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# Evaluation of Heavy Metal Concentration in Drinking Water Collected from Local Wells and Boreholes of Dutse Town, North West, Nigeria

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**Abstract**
Water samples collected from Dutse Town, Jigawa State, were studied and analyzed for heavy metals. A total of 48 samples were collected from 24 different sampling sites in Dutse town namely: FUD, Gidan Dubu Yadi, Bakwato 1, Bakwato 2, Tashar Danwake, Fatara, Kargo, Garu/Emir palace, Fagoji 1, Fagoji 2, Zai, Jigawa Sarki, Kachi, Limawa, Galamawa, Dasina, Takur Adua, Jigawar Tsada, Takur Site, Dan Masara, Mopol Base, G-9 Site and Aminu Kano Way/Cikin Gari. The samples were studied and analyzed for eight (8) heavy metals namely; Cadmium (Cd), Cobalt (Co), Copper (Cu), Iron (Fe), Manganese (Mn), Lead (Pb), Mercury (Hg) and Nickel (Ni). The results obtained were compared with the international standards. The samples were analyzed at the Central Laboratory, Ahmadu Bello University, Zaria. Atomic Absorption Spectrometer (AAS) was used in this study and the average concentration of these heavy metals are 0.0034, 0.0409, 0.0151, 1.8241, 0.01471, 0.2731, 2.2829 and 0.0433 mg/l for Cd, Co, Cu, Fe, Pb, Mn, Hg and Ni respectively. Among the analyzed heavy metals, Cd, Co, Cu and Ni were below the recommended level set by United State Environmental Protection Agency (USEPA) and World Health Organization (WHO) while Fe, Pb, Mn and Hg were higher than the recommended level set by USEPA and WHO for safe drinking water. This imply that the water collected from these sampling areas were contaminated with heavy metals which may have serious health hazard to the people using such water for drinking and other domestic activities.
**Keywords:** Heavy metals, Wells, Boreholes, Drinking Water, Dutse Town

## 1. INTRODUCTION

Heavy metal poisoning can be defined as the excess accumulation of heavy metals into the soft tissues of the body. There are several signs and symptoms associated with heavy metals poisoning depending on the type of the heavy metals ingested. Small amount of some heavy metals are essential to human body function amongst these metals are Cu, Zn, Cr, Fe and Mn, but when the recommended level is exceeded, they may also be poisonous to human health. The most common heavy metals causing serious damage to the human body include Lead, Mercury, Arsenic and Cadmium. Heavy metal poisoning can result from the following: industrial exposure, water or air pollution, foods, drugs, improperly coated food containers or the ingestion of lead-based paints [1].

Toxic metals are usually present in industrial, municipal and urban runoff, which can be harmful to humans and other forms of life. Increased concentration of heavy metals are associated with urbanization and industrialization. Particularly, heavy metals in our drinking water supplies have been a major source of concern. The dangerous chemicals released in our environment, accumulate in the soil and sediments of our drinking water bodies. More than 50 elements are categorized as heavy metals, but only 17 out of 50 elements are considered to be very toxic and relatively accessible. Heavy metal poisoning depends on the type of metal, its biological role and the type of organisms that are exposed to it. It also recorded that it has a serious effect on aquatic flora and fauna where it enters the food chain and eventually affect the human health as well. The common heavy metal poisoning in drinking water are lead, iron, copper, zinc and chromium. They can cause significant effects to the human body in small amount and are toxic in large doses [2].

Copper is a significant trace element but indicate toxicity if in excess amounts in drinking water but cadmium is extremely toxic even in low concentrations and will bio-accumulate in organisms and ecosystems and it has along biological half –life in the human body, ranging from 10 to 33years. Long term exposures to Cadmium also induces renal damage. So cadmium is considered as one of the primary pollutants and is monitored in most countries and international organizations.

The contamination of water is directly related to water pollution. There is need to continuously assess the quality of ground and surface water sources. The known fatal effects of heavy metal toxicity in drinking water include damaged or reduced mental and central nervous function and lower energy level. They also cause irregularity in blood composition, adverse effects on vital organs such as kidneys and liver. The long term exposure of these metals result in physical, muscular, neurological degenerative processes that cause

Alzheimer's disease ( brain disorder), Parkinson's disease (degenerative disease of the brain), muscular dystrophy (progressive skeletal muscle weakness), multiple sclerosis (a nervous system disease that affects brain and spinal cord).

Lead is one of the most common heavy metal in drinking water. If it occurs more than its permissible limit it acts like a general metabolic poison and enzyme inhibitor. Lead has the ability to replace calcium in bone to form sites for long term replacements. Drinking water is obtained from variety of sources like wells, rivers, lakes, reservoirs, ponds etc. The various sources of water poses the greatest risk to human health due to contamination of these sources. Water pollutants mainly consists of heavy metals, microorganisms, fertilizers and thousands of toxic organic compounds. Heavy metals in water occur only in trace levels but are more toxic to the human body. Keeping in view the hazardous nature of heavy metal contamination in water, it became necessary to study the concentration of heavy metals in drinking water in Dutse and highlight the danger if the concentration exceed the maximum contamination level recommended by World Health Organization (WHO) and other international organization such as USEPA, and EPA.

Many works have been done on assessment of heavy metals in water in most areas where people live. A study was carried to determined Heavy Metals Contaminations of Soil and Water at Agbogbloshie Scrap Market, Accra. The results showed that the mean concentrations of soil samples ranged from 173.60 to 899.90, 9.57 to 57.73, 226.80 to 6291.33, 3.47 to 13.80, 127.83 to 1392.67, 17.03 to 64.43 and 6.47 to 62.53 (mg/kg dry weight) for Zn, Cr, Cu, Cd, Pb, Co and Ni respectively. The concentration of Zn, Cu and Pb were higher than the recommended level while the rest of the heavy metals were below recommended level. The corresponding average concentration of these heavy metals in water ranges from 0.039 to 0.060, 0 to 0.012, 0.007 to 0.019, 0.069 to 0.074 and 0 to 0.23 (mg/L) for Zn, Cu, Cd, Co and Ni respectively while Cr and Pb were below detection limit of the system [3]. Similar study was also conducted to evaluate the concentration of heavy metals in water, sediments and Fish samples of Madivala lakes of Bangalore, Karnataka. The result indicated that there was an appreciable increase in the metals concentration from water to sediment samples. The order of the metals in water and sediments are Pb > Cr > Cd > Ni. Similar analysis was conducted on the fish samples collected from the same lakes [4]. Further study was carried out to determine the level of heavy metals in water from urban areas of the Tigray region, northern Ethiopia. The samples were analyzed for six physicochemical parameters including temperature, conductivity, total dissolved solids (TDS), salinity, pH, and turbidity and some traces of heavy metals such as As, Cd, Co, Cu, Cr, Fe, Mn, Ni, Pb, and Zn using standard procedures and the results were compared with other national and international standards. The result indicated that Mn and Cu were below the maximum contamination level set by World Health Organization (WHO) but As, Cd, Cr, Fe, Ni and Pb exceeded the recommended level set by WHO. The maximum contamination level of Cobalt in drinking water is not stated by WHO but all analyzed samples comply with the maximum contamination level guidelines recommended by New Zealand of 1 mg/l and United State Environmental Protection Agency (USEPA) of 0.1 mg/l [5]. Based on the increasing influx of the people in Dutse town, it become necessary to determine the level of heavy metals in underground drinking water sources of the town.

## 2.0 MATERIAL AND METHOD

### 2.1 Materials and Equipment

The materials and equipment used in this work are; plastic containers, hand gloves, reagents, syringes, masking tape and Atomic Absorption Spectrometer (AAS).

#### 2.1.1 Atomic Absorption Spectrometer (AAS)

Atomic Absorption Spectrometry (AAS) is a method for evaluating the quantities of chemical elements available in an environmental samples such as water, soil, plants and other food stuffs. This method can be done by measuring the absorbed radiation passing through the samples and the energy of the radiation was initially calibrated for the element of interest using a standard. The quantities of the elements can be determine by reading the spectra produced when the sample is excited by the radiation. The radiation are usually ultraviolet or visible light. The atoms absorb such radiation and make transitions to a higher energy levels. The absorbed photons of light by the samples can then be measured using a detector. The detector measures the wavelengths of light transmitted by the sample and compares them to the wavelengths which was originally passed through the sample. A special device used for signal processing would then identify the changes in the wavelength absorbed and it appear in the readout as peaks of energy absorption at discrete wavelengths. The concentration is computed based on the Beer-Lambert law which stated that absorbance is directly proportional to the concentration for the existing set of conditions. The concentration is commonly measured from a calibration curve which was obtained using standards of known concentration. Though using Beer-Lambert law directly in AAS is problematic due to the following; variation in atomization efficiency from the sample matrix, non-uniformity of the concentration and path length of atoms of interest [6].

 

## 2.2 Sampling Frame

The area under study is Dutse town and this investigation is limited to underground water sources in local boreholes and wells used by people for drinking, domestic activities, irrigation and animal husbandry. The method adopted for the sampling is stratified random sampling [7].

## 2.3 Sampling Procedure

The sampling procedure involved the following:

- The sample containers were rinsed three times with the water to be collected, to minimize contamination from the original content of the sample container.
- An air space of about 1% in the container of water collected was left for each sample to give room for thermal expansion. 20 ml of diluted nitric acid was also added to the sample immediately after collection to reduce the pH and to minimize precipitation and absorption on container walls.
- The samples were tightly covered with container cover and masking tape and kept in the laboratory for analysis
- Two samples was collected per sampling point which gave a total of 48 samples from 24 different sampling points.

## 2.4 Sample Analysis

The samples were subjected to Atomic Absorption Spectroscopy (ASS) for analyzing some trace elements such as Cadmium, Cobalt, Copper, Iron, Lead, Manganese Mercury and Nickel. The system setup and working conditions have been done in agreement with the system manual.

## 3.0 RESULTS AND DISCUSSION

Heavy metal concentration collected from different sampling sites in Dutse using Atomic Absorption Spectrometer (AAS) had been studied and analyzed. The graphs plotted are concentration (ppm) against elements for each sampling point, concentration (ppm) for each element against sampling points, relationship between the elements such as Lead and Cadmium, Copper and Cadmium, Iron and Manganese, Nickel and Cobalt.

## 3.1 Concentration and Elements for Each Sampling Point

Below are the plots of Concentration in ppm against elements for each sampling point. An excess mercury (Hg) was observed in all the sampling points indicating that, it has exceeded the guidelines recommended by United State Environmental Protection Agency (USEPA), World Health Organization (WHO), Nigerian Standard for Drinking Water Quality (NSDWQ) and National Agency for Food and Drug Administration and Control (NAFDAC). The standard values are 0.002 mg/l for USEPA, 0.001 mg/l for WHO/NSDWQ and 0 mg/l for NAFDAC as shown in figures 1 to 24.

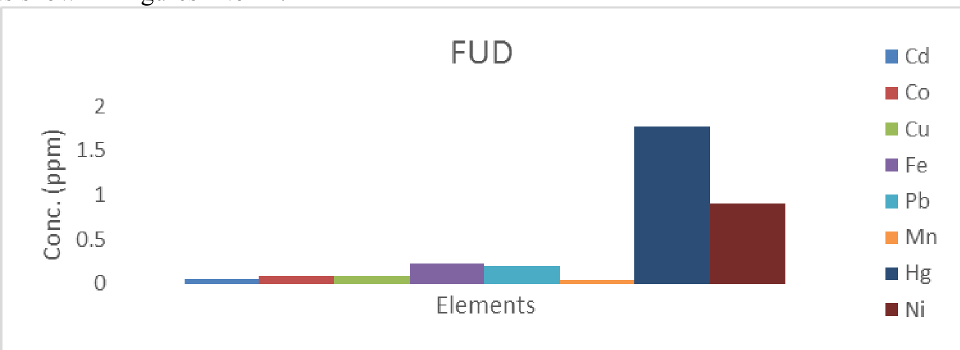


Fig. 1: Plot of Concentration (ppm) against Elements for FUD

Figure 1 shows the concentration of each heavy element in ppm for FUD. The chart indicated that, the following elements; Pb, Hg and Ni of values 0.194 mg/l, 1.776 mg/l and 0.9 mg/l respectively are higher than the recommended level set by USEPA of 0.015, 0.002 and 0.1 mg/l.

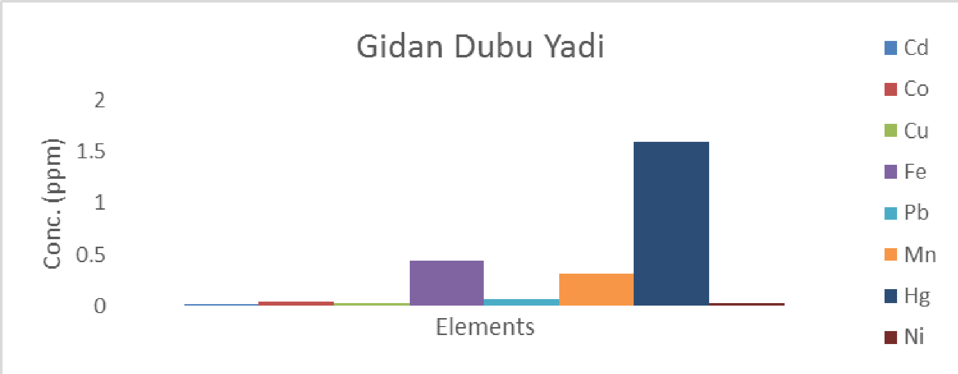


Fig. 2: Plot of Concentration (ppm) against Elements for Gidan Dubu Yadi

Figure 2 shows the concentration of the heavy elements recorded for the sample collected at Gidan Dubu Yadi. It could be seen that four heavy metals recorded including Fe, Pb, Mn and Hg of values 0.44 mg/l, 0.062 mg/l, 0.314 mg/l and 1.595 mg/l exceeded the recommended level set by USEPA of corresponding values 0.3 mg/l, 0.015 mg/l, 0.05 mg/l and 0.002 mg/l respectively.

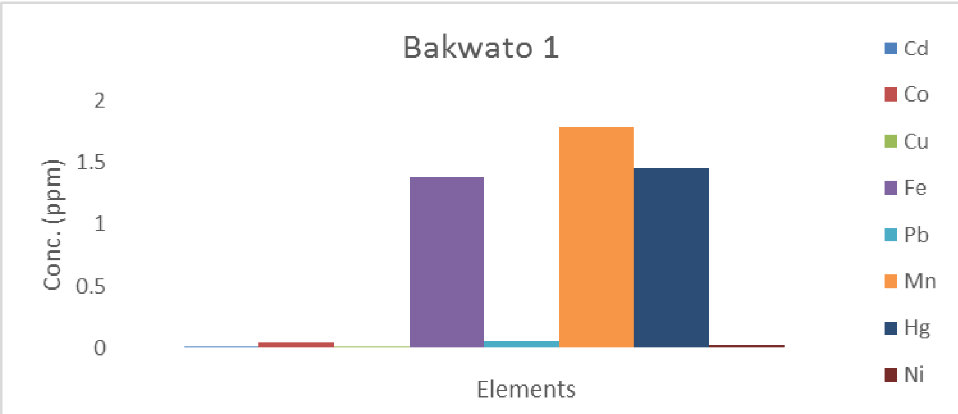


Fig. 3: Plot of Concentration (ppm) against Elements for Bakwato 1

Figure 3 shows the variation of the heavy elements at Bakwato 1. The chart illustrated that the heavy elements ranges from Iron to Mercury of values 1.382, 0.053, 1.787 and 1.454 mg/l for Fe, Pb, Mn, and Hg exceeded the maximum contamination level set by USEPA of values 0.3, 0.015, 0.05 and 0.002 mg/l respectively while all other elements comply with the maximum contamination level set by USEPA, WHO and NSDWQ.

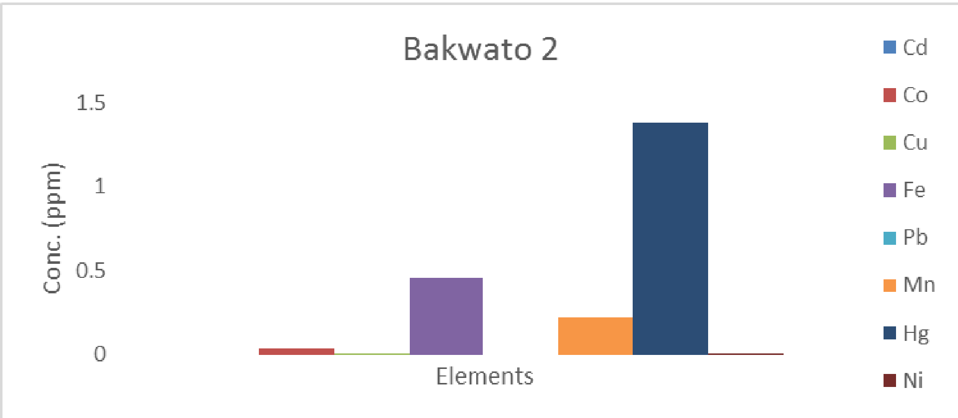


Fig. 4: Plot of Concentration (ppm) against Elements for Bakwato 2

Figure 4 illustrated the concentration of the measured heavy elements at Bakwato 2. It was indicated that Cd, Co, Cu, Pb and Ni were below the recommended level set by USEPA and WHO while Fe, Mn and Hg of 0.454, 0.22 and 1.38 mg/l were observed to have exceeded the recommended level set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

 

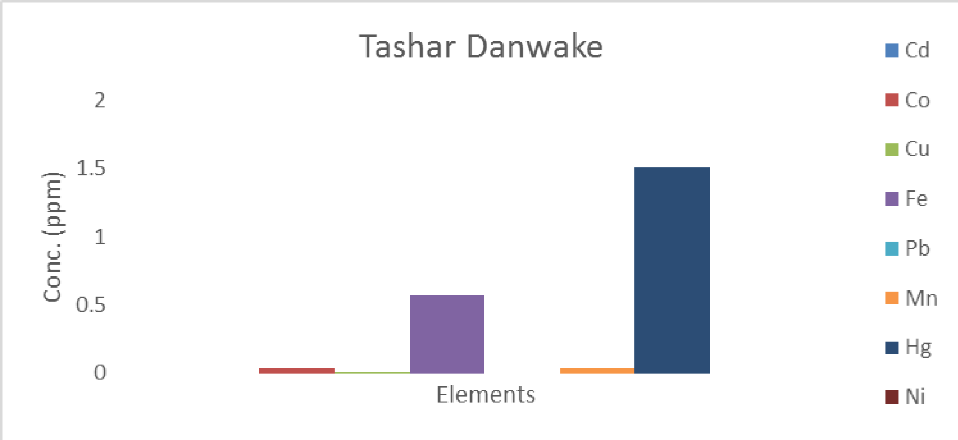


Fig. 5: Plot of Concentration (ppm) against Elements for Tashar Danwake

Figure 5 shows the variation in the concentration of the measured heavy metals from Tashar Danwake sample. It was observed that only Fe and Hg of values 0.571 and 1.507 mg/l have exceeded the recommended level set by USEPA of corresponding values of 0.3 and 0.002 mg/l respectively.

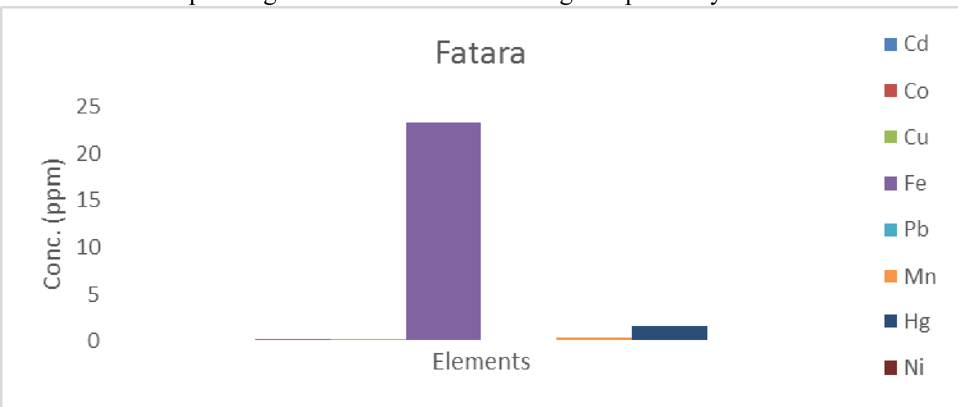


Fig. 6: Plot of Concentration (ppm) against Elements for Fatara

Figure 6 indicated the concentration of measured heavy elements for Fatara sample. It was observed that Fe, Mn and Hg of values 23.256, 0.245 and 1.458 mg/l are higher than maximum admissible limit set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

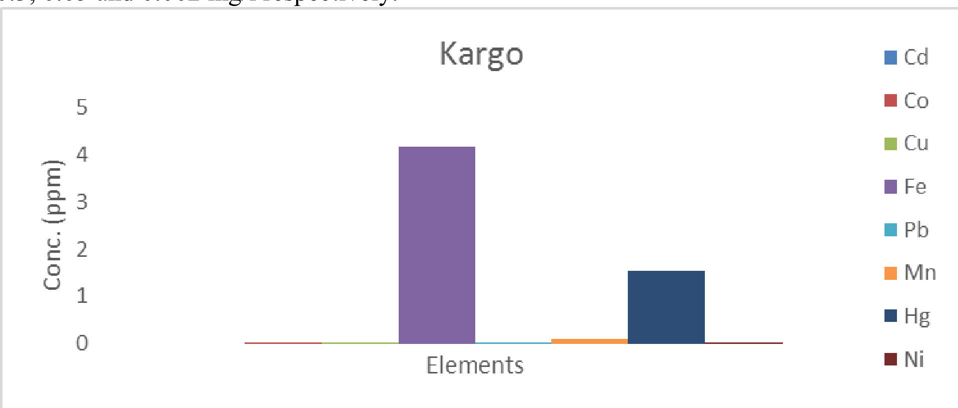


Fig. 7: Plot of Concentration (ppm) against Elements for Kargo

Figure 7 shows the variation in the concentration of the measured heavy metals for Kargo area. It was indicated that Fe, Mn and Hg of 4.156, 0.094 and 1.549 mg/l were higher than the recommended level for a safe drinking water set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

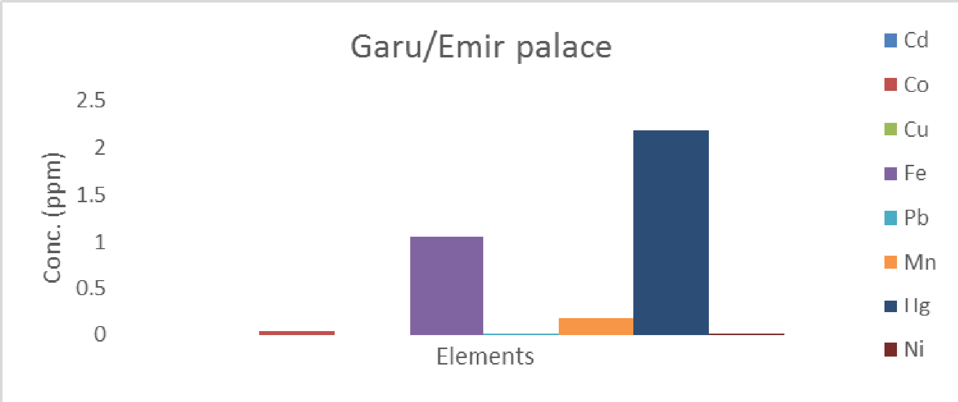


Fig. 8: Plot of Concentration (ppm) against Elements for Garu/Emir Palace

Figure 8 indicated the concentration of various heavy metals for Garu/Emir palace. The concentration of some heavy metals including Fe, Mn and Hg with corresponding values of 1.057, 0.175 and 2.179 mg/l have exceeded the recommended level set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

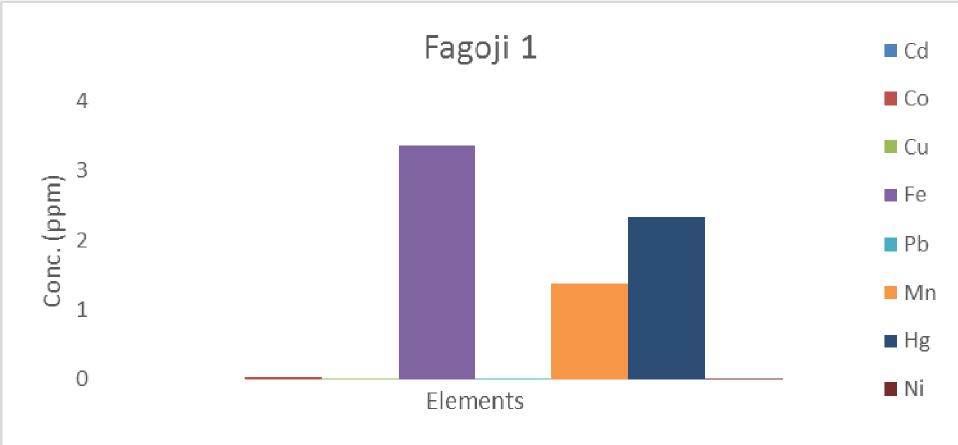


Fig. 9: Plot of Concentration (ppm) against Elements for Fagoji 1

Figure 9 shows the measured heavy elements with their corresponding concentration for Fagoji1. The histogram indicated that Fe, Mn and Hg of values 3.359, 1.388 and 2.329 mg/l were above the permissible limit set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

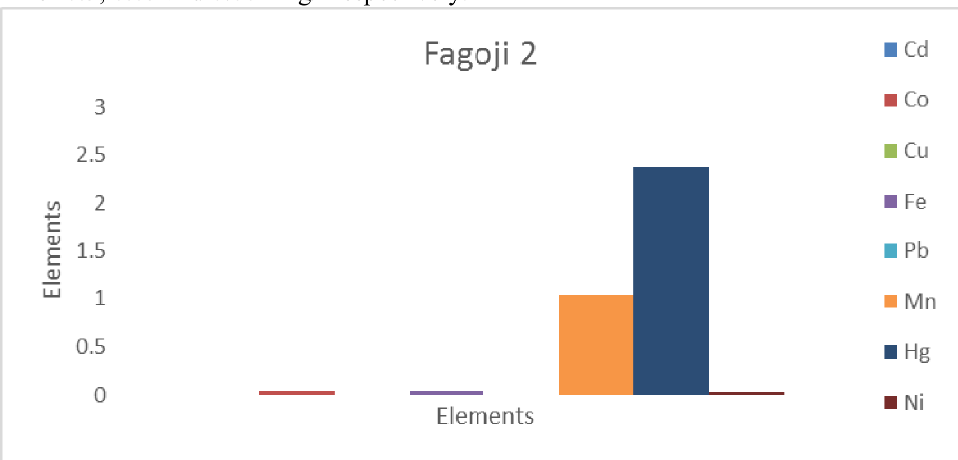


Fig. 10: Plot of Concentration (ppm) against Elements for Fagoji 2

Figure 10 shows the concentration of measured heavy elements for Fagoji 2. The result was similar to Fagoji1 which was indicated that Fe, Mn and Hg of values 0.044, 1.033 and 2.384 mg/l were above the admissible limit set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

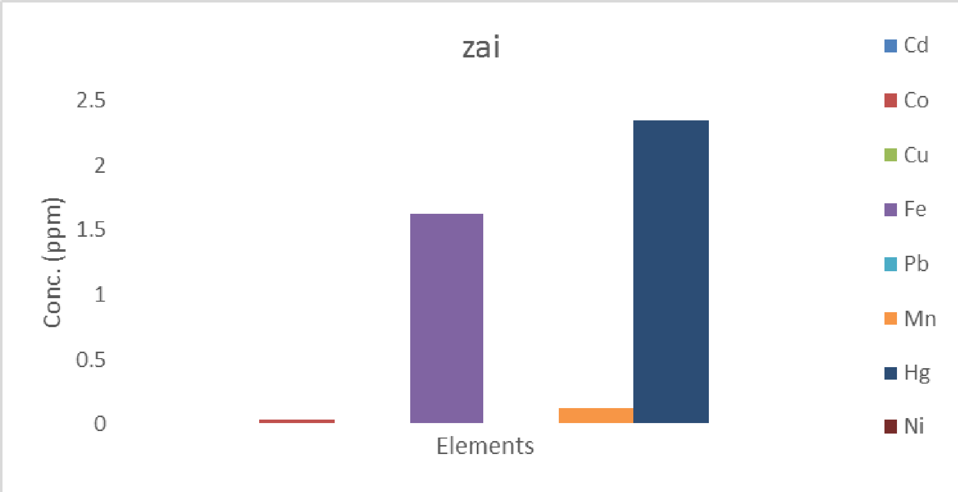


Fig. 11: Plot of Concentration (ppm) against Elements for Zai

Figure 11 illustrated the concentration of the measured heavy elements for Zai. The results obtained indicated Fe, Mn and Hg with corresponding concentration of 1.631, 0.136 and 2.349 mg/l were above the permissible limit set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively

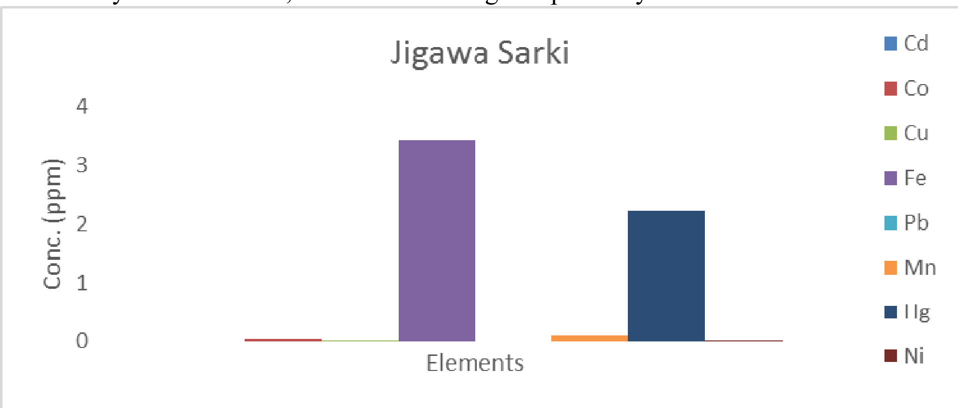


Fig. 12: Plot of Concentration (ppm) against Elements for Jigawa Sarki

Figure 12 shows concentration of measured heavy elements for Jagawa Sarki. It was realized that Fe, Mn and Hg of values 3.428, 0.095 and 2.236 mg/l exceeded the recommended level set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

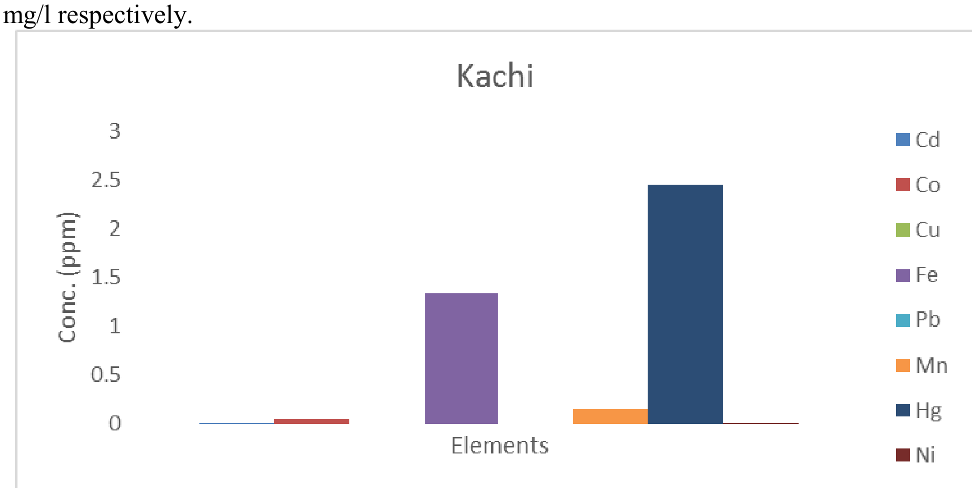


Fig. 13: Plot of Concentration (ppm) against Elements for Kachi

Figure 13 indicated the concentration of the eight heavy metals for Kachi. It was observed that Fe, Mn and Hg of values 1.340, 0.145 and 2.450 mg/l were above the maximum contamination level set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

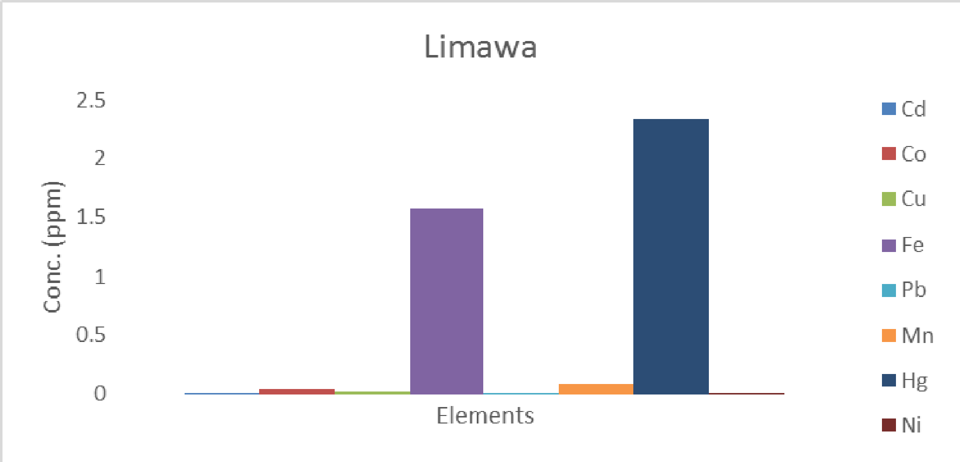


Fig. 14: Plot of Concentration (ppm) against Elements for Limawa

Figure 14 shows the concentration of measured heavy metals for Limawa. The histogram indicated same elements Fe, Mn and Hg of values 1.568, 0.079 and 2.336 mg/l were above the recommended level set by USEPA of 0.3, 0.05 and 0.002 mg/l respectively.

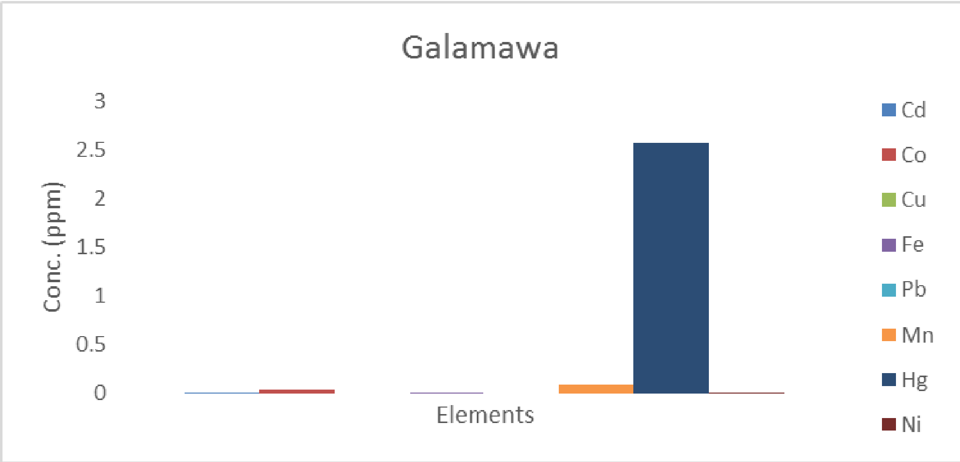


Fig. 15: Plot of Concentration (ppm) against Elements for Galamawa

Figure 15 shows the concentration of heavy elements for Galamawa. It realized that only Mn and Hg of values 0.092 and 2.556 mg/l were above the recommended level set by USEPA of 0.05 and 0.002 mg/l respectively.

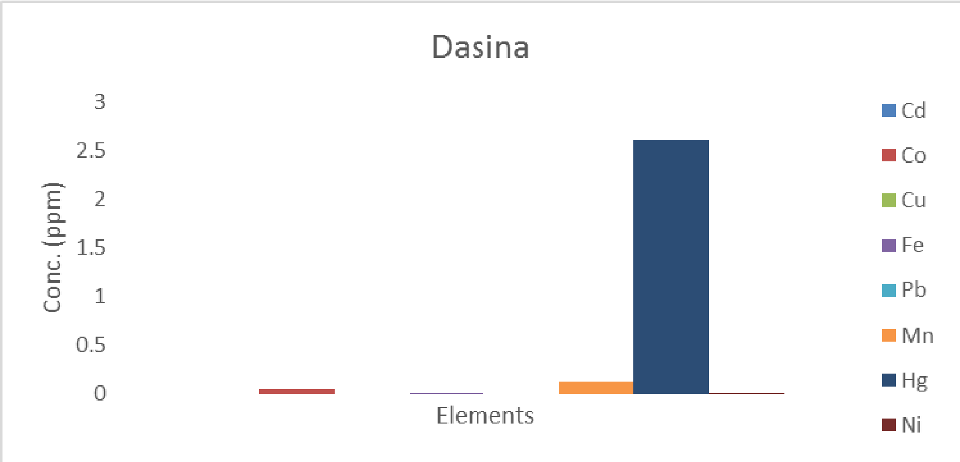


Fig. 16: Plot of Concentration (ppm) against Elements for Dasina

Figure 16 illustrated the variation in the concentration of some measured heavy metals for Dasina. It was observed that only Mn and Hg with corresponding concentration of 0.130 and 2.607 mg/l have exceeded the admissible limit set by USEPA of 0.05 and 0.002 mg/l respectively.

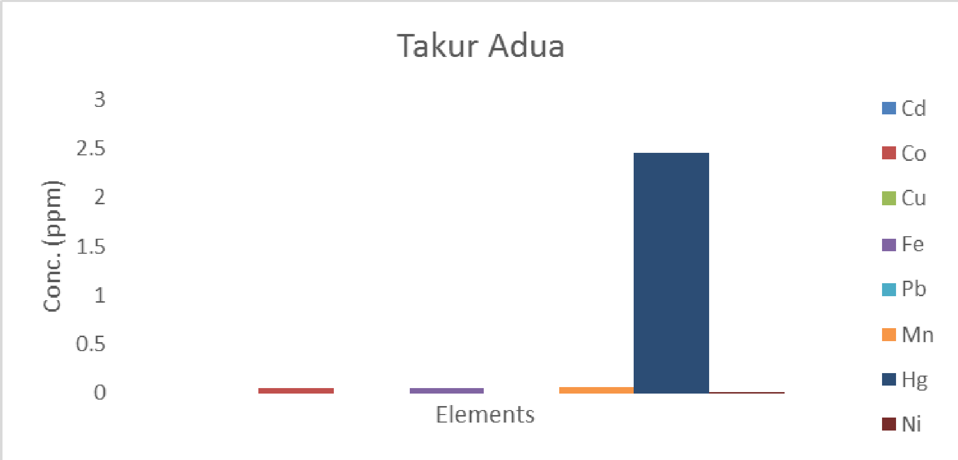


Fig. 17: Plot of Concentration (ppm) against Elements for Takur Adua

Figure 17 shows the plot of concentration of the measured heavy metals for Takur Adua. It was observed that only Hg of 2.448 mg/l have obviously exceeded the recommended level of 0.002 mg/l and Mn with corresponding concentration of 0.059 mg/l have also slightly exceeded the recommended level set by USEPA of 0.05 mg/l respectively.

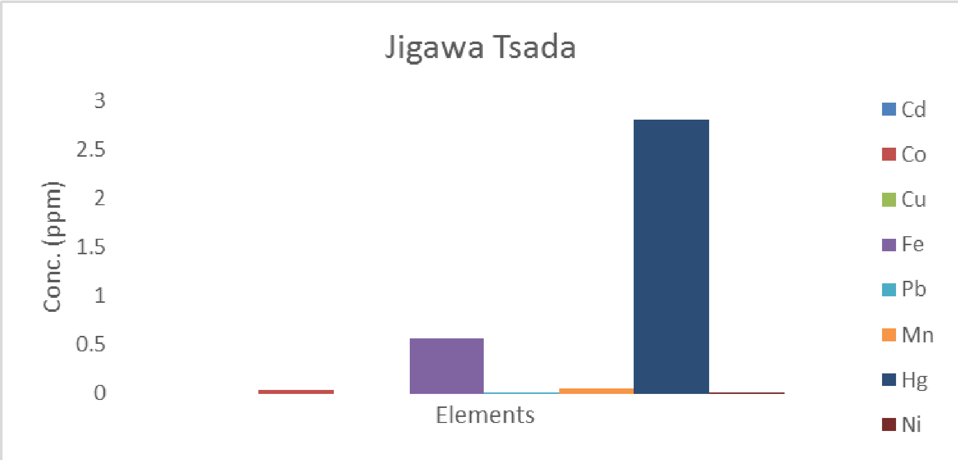


Fig. 18: Plot of Concentration (ppm) against Elements for Jigawa Tsada

Figure 18 shows the concentration of the measured heavy elements for Jigawa Tsada. It was realized only Fe and Hg with corresponding of 0.564 and 2.806 mg/l have exceeded the permissible limit set by USEPA of 0.3 and 0.002 mg/l respectively.

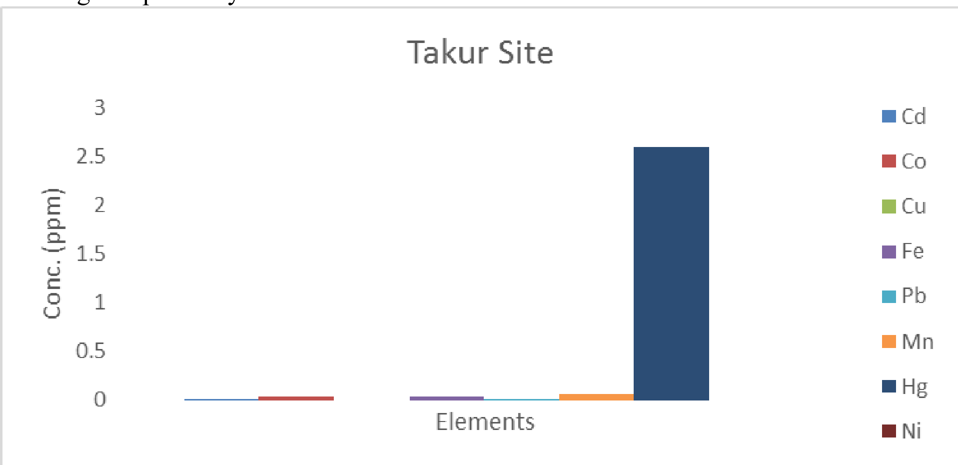


Fig. 19: Plot of Concentration (ppm) against Elements for Takur Site

Figure 19 indicated the concentration of the measured heavy metals for Takur Site. It was observed that only Mn and Hg of values 0.062 and 2.597 mg/l have exceeded the maximum contamination level set by USEPA of 0.05 and 0.002 mg/l respectively.

 

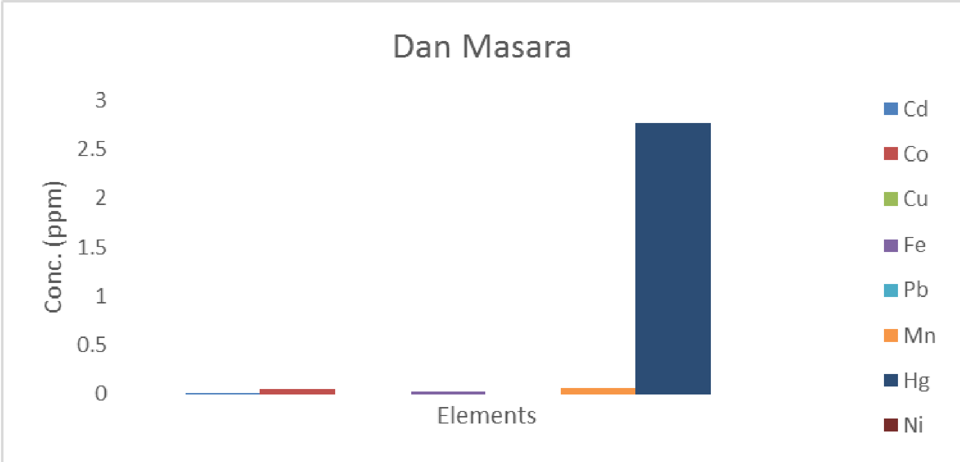


Fig. 20: Plot of Concentration (ppm) against Elements for Dan Masara

Figure 20 shows the concentration of the measured heavy metals for Dan Masara. It was reveals that Mn have slightly exceeded the recommended level with 0.009 mg/l and Hg of value 2.761 mg/l have also exceeded the recommended level set by USEPA of 0.002 mg/l.

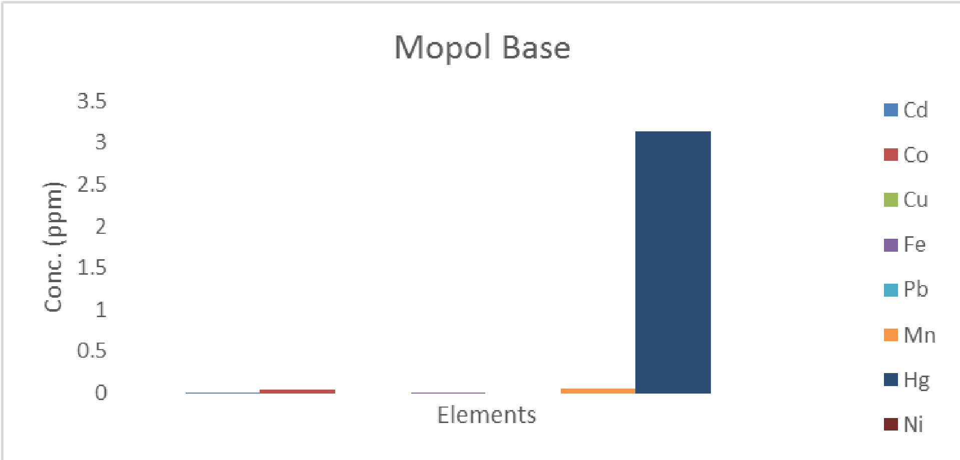


Fig. 21: Plot of Concentration (ppm) against Elements for Mopol Base

Figure 21 shows the variation in the concentration of the measured heavy metals for Mopol Base. It was indicated that only Mn and Hg of values 0.057 and 3.13 mg/l have exceeded the recommended level set by USEPA of 0.05 and 0.002 mg/l respectively while all other heavy elements were below the recommended level.

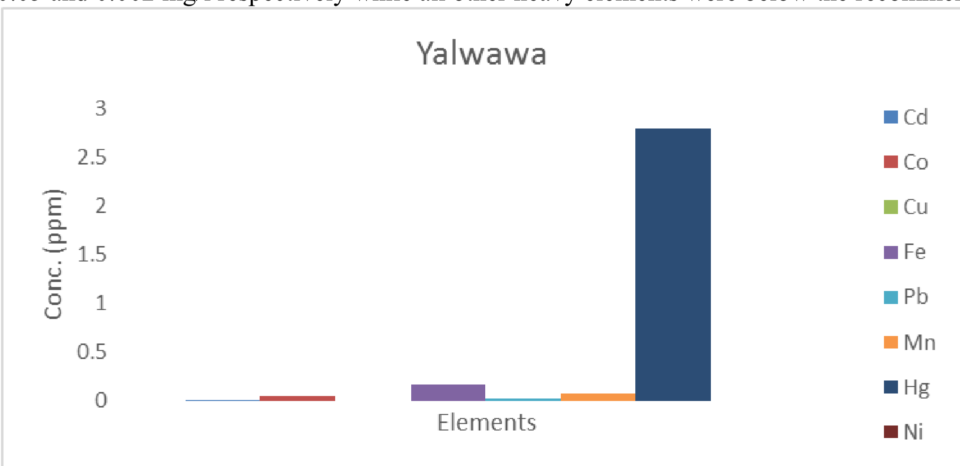


Fig. 22: Plot of Concentration (ppm) against Elements for Yalwawa

Figure 22 described the concentration of measured heavy metals for Yalwawa. It was observed that Pb, Mn and Hg with corresponding concentration of 0.021, 0.069 and 2.788 mg/l were above the maximum admissible limit set by USEPA of 0.01, 0.05 and 0.002 mg/l respectively.

 

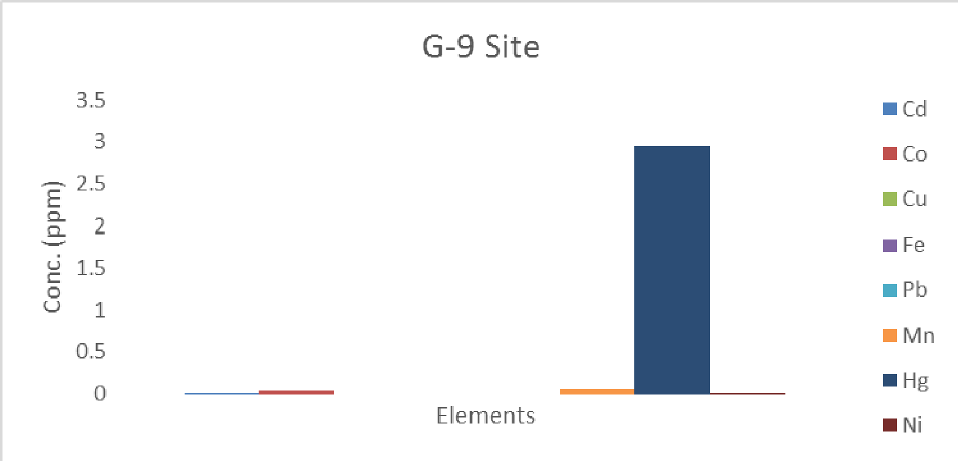


Fig. 23: Plot of Concentration (ppm) against Elements for G-9 Site

Figure 23 illustrated the concentration of measured heavy metals for G-9 Site. It was realized that only Mn and Hg with corresponding concentration of 0.061 and 2.958 mg/l have exceeded the maximum permissible limit set by USEPA of 0.05 and 0.002 mg/l while the rest of the measured concentration comply with the guidelines for a safe drinking water.

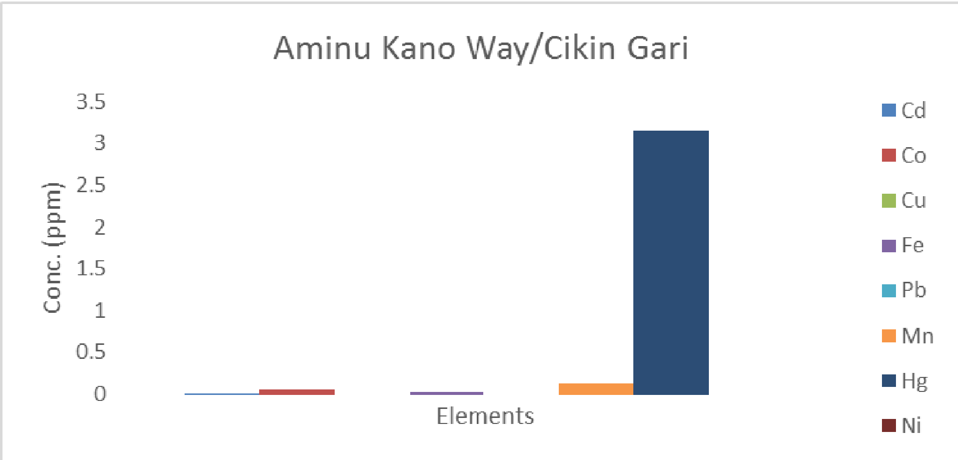


Fig. 24: Plot of Concentration (ppm) against Elements for Aminu Kano way/Cikin Gari

Figure 24 shows the variation in the concentration of measured heavy metals for Aminu Kano way/Cikin Gari. Manganese (Mn) and Mercury (Hg) indicated higher concentration of values 0.126 and 3.148 mg/l which have exceeded the maximum contamination level set by USEPA of 0.05 and 0.002 mg/l respectively.

Figures 1 to 24 show the variation of the concentration of the elements with respect to the sampling points. The concentration of the elements varies across the sampling points. It could be seen that Mercury, Iron and manganese indicate highest concentration in almost all the sampling points especially in Kachi, Zai, Fagoji 2, Garu/Emir Palace, Bakwato 1 & 2 and Gidan Dubu Yadi and these elements have exceeded the recommended level guidelines set by World Health Organization (WHO) and United State Environmental Protection Agency (USEPA) for a safe drinking water. Despite this, in some places Pb, Cd and some other elements were obtained at extreme minimum and yet they were determined in excess concentration in some other places which is a very unusual looking at the strict recommendation of National Agency for Food and Drug Administration and Control (NAFDAC) which state that Hg, Pb, and Cd should be zero in our drinking water. The concentration of Hg seem to have exceeded all the guidelines recommended by national and international organizations. From the above figures: It was revealed that the concentration determined for some elements need to be restudied in order to ensure the safety of the people using such water for drinking, irrigation and domestic activities

### 3.2 Concentration of Each Element and Sampling Points

The plots presented in figures 25 to 32 are the concentration of each element against the sampling points

 

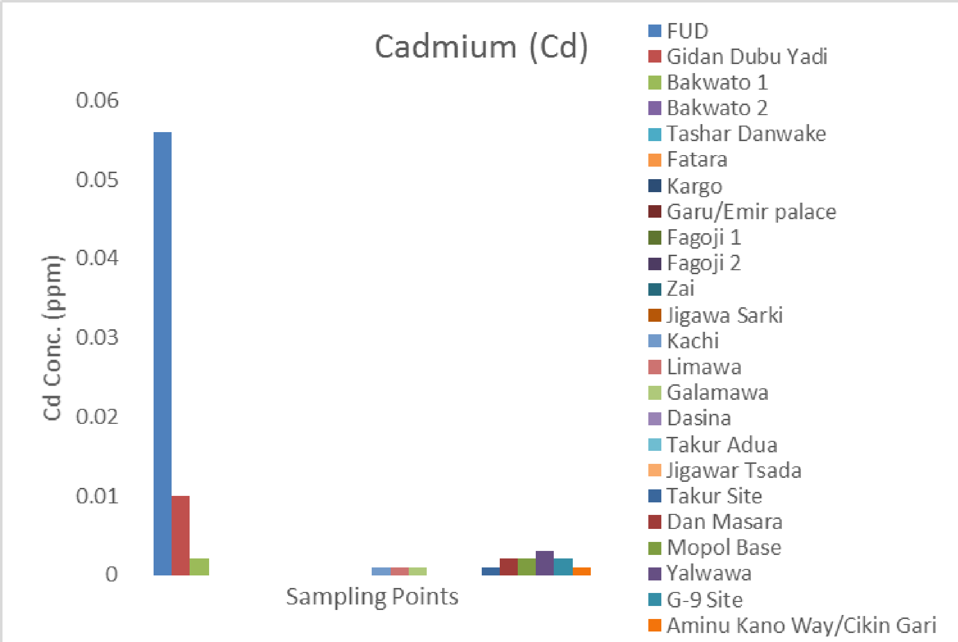


Fig. 25: Plot of Concentration (ppm) against Sampling Points for Cadmium

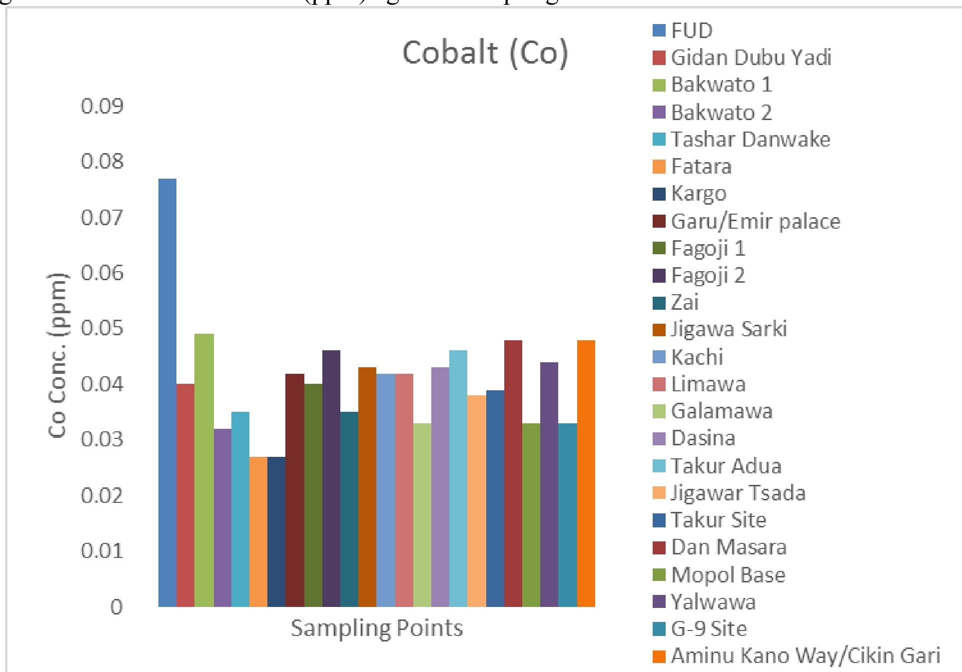


Fig. 26: Plot of Concentration (ppm) against Sampling Points for Cobalt

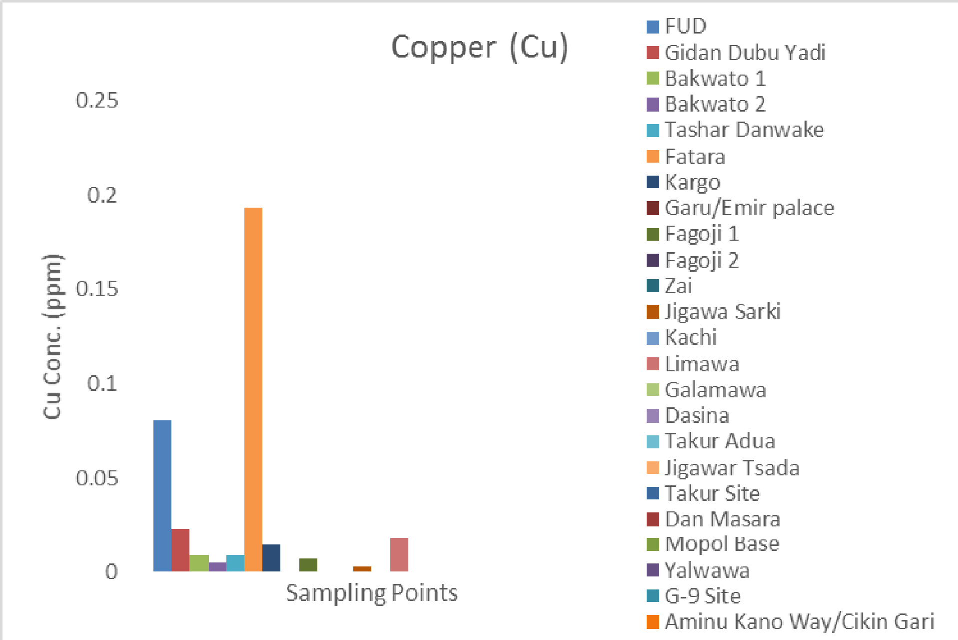


Fig. 27: Plot of Concentration (ppm) against Sampling Points for Copper

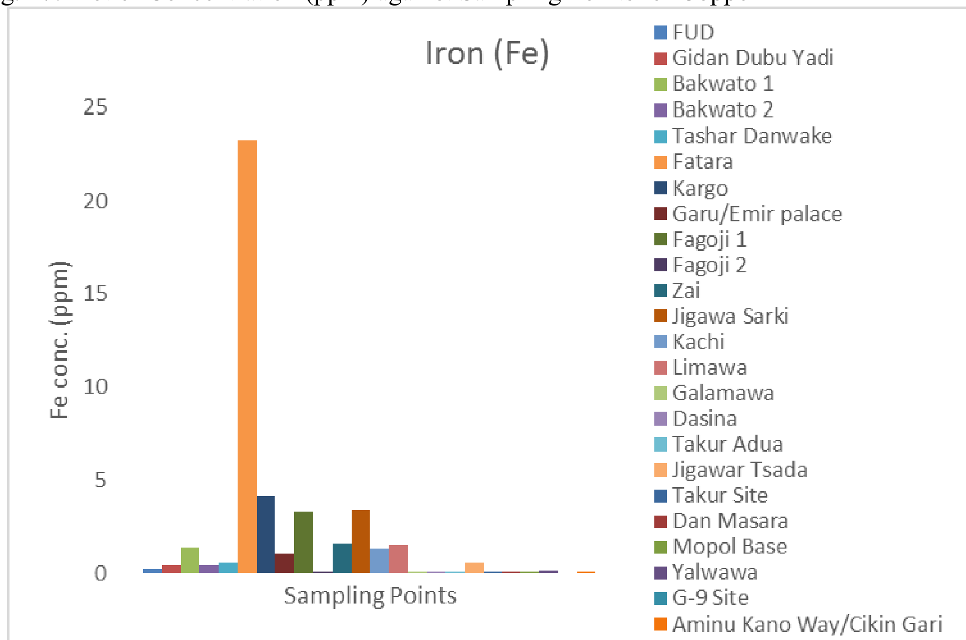


Fig. 28: Plot of Concentration (ppm) against Sampling Points for Iron

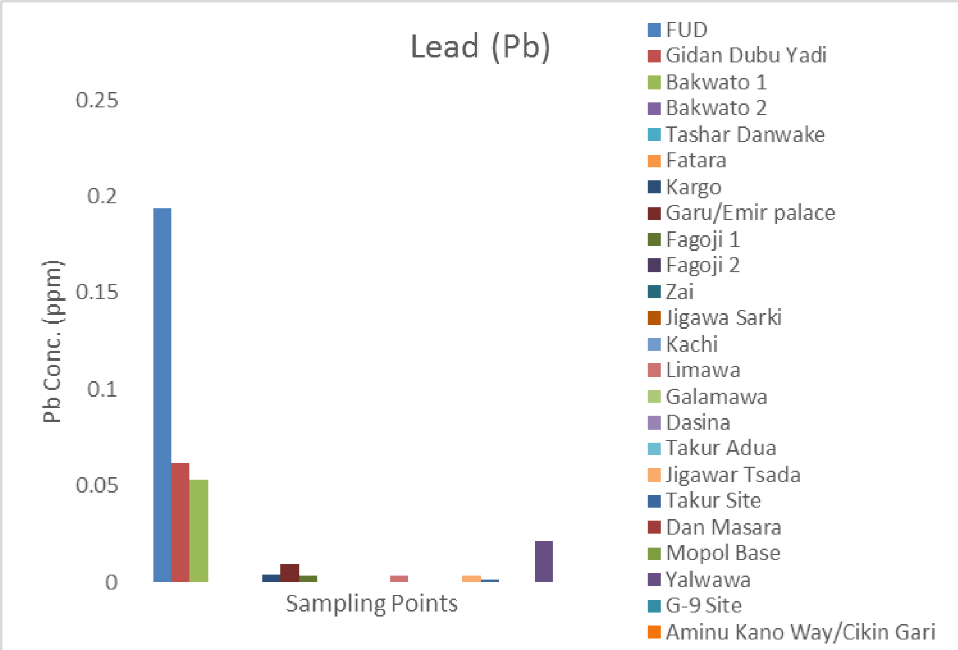


Fig. 29: Plot of Concentration (ppm) against Sampling Points for Lead

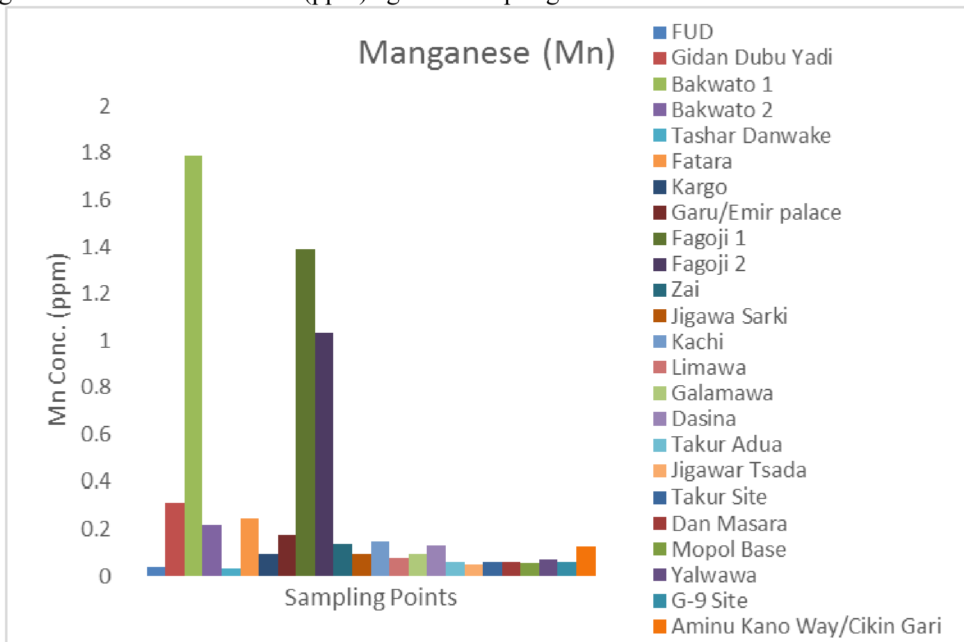


Fig. 30: Plot of Concentration (ppm) against Sampling Points for Manganese

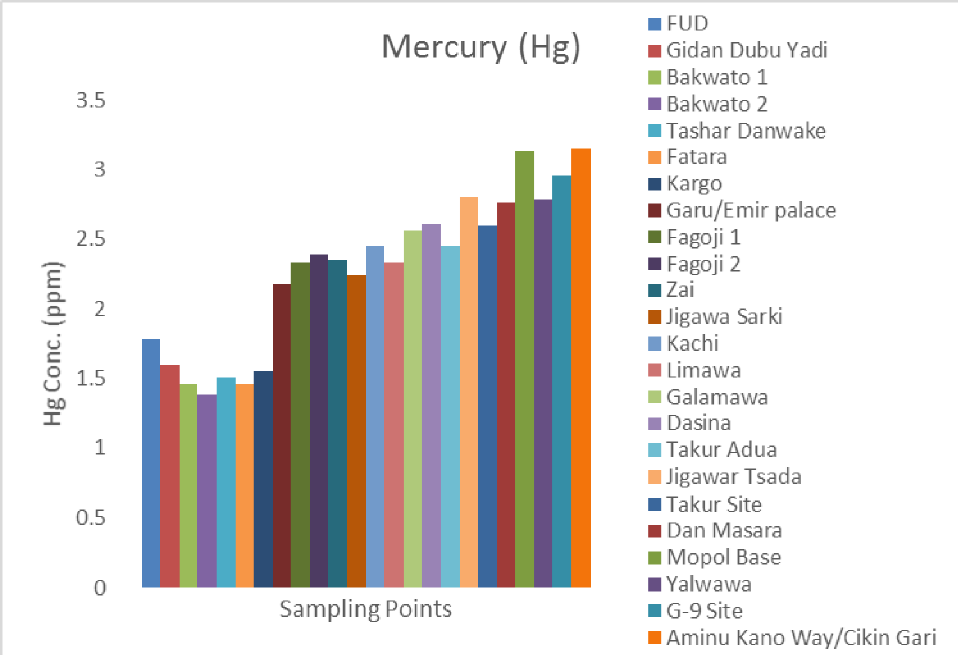


Fig. 31: Plot of Concentration (ppm) against Sampling Points for Mercury

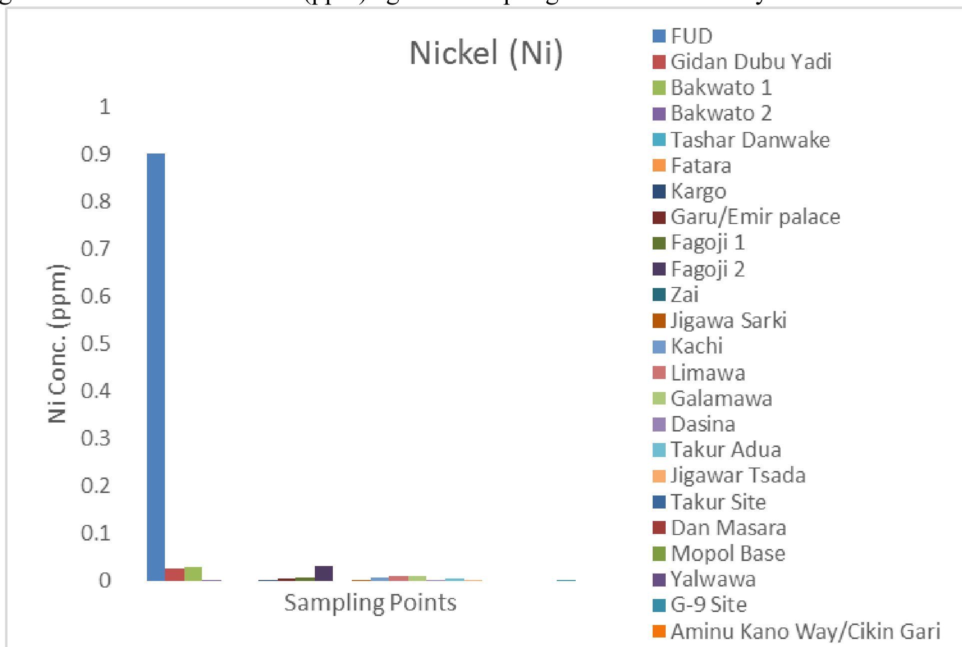


Fig. 32: Plot of Concentration (ppm) against Sampling Points for Nickel

Figure 25 shows the plot of Cd concentration in ppm against sampling points. The maximum concentration of Cd was obtained at FUD with the corresponding value of 0.056 mg/l and the minimum recorded was observed in many places of value 0 mg/l. FUD and Gidan Dubu Yadi exceeded the permissible level of Cd in drinking water recommended by USEPA and Nigerian Standard for Drinking Water Quality (NSDWQ) and only few places agreed with recommended level set by NAFDAC of 0 mg/l.

Figure 26 shows the plot of Co concentration in ppm against sampling points. The maximum and minimum concentration of Co recorded were 0.077 mg/l and 0.027 mg/l at FUD and Kargo/Fatara respectively. These values obtained does not exceeded the maximum contamination level of Co recommended level set by USEPA of 0.1 mg/l.

Figure 27 shows the plot of Cu concentration in ppm against sampling points. The result obtained indicated very low concentration of Cu and far below the guidelines recommended level set by USEPA/WHO in drinking water. The maximum and minimum concentration of Cu recorded were 0.193 mg/l and 0 mg/l respectively.

Figure 28 shows the plot of Fe concentration in ppm against sampling points. It was illustrated that the maximum and minimum recorded of Fe concentration from the samples collected in Dutse were 23.256 mg/l and 0 mg/l respectively. The maximum permissible level of Fe in drinking water set by USEPA/WHO is 0.3 mg/l but it could be seen that many places have exceeded the recommended level as shown in the figure above.

Figure 29 shows the plot of Pb concentration in ppm against sampling points. The behavior of the plot indicated that FUD has the maximum recorded Pb concentration of value 0.194 mg/l and three other places which have exceeded the recommended level set by USEPA were Gidan Dubu Yadi, Bakwato 1 and Yalwawa with the corresponding values of 0.062 mg/l, 0.053 mg/l and 0.021 mg/l respectively and the minimum recorded concentration was 0 mg/l.

Figure 30 shows the plot of Mn concentration in ppm against sampling points. The concentration of Mn varies from one place to another as shown in the figure. The maximum concentration of Mn was found at Bakwato 1 of value 1.787 mg/l and other sampling points which have exceeded the recommended level set by USEPA were Fagoji1 and Fagoji 2 with corresponding values of 1.388 mg/l and 1.033 mg/l respectively and the minimum concentration observed at Tashar Danwake of value 0.035 mg/l.

Figure 31 shows the plot of Hg concentration in ppm against sampling points. The maximum and minimum concentration of Hg recorded was found at Aminu Kano way/Cikin Gari and Bakwato 2 of values 3.148 mg/l and 1.38 mg/l respectively. The maximum contamination level of Hg in water set by USEPA is 0.002 mg/l. It could be seen that even the minimum value recorded exceeded the recommended level of all the guidelines for safe drinking water.

Figure 32 shows the plot of Ni concentration in ppm against sampling points. FUD was observed to have the maximum concentration of value 0.9 mg/l and the minimum recorded was 0 mg/l. All points are below the maximum contamination level recommended by USEPA except for the FUD which have exceeded the maximum permissible level for Ni.

### 3.3 Comparison between the Heavy Elements

In order to study the relationship between the present of these elements in the sample collected, an attempt has been made to observe the relationship between Pb and Cd, Cu and Cd, Fe and Mn and finally Ni and Co by comparing their plots as shown in the figures 33 to 36 below.

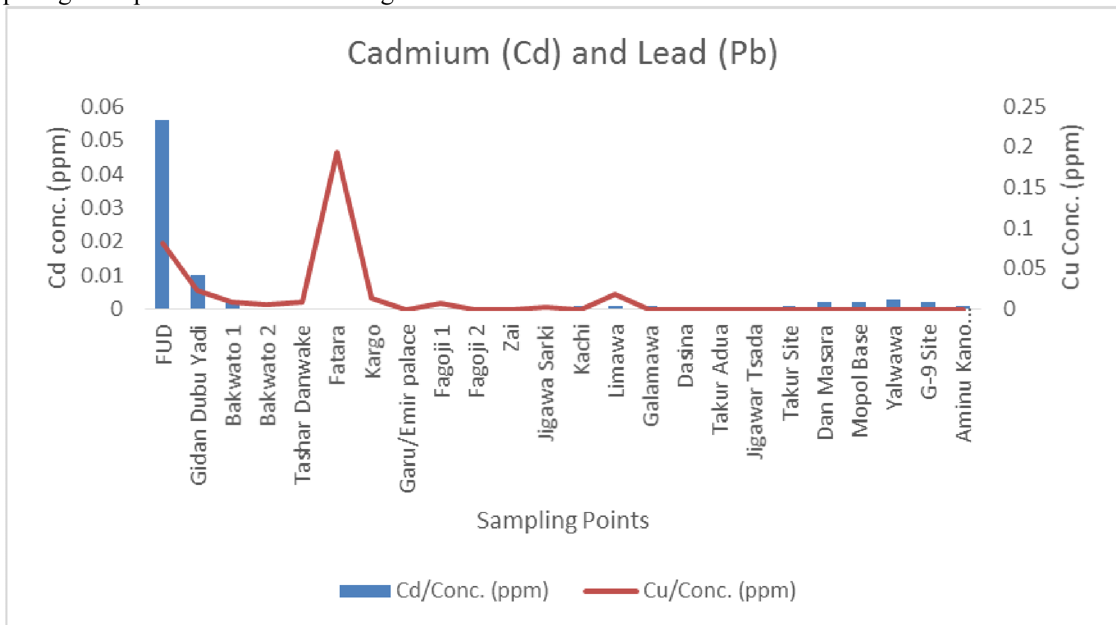


Fig. 33: Plot of Cadmium (Cd) and Copper (Cu) against Sampling Points

Figure 33 illustrate the comparison between Cd and Cu concentration measured against sampling points. The behavior of the plot was seem to have similar behavior starting from FUD at maximum and fall together to Tashar Danwake and the behavior changed at Fatara when the Cu was at Peak and Cd was at its minimum point. However, starting from Kargo a uniform behavior was observed until Dan Masara when the Cu concentration was at minimum to almost Aminu Kano Way and some traces of Cd was observed at those points.

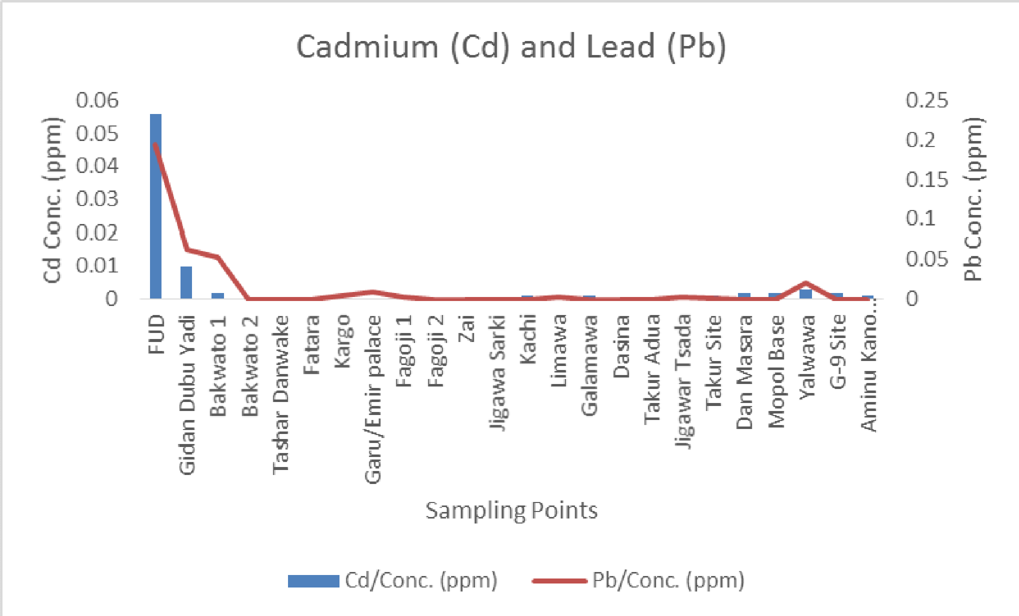


Fig. 34: Plot of Cadmium (Cd) and Lead (Pb) against Sampling Points

Figure 34 illustrates the comparison between Cd and Pb concentration measured against sampling points. A uniform fluctuation with almost similar amplitudes were observed except for three different points namely; Dan Masara, Mopol Base and G-9 Site when Pb was at zero point and some traces of Cd was observed at those points.

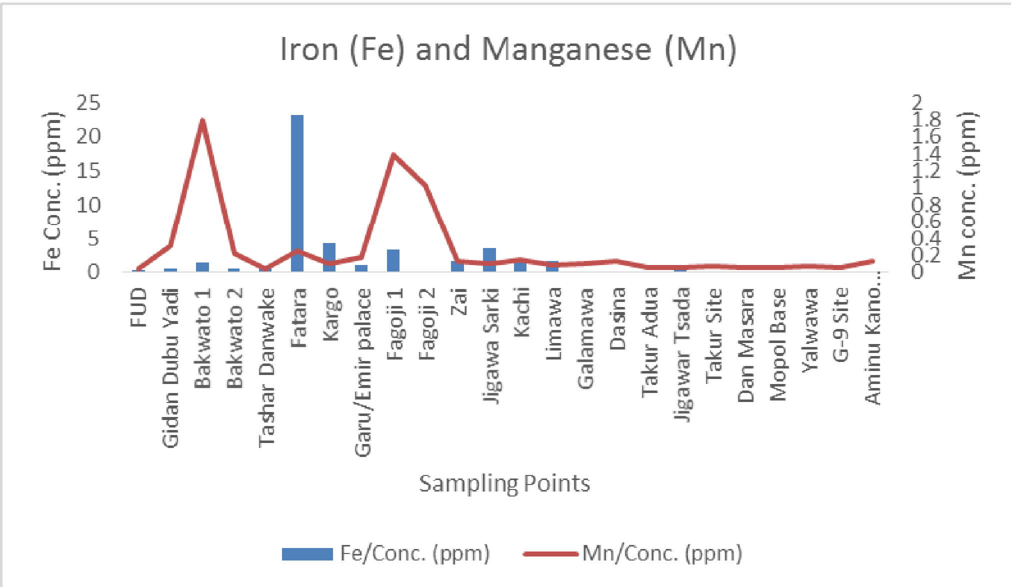


Fig. 35: Plot of Iron (Fe) and Manganese (Mn) against Sampling Points

Figure 35 illustrates the comparison between Fe and Mn concentration measured against sampling points. Irregular fluctuation was observed, but it indicated that whenever there is Fe in a sampling point there is also a high chance of getting Mn in that same point. Despite a clear different in the amplitudes it could be seen that wherever there is a peak for Mn a corresponding peak for Fe is also observed.

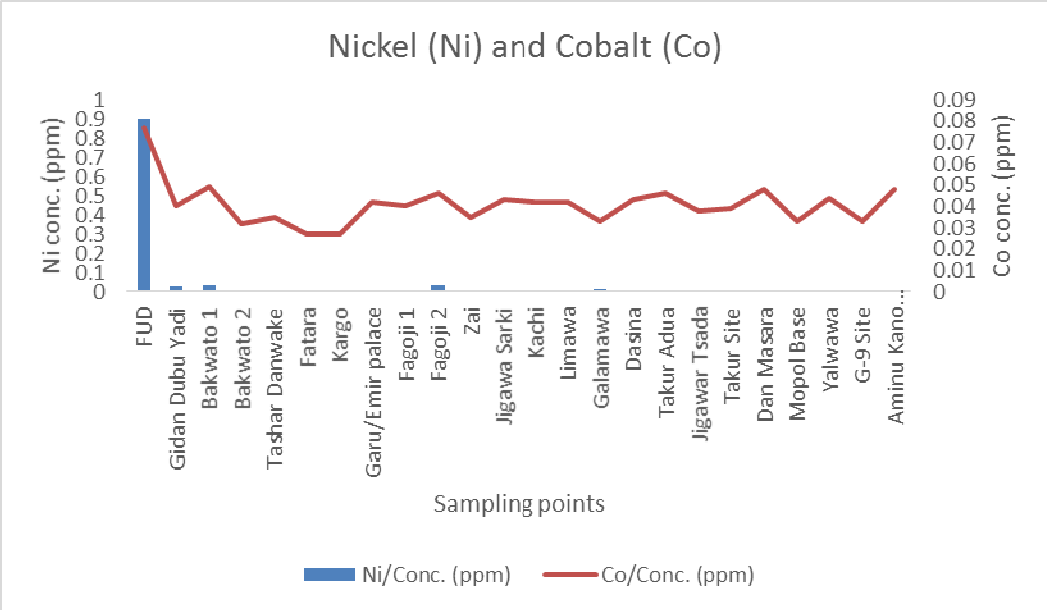


Fig. 36: Plot of Nickel (Ni) and Cobalt (Co) against Sampling Points

Figure 36 illustrates the comparison between Ni and Co concentrations measured against sampling points. A clear different in the amplitudes were observed. Despite the different in the concentration it also indicated that there is small correlation between Ni and Co in the sampling points as shown in the figure.

### 3.4 Comparison of Measured heavy metals with Maximum Contamination Level and Other Regions

The table 1 illustrated the comparison between the average measured heavy metals in Dutse town with the maximum permissible limit set by USEPA.

**Table 1: Comparison between Average Concentrations of Measured Heavy Metals with Maximum Permissible Limit Set by USEPA and Remark**

| Elements | Average Conc. (mg/l) in Dutse | Max. Permissible Conc. USEPA | Remark |
|---|---|---|---|
| Cadmium (Cd) | 0.003 | 0.005 | BPL |
| Cobalt (Co) | 0.041 | 0.1 | BPL |
| Copper (Cu) | 0.015 | 1.3 | BPL |
| Iron (Fe) | 1.824 | 0.3 | APL |
| Lead (Pb) | 0.0147 | 0.015 | BPL |
| Manganese (Mn) | 0.273 | 0.05 | APL |
| Mercury (Hg) | 2.283 | 0.002 | APL |
| Nickel (Ni) | 0.043 | 0.1 | BPL |

- BRL: Below the Permissible Level
- ARL: Above the Permissible Level.
- USEPA: United State Environmental Protection
- Conc.: Concentration

The table 1 above illustrated the average concentration of the measured heavy metals in Dutse and compared with the maximum permissible level of heavy metals in drinking water by United State Environmental Protection Agency (USEPA). Cadmium, Cobalt, Copper, Lead and Nickel are below the recommended level while Iron, Manganese and Mercury are above the guidelines recommended by national and international organizations for safe drinking water. But the studies for each sampling site as shown in figures 25 to 32 indicated that 50% of the Iron, 17% of Lead, 92% of Manganese, 100% of Mercury and 4% of Nickel measured exceeded the recommended level set by USEPA which are of agreement with table 1 except for Lead and Nickel which indicated below permissible level in table 1 even though the percentage exceeded from different sampling sites were negligible and it can be easily disappear in mean computation if the other values were far below the recommended level.

**Table 2: Comparison of Measured Heavy elements in Dutse town with Other Places**

| Location | Measured Concentration (mg/l) | | | | | | | | Sources |
|---|---|---|---|---|---|---|---|---|---|
| | Cd | Co | Cu | Fe | Pb | Mn | Hg | Ni | |
| **Gombe** | - | - | 0.02 | 0.62 | - | 0.12 | - | - | [8] |
| **India** | 0.002 | - | - | - | 0.003 | - | - | 0.003 | [4] |
| **Ethiopia** | 0.017 | 0.018 | BDL | - | - | - | - | - | [5] |
| **Pakistan** | 0.067 | - | 0.433 | 1.676 | 0.351 | - | - | 0.004 | [9] |
| **Dutse** | 0.003 | 0.041 | 0.015 | 1.824 | 0.015 | 0.273 | 2.283 | 0.043 | This work |

Table 2: shows the comparison between the measured heavy metals in Dutse town with that of other places including Gombe, India, Ethiopia, and Pakistan. It was observed that the Cadmium measured in Dutse was 10% above the one measured at India and 1.4% less than that of Ethiopia, for Cobalt; it was 2.3% above the one measured at Ethiopia, for Copper; it was 0.5% less than that of Gombe and 41.8% less than that of Pakistan, for Iron; it was 14.8% above the one measured at Pakistan, for Lead; it was 1.2% above the one measured at India, for Manganese; it was 15.3% above the one measured at Gombe, for Nickel; it was 3.9% above the one measured at Pakistan and 4% above the one measured at India.

The results obtained from different places indicated some heavy metals concentration were below the maximum permissible limit and some were above the maximum permissible limit set by USEPA and WHO in general. For the case of Cadmium, Lead and mercury were above the maximum permissible limit set by NSDWQ which stated its maximum desirable level as 0 mg/l.

## 4.0 Conclusion

The presence of the heavy metals above the contamination levels in the study area would be from the sources such as transportation, dirty water, industrial activities, atmospheric deposition, geological impact, etc. The major aim of this study was to evaluate the quality of drinking water by measuring the level of heavy metals in Dutse metropolis of Jigawa State. A total of 48 drinking water samples were collected from 24 different sampling sites. Emphasis were given to the densely populated areas in the region. These samples were studied and analyzed for Heavy metals. Eight heavy metals such as Cd, Co, Cu, Fe, Pb, Mn, Hg and Ni were analyzed using Atomic Absorption Spectrometer (AAS) stationed at General Laboratory, Ahmadu Bello University, Zaria. The results showed that the concentration of Cadmium (Cd) ranges from 0.0 to 0.06 mg/l, for Cobalt (Co) ranges from 0.027 to 0.08 mg/l, for Copper (Cu) ranges from 0.0 to 0.08 mg/l, for Iron (Fe) ranges from 0.0 to 23.26 mg/l, for Lead (Pb) ranges from 0.0 to 0.19 mg/l, for Manganese (Mn) ranges from 0.035 to 1.79 mg/l, for Mercury (Hg) ranges from 1.380 to 3.15 mg/l, for Nickel (Ni) ranges from 0.00 to 0.09 mg/l. The average concentration for each heavy metals was also computed and some heavy metals indicated higher concentration for examples, Iron (Fe) concentration of 1.82 mg/l exceeded the recommended level set by United State Environmental Protection Agency (USEPA) of 0.30 mg/l, Lead (Pb) concentration of 0.015 mg/l which is the recommended level of 0.015 mg/l, Manganese (Mn) of 0.27 mg/l exceeded the recommended level of 0.05 mg/l and Mercury (Hg) concentration of 2.28 mg/l exceeded the recommended level of 0.002 mg/l. These imply that the sampling regions are polluted and the water should be treated before it is used for drinking and other domestic activities. If these sampling regions are continue to use this water without any treatment, it may have serious health effect to the people around the sampling areas using such water for drinking, domestic activities and irrigation. During the sampling period, very dirty, shortage and poor drinking water storage practices have also been observed. The shortage water in some area have gone to the extent that they have to wait for sometimes so that the well may raise a little water for them to use.

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