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Water Quality Assessment Of Wyitt and Environs, Part Of Jos-Bukuru Metropolis, North Central Nigeria

Joyce Ayuba Ramadan*
Department of Mineral and Petroleum Resources Engineering, Plateau state Polytechnic, Barkin Ladi, P. M.B 02023, Bukuru, Plateau state.

***Abstract* -** The quality of the water resource within the area was imperative owing to the fact that the most decent source utilized by the residents for domestic and other uses is the groundwater from wells and boreholes. This aroused the need for the chemical and bacteriological analysis of both ground and surface water within the study area with the sole aim of verifying the water sources in order to determine the suitability for consumption which would aid in controlling outbreaks of water borne diseases within the area of investigation. The Garmin Global Positioning System (GPS) was used to locate the sample points with a total of 36 (thirty six) water samples represented by 15 (fifteen) groundwater from wells and 3 (three) stream channels all taken in pairs inside sterilized polythene containers and subsequently transported to the laboratory. A pair of 18 (eighteen) samples were analyzed for the following chemical constituents Cr, As, Ca, Fe and Mg; others include Pb, Cd, Ni and K. using the Atomic Absorption Spectrometry (AAS) technique. The second pair of 18 (eighteen) water samples were analyzed for microbes employing the tube dilution method in order to test for total coliform bacteria resulting to the Total Coliform Counts (TCU) which gives a general indication of the sanitary condition of a water samples taken. The results from the both analyses were compared with the World Health Organization (WHO) standard for drinking water quality. The outcome from the chemical analysis reveal arsenic abov the WHO standard in sample 1,2,3,4,5,13,15 and 18, likewise iron in samples 3,4,5,6,7,8,9,10,11,13,15 and 16. Lead was also discovered above the required standard in samples 3,13 and 16; similarly, Cadmium was detected in sample 3 and 11 in excess of the standard value. Sample points 2,3,4,6,7,8,10 and 16 contained nickel above the WHO permissible level. The microbial analysis of the samples equally revealed an alarming contamination with all the samples which contained coliform bacteria. The surface water sources represented by sample 1,3 and 5 were more contaminated with an evidence of the infiltration of same in the wells situated close to these sources(SP 2 and 4). Treatment of both surface and groundwater sources within the area before consumption was recommended to lessen the health hazards that inhabitants would be exposed to.

***Index Terms*-** Chemical, Bacteriological, Groundwater, Surface water, Analysis

1. INTRODUCTION

The study area is located within the Jos-Bukuru metropolis and has experienced a sudden growth in population lately; this has led to an intense competition on the available resources including water. Also, the generation and indiscriminate dumping of wastes in water ways and the use of available land resources for dry and wet season farming with the application of fertilizer to same has triggered this piece of research. The main objective here is to establish the evidence of the interaction between the human activities and the water sources within the study area.

However, it is pertinent to note the fact that the inhabitants within the area depend solely on groundwater for domestic use as no pipe-borne water is connected in the area. Therefore the health and well being of the population depends on the quality of this very fundamental resource. Surface water is open to several kinds of abuse which renders it more contaminated than groundwater though the two sources are interdependent as surface water in most cases recharges the groundwater. Generally, it is difficult to correct groundwater pollution depending on the level and type of groundwater pollutants [2] and so, the need for the protection of both sources. In general, shallow aquifers are mostly affected from the negative impacts of anthropogenic soil use in urban agglomerates and owing to the large quantity of effluent discharged into most surface waters, the natural processes of pathogen reduction are inadequate for protection of public health [13] posing a significant danger to the immediate consumers of same as sanitizing the waters will be expensive and may not even be achieved before use.

Prevention of water sources is therefore important and this requires effective monitoring by sampling the parameters from time to time as check. The bacteriological examination of water has a special significance in pollution studies, as it is a direct measurement of lethal effect of pollution on human health [13]. So also the chemical investigation as this enables one to identify and quantify the chemical components and properties of a certain water. This usually forms the groundwork for water quality and pollution studies.

2. LOCATION, PHYSIOGRAPHY AND GEOLOGY

The area under investigation is part of the Jos Plateau, located in the north-central part of Nigeria (Fig. 1) and lies within latitudes 8^0 51' 33''N and 8^0 52' 26''N and longitudes 9^0 47' 30''E and 9^0 49'27''E (Fig. 2). It covers an area extent of about 4.0 km^2, and is accessible through several untarred roads and footpaths linking the major Jos-Bukuru express way.

The settlements are situated on a gently undulating terrain with mined out areas (ponds) sited at the eastern part of the study area. The topographic elevations vary from 4000m to 4200m above sea level and is drained up by a major river channel which is a tributary of river N'gell (fig. 2).

The study area is underlain by the rocks of the Basement complex which were intruded by Younger Granite complex rocks (fig. 3) seen as outcrops within the area. These rocks include the Rayfield Gona biotite granite, Bukuru biotite granite, N'gell biotite granite and the Jos biotite granite.

3. METHODS OF STUDY

The equipment used to carry out this research include the Global Positioning System (GPS) used to take the coordinates as well as the elevations of the sampling points .In addition, 18 (eighteen) water samples were collected from a mined-out pond (dumpsite), stream channels (seasonal farmlands) and wells in sterilized plastic containers which were labeled appropriately and taken to the laboratory for analysis. This was done in pairs so as to conduct both the chemical and bacteriological analysis concurrently.

A. Chemical Analysis

Atomic Absorption Spectrometry (AAS) is a technique for measuring quantities of chemical elements present in environmental samples by measuring the absorbed radiation by the chemical element of interest [10]. A total number of eighteen (18) water samples were collected in sterilized polythene containers, which were labeled appropriately. These were acidified with conc. HNO_3 for preservation and then immediately transported to the laboratory for the analysis using Atomic Absorption Spectroscopy (AAS) technique. The samples were first of all stored under refrigeration to stabilize the metals for up to two weeks and then analyzed directly with 1-2% of HNO_3 at blank and standard level. One (1) liter of each of the samples was evaporated with 25ml of HNO_3 to 100ml volume for 10 times concentration and analyzed with aqueous 1-2% of HNO_3 blank and standard to give total metal which are extractable, suspended and dissolved. While analyzing for Lead (Pb) only, one (1) liter of sample was extracted with a pH=2, with 0.2 grams Dithizone and 20ml MIBK for a 50 times concentration which was further analyzed with oil-based Pb standard in MIBK and extracted at an aqueous standard for calibration.

Also, the Global Positioning System (GPS) was used to document the exact locations where these samples were acquired and plotted eventually on the map.

B. Bacteriological analysis

The microbiological examination of water emphasizes assessment of the hygienic quality of the supply. This requires the isolation and enumeration of organisms that indicate the presence of faecal contamination (www.who.int/water_sanitation_health/dwq/2edvol3d.pdf). Similarly, a set of eighteen (18) water samples were collected in sterilized plastic containers and transported to the laboratory for the microbial analysis which was done to determine the Colony Forming Unit (CFU) i.e. coliform bacteria (Escherichia coli) present in the samples using the tube dilution method. 1ml of each sample was inoculated into 10ml of already prepared sterile lactose broth containing inverted durham tubes. The tubes were then incubated at $37^{\circ}C$ for 24 hours and further observed for acid and gas production which is usually an indication of the presence of coliform.

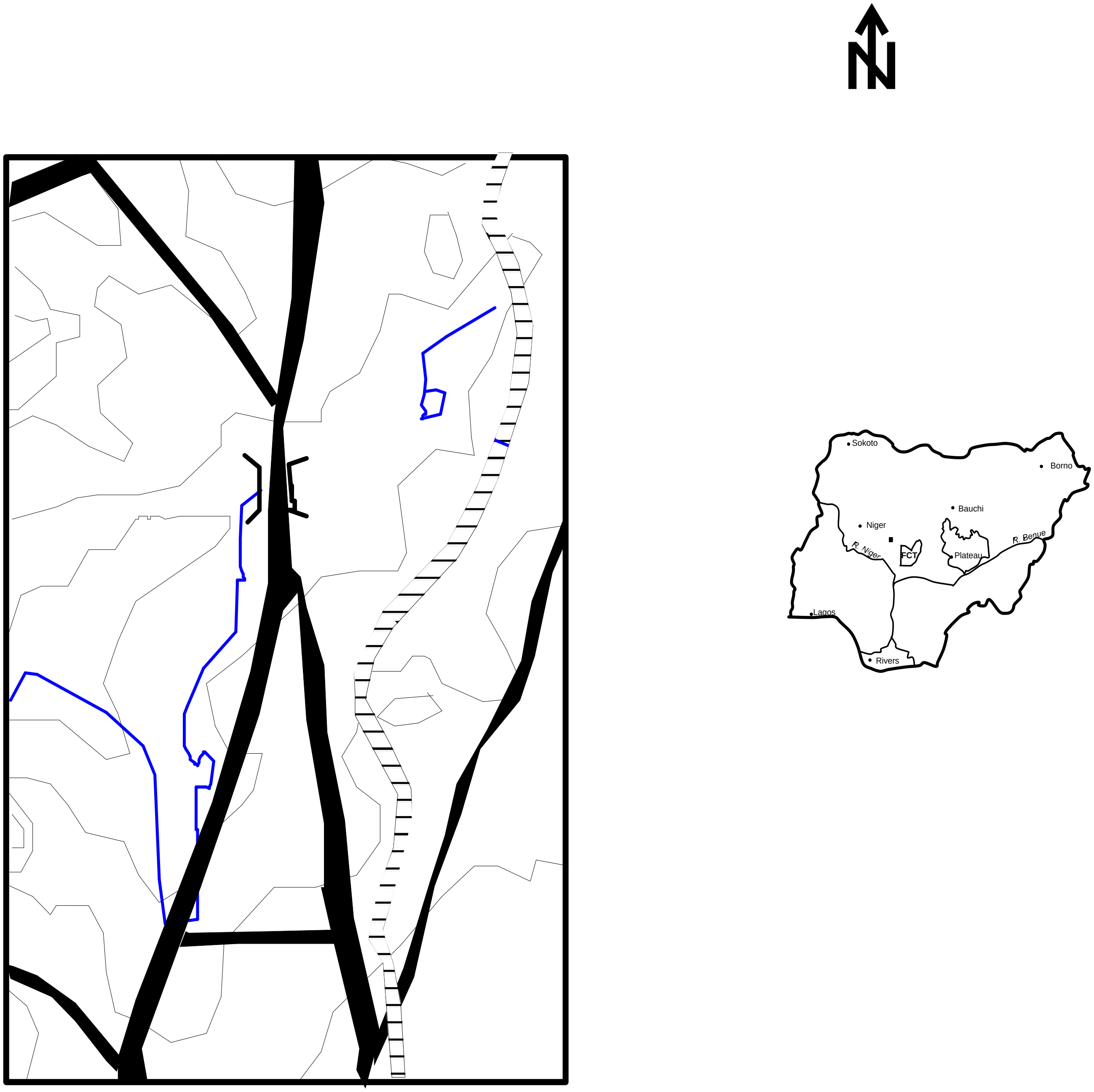

Fig. 1 Location Map of the Study Area

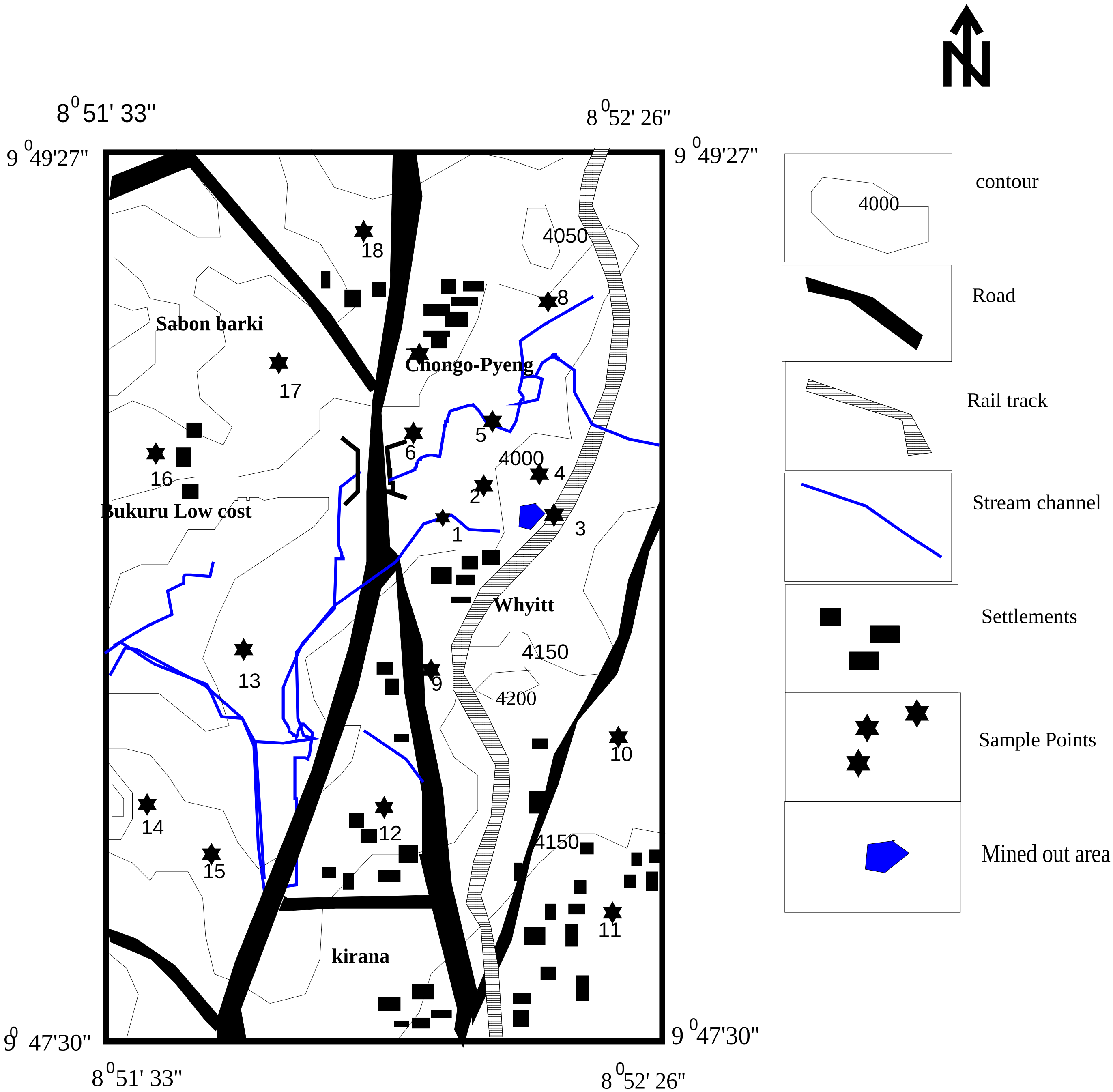

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Fig. 1.2 Map of the Study area showing the Sample points

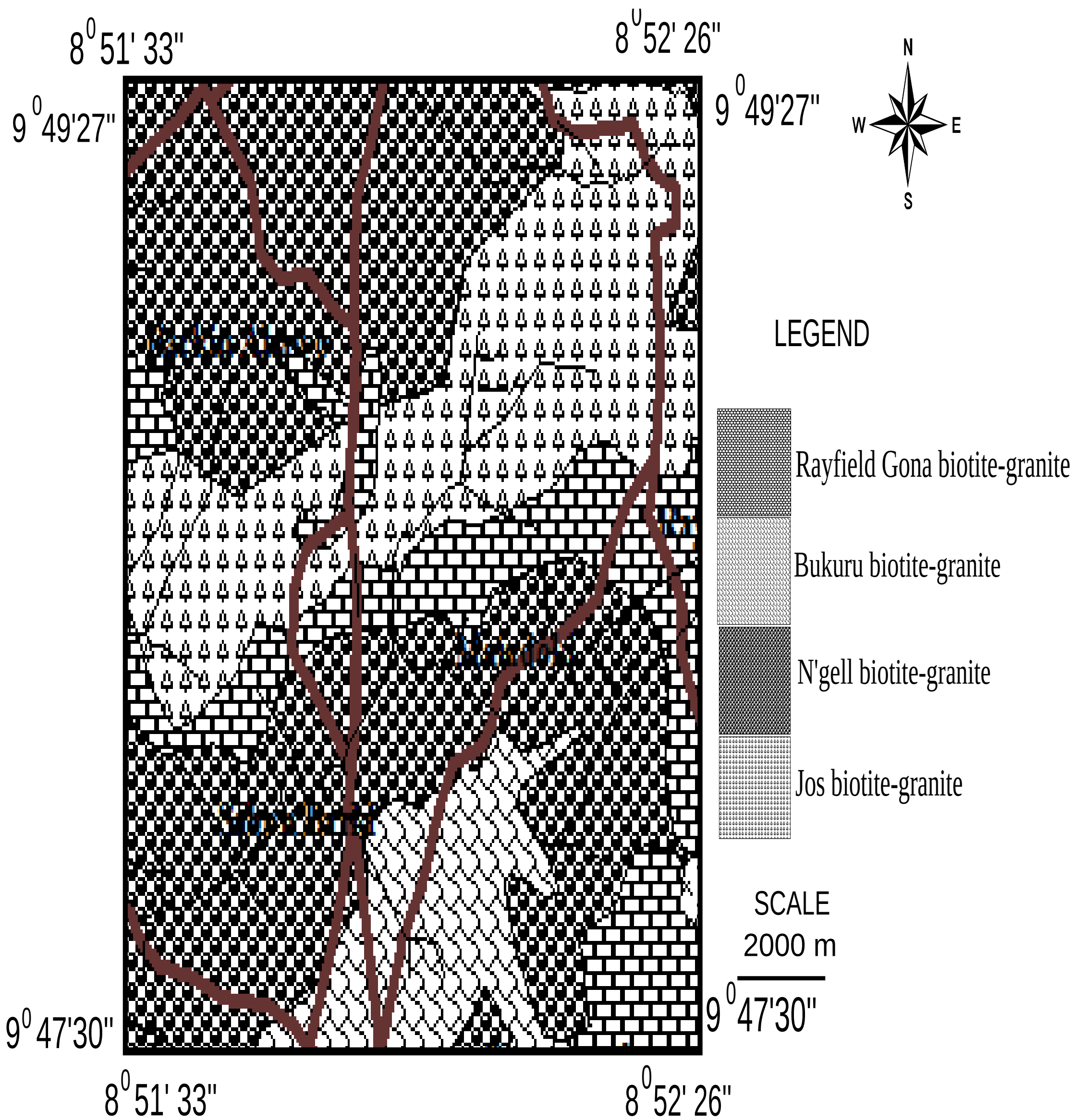

Fig. 1.3 Geological Map of the Study area showing the different Rock types after [12]

4. RESULTS AND DISCUSSIONS

A. *Chemical Analysis*

The outcome of the chemical analysis of the samples collected were compared with the World Health Organization (WHO) standard for drinking water quality as displayed on Table 1 below. This was done to check the excesses /deficiencies and proffer solutions that would be useful to the inhabitants within and around the area under investigation.

pH is categorized as one of the most significant water quality parameters. Measurement of pH relates to the acidity or alkalinity of the water where a sample is considered to be acidic if the pH is below 7.0 or alkaline if above 7.0. The pH values of all the samples were measured range from 6.5 – 7.0 (Table 1) below. This was achieved on the field, using a pH meter. All the values recorded against the sample points fall within the WHO standard range of 6.5 – 8.5 and are therefore considered acceptable.

Chromium (Cr) is one of the less common elements and does not occur naturally in elemental form, but only in compounds. Major sources of Cr-contamination include releases from electroplating processes and the disposal of Cr containing wastes [16]. The chemical analysis confirm that there is no Cr- contamination in any of the samples collected, which is evident in the display of results in Table 1 above.

Arsenic (As) was also analyzed for and detected above the WHO permissible level in Sample Points (SP) 1,2,3,4 and 5, others include SP 13,15 and 18 (Table 1) above. Arsenic is associated with skin damage, increased risk of cancer, and problems with circulatory system [15]. Also Long-term exposure to arsenic via drinking-water causes cancer of the skin, lungs, urinary bladder, and kidney, as well as other skin changes such as pigmentation changes and thickening (hyperkeratosis).

Calcium (Ca) was detected in all the samples collected as displayed in Table 1above; and within the acceptable WHO standard for drinking water quality.

Iron (Fe) making up at least 5 percent of the earth's crust, iron is one of the earth's most plentiful resources. Rainwater as it infiltrates the soil and underlying geologic formations dissolves iron, causing it to seep into aquifers that serve as sources of groundwater for wells. Iron is not hazardous to health, but it is considered a secondary or aesthetic contaminant and the WHO recommends that the iron content of drinking water should not be greater than 0.3 mg/L (Table 1). On the contrary, the iron content of groundwater is important in small amounts because it helps transport oxygen in the blood [8]. From the analysis of the samples collected within the study area, SP 3,SP 4, SP 5,SP 6, SP 7 and SP 8 contained iron above the recommended quantity by WHO. Similarly, SP 9, SP 10, SP 11, SP 13, SP 15 and SP 16 comprised iron which exceeded the recommended limit (Table 1).

Magnesium (Mg) is present in all natural waters and have many beneficial effects which makes it essential to human health [3]. All the samples analysed within the area of investigation comprised magnesium within the acceptable WHO standard limit as shown in Table 1.

Lead (Pb) is a toxic metal that is harmful to human health. It has been estimated that up to 20 % of the total lead exposure in humans can be attributed to a waterborne route, i.e., consuming contaminated water [5]. From the investigation conducted, lead (Pb) was discovered above the WHO standard in SP 3, SP 13 and SP 16 and high levels of lead contamination in a child can result in convulsions, major neurological damage, organ failure, coma, and ultimately death. Moderate to low levels of exposure may result in hearing loss, inhibit growth, and cause learning disabilities [4]. It is pertinent to note that some of the effects of lead poisoning cannot be cured, but it is possible to reduce exposure to lead.

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Cadmium (Cd) is a metal found in natural deposits as ores containing other elements. Cadmium occurs naturally in zinc, lead, copper and other ores which can serve as sources to ground and surface waters, especially when in contact with soft, acidic waters. Major industrial releases of cadmium are due to waste streams and leaching of landfills, and from a variety of operations that involve cadmium or zinc. In particular, cadmium can be released to drinking water from the corrosion of some galvanized plumbing and water main pipe materials[7] within the study area, Cadmium was detected in some samples though below the WHO permissible level while in some others it was not detected at all. However in SP 3 and 5, cadmium was discovered above the WHO permissible level (Table 1) and it is not surprising as the sample was collected from an abandoned Tin mine pond though in use as irrigation water for dry season farming. The potential dangers to human health if exposed to it over a prolonged period of time are kidney, liver, bone and blood damage.

Nickel (Ni) is a naturally occurring, hard but pliable, silvery-white metal found in nearly all soils or released through industrial wastewater which ends up in soil or sediment where it attaches to particles containing iron or manganese. Therefore when it rains small particles of nickel in the soil can be washed into surface water by runoff combined with other elements to form compounds that are often green and dissolve fairly easily in water. Major sources of exposure for most people are by eating food and drinking water that contain natural amounts of nickel [11]. From the display of results in Table 1, nickel was observed above the WHO standard in SP 2, 3, 4, 5, 6, 7, 8 and 10 which could be quite hazardous to the human health if it gets into the system by any means. The most common harmful health effect of nickel in humans is an allergic reaction, others include cancers and birth defects [1].

Potassium (K) is an essential element in humans and is seldom, if ever, found in drinking water at levels that could be a concern for healthy humans. This is factual of all the samples collected within the study area as displayed in Table 1.

B. *Microbial Analysis*

In like manner, Table 2 below is an exhibition of the results of the microbial analysis placed side by side with the World health Organization standard. Coliforms are bacteria that are always present in the digestive tracts of animals, including humans, and are found in their wastes. They are also found in plant and soil material [6]. It is important to note that the presence of pathogens is determined with indirect evidence by testing for an “indicator” organism such as coliform bacteria. The most basic test for bacterial contamination of a water supply is the test for total coliform bacteria resulting to the total coliform counts which gives a general indication of the sanitary condition of a water supply.

From the analysis of the water samples carried out within the study area, it is apparent that all the samples contain coliform bacteria (Table 1), however Total coliform bacteria are not likely to cause illness, but their presence indicates that your water supply may be vulnerable to contamination by more harmful microorganisms [9] thereby increasing the risk of contracting a water-borne illness.

5. CONCLUSION

This research revealed that the surface water sources (SP 1, 3 and 5) are more contaminated than the well/groundwater sources. Also, it would not be out of place to conclude that the surface water sources contribute immensely to recharging groundwater within the area; this was made evident by the groundwater samples collected from wells sited closer to the streams and pond (SP 2 and 4) which comprise more contaminants than the wells sited farther away from the surface sources. In addition, from the results of the chemical and bacteriological analysis a presentation of most of the drinking water sources show contamination and if consumed without treatment then health problems would be imminent.

Table 1: Results of The Chemical Analysis compared with the WHO standard

Sample Points	pH	Cr (Mg/L)	As (Mg/L)	Ca (Mg/L)	Fe(Mg/L)	Mg (Mg/L)	Pb (Mg/L)	Cd (Mg/L)	Ni (Mg/L)	K (Mg/L)
SP1	6.50	0.010	0.022	4.108	0.241	0.255	0.002	0.002	0.02	5.831
SP2	6.99	0.040	0.070	3.162	0.202	0.700	0.012	-	0.03	3.416
SP3	7.02	0.090	0.280	4.401	0.550	0.372	0.017	0.006	0.14	5.202
SP4	6.60	0.002	0.082	2.802	0.602	0.905	0.009	0.004	0.09	3.751
SP5	6.71	0.043	0.220	3.201	1.041	3.680	0.013	0.008	0.02	3.310
SP6	6.91	0.011	0.005	3.400	2.012	1.614	0.008	-	0.06	3.216
SP7	7.02	0.001	0.010	4.074	0.591	1.467	-	-	0.04	3.621
SP8	6.96	0.021	0.004	3.207	0.621	1.070	0.001	0.002	0.50	3.518
SP9	7.01	0.001	0.002	3.587	1.091	0.662	-	-	-	3.381
SP10	6.52	0.002	0.004	3.722	1.017	0.794	0.007	-	0.02	3.550
SP11	7.08	0.002	0.002	3.014	0.448	2.921	0.012	-	-	3.351
SP12	7.03	0.020	0.008	4.210	0.300	1.460	0.003	0.001	-	3.301
SP13	7.02	0.010	0.011	5.098	0.365	1.606	0.019	-	-	2.019
SP14	7.01	-	0.003	4.864	0.166	2.670	0.013	-	-	2.013
SP15	7.00	-	0.012	2.986	3.080	2.532	0.014	0.001	-	3.014
SP16	6.89	0.021	0.009	3.094	1.860	1.091	0.016	-	0.03	02016
SP17	6.90	0.001	0 004	4.006	0.127	2.109	0.001	0.001	-	1.001
SP18	7.01	-	0.015	4.328	0.021	0.321	0.010	-	-	3.010
WHO Maximum Permissible Level	6.5-8.5	0.1	0.01	>10	0.3	10	0.015	0.005	0	10

Table 2: Results of the Bacteriological Analysis compared with the WHO standard

Sample Point	Physical Observation	Total Coliform Counts	WHO Permissible Standard
SP1	Clear	188	0
SP2	Clear	120	0
SP3	Colloidal	245	0
SP4	Colloidal	134	0
SP5	Colloidal	233	0
SP6	Clear	180	0
SP7	Clear	155	0
SP8	Clear	162	0
SP9	Clear	108	0
SP10	Clear	111	0
SP12	Colloidal	123	0
SP13	Clear	104	0
SP14	Clear	106	0
SP15	Colloidal	117	0
SP16	Colloidal	118	0
SP17	Colloidal	120	0
SP18	Clear	113	0

6. RECOMMENDATION

By way of minimizing the health hazards that would be experienced in event of consumption of such waters, the following suggestions are made:

- Treatment of water sources that contain Arsenic, Iron and Lead above the WHO permissible level can be achieved through the Reverse Osmosis (RO) technique as it is considered effective and most cost effective in the removal of inorganic molecules. This is filtration at molecular level. It works by forcing water through a special, selective membrane that has microscopic pores, specially sized to allow water molecules through, while trapping larger inorganic molecules like lead, iron, chromium and arsenic.
- Similarly, Reverse Osmosis will remove 95 - 98% of the cadmium in the water, others include the use of sodium form cation exchanger (softener) and electrodialysis which will also remove the majority of the cadmium.
- Reverse osmosis will remove 97 - 98% of the nickel from drinking water. Also Nickel can be removed by a strong acid cation exchanger and reduced in extent by the activated-carbon filtration.
- For water sources contaminated with coliform bacteria, disinfection is recommended. The most commonly used well water disinfectants are sodium hypochlorite (chlorine bleach) and calcium hypochlorite. Other options include ozonation,boiling and iodination.

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Author's Biography: My name is Joyce Ayuba Ramadan, I have obtained a B.sc. in Geology and Mining form University of Jos, Nigeria in 1999; a Master of Science degree in Hydrogeology and Engineering Geology from University of Jos in the year 2009 and currently a PhD research student in Abubakar Tafawa Balewa University (ATBU) Bauchi, in Nigeria. I am a lecturer with Plateau state Polytechnic, Barkin Ladi, attached to the Department of Mineral and Petroleum Resources Engineering.

E-mail: ramadanjoyce@gmail.com