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Determination of heavy metals pollution in Haffirs Soil at Elgadarif State, Sudan

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Abstract

The study was conducted in 2017 and 2018 at Elgadarif State Sudan in Azaza, Trafa and Elkafey affairs soils.

The main objective of this study was to determine polluted heavy metals in Shaffer's soil compared with the standard scale of WHO. Concentrations of fourteen heavy metals, which include Cu, Fe, Mo, Ni, Cr, Co, V, Sr, Mn, Ti, Cd, Pb, and Zn in soil, were estimated in three different locations in Azaza, Trafa and Elkafey haffairs and three different depths (surface, 30 and 60 cm soil depths) at Elqadarif state, Sudan. Heavy metals were analyzed using Inductively Coupled Plasma Optical Emission (ICP-OE).

The results showed that surface soil pH was (9.1, 9.9 and 9.5); 30 cm soil depth pH was (8.3, 9.8 and 9.7); and 60 cm soil depth pH was (8.5, 9.8 and 9.5); for the Azaza,Trafa and Elkafey hair soils respectively. The concentration of Pb in Azaza haffir was significant ($P \leq 0.05$) higher than those of Trafa and Elkafey haffirs at surface soil and 60cm soil depth. Fe concentration was significantly ($p \leq 0.05$) higher than Azaza and Trafa haffirs. The levels of Cu in different depths at Elkafey haffir were (167.7, 169.2 and 165.3 ppm) was significantly ($p \leq 0.05$) higher than those of Azaza and Trafa haffirs. There were no significant differences in the concentration of Co and Cd ions at the surface of 30 and 60 cm soil depths of each haffier. As for the MO and Ti ions concentrations, depth in Elkafey haffir increased significantly ($P \leq 0.05$) than the Trafa and Azaza haffisr at surface soil, 30cm and 60 cm soil. V ion concentration in different soil depths of Elkafey haffir was significantly higher ($P \leq 0.05$) than that of Trafa and Azaza haffir. Sr ion concentration in Altarfa and Elkafey haffirs soil was significantly ($p \leq 0.05$) higher than the Azaza haffir at surface soil, 30cm and 60 cm soil. The concentration of Cr and Ni ions in Elkafey haffir was significant ($P \leq 0.05$) higher than in Azaza and Trafa haffir at surface and, 30 cm. As for Mn ions, the data showed that Trafa and Elkafey haffir was higher ($P \leq 0.05$) in M^{+2}, M^{+5} ions concentration than the Azaza haffir.

The data indicated that all heavy minerals concentrations were higher than their permissible limits (PLs) according to WHO (2014) except for Co, Cd, V, and Mn ions.

Keywords: Heavy Metals; Haffirs; Soil; Elgadarif State; WHO; Sudan

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1. Introduction

Sudan is a vast country. Therefore, the most suitable way to estimate the concentration of heavy elements throughout the country is to take samples from different parts with different locations, climates, and soil.Samples are collected from Sudan's south, middle, east, and west regions, including desert, tropical, and equatorial climates in Zozulya [1]. Heavy metals are a general collective term applying to the group of metals and metalloids with a density greater than 6 gm/cm. Although it is only a loosely defined term, it is widely recognized and applied to elements such as Cd, Cr, Cu, Hg, Ni, Pb and Zn, commonly associated with pollution and toxicity problems [2]. The soils of the Gadarif area are described as having deep dark colours, high clay content and strong vitriolic properties. The area is a large, uniform clay plain intersected by small valleys. The clay content is rather high, at up to 80% [3]. A minimal amount of organic matter and nitrogen content exists in the soil in the area, and the soil is moderately fertile. The soil is shallow when wet, which can be one source of waterlogging for a certain period during the rainy season. The soils are tough in the dry season and difficult to cultivate, and also, during the wet season, soils are very sticky [4]. Climatologically, the Gadarif state lies in the semi-arid zone, with summer rains and warm winters, characterized by unimodal rainfall patterns ranging from 400 mm to 800mm with an annual average of 600 mm. [5] A study carried out in the Gadarif State showed that the rainfall pattern in the area is characterized by its variability from one year to another [6]. Almost eight months a year, Elgadaarif state experiences a dry season [7]. Rainfall in this area is markedly seasonal; the length of the rainy season fluctuates around the four months between June and September, reaching its peak in August [8]. Most rainfall from June to September comes in heavy downpours during thunderstorms, causing heavy runoff and initiating erosion on sloping, unprotected land [9]. From November to April, the area experiences the northerly wind, the same as the dry North East Trade winds. Temperatures are very high in summer and mild in winter. The average daily maximum temperature ranges from 25° to 40° C. In comparison, the average daily minimum temperature ranges between 13° and 20° C. Humidity in the area fluctuates from its normal level of around 20-30% through most of the year to 60-70 % in the wet season [10] The term ''heavy metal'' refers to any metal and metalloid element that has are natively high density ranging from 3.5 to 7 g c -3and is toxic or poisonous at low concentrations. It includes mercury (Hg), cadmium (Cd), arsenic(As), chromium (Cr), thallium (Ti), zinc (Zn), nickel (Ni), copper (Cu) and lead (Pb). Although ''heavy metals'' is a general term defined in the literature, it is widely documented and frequently applied to the widespread. Pollutants of soils and water bodies [11]. Soil texture plays an important role in the soil-plant-water relationships and, hence, in determining the type and extent of vegetation cover in an area [12]. Contamination of soils by heavy metals, such as Cd, Ni, Zn, Pb, and Cu, has increased dramatically during the last few decades due to mining, smelting, manufacturing, use of agricultural fertilizers and pesticides, municipal waste, traffic emissions, and industrial effluents Contamination of soils by heavy metals is now widespread. Land degradation caused by heavy metals significantly affects the environment and ecosystem worldwide. Dispersion of heavy metals in irrigated soils and growing plants results in food contamination that may be hazardous to humans and animals. Heavy metals in effluents are poorly soluble in water and cannot be degraded; they tend to accumulate in soils and subsequently accumulate in plants. In addition, heavy metals persist in soil, which leach down into the groundwater. They may induce enhanced antioxidant enzymatic activities in plants or become adsorbed from solid soil particles [13].Excess heavy metals in the soil originate from many sources, including atmospheric deposition, sewage irrigation, improper stacking of industrial solid waste, mining activities, pesticides and fertilizers [14], and Various sources of heavy metals contaminating the world [15]. Agricultural soil contamination with heavy metals is of increasing worldwide concern because of food safety issues and potential health risks [16].The uptake of metals from the soil depends on different factors, such as their soluble content it, soil pH, plant species, fertilizers, and soil [17]. The soil-accumulated heavy metals can also pose potential long-term hazards to plants, animals, and humans that consume these plants [18]. Heavy metals are currently of much environmental concern. They harm humans and animals and are susceptible to bioaccumulation in the food chain[19]. Heavy metals may come from many different sources in urban areas.Atmospheric pollution is a major contributor to soil contamination [20].Heavy metals such as Cr, Mn, Zn, Cu, and Fe are considered essential components of biological activities in the body; however, in excess, they are reported to cause human problems [21].On the other hand, Pb, Cd, and As have no important functions in the human body but rather play a toxic role in living organisms; hence, they are considered toxic elements Loke.[22], In humans, cadmium exposures have been associated with cancers of the prostate, lungs and test.In Poland, the symptoms of Lead toxicity were high blood pressure, slow nerve conduction, fatigue, mood swings, drowsiness, impaired concentration, fertility disorders, decreased sex drive, headaches, constipation and, in severe cases, encephalopathy or death.[23].

Heavy metal accumulation in agricultural soils can lead to the disorder of soil function, which in turn affects crop growth and can also be transferred to crops, thus posing a risk to human health [24] . Heavy metals are potentially hazardous substances in natural and contaminated environments. In natural environments, they occur at low concentrations. However, at high concentrations, as is the case in contaminated environments.[25] They result in public health impacts. The elements of concern include Hg, Cd, As, Zn, Ni, and Cu. They can be released into the environment from metal smelting and refilling industries, scrap metals, plastic and rubber industries, various consumer products, and burning of waste containing these elements on release into the air. The elements travel for considerable distances and are deposited onto the soil; once deposited, these metals are not degraded and persist in the environment for many years, poisoning humans through inhalation, skin absorption, acute exposure leads to nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis [26], [27] and [28]. as there is no such deficiency of other plant nutrients. The soils have a very high water-holding capacity. This high water-holding property of the soils in this area allows crops to grow on the stored water during dry spells. The permeability. The main objective of this study was to determine polluted heavy metals in haffir's soil compared with the WHO standard scale.

2. Material and methods

The study was carried out in Gedaref, Gedaref State (Eastern Sudan; population 300,000). Nine soil samples will be taken for each haffirs on 1/6/2015 at surface soil, at 30 cm and 60 cm depths from the top of haffir boundary where the soil is runoff using a spiral auger of 2.5cm diameter. The Soil samples were then randomly selected and bulked together to form a composite sample before being placed in clean plastic bags. All samples were collected within a week, stored dry, and placed before preparation. Samples were prepared and analyzed in Petroleum Laboratories Research and Studies.

The reagents required for this work were acids (HCL37%, HF40%, HNO3 65% and H3BO335%), and boiling chips. Filter paper (MN640m.O125mm) and distilled water were then analyzed by (ICP-OE). Volumetric flask (100ml) evaporate, hot plate, Inductivity Coupled Plasma ICP-OES 725 ES (ICP-0E), plastic bottles, measuring a conical flask, cylinders of different sizes, pipettes, test tube and microwave. Samples were whited 0.5g in the vessel soil. Added acids (HCL37%, HF40%, HNO3 65%, and H3BO335%), adding acids drop by drop, then gently swirling the solution to homogenize the sample with the acids. The vessel was closed, introduced into the rotor segment, and then tightened using the torque wrench. Insert the segment into the microwave cavity and connect the temperature sensor. Run the microwave to cool the rotor with water until the solution reaches room temperature. Open the vessel and transfer the solution to a marked flask. Then analyzed by (ICP-OE)

Stock volume (1000 ppm) taken 8, 4 , 2 and 20 ml for the group (1) (Al, Ba,Sr, Zn,Pb), group (2) (Ag,Co,Cu,Cr, Mn,Ni, Li) group (3) (Cd,As,V,Mo,Sb,Ti,B,Be,Se) and group (4) from1000 ppm pb ,Zn ,Sr, C0, Cu, Cr, Mn Ni, As, V, Mo, Ti, Fe and Se standard for AAS and these volume were completed to 200 ml Deionized water. From those 40,20 ,10, and100g/ ml(ppm), .taken100sd3,100sd4,100sd5 completed to 200 ml Deionized water yield 5,100 and50 ppm 5ppm for example completed to 5L Deionized water yield 5000ppb taken 125,250,500,1000,2000ppb were prepared for the standard curve were ready for the standard curve. The prepared eight soil samples were placed in the glass–stoppered test tube, which takes the samples into the ICP-OE that reads the spectra automatically and shows the amount/concentration of Pb Cu.,Zn, ,Fe, Mn ,Mo Ni, Cr, Co,Ti, Sr, Ag and V in the screen.

3. Results and discussion

3.1. Soil pH and Pb, Pb,Cu, Zn and Fe ions concentrations in ppm

Soil pH is important because it influences nutrient availability (especially micronutrients), solubility of toxic ions and microbial activity. The pH of the current study of the Azaza,Trafa and Elkafey haffirs soils were (9.1, 9.9 and 9.6), (8.2, 9.8 and 9.7) and (8.5, 9.3 and 9.5) for the surface soil, 30 cm depth and 60 cm soil depth respectively, similar results were obtained by Isirimah et al. [10]—the result of the data analysis of the Pb. Cu, Zn, and Fe showed that the concentration of Pb was higher than their permissible limits (PLs) according to WHO (2014) for each haffir and soil depth (Table 1). The concentration of Pb in Azaza haffir was significant ($P \leq 0.05$) higher than those of Trafa and Elkafey haffir at surface soil and at 60cm soil depth. However, at 30 cm soil depth, the concentration of Pb in Elkafey haffir was significantly ($P \leq 0.05$) higher than those of Azaza and Trafa haffirs. The mean concentrations of Pb in Azaza haffir were 194, 141 and 245 at the surface, 30 cm and 60 cm soil depths, respectively. As for the Cu the data indicated that Cu concentration was higher than their permissible limits (PLs) according to WHO (2014) for each haffir and soil depths. There is no significant difference in Cu concentration at the surface, 30 and 60 depths soil of Azaza, Trafa Elkafey haffir. Cu can cause cirrhosis, nausea, vomiting and diarrhoea [29]. Cu content has been reported to differ according to the soil type and pollution source [30]. The high concentration in some sites may result from burnt vehicles along the major roads because copper is commonly found in electrical wirings. The Zn concentration by using ICP-OE method was higher than their permissible limits (PLs) according to WHO (2014) for each haffir and soil depths. Zn concentration in Azaza and Elkafey haffir was significantly higher higher ($P \leq 0.05$) than the Trafa haffir at surface soil and 60 cm soil depth. However, at 60 cm soil depth only Azaza haffir was significantly ($P \leq 0.05$) in Zn concentration. The concentration may be due to the number of trucks and emissions that pass through these roads. As for Fe concentration (Table.1), the data showed that the concentration of Fe was higher than their permissible limits (PLs) according to WHO (2004) for each haffir and soil depth except at 60 cm soil depth of Trafa haffir was lower. The Fe concentration in Elkafey haffir soil was significantly higher (P≤0.05) than the other haffir in all soil depths. The effects of toxic doses of iron include depression, rapid and shallow respiration, coma, convulsions, respiratory failure, and cardiac arrest. Compared with the study in Manzala Lake in Egypt, the concentration of heavy metals in the soil samples for Fe (14130 ppm), Cu (110 ppm), Zn (110 ppm, Pb (500). However, the mean concentration of heavy metals in this study was Fe (45633, 50709.3, and 67538.3), Cu (156, 145.6 and 169.3), Zn (1448.6, 653.6 and 1624.6), Pb (194.6, 131.3 and 212,3) for the Azaza, Tarafa and Elkafey haffirs respectively. All the heavy element concentrations of this study were higher than the concentration element in the Eygpt study except for the Pb, which was lower.

Table 1 The concentration of Pb,Cu, Zn and Fe ions in ppm In Azaza, Trafa and Elkafey affairs at the surface, 30 cm, and 60 cm soil depth, and the standard value of WHO. By ICP method

Haffir	**Surface soil**	**30 cm soil depth**	**60 cm soil depth**	**WHO value**
Concentration of Pb element (ppm)				
Azaza	194.0 a	141.4 b	245.8 a	100
Trafa	139.0 b	122.7 b	132.4 c	100
Elkafey	172.2 c	238.4 a	181.1 b	100
SE(±)	7.7	17.9	16.6	
CV%	1.5	0.64	1.46	
Concentration of Cu element (ppm)				
Azaza	156 a	157.3 a	155.7 a	100
Trafa	156 a	152.4 a	156.2 a	100
Elkafey	167 a	167.2 a	165.3 a	100
SE(±)	0.88	4.8	6.1	
CV%	0.57	0.2.5	1.47	
Concentration of Zn element (ppm)				
Azaza	2073 b	2066 b	207.3 a	300
Trafa	832 c	992.5 c	135.6 b	300
Elkafey	2380 a	2375 a	119.2 c	300
SE(±)	236.7	259.5	13.5	
CV%	0.5	0.44	0.19	
Concentration of Fe element (ppm)				
Azaza	53769 b	55904 b	57226 b	50000
Trafa	52454 b	50041 c	49633 c	50000
Elkafey	65422 a	67760 a	69433 a	50000
SE(±)	982.7	4071	2056	
CV%	5.5	4.5	5.5	

Means followed by the same letter (s) in column are not significantly at P ≤ 0.05, according to LSD Tes

3.2. Co, Cd, Mo and Ti ions concentrations in ppm

Data in table.2, showed that the concentration of both Co and Cd determined by ICP-OE method were lower than their permissible limits (PLs) according to WHO (2004) for each haffir and soil depths (Table 2). There were no significant differences in both ion's concentration at the surface 30 and 60 cm soil depths of each haffir. However, the concentrations of Mo and Ti by using ICP-OE method were higher than their permissible limits (PLs) according to WHO (2004) for each haffir and soil depths (Table 2). MO and Ti concentrations depth in Elkafey haffir increased significantly

($P \leq 0.05$) than the Trafa and Azaza haffir at surface soil,30cm and 60 cm soil. Symptoms of excessive molybdenum include joint pain, side, lower back, or stomach pain, and swelling of feet or lower legs. Titanium dioxide has a toxic effect on glial cells in the brain, suggesting that exposure to titanium dioxide may cause brain injury and be a health hazard.[34] . Márquez-Ramírez SG et al. (2012){19} titanium dioxide causes adverse effects by producing oxidative stress, resulting in cell damage, redness, and immune response. Skocaj M etal(2011)[35].

Figure 2 Concentration of Co, Cd, Mo and Ti ions in ppm In Azaza, Trafa and Elkafey haffirs at surface, 30 cm, and 60 cm soil depth, and the standard value of WHO. By ICP method

Haffir	Surface soil	30 cm soil depth	60 cm soil depth	WHO value
Concentration of Co element (ppm)				
Azaza	0.0018 a	0.0015 a	0.0018 a	50
Trafa	0.0017 a	0.0017 a	0.0017 a	50
Elkafey	0.0015 a	0.0015 a	0.0016 a	50
SE(±)	0.00012	0.0003	0.0005	
CV%	8.07	7.07	10.1	
Concentration of Cd element (ppm)				
Azaza	0.0009 a	0.0008 a	0.0009 a	3.00
Trafa	0.0008 a	0.0009 a	0.0009 a	3.00
Elkafey	0.0009 a	0.0009 a	0.0009 a	3.00
SE(±)	0.0002	0.0002	0.0002	
CV%	20.3	20.3	20.3	
Concentration of Mo element (ppm)				
Azaza	7713 b	8039 b	8221 b	250
Trafa	7586 b	7182 c	7113 c	250
Elkafey	9724 a	9965 a	10374 a	250
SE(±)	140	140.2	140.2	
CV%	0.06	0.06	0.06	
Concentration of Ti element (ppm)				
Azaza	6350 c	6511 b	7035 a	300
Trafa	7043 b	6633 b	6415 c	300
Elkafey	7809 a	8418 a	8581 a	300
SE(±)	169.6	1406	169.8	
CV%	0.05	0.05	0.05	

Means followed by the same letter (s) in column are not significantly at $P \leq 0.05$, according to LSD Test

3.3. V, Sr, Cr and Ni ions concentrations in ppm

Data in table3, revealed that the concentration of V by using ICP-OE method was lower than their permissible limits (PLs) according to WHO (2014) for each haffir and soil depths (Table 3). V concentration in different soil depths of Elkafey haffir was significantly higher ($P \leq 0.05$) than that of Trafa and Azaza haffisr. However, the concentration of Sr was higher than their permissible limits (PLs) according to WHO (2014), except for Azaza soil in all depths. The amounts of strontium in soil vary over a wide range. The average concentration is 240 mg Sr/kg [31]. Whereas, for Cr concentration was higher than their permissible limits (PLs) according to WHO (2014) for each haffir and soil depths (Table 3). The concentration of Cr in Elkafey haffir was significant ($P \leq 0.05$) higher than were Azaza and Trafa haffir at the surface and 30cm . Trafa haffir was significantly ($P \leq 0.05$) higher than those Azaza and Elkafey haffirs at 60 Cm soil depths. High concentration of Cr caused carcinoma [32]. As for Ni concentration, the data showed that the concentration of Ni by using the ICP-OE method was higher than their permissible limits (PLs) according to WHO (2004) for each haffir and soil depths. The concentration of Ni in Elkafey haffir was significant (P≤0.05) higher than those of Azaza and Trafa haffir at the surface of 30 cm depths soil. Nickel has been considered to be an essential trace element for human and animal health. It is associated with DNA and RNA molecules in living systems and is a regulatory element for the various enzyme systems [33].

Accumulated heavy metals in the soil, such as Cd, Ag, Pb and Cr, may have toxic effects since they are not disposed out of the human body by natural physiological mechanisms [36]. They tend to accumulate to a critical level when entering the food chain. This is considered the most crucial impact of soil pollution. Wang et al. (2003) [37] reported that the dynamics of soil metal contamination of plants and the onward movement. The existence of toxic elements with different values causes many diseases if they reach human bodies with a high ratio [38]. For example, Cr caused carcinoma; Cu caused cirrhosis, nausea, vomiting and diarrhoea [39]. These numbers were significantly different from those in soil, indicating that many other factors, such as soil pH, organic matter and phosphorous content, [40] might influence metal uptake by crops.

Figure 3 Concentration of V, Sr, Cr and Ni ions in ppm In Azaza, Trafa and Elkafey haffirs at surface, 30 cm, and 60 cm soil depth, and standard value of WHO. By ICP method

Haffir	**Surface soil**	**30 cm soil depth**	**60 cm soil depth**	**WHO value**
Concentration of V element (ppm)				
Azaza	156.4 b	158.4 b	163.1 b	310
Trafa	164.0 b	157.7 b	159.4 b	310
Elkafey	285.9 a	196.9 a	207.7 a	310
SE(±)	5.04	6.94	7.6	
CV%	1.72	1.16	2.05	
Concentration of Sr element (ppm)				
Azaza	124.0 b	235.3 c	220.6 b	240
Trafa	297.3 a	365.8 a	367.7 a	240
Elkafey	302.0 a	347.5 a	324.0 a	240
SE(±)	158.1	10.04	22.3	
CV%	0.002	0.48	4.4	
Concentration of Cr element (ppm)				
Azaza	133.8 b	136.9 c	173.1 b	100
Trafa	273.5 a	236.2 b	228.3 a	100
Elkafey	269.7 a	317.9 a	147.0 c	100
SE(±)	10.6	14.4	19.1	
CV%	19.9	15.7	7.22	
Concentration of Ni element (ppm)				
Azaza	087.2 c	88.6 c	091.6 b	50
Trafa	115.8 b	112.1 b	110.6 a	50
Elkafey	136.7 a	135.3 a	60.0 c	50
SE(±)	7.5	10.1	4.2	
CV%	15.6	6.9	14.7	

Means followed by the same letter (s) in column are not significantly at P ≤ 0.05, according to LSD Test

3.4. Concentration of Mn^{+2},Mn^{+5} ions in ppm

Data in Fig.1 showed that the concentration of Mn+2 and Mn+5 ions, using the ICP-OE method, was lower than their permissible limits (PLs) according to WHO (2004) for each haffirs and soil depths. Also, Tarfa and Elkafey haffir were higher ($P \leq 0.05$) in M+2 and M+5 ions concentration than the Azaza haffir. However, the concentration of Mn+2, Mn+5 ions in Elkafey haffir was lower than their permissible limits (PLs) according to WHO (2014) at each soil depths. The concentrations of both ion in Azaza haffir increased with increases soil depth M+2 at surface and 60cm depth decreased at 30cm depth(533.5, 471.6, 538.3 ppm) and M+5(621.4,562.1,631.9). But (M+2,M+5) concentrations in Trafa haffir (M+2) constant value in surface and 60cm depth higer at 30cm (873.2,1135,873.2ppm) andM+2 (778.8, 1030,778.8 ppm) and Elkafey haffir decreased the value M+2 (1236, 990, .and 538.3ppm) and Mn+5 (1369, 1113, 631).

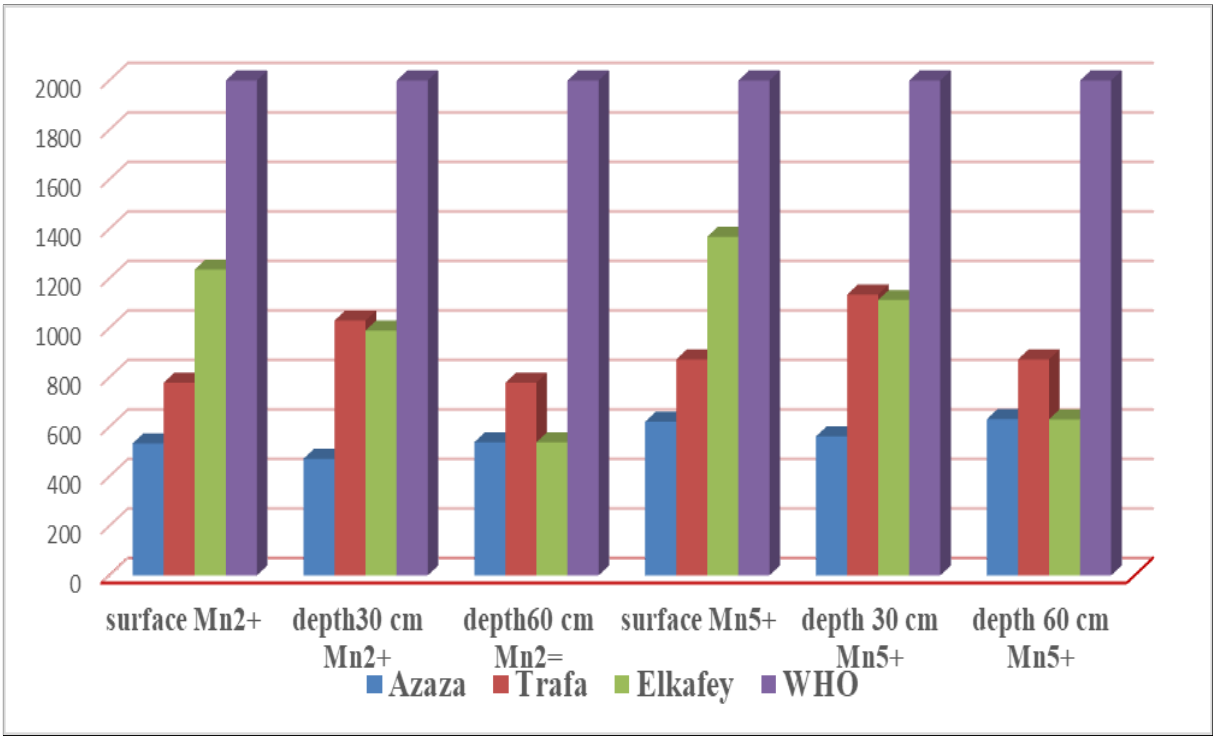

Figure 1 Concentrations of Mn2+ and Mn5+ in haffir soils at surface, 30cm and 60cm soil depth

4. Conclusion

Our data indicated that all heavy minerals concentrations were higher than their permissible limits (PLs) according to WHO except for Co, Cd, V, and Mn ions.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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