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Heavy Metals Concentration and Health Risks Assessment of Drinking Water Sources from Jibia Town, Katsina State, Nigeria

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ABSTRACT

The domestic and agricultural application of chemicals made from heavy metals has led to their contamination of our environments, raising concerns over their potential effects on human health and the environment. People that consume high levels of heavy metals risk acute and chronic toxicity, intestinal damage, anemia, and cancer. This study aimed to analyzed the concentrations of the heavy metals (As, Cd, Cr, Co, Pb) and assess human exposure risks via drinking water pathway from Jibia Town, Katsina State. Twenty samples were collected from Jibia, Kagadama, and Magama Communities and analyzed using *Flame Atomic Absorption Spectrometer*. The overall mean concentrations of the heavy metals for the entire study area were 0.0066 mg/L, 0.0029 mg/L, 0.0287 mg/L, 0.0500 mg/L and 0.0073 mg/L for As, Cd, Cr, Co and Pb, respectively. These values were all recorded to be within the permissible limits set by WHO for the quality of drinking water. The hazard indices were 0.430 and 0.123 for adult and children, respectively. These values are less than USEPA (2011) limit of 1.000 as threshold value. Similarly, the excess lifetime cancer risks revealed that the non-carcinogenic and carcinogenic risks respectively in the drinking water sources in both adults and children were 4.05×10^{-5} (4 people/ hundred thousand may be affected) for adult and 6.12×10^{-5} (6 people/hundred thousand may be affected) for children. These values are within the WHO limit. Conclusively, within the restrictions of the study, the current level of heavy metals does not suggest significant non-carcinogenic and carcinogenic health risks. However, continued monitoring is necessary, especially for surface water sources whose values were just slightly below the WHO limits.

Keywords: Heavy Metals, Health Risk Assessment, Drinking Water, Jibia

INTRODUCTION

Radioactive elements are part of our daily life, most living and inanimate matter was made up of them and virtually every manufactured product involves the use of elements. Many chemicals made from elements can (when properly used) significantly contribute to the improvement of the quality of our life, health and well-being. But other chemicals are highly perilous and can negatively affect our health and environment when improperly managed (WHO, 2020). Heavy metals are considered among the chemical contaminants of water sources from household plumbing and service lines, mining operations, petroleum refineries, electronics manufacturers, municipal waste disposal, cement plants, and natural mineral deposits through groundwater movement and surface water seepage and run-off (WHO, 1998). People that consume high levels of heavy metals risk acute and chronic toxicity, intestinal damage, anemia, and cancer (WHO, 1993). Because of their high degree of toxicity "WHO 2020" listed four heavy metals (arsenic, cadmium, lead and mercury) in its list of ten chemicals that are of public health significance. They are considered systematic toxicants even at lower levels of exposure; they are also classified among human carcinogens (probable) according to IARC (1987).

Africa, the second largest continent experiences water crisis and the problem is more aligned towards water quality than the quantity. Challenges to water shortage and access to water of desirable quality include population increase, economic growth, climate change and agricultural practices (Vetrimurugan *et al*, 2017). Hence, there is increasing stress to maintain the quality of water so that it does not have any negative impact on human health. In Nigeria and most African nations today, the use of ground water has become a means of survival, more especially in rural areas because the government is unable to meet the ever increasing water demand. Thus, inhabitants haved to look for alternative ground water sources such as shallow wells and boreholes for drinking and other domestic uses (Nwankwo *et al*, 2013; Olukanni and Ugwu, 2013). The quality of these ground water sources are affected by the characteristics of the media through which the water passes on its way to the ground water zone of saturation (Adeyemi *et al*., 2007).

Toxic heavy metals are among harmful water contaminants that are colourless, odourless and therefore cannot be detected by human senses; one might go years before realizing a problem exists (USEPA, 1992).Their multiple domestic, industrial and agricultural applications have led to their wide distribution in the environment, raising concerns over their potential effects on human health and the environment (Paul *et al*, 2012). Toxic heavy metals can explicitly spoil the environment in a short time thereby causing serious ecological damage (Wood, 1974).

Several studies assessed heavy metals exposure risks in surface and groundwater from different parts of the world including some urban areas in Nigeria. Some of the studies include; Ukibe *et al* (2016) analysed heavy metals contamination of drinking water in Anambra State, Southern Nigeria, using Atomic Absorption Spectrophotometry. The concentrations of the three heavy metals (Pb, Cr, and Cd) were found to be significantly high compared to the maximum acceptable safe concentration of the metals (0.015, 0.100 and 0.005, respectively) set by WHO and USEPA. According to the analysis, the heavy metals contamination of sachet water may be a source of ill health in the study areas if care is not taken to reduce their concentrations. Oruson *et al* (2016) assessed the health risk of heavy metals in well and tap water in Ajaokuta, Nigeria. He used atomic absorption spectrometry investigation on 60 samples of water (well and tap). The concentration of the heavy metals Cd, Cr Zn and Mg were within the acceptable limit for WHO drinking water guidelines. However, arsenic was well above the WHO recommended limit for consumption for both well and tap water sources, which could lead to arsenic poisoning if consumed over a long period of time.

However, in some rural areas were domestic and agricultural activities critically affect the water sources have no data on the water quality. Among such areas was Jibia Town, Katsina State of Northern Nigeria. The land of the area was degraded and deserted such that some of the water sources dried off, thereby pressuring the populace to rely heavily on untreated water sources for drinking and other domestic uses and it may be possible that the water they use contains a higher than permissible contamination limits of heavy metals; whose accumulation in the body overtime may lead to several types of cancer and other health effects (Mohammed *et al*, 2020). Studies on regional water quality based on heavy metals are essential to quantify the extent of pollution and plan for possible measures of mitigation. Thus, in this study, water quality assessment was carried out in Jibia, Kagadama and Magama communities of Jibia Town were the demand for water in these areas is increasing. This study was aimed to quantify toxic heavy metals in surface and ground water sources and assess the human health risk through the drinking water pathway.

The Study Area

Jibia is located at an approximate distance of 43Km west of Katsina, situated on the extreme part of Northern Nigeria. It lies between Latitude 13º5´37´´N and Longitude 7º13´34´´E.The population of the LGA was about 167,435 (as at the 2006 census) and 226,000 according to 2016 estimation. Jibia have total land area of about 1037 km². It is bordered with Niger Republic to the North, Katsina and Kaita to the North East, and to the South by Batsari and Batagarawa (NPC, 2010 and 2016). Figure 1 shows the location of Jibia local government area in Katsina State and the location of Katsina State in Nigeria.

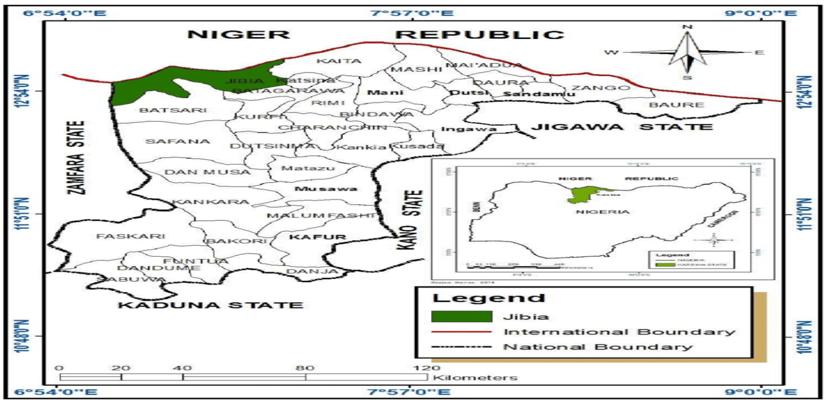

Figure 1: Map Showing the Study Area

MATERIALS AND METHODS

Sample Collection

The factors considered during the sampling were; random strategic sampling, whereby each sampling point was selected independent of the other points. All points were given equal chance to be selected serve as representative sampling and that the samples taken were delegate of the different sources from which water is obtained by the public or enters the system as a whole (USEPA 1989 and WHO 2000). Twenty (20) samples were collected which comprises of 6 surface water, 5 borehole water and 9 well water sources, using 100ml clean sample collection bottles with tight covers. Before the sampling, the sample bottles were rinsed thoroughly with the water to be collected and later with concentrated Nitric acid. During the sampling; the surface water samples were collected with the aid of bailer, the well water were first purged by drawing it out severally to ensure fresh samples were obtained, and lastly the borehole water samples were collected after evacuating the existing water is the pipe. The samples collected were labelled with a marker and masking tape for easy identification.

Sample Preservation

To avoid contamination, the water samples were preserved with concentrated Nitric Acid to minimize precipitation and adsorption of particles in the water on the containers walls. The sample bottles were also filled to the brim without any head space to prevent CO_2 from being trapped because it could dissolved in and affects the chemistry. In order to achieve accuracy, the samples were transferred to the laboratory at Institute of Agricultural Research, ABU Zaria immediately after collection and analyzed within 2 days so that the composition will not change (WHO, 2000)

Sample Location

The communities from which the samples were collected are Jibia, Kagadama and Magama all of Jibia Local government, Katsina State. During the sampling, a Global Positioning System (GPS) was used to mark the geographical locations of the sample collection points on the earth surface.

Sample Preparation/Digestion

From each of the twenty samples collected, 50ml was measured into a clean digestion flask, 9ml of concentrated HNO_3 and 3ml of concentrated HCl were added into the flask (USEPA, 1986). The whole samples were then heated on a hot plate until all the fumes was expelled (Nitrogenous compound) and allowed to cool at room temperature. A few millimetres of distilled water were later added and the mixtures were filtered into a 25ml standard flask. The filtered were transferred to plastic bottle for the Flame Atomic Absorption Spectroscopy analysis (FAAS)

Sample Analysis

The samples were analyzed using Flame Atomic Absorption Spectrometer (Model 230 Buck Scientific). The quality of the analytical data was guaranteed through the implementation of laboratory quality assurance and quality laboratory methods, including observing standard operating procedures and calibration with standards. The theory of heavy metals exposure risks assessment provided by "USEPA 1988 & 1989) was adopted in the heavy metals risk assessment of the study. Below are the assessment parameters and equations.

Exposure Assessment:

The exposure assessment which aimed to estimate the intensity, frequency and duration of human exposures to the heavy metals via drinking water pathway, was computed using Equation 1 (USEPA, 1988 and 1989)

$$\mathrm{ADI} = \frac{\mathrm{C_{eng}} \times \mathrm{IR} \times \mathrm{EF} \times \mathrm{ED}}{\mathrm{BW} \times \mathrm{AT}} \qquad (1)$$

Where; ADI is the Average Daily Intake through drinking water pathway (mg/kg/day), $\mathrm{C_{eng}}$ is the Concentration of heavy metals (mg/L). The remaining exposure parameters are given in Table 1

Table 1: Exposure Parameters

Parameter		Unit	Adults	Children	References
Exposure Rate (IR)		litre/day	2	1.5	DEA, 2010 and USEPA,2004
Exposure Frequency (EF)		days/year	350	350	(DEA,2010)
Exposure Duration (ED)		years	30	6	(DEA,2010)
Average Body Weight (BW)		kg	61	32	Poh *et al*,2013 Chee *et al*, 2008 Azmi *et al*, 2009
Averaging Time (AT)	Non-Carcinogenic	days	365 × 70		(DEA,2010)
	Carcinogenic		365 × ED		

Sources: (Kamunda *et al*, 2017; and Naveedullah *et al*, 2014)

Non-Carcinogenic Hazards Assessment:

The probability of an individual suffering an adverse health effects due a specific heavy metal was characterized by the unit less term Hazard Quotient (HQ). It is expressed as the quotient of Average Daily Intake (ADI) by the toxicity threshold value well known as Reference Dose (RfD) measured in mg/kg/day of a specific heavy (USEPA, 1988 and 1989). This is given in equation 2

$$\mathrm{HQ} = \frac{ADI}{\mathrm{RfD}} \qquad (2)$$

The Chronic Reference Doses (RfD) of the heavy metals under investigation are given in Table 2

Table 2: the Chronic Reference Doses (RfD)

Heavy Metal	Oral RfD (mg/kg/day)	References
As	0.003	USEPA, 2002b
Cd	0.001	Oyewumi *et al*, 2019 and Walpole *et al*, 2012
Cr	1.500	Oyewumi *et al*, 2019 and Walpole *et al*, 2012
Co	0.002	USEPA, 2011
Pb	0.004	Oyewumi *et al*, 2019 and Walpole *et al*, 2012

Source: (Kamunda *et al*, 2017, Chunyuan *et al*, 2016 and Oludare *et al*, 2019)

The hazard index (HI) was ised to evaluate the potential non-carcinogenic health risk associated with exposure to contaminants through drinking water pathway of the studied heavy metals (USEPA, 1988 and 1989). The HI was obtained by summing the individual Hazard Quotient (HQ) for all detected contaminants and the exposure pathway considered in the study. The Hazard Quotient (HQ) for each contaminants was calculated using the equation

$$\mathrm{HQ} = \frac{ADI}{\mathrm{RfD}}$$

Where (ADI) is the average Daily Intake by the toxicity and (RfD) is well known as Reference Dose measured in mg/kg/day of a specific heavy (USEPA, 1988 and 1989). And equation 3 represents the overall Hazard Index was.

$$\mathrm{HI} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{HQ_i} \qquad (3)$$

Carcinogenic Risks Assessment

The probability of an individual developing cancer over a lifetime as a result of exposure to a specific heavy metal via drinking water pathway was characterized by the term Cancer Risk (CR). Equation 4.0 represented the mathematical expression of the term (CR) as provided by USEPA (1988 and 1989).

$$CR = ADI \times CSF \qquad (4)$$

Whereby; CR (Cancer risk) is a unit less probability of an individual developing cancer over a lifetime due to exposure of a specific heavy metal, ADI is the average daily intake and CSF is Cancer Slope Factor. The Cancer Slope Factors (CSF) for the heavy metals under study are given in Table 3.0

Table 3: Cancer Slope Factors (CSF)

Heavy Metal	CSF $(\mathrm{mg/kg/day})^{-1}$
As	1.5000
Cd	1.5000
Cr	0.5000
Co	2.0000
Pb	0.0085

Source: USEPA, 1989 (5)

For n number of heavy metals, the total excess lifetime cancer risk that revealed the carcinogenic risk, which is the average contribution of the all the studied heavy metals was computed using Equation 4 (USEPA, 1988 and 1989).

$$\mathrm{CR}_{\mathrm{excess}} = \sum_{\mathrm{I}=1}^{\mathrm{n}} CR_i \qquad (6)$$

Statistical Analysis

The parameters obtained in the analysis were expressed as mean and Standard Deviation (SD).

RESULTS AND DISCUSSION

Heavy Metals Concentrations

The average concentrations of the studied heavy metals in milligram per Litre (mg/L) from the samples collected are presented in Tables

Table 5: Heavy Metals Concentrations

Source	Sample Code	Concentration (mg/L)				
		As	**Cd**	**Cr**	**Co**	**Pb**
Surface	JSW 1	0.0031	0.0048	0.0590	0.0520	0.0061
	JSW 2	0.0112	0.0032	0.0261	0.0431	0.0071
	JSW 3	0.0123	0.0048	0.0340	0.1110	0.0083
	JSW 4`	0.0064	0.0028	0.0294	0.1101	0.0102
	JSW 5	0.0093	0.0028	0.0403	0.0861	0.0101
	JSW 6	0.0089	0.0019	0.0421	0.0021	0.0035
	Mean	0.0085	0.0034	0.0385	0.0674	0.0076
	SD	0.0021	0.0007	0.0081	0.0148	0.0016
Well	JWW 1	0.0054	0.0015	0.0310	0.0108	0.0099
	JWW 2	0.0071	0.0026	0.0028	0.0416	0.0060
	JWW 3	0.0037	0.0017	0.0033	0.0677	0.0046
	KWW 1	0.0028	0.0034	0.0029	0.0562	0.0071
	KWW 2	0.0034	0.0018	0.0203	0.0531	0.0063
	MWW 1	0.0046	0.0032	0.0461	0.0530	0.0050
	MWW 2	0.0039	0.0020	0.0347	0.0472	0.0047
	MWW 3	0.0066	0.0043	0.0302	0.0918	0.0043
	MWW 4	0.0129	0.0027	0.0252	0.0601	0.0180
	Mean	0.0056	0.0026	0.0218	0.0535	0.0073
	SD	0.0011	0.0009	0.0058	0.0116	0.0024
Borehole	JBW 1	0.0068	0.0034	0.0274	0.0210	0.0082
	KBW 1	0.0033	0.0023	0.0290	0.0041	0.0062
	MBW 1	0.0035	0.0026	0.0308	0.0102	0.0074
	MCBW1	0.0054	0.0033	0.0312	0.0776	0.0037
	MFBW 1	0.0110	0.0024	0.0286	0.0011	0.0101
	Mean	0.0060	0.0028	0.0294	0.0228	0.0071
	SD	0.0013	0.0005	0.0016	0.0036	0.0024
Overall (All Samples)	Mean	0.0066	0.0029	0.0287	0.0500	0.0073
	SD	0.0013	0.0005	0.0039	0.0144	0.0013

The average concentrations of Arsenic (As) in mg/L from surface, well, borehole and overall (all samples) were all recorded to be within the permissible limits of 0.0100mg/L, set by WHO (2008) for quality drinking water guidelines. However, the concentrations in some samples; JSW2, JSW3, MWW4 and MFBW1 were found to be slightly above the permissible limit.

The average concentrations of Cadmium (Cd) in mg/L from surface, well, borehole and overall (all samples) were all recorded to be within the permissible limits of 0.0030mg/L, set by WHO (2008) for quality drinking water guidelines. However, the concentrations in MCBW1, JBW1, KWW1, MWW1, MWW3, JSW1, JSW2 and JSW 3 were found to be slightly above the permissible limit.

The average concentrations of Chromium (Cr) in mg/L from surface, well, borehole and overall (all samples) were all recorded to be within the permissible limits of 0.0500mg/L, set by WHO (2008) for quality drinking water guidelines. However, the concentrations in JSW3 and JSW4 were found slightly above the permissible limit.

The average concentrations of Cobalt (Co) in mg/L from surface, well, borehole and overall (all samples) were all recorded to be within the permissible limits of 0.1100 mg/L, set by WHO (2008) for quality drinking water guidelines. However, the concentration in JSW1 was found to be slightly above the permissible limit.

The average concentrations of Lead (Pb) in mg/L from surface, well, borehole and overall (all samples) were all recorded to be within the permissible limits of 0.010mg/L, set by WHO (2008) for quality drinking water guidelines. However, the concentrations in JSW4, JSW5, MWW4, MCBW1 were found to be slightly above the permissible limit.

The abundance of the heavy metals from the study area has the following order; surface water (Co > Cr > As > Pb > Cd), Well Water (Co > Cr > Pb > As > Cd), Borehole water (Cr > Co > Pb > As > Cd) and Overall (All Samples) (Co > Cr >

Pb > As > Cd). The average concentration of the heavy metals for surface, well and borehole water and their overall mean values were presented in Figures 2

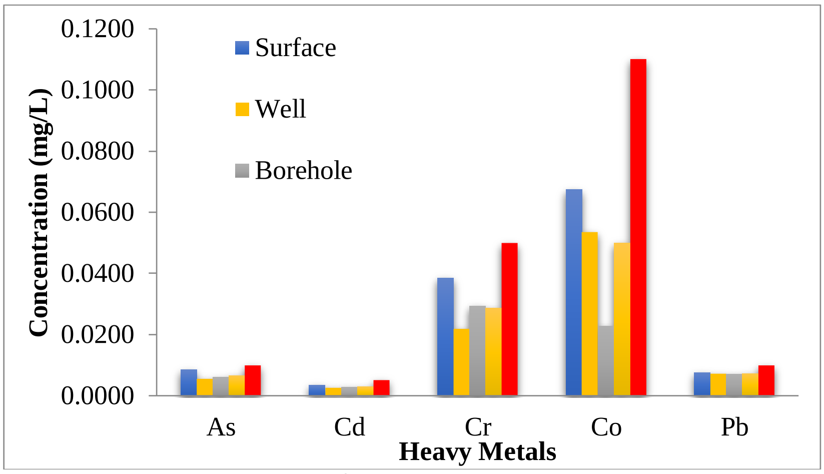

Figure 2 Average Concentrations of Heavy Metals

From Figure 2, the concentration of the heavy metals were all higher in surface water samples than in ground water (well and borehole), following the order (surface > well > borehole). This could be attributed to the domestic and agricultural application of chemicals made from these heavy metals "such as solid waste incineration, coal and oil combustion, application of fertilizer, sandstone" and natural sources "wet and dry deposition of atmospheric salts and water soil interaction" in the study area which contribute significantly to their concentrations in the surface water sources via running water sea page and in appropriate was disposal (Priti *et al.* 2016).

Non Carcinogenic Health Risk Assessment

Hazard Quotients and result hazard indices associated with the exposure of the studied heavy metals through surface, well and borehole drinking water pathway for adults and Children are presented in table 6

Table 6: Hazard Quotients and Hazard Indices

Water Samples	**Human Category**	**Hazard Quotients**					**∑ = HI**
		As	Cd	Cr	Co	Pb	
Surface	Adult	0.03820	0.04580	0.00035	0.45400	0.02560	0.56400
	Children	0.01090	0.01310	0.00010	0.13000	0.00732	0.16100
Well	Adult	0.02520	0.03500	0.00020	0.36000	0.02460	0.44500
	Children	0.00719	0.01000	0.00006	0.10300	0.00703	0.12700
Borehole	Adult	0.02690	0.03770	0.00026	0.15400	0.02390	0.24200
	Children	0.00771	0.01080	0.00008	0.04390	0.00684	0.06930
Overall	Adult	0.02960	0.03910	0.00026	0.33700	0.02460	0.43000
	Children	0.00848	0.01120	0.00007	0.09630	0.00703	0.12300

The hazard quotients (HQ) associated with As, Cd, Cr, Co and Pb in both Surface, Well and Borehole via drinking water pathway for Adult and Children were all recorded below the maximum acceptable limits of 1.0 set by USEPA (2011). Similar, the resulting Hazard Indices which the total probability of individual suffering adverse health effects within the study area via the drinking water pathway were 0.430 and 0.123 for adult and children, respectively. These values are less than USEPA (2011) limit of 1.000 as threshold value. Thus, indicating that the exposed receptors are unlikely to experience any adverse non-carcinogenic risks. However, it is worth to note that adults are at higher risk than children.

The low level non-carcinogenic risks reported in this study corroborate with the levels reported by similar studies such as Ahmed *et al* (2018); Tuzen *et al,* (2006); Oruson *et al*, (2016) and Estesar *et al,* (2019). The values were lower than the values reported in sugarcane farms of Jibia local government, Katsina state by (Mustapha, 2017) and around Shanono and Bagwai gold mines, Kano state by (Bello, 2019). This observation could be attributed to the application of fertilizer and pesticides/insecticides in the sugarcane farms; and the gold mine, respectively. Figure 3 demonstrated the hazard indices of the different water sources.

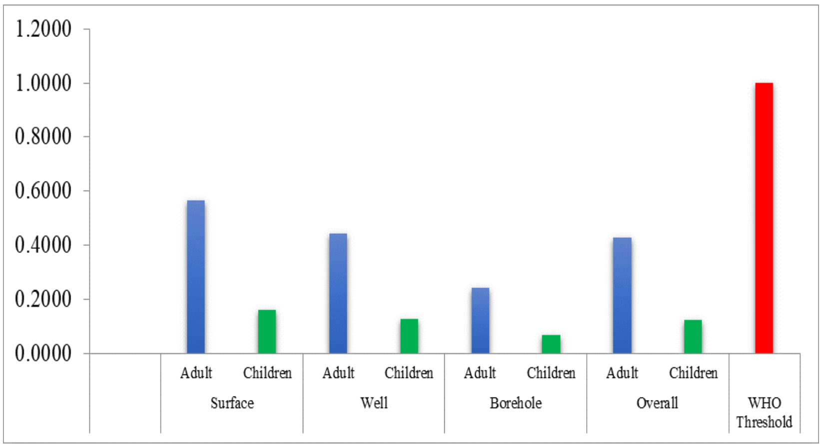

Figure 3 Hazard Indices of the Water Samples

Carcinogenic Health Risk Assessment
Cancer risks and resulting excess total lifetime cancer associated with the exposure of the studied heavy metals through surface, well and borehole drinking water pathway for adults and Children are presented in table 6

Table 7

Water Samples	Human Category	Cancer Risks					$\sum = CR_{total}$
		As	**Cd**	**Cr**	**Co**	**Pb**	
Surface	Adult	4.00×10^{-6}	1.60×10^{-6}	6.10×10^{-6}	4.24×10^{-5}	1.00×10^{-7}	5.42×10^{-5}
	Children	5.70×10^{-6}	2.30×10^{-6}	8.70×10^{-6}	6.06×10^{-5}	3.40×10^{-6}	8.07×10^{-5}
Well	Adult	2.60×10^{-6}	1.20×10^{-6}	3.40×10^{-6}	3.36×10^{-5}	1.00×10^{-7}	4.09×10^{-5}
	Children	3.80×10^{-6}	1.80×10^{-6}	4.90×10^{-6}	4.81×10^{-5}	3.30×10^{-6}	6.19×10^{-5}
Borehole	Adult	2.80×10^{-6}	1.30×10^{-6}	4.60×10^{-6}	1.43×10^{-5}	1.00×10^{-6}	2.30×10^{-5}
	Children	4.10×10^{-6}	1.90×10^{-6}	6.60×10^{-6}	2.05×10^{-5}	3.20×10^{-6}	3.63×10^{-5}
Overall	Adult	3.10×10^{-6}	1.40×10^{-6}	4.50×10^{-6}	3.14×10^{-5}	1.00×10^{-7}	4.05×10^{-5}
	Children	4.50×10^{-6}	2.00×10^{-6}	6.50×10^{-6}	4.49×10^{-5}	3.30×10^{-6}	6.12×10^{-5}

The Cancer Risks (CR) associated with As, Cd, Cr, Co and Pb in both Surface, Well and Borehole via drinking water pathway for Adult and Children were all recorded within the USEPA (2011) Threshold (1×10^{-6} to 1×10^{-4}). Similarly, the total excess lifetime cancer risks (CR_{total}) which is the probability of an individual developing cancer over a lifetime within the study were 4.05×10^{-5} (4 people/ hundred thousand may be affected) for adult and 6.12×10^{-5} (6 people/hundred thousand may be affected) for children. These values are within the USEPA (2011). Thus, indicating that the exposed receptors are unlikely to experience any carcinogenic risks. However, it is worth to note that children are at higher risk than adults. The excess life time cancer risks within the study area are further elaborated in figure 4.0.

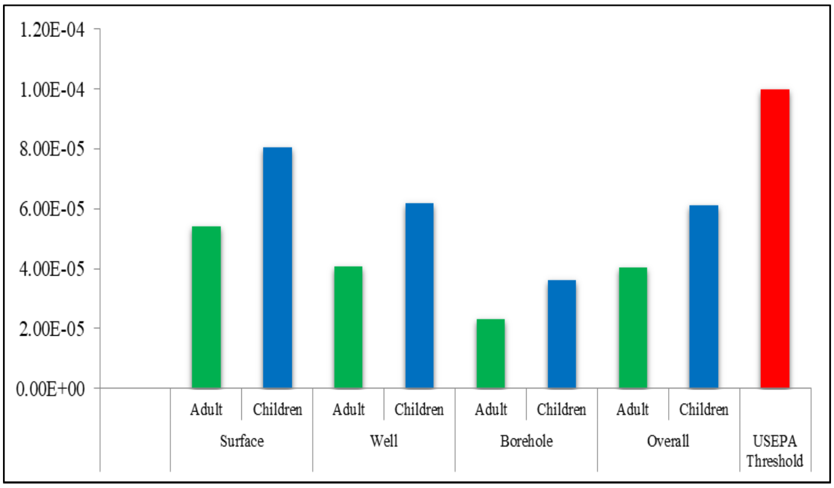

Figure 4 Excess Lifetime Cancer Risks

With references to Figure 3 and 4, the non-carcinogenic and carcinogenic risks indices; revealed that surface water samples have higher values in all the analysis (yet below maximum contamination levels). The surface water samples therefore, extensively contributed to the health risks via the drinking water pathway. However, the levels of contribution posed by the different heavy metals to the non-carcinogenic and carcinogenic risks could be explained by the fact that different heavy metals do not have the same toxicity levels and penetration characteristics and may cause health effects at different pollution degrees (Gevorgyan *et al*., 2017).

CONCLUSION

The average concentrations of the heavy metals (As, Cd, Cr, Co, Pb) in both surface, well and borehole water samples across the study area were recorded to be within the permissible limit set by WHO as guideline for drinking quality water. However, some sampling points were recorded slightly or non-significantly above the WHO guidelines. For example the average concentrations of Arsenic (As) in mg/L, the concentration in JSW2, JSW3, MWW4 and MFBW1 were found to be slightly above the permissible limit. For the average concentrations of Cadmium (Cd) in mg/L, the concentrations in MCBW1, JBW1, KWW1, MWW1, MWW3, JSW1, JSW2 and JSW 3 were found to be slightly above the permissible limit. For the average concentrations of Chromium (Cr) in mg/L, the concentrations in JSW3 and JSW4 were found slightly above the permissible limit. For the average concentrations of Cobalt (Co) in mg/L, the concentration in JSW1 was found to be slightly above the permissible limit. And for the average concentrations of Lead (Pb) in mg/L, the concentrations in JSW4, JSW5, MWW4, and MCBW1 were found to be slightly above the permissible limit. The hazard indices and the excess lifetime cancer risks through drinking water pathway of the studied heavy metals revealed that the non-carcinogenic and carcinogenic risks, respectively; in both adults and Children were all recorded below the maximum acceptable limits set by USEPA. Within the limits of the study, the current level of heavy metals does not suggest significant adverse health effects or lifetime cancer risks. However, continued monitoring is necessary, especially thus points whose concentrations were found above the WHO guidelines Similarly, from the five studies heavy metals, Figures, 2, 3 and 4 illustrated that Cobalt have the highest concentration (though below permissible limits) and has contributed significantly to the health risks (non-carcinogenic and carcinogenic) indices. It is therefore recommended that routine water quality monitoring, public awareness campaign and potential treatment plans (such as adsorption filtration for cobalt) should be implemented to maintain the safety of the water sources.

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