid fever, hepatitis, gastroenteritis, dysentery and ear infections (Ngoye *et al.,* 2004).These high level contaminations may be attributed to the fact that in those areas, there were no special facilities for public places convenience, which caused the inhabitant to adapt to indiscriminate defecation. Again, the level of contamination may be as a result of animal grazing along the area where by the tendency of increasing the risk of animal faeces water contamination is high.

Evaluation of suitability of water from the stream for domestic use

The fitness of water in the ponds for domestic use was evaluated taken into consideration those variables that affect the use of water for domestic purposes. The variables likely to affect the palatability and wholesomeness of water were taken into consideration. The result of properties covered by this study were compared with the World Health Organization, (WHO, 2012 and WHO, 2015) Guidelines for Drinking Water. The physical properties determine the beauty and aesthetic value of the water (palatability) while the chemical properties determine how free the water is from disease causing organisms and chemicals (wholesomeness).

Table 4: Maximum Allowable Limit of Water for Domestic Use.

Chemicals	SDWR
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 color units
Copper	1.0 mg/L
Corrosivity	non-corrosive
Fluoride	2.0 mg/L
Foaming agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor numbers
Ph	6.5 – 8.5
Silver	0.1 mg/L
Sulfate	250 mg/L
Total dissolved solids (TDS)	500 mg/L
Zinc	5 mg/L
Total Coli forms	5.0%
Turbidity	5 NTU

Source: WHO Guidelines for Drinking Water (2012).

The temperature recorded of the water of the ponds were within the limit considered for domestic water use as the concentration was not above 32^0c considered by WHO. The range of pH 7.32 to 10.2 with a mean of 8.48 recorded for water in the area falls above 6.5 to 8.5 the

permissible limit considered by WHO (2012) for domestic water as shown in table 4. 3. The use of the water with pH at the concentration observed by this study will affect solubility as such its palatability for human consumption. Though some pH of river were within the limit however majority fall above the level considered safe for domestic use. The mean electrical conductivity of 1332 uS/cm for the water was above the 500 uS/l limit considered for domestic water. Turbidity of 5 to 44 NTU was also above the 5 NTU recommended by WHO 2012 for domestic water use.

The mean concentration 1.21 mg/l of chlorides of water was low and within 250 mg/l the maximum allowable limit for domestic water use while iron which ranged from 1.18 to 5.7 mg/l was high and above 0.3 mg/l the maximum allowable limit considered for domestic water supply. The high iron ion observed for the water of the ponds will affect the taste and as well cause coloration thus making it unpalatable for domestic use especially for drinking.

The mean manganese of 0.04 mg/l was within the allowable limit however; about half of the river had their water above the limit. Hardness as indicated by $CaCO_3$ was high for the water indicating that should the water be used for domestic purpose it will require the high use of foaming agents thus it will be expensive to use such water. Zinc 0.04 to1.18 mg/l was low for water and was within the limit of 5 mg/l recommended by WHO 2012 for domestic water use. Lead of 0.01 to 0.05 mg/l was within the limit of 0.05 mg/l of WHO (2015) safe for domestic use as indicated in table 4.4. The concentration of magnesium of between 5.3 and10.7 mg/l was high against the 0.5 mg/l maximum permissible level for domestic water. The use of water with high magnesium as observed by this study may affect the taste and colour of the water thus making the water objectionable for use. The range of calcium of between 15.4 and 32.6 mg/l was low and within the 75 mg/l of desirable level considered for domestic water use. This implies that in-term of calcium in the water it will not result in excessive scales formation and cause hardness of the water.

The suitability of the water as evaluated by this study showed that most of the parameters covered by this study were high compared to the WHO standards considered for domestic water use. This therefore implies that should the water be used for domestic use it will likely be accompanied by after effects on human health. The high concentrations of the properties observed for water of the ponds for domestic use therefore is objectionable. Though the water may not be suitable for domestic use it can be evaluated for other uses that require less stringent water quality such as irrigation.

Table 5: WHO Standard for domestic water use

Substance	Undesirable effect	Highest desirable level	Maximum Permissive level
Copper	Astringent taste, corrosion of pipe fittings and utensil	0.0mg/1	**1.5mg/1**
Iron (Fe)	Taste discoloration; and growth of iron bacteria; turbidity	0.1mg/1	**1.0mg/1**
Magnesium (Mg)	Taste; discoloration	0.05mg/1	**0.5mg/1**

Zinc (Zn)	Astringent taste; opalescence	5.0mg/1	**0.5mg/1**
Total Hardness	Excessive Scale formation	2mEq/[ab] ($100mg/CaCo_3$)	**10mg/l to100mg/$CaCo_3$**
Calcium	Excessive scale formation	75mg/1	**200mg/1**
Lead (Pb)	Plumbish; Highly toxic	-	**0.05mg/1**
Arsenic (As)	Human Cancer	-	**0.01mg/1**
Cadmium (Cd)	It affects metabolism	-	**TJV 0.0mg/1**
Sliver (Ag)	**Upon chronic ingestion causes**	**-**	**MAC 50mg/1**

Source: WHO, 2015

Conclusion and Recommendation

Conclusion

The results from this study showed that water in Lakpah stream vary in the concentration of the physio-chemical properties. Most of the properties of the water were generally high above the limit considered safe for domestic use as such the water in the area is not good for domestic use. The use of water in the area will be accompanied by ill effect to human health. If the water is to be used for domestic purposes caution must be observed. The study therefore rated the water from the stream as being objectionable for domestic use because of the high level concentration observed for most properties. Potable water should be made accessible and affordable to the community and by the government

Recommendations

Based on the results obtained from this study, the following recommendations become necessary:

Since the water is found to have most properties evaluated above the desirable level considered for domestic water there is the need for inhabitants' around the river to be cautious in the use of the water from the water for domestic purposes.

There is need for adequate funding of the nation's environmental programs for water quality.

i. Public enlightenment on health hazard associated with contaminated groundwater should be given to the populace by health workers.
ii. There should be provision of adequate disposal facilities by government authorities and agencies to each residential area/household to aid proper refuse collection and effective disposal.
iii. Solid waste dumpsite sites should be created by relevant authorities, and these sites should be far from residential areas. By doing this, strict environmental laws and regulations should be put in place for anyone who breaks the law, by this, people would be careful in the way and manner the dumpsite their waste.

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