

Studies on Water-Harvesting Ponds (Haffirs) in Gedarif State, Eastern Sudan: I. Determination of Haffir Soil Heavy Metals

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Abstract

The Sudan is a country of rich water resources, however, some areas and states (Red Sea, Gedarif, Kordofan and Darfur) suffer from scarcity of water during the dry-season. The wet-season (Autumn/Kharif, about 4 months), extends from July to mid-October. Therefore, these states resort to water-harvesting in ponds (locally known as haffirs). Haffirs are used for drinking (human and animal), agriculture, and domestic needs and activities. These haffirs can store water for a few months during the dry-season (7-8 months). The objectives of the present study, as one of a series of studies, was to measure the concentrations of heavy metals (HMs) in the soils of 3 haffirs of Gedarif as a potential of contaminating the stored water coming from different directions, sources and sites, including streams, farms, mountains, roads, vehicle emissions, etc. This harvested water is intended for storage during the rainy-season to be used during the dry-season. The haffirs studied were Azaza, Tarfa and Elkafay. Soil samples were taken from 3 layers before water-storage (June), the surface of the haffirs, 1 - 30 cm and 31 - 60 cm depth. Samples were prepared as required, extracted, cleaned, and concentrated and the levels (ppm) of the HMs were determined using inductively coupled plasma-optical emission spectrometer ICP-OES 725 E). The HMs of concern were Pb, Cu, Zn, Fe, Cd, Mn, Ni, Mo, Ti, V, Sr, and Cr. The results showed almost all that levels of several HMs were higher than the WHO (2004) permissible levels (PLs) in soil. It is concluded that the levels of some of these pollutants might be behind the incidence of some of the reported cancers and the renal failure cases in the area. The study recommended that haffirs site selection, design, facilities, logistics and protection must be given the proper attention by researchers, health authorities, water corporations, the states and the municipalities. The other studies will cover other pollutants like pesticides and hydrocarbons in the soil and the harvested water.

Keywords: Heavy Metals; Soil Pollution; Haffirs; Water Harvesting Ponds; Gedarif; Sudan

Introduction

The Sudan (12.8628° N, 30.2176° E) is a very large country (1,886 million km²). Around 8 of the 18 Sudanese states are suffering from the scarcity of water during the dry-season (November to June). Gedarif State (GS), 14.0086° N, 34.8624° E, is one of these states that resort to the water-harvesting practices in man-made water ponds (haffirs) for human and animal consumption, agriculture, and other anthropogenic activities. Depending on the size of the haffir, the water can cover the above-mentioned needs for a few months during the dry-season, this water before being harvested pass through mountains, valleys, farms, industrial areas, roads, etc. Therefore, is expected to be contaminated with several pollutants, e.g. heavy metals (HMs), pesticides, hydrocarbons, fertilizers, etc. The soil of GS is mostly heavy clay cracking soil [1].

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HMs are associated with pollution and toxicity problem. They are a group of metals and metalloids with a density $> 6 \text{ g/cm}^3$. Although it is only a loosely defined term, it is widely recognized and applied to the elements such as Cd, Cr, Cu, Hg, Ni, Pb and Zn [2,43]. These metals are currently of much environmental concern. They are harmful to humans, animals and are susceptible to bioaccumulation in the food chain. HMs may come from many different sources in urban areas. Atmospheric pollution is a major contributor to HM contamination in to soils [3,19-21,60]. Cr, Mn, Zn, Cu, and Fe are considered essential components of biological activities in the body, however, in excess are reported to cause problem to human. On the other hand, Pb, Cd, and As have no important functions in human body rather play toxic role to living organism, hence are considered as toxic elements [4]. HMs accumulation in agricultural soils cannot only lead to the disorder of soil function, which in turn affects crop growth, but HMs can be transferred to crops, thus, posing a risk to human health [5,6,23,26]. HMs are present in both natural and contaminated environments. In natural environments they occur at low concentration. Hg, Cd, As, Zn, Ni, Cu may be released into the environment from metal smelting and refilling industries, scrap metals plastic and rubber industries, various consumer products and from burning of waste contains. These elements, on release to the air, travel for large distance and are deposited on to the soil. Once deposited, HMs 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 [7-9,60].

The soils of the Gedarif area are described as deep dark colors, high clay content and strong vitriolic properties. The area consists of a large uniform clay plain intersected by small valleys. The clay content is rather high with up to 80% [1,10]. A very small amount of organic matter- and nitrogen-content of the soil in the area exist, and soil is moderately fertile as there is no such deficiency of other plant nutrients. The soils have a very high-water holding capacity that allows crops to grow on the stored water during dry spell. The permeability of the soils is very low when wet, that can be one source of waterlogged for certain period during the rainy-season. The soils are very hard in the dry-season and difficult to cultivate, and also during wet-season soils are very sticky [1].

Climatologically GS lies in the semi-arid zone, with summer rains and warm winters, characterized by unimodal rainfall pattern ranging from 400 mm to 800 mm, with annual average of 600 mm [11]. A study carried out in the GS showed that the rainfall pattern in the area is characterized by its variability from one year to another [11]. Almost 8 months a year GS experiences a dry-season. Rainfall in this area is markedly seasonal in nature; length of the rainy-season fluctuates around the 4 months between June and September, reaching its peak in August. Most of the rainfall from June/July to September/October comes in the form of heavy downpours during thunderstorms, causing heavy runoff, initiating erosion on sloping, unprotected land. From November to April the area experiences the northerly wind or 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 , while 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 [1].

HMs in effluents are poorly soluble in water, and cannot be degraded; they tend to accumulate in soils and subsequently accumulate in plants. In addition, HMs persist in soil, which then leach down into the groundwater and may induce enhanced antioxidant enzymatic activities in plants or become adsorbed with solid soil particles [12,15-17].

Materials and Methods

Sites: Three locations were selected for this study. These are: northern area for the Tarfa haffirs, and Elazaza Safora haffirs located in the middle area, and Elkafay haffirs located in the southern area.

Samples collection: Nine soil samples were taken from haffirs during the 1st of June from the soil surface, up to 30 cm, and 30 - 60 cm deep using spiral auger of 2.5 cm dia. The soil samples were bulked together to form a composite sample before being placed in clean plastic bags [6,7,13].

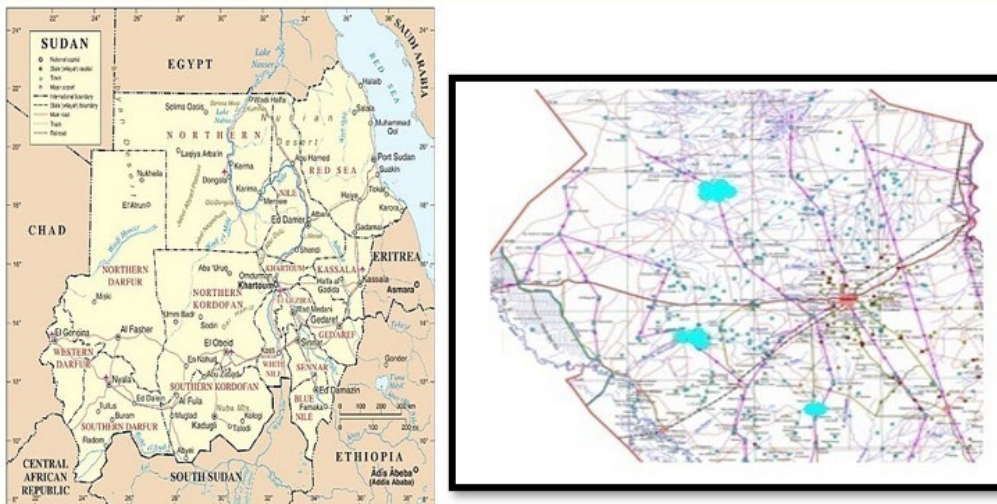


Figure: Sudan map showing GS and the 3 haffirs locations (blue).

Sample preparation: Exactly 0.5g of the composite soil samples was weighed in the vessel, and 1 ml HF40%, 8 ml HNO₃ 65%, 5 ml HCl 37%, and 5 ml H₃BO₃ 35% were added drop by drop. The solution was gently swirled for homogeneity. The sample was placed into the microwave (200°C) for 1 hr. Then removed and left outside until the solution reaches room temperature 15°C; the vessel was opened and the digested sample was transferred in to 100 ml volumetric flask using deionized water to the mark. The sample was ready for analysis as applied by ICP-OE (APHA3030E) [6,7,13].

Data analysis

The data was subjected to ANOVA, using the SAS statistical package (SAS 2004), and the means were separated by Duncan’s Multiple Range Test.

Results

Azaza haffir

The means concentrations of Pb in Azaza haffir samples were 194, 141 and 245 ppm at surface, up to 30 cm and up to 60 cm depths, respectively (Table 1). Cu concentrations for the same layers were 156.2 ppm, 157, 3 ppm and 155.7 ppm, respectively. The respective concentrations for Zn were not significantly different between the 3 layers depth 2,073.3, 2,066, and 2,073 ppm. The Fe concentration registered very high concentrations, i.e. 53,769 ppm, 55,904 ppm and 57,226 ppm, following the same order of layers. The Co, Cd concentration in the 3 layers showed the same concentration of the metals, viz. 0.0018, for Co, and 0.0009 ppm for Cd. The means for Mo (7,713), (6,511) and (8,221 ppm) at surface, 30 cm and 60 cm soil depths. Regarding Ti levels were also high, i.e. 6.350, 6,511 and 7,053 ppm following the same order of layers. Ni means were 87.2, 88.6, and 91.6 ppm, respectively. But V concentrations were not significantly different from each other in the 3 layers, i.e. 156.4, 158.4, and 163.1 ppm. However, the means for Mn⁺² and Mn⁺⁵ proved to be 533.5 ppm, 471.6 ppm and 538.3 ppm for the former; and 621.4 ppm, 562.1 ppm and 631.9 ppm for the latter. The respective mean concentrations of Sr were 128.4 ppm, 235.3 ppm and 220.6 ppm. Finally, the respective values of Cr were 133.8 ppm, 136.9 ppm and 137.1 ppm. All examined HMs proved to have concentrations higher than those recommended by WHO (2004), except Co, Cd, V, the 2 Mn ions and Ni.

HM	Surface (Mean ± SE)	C.V (%)	Up to 30cm (Mean ± SE)	C.V (%)	Up to 60 cm (Mean ± SE)	C.V (%)	WHO 2004
Pb	194 ± 7.66	1.5	141.4 ± 5.9	0.64	245.8 ± 16.6	1.46	100
Cu	156.2 ± 0.57	0.88	157.3 ± 4.8	2.5	155.7 ± 6.1	1.47	100
Zn	2,073.5 ± 236.7	0.5	2,066 ± 259.5	0.44	2,073 ± 135.0	0.19	300
Fe	53,769 ± 982.7	5.5	55,904 ± 407.1	4.5	57,226 ± 205.6	0.04	50,000
Co	0.0018 ± 0.00012	8.07	0.0018 ± 0.00033	7.06	0.0018 ± 0.0005	10.1	50
Cd	0.009 ± 0.00002	20.3	0.009 ± 0.00002	20.3	0.009 ± 0.00002	20.3	3.0
Mo	7,713 ± 1409.0	0.06	6,511 ± 1406.2	0.05	8,221 ± 1402.2	0.06	250
Ti	6,350 ± 169.8	0.05	1,584 ± 79.4	1.16	7,035 ± 189.8	0.05	300
V	156.4 ± 5.04	1.72	158.4 ± 6.02	0.06	163.1 ± 7.61	2.05	310
Mn ⁵⁺	621.4 ± 70.31	0.021	562.1 ± 10.8	0.14	631.9 ± 8.4	0.04	2,000
Mn ²⁺	533.5 ± 9.55	0.024	471.6 ± 7.36	14.6	538.3 ± 7.31	0.5	2,000
Sr	124.8 ± 15.81	0.002	235.3 ± 19.04	0.48	220.6 ± 22.3	4.4	240
Cr	133.8 ± 10.6	19.9	136.9 ± 14.4	15.7	137.1 ± 19.1	7.22	100
Ni	87.15 ± 7.5	15.6	88.6 ± 10.1	6.9	91.64 ± 4.2	14.7	50

Table 1: Concentrations (ppm) of HMs in the 3 tested soil layers of Azaza haffir.

Tarfa haffir

From table 2, the means concentrations of Pb were 139, 122.7 and 132.4 ppm at surface layer, up to 30 cm and up to 60 cm soil depths, respectively. Whereas, the respective means for Cu were 156.9, 152.3 and 156.2 ppm. Following the same order of layers, Zn concentrations increased with increase of depth (832.5, 992.5, and 1,356 ppm). The Fe concentration, following the same order, were 52,454 ppm, 50,041 ppm, and 49,633 ppm. The Co, Cd concentrations in the 3 layers did not change; 0.0018 ppm for Co, and 0.0009 ppm for Cd. When it comes to Mo, the respective concentrations were 7,586 ppm, 6,633 ppm and 7,113 ppm. The means for Ti were 7,043 ppm, 6,633 ppm and 6415 ppm, respectively. V in the surface was 164 ppm, in the 2nd layer was, 154.7 ppm and 154.4 ppm in the 3rd layer. M²⁺ levels were 778.8 ppm, 1,030 ppm and 778.8 ppm from top to bottom, whereas the respective levels for M⁵⁺ were 873.2 ppm, 1,135 ppm and 873.2 ppm. The means of Sr concentrations in were 279.3, 365.8 and 368 ppm in these layers. Cr concentrations were 273.5, 236.2 and 228.3 ppm, following the same order of layer. Whereas, the means of Ni concentrations were 115.8, 111.1 and 110.6 ppm in these layers

HM	Surface (Mean ± SE)	C.V (%)	Up to 30 cm (Mean ± SE)	C.V (%)	Up to 60 cm (Mean ± SE)	C.V (%)	WHO 204
Pb	139.5 ± 7.66	1.5	122.7 ± 17.9	0.64	132.4 ± 16.6	1.46	100
Cu	156.9 ± 0.57	0.56	152.4 ± 4.8	2.5	156.2 ± 6.1	1.47	100
Zn	832.5 ± 236.7	0.5	992.5 ± 259.5	0.44	1,356 ± 135.0	0.19	300
Fe	52,454 ± 982.7	5.5	50,041 ± 407.1	4.5	50,041 ± 205.6	5.5	50,000
Co	0.0018 ± 0.00012	8.07	0.0018 ± 0.0003	7.06	0.0018 ± 0.0005	10.1	50
Cd	0.0009 ± 0.0002	20.3	0.0009 ± 0.0002	20.3	0.0009 ± 0.0002	20.3	3.0
Mo	7,586 ± 1400.0	0.06	6,633 ± 1406.2	0.06	7,113 ± 1402.2	0.06	250
Ti	7,043 ± 1406.2	1.02	6,633 ± 1062	1.16	6,415 ± 1406.2	1.9	300
V	164.0 ± 5.04	1.72	154.7 ± 7.31	0.06	154.4 ± 7.61	2.05	310

Mn ⁵⁺	873.2 ± 70.31	0.021	1,135 ± 108.03	0.14	873.2 ± 84.4	0.04	2,000
Mn ²⁺	778.8 ± 95.5	0.024	1,030 ± 73.61	14.6	778.8 ± 70.31	0.05	2,000
Sr	279.3 ± 15.1	0.002	365.8 ± 19.04	0.48	368 ± 22.3	4.4	240
Cr	273.5 ± 10.6	19.9	236.2 ± 14.4	15.7	228.3 ± 19.1	7.22	100
Ni	115.8 ± 7.5	15.6	111.1 ± 10.1	6.9	110.6 ± 4.2	14.7	50

Table 2: Concentration (ppm) of HMs in Tarfa haffir 3 tested soil layers.

Elkafay Haffir

Table 3 reflected the following: The means of Pb concentrations were 172.7 ppm, 238.4 ppm and 181.1 ppm at surface, up to 30 cm and up to 60 cm soil depths, respectively. Cu levels were 167.7, 169.2 and 165.3 ppm, Zn 2,380 ppm, 2,375 ppm, and 1,192 ppm. Fe 65,422 ppm, 67,760 ppm and 69,433 ppm, following the same order of layers. The Co, Cd concentration behaved similar to what was detected in the other two haffirs (0.0018 and 0.0009 ppm). Mo showed high (9,724 ppm, 8,418 ppm and 10,374 ppm) from top to bottom. Whereas, the means of Ti concentrations were also high (7,809 ppm, 8,418 ppm and 8,581 ppm), following the same order of layers. The V concentrations increased with soil depth (185.9 ppm at surface, 196.9 ppm at the 2nd layer, and 207.7 ppm in the bottom layer). Mn⁺² levels 1,236 ppm, 990 ppm and 538.3 ppm, and these of Mn⁺⁵ proved to be 1,369 ppm, 1,113 ppm and 631 ppm, for the respective layers. Sr concentrations were 302 ppm, 317.5 ppm and 324 ppm in these layers. Cr concentrations were 296.7 ppm, 317.9 ppm and 147.6 ppm, respectively, whereas, the means of Ni concentrations were 136.7 ppm, 135.3 ppm and 60 ppm, following the same layers order.

HM	Surface (Mean ± SE)	C.V. (%)	Up to 30 cm (Mean ± SE)	C.V. (%)	Up to 60 (Mean ± SE)	C.V (%0)	WHO 2004
Pb	172.2 ± 7.66	1.5	238.4 ± 17.9	0.64	181.1 ± 16.6	1.46	100
Cu	167.7 ± 0.57	0.56	169.2 ± 4.8	2.5	165.3 ± 6.1	1.47	100
Zn	2,380 ± 236.7	0.5	2,375 ± 259.5	0.44	1,192 ± 113.5	0.19	300
Fe	65,422 ± 982.7	5.5	67,760 ± 1071	4.5	69,433 ± 2056	5.5	50,000
Co	0.0018 ± 0.00012	8.07	0.0018 ± 0.00033	7.06	0.0018 ± 0.0005	10.1	50
Cd	0.009 ± 0.00002	20.3	0.009 ± 0.00002	20.3	0.009 ± 0.00002	20.3	3.0
Mo	9,724 ± 1400	0.06	8,418 ± 1406.2	0.06	10,374 ± 140.22	0.06	250
Ti	7,809 ± 1406.2	0.06	1,969.0 ± 169.4	1.16	8,581 ± 1406.2	0.06	300
V	185.9 ± 5.04	1.72	196.5 ± 14.22	0.06	207.7 ± 7.61	2.05	310
Mn ⁵⁺	1,369 ± 70.31	0.021	1,113 ± 108.03	0.14	631 ± 84.4	0.04	2,000
Mn ²⁺	1,236 ± 95.5	0.024	990.2 ± 73.61	14.6	538.3 ± 70.31	0.05	2,000
Sr	302 ± 15.81	0.002	317.5 ± 19.04	0.48	324 ± 22.3	4.4	240
Cr	269.7 ± 10.6	19.9	317.9 ± 14.4	15.7	147.6 ± 19.1	7.22	100
Ni	136.7 ± 7.5	15.6	135.3 ± 10.1	6.9	60 ± 4.2	14.7	50

Table 3: Concentration (ppm) of HMs in the 3 tested soil layers of Elkafey haffir.



Figure

Discussion

Gedarif State and the capital Algedarif town, in addition to the rest of the towns and village in the state, and all activities in the state depend on man-made/excavated or natural haffirs water during the 87-8 months of the dry-season. HMs-contamination of water resource is of great world-wide concern, because of the toxic effect to human beings, animals, and plants in the environment even at very low concentrations. Since HM ions are water-soluble, not biodegradable in nature, effective removal of HM ions from aqueous solutions through other technologies (physical or chemical) is important in the protection of environmental quality and public health. In natural aquatic ecosystems, HMs occur in low concentrations, but in recent times, the occurrence of these metals in excess of natural loads has become a problem of increasing concern. This situation has arisen as a result of industrialization and urbanization [1,14]. However, in the Sudan, in general, the rural population is ca. 80% of the country’s population most the year, use untreated water directly from sources, such as traditional surface water, deep bores, rivers, intermittent rainy-seasons streams (Khors), natural rain ponds and artificial haffirs [15]. Accumulated heavy HMs in the soil, e.g. Cd, Ag, P and Cr might have toxic effects, since they are not disposed out of human body by natural physiological mechanisms. Unfortunately, these metals tend to accumulate to a critical level, when they enter into the food-chain. Existence of toxic elements with different values can cause many diseases, if reached to human and animal bodies with high ratio [12]. HMs toxicity can lower energy levels and damage the functioning of the brain, lungs, kidney, liver, blood composition and other important organs. Long-term exposure can lead to gradually progressing physical, muscular, and neurological degenerative processes that imitate diseases, e.g. multiple sclerosis, Parkinson’s disease, Alzheimer’s disease and muscular dystrophy. Repeated long-term exposure of some metals and their compounds may even cause cancer [16]. The toxicity level of a few HMs can be just above the background concentrations that are being present naturally in the environment. Hence, thorough knowledge of HMs is rather important for allowing to provide proper protective measures against their excessive contact [17].

The present data showed that the concentration of Pb (122.7 to 238.4 ppm) proved to be higher than their PLs (100 ppm) [10] in the 3 haffirs and the 3 tested soil layers. The concentration of Pb in Azaza haffir was significant ($P \leq 0.05$) higher than those of Tarfa and Elkafay haffirs at surface soil. However, at up to 30 cm soil depth the concentration of Pb in Elkafay haffir was significant ($P \leq 0.05$) higher than those of Azaza and Tarfa haffirs. The high concentration depicts the environment is polluted, due to human activities, e.g. fuel combustion and vehicular emissions, because of the heavy traffic on the roads and national highways [18]. Pb is a naturally-occurring, and can occur in different forms, e.g. organic and inorganic forms, and human exposure to the inorganic forms is through ingestion of food, water, and inhalation. The major reason for Pb pollution in environment is due to anthropogenic factor from Pb intensive use in industries, e.g. storage-battery manufacture, printing, pigment manufacturing, petrochemicals, fuel combustion and photographic materials. The presence of Pb in drinking water even at low concentration may cause diseases, e.g. anemia, encephalopathy, hepatitis and nephritic syndrome [20]. Pb poisoning in humans causes severe damage to kidney, nervous system, reproductive system, and liver [16,31,40,44,49,56,60].

No significant differences in Cu concentrations in the 3 tested layers of Azaza and Tarfa haffir (152.4 to 157.4 ppm). But it was significantly higher Elkafay haffir (165.3 to 167,2 ppm) than the other 2 haffirs ($P \leq 0.05$). The PL is 100 ppm. Cu causes cirrhosis, nausea, vomiting and diarrhea [9]. Cu content has been reported to differ according to the soil type and pollution source [31,42,47,49]. High concentration in some sites may be as a result of burnt vehicles along the major roads, because copper is commonly found in electrical wirings.

Zn concentration in Azaza and Elkafay haffirs was significantly higher ($P \leq 0.05$) than that of Tarfa haffir at surface soil and up to 30 cm depth. However, at 31 - 60 cm soil depth, only Azaza haffir showed significantly higher level ($P \leq 0.05$) than the other 2 haffirs. This could be resulting from the large number of trucks, buses, tractors and other agricultural machineries and their emissions in the area. The PL for Zn is 300 ppm, whereas the lowest detected level was 832.5 ppm and the heighest was 2,380 ppm. Ingestion of large amounts of Zn, even for a short time, can cause stomach cramps, nausea, and vomiting. Taken longer, it can cause anemia, pancreas damage, and lower levels of high-density lipoprotein cholesterol. Free Zn ion in solution is highly toxic to plants, invertebrates and even vertebrate fish [16,30,37,43,46-48].

The concentration of Fe was higher than their PLs (50,000 ppm) [10] in each haffir and soil depths, except at up to 60 cm depth of Tarfa haffir. The Fe concentration in Elkafay haffir soil ranged between > 65,000 to > 69,000. The levels of Tarfa haffir significantly ($P \leq 0.05$) lower than the other haffir, i.e. 52,454 ppm, 50,041 ppm, and 50,041 ppm from top to bottom layers, respectively. However, Azaza hafir Fe level ranged between > 53,000 to > 57,000 ppm. It is strongly advised not to let the Fe enter into the environment, because it persists in the environment. Excess Fe in the body causes liver and kidney damage (hemochromatosis). Some Fe-compounds are suspect carcinogens [42,54,59].

The concentration of Co and Cd in the 3 haffirs and all tested layers were very small (0.0018 for Co and 0.009 ppm for Cd) where their PL is 50 ppm for Co and 3.0 ppm for Cd. Co is a naturally-occurring element that has properties similar to those of Fe and Ni. Co is usually found in the environment combined with other elements, such as O, S, and As. It is an essential element, required for good health in animals and humans and, therefore, it is important that foodstuffs contain adequate quantities of Co [10]. People exposed to 0.007 mg Co/m³ at work have also developed allergies to Co that resulted in asthma and skin rashes. Chronic exposure to elevated levels of Cd is known to cause renal dysfunction, bone degeneration, liver damage and blood damage. There are sufficient evidences in humans for the carcinogenicity of Cd and Cd compounds [16,37]. Cd pollution is mainly caused by anthropogenic factor of industrial applications. Other sources include, domestic activities, agricultural practices, the use of Cd containing goods, and disposal of waste [16,37,41,43,46,47,51-53,56-58].

Titanium (Ti) is the 9th most abundant element in the Earth's crust. Ti exposure may be harmful to the brain. Ti nano particles can enter directly into the hippocampus region of the brain through the nose and olfactory bulb. Titanium dioxide causes toxic effect on glial cells in the brain, suggesting that exposure to titanium dioxide may cause brain injury and be a health hazard. Studies show that titanium dioxide causes adverse effects by producing oxidative stress, resulting in cell damage, redness, and immune response [29,33,43,46-48,51,56]. The PL is 300 ppm. Surprisingly, all layers of the 3 haffirs showed extremely high level, i.e. 1,969.0 to 8,581 ppm.

The average concentration of vanadium (V) in the earth's crust is 150 µg/g. Concentrations in soil vary in the range 330 µg/g and may reach high values (up to 400 µg/g) in areas polluted by fly ash [1]. The concentration of V in water is largely dependent on geographical location and ranges from 0.2 to > 100 µg/L in freshwater. and from 0.2 to 29 µg/L in sea water [47,48,51]. Several observers described only vague, general signs or symptoms and reported nervous disturbances, neurasthenic or vegetative symptoms, occasionally tremors, palpitation of the heart, high incidence of extra systoles, changes in the blood picture (anemia, leukopenia, punctate basophilia of the erythrocytes), reduced level of cholesterol in the blood, etc. [16-18]. The results of the present work showed that V concentration in all haffirs and the 3 tested layers was by far lower than the PL (310 ppm). Elkafay haffir registered the highest concentration among the 3 haffirs (185.9 to 207.7 ppm). The other 2 haffirs their concentrations did not exceed 164.0 ppm.

Overall, the concentration of Mn^{+2} , and Mn^{+5} ions were lower than their PLs (2,000 ppm) [10]. The concentrations range for both ions in all tested levels in the 3 haffirs was from 533.5 to 1,369 ppm. Elkafay haffir levels were 1,236 ppm, 990 ppm and 538.3 ppm for M^{+2} and 1,369 ppm, 1,113 ppm, 631 ppm for Mn^{+5} . Mn occurs naturally in many surface water and groundwater sources and in soils that may erode into these waters. The central nervous system is the chief target of Mn toxicity, chronic ingestion [16,17,54].

The concentration of Sr was higher than their PLs (240 ppm) [10] in all haffirs soil depths; the range was from 124.8 to 368.0 ppm. The concentrations of Sr in Azaza haffir were significantly ($P \leq 0.05$) higher than those Tarfa and Elkafay haffirs at surface soil. However, at up to 30, and up to 60 cm soil depths, the concentrations in Tarfa haffir were significantly ($P \leq 0.05$) higher than those of Azaza haffirs. Sr is fairly reactive and, therefore, is rarely found in its pure form in the earth's crust [22]. Examples of common Sr compounds include strontium carbonate, strontium chloride, strontium hydroxide, strontium nitrate, strontium oxide, and strontium titanate. The most toxic Sr compound is strontium chromate. According to the same reference, there is no direct evidence that Sr is toxic to humans, but there is suggestive epidemiological evidence that oral toxicity observed at high dose in juvenile laboratory animals, under special circumstances, is of relatively low toxicity. It comprises about 4.6 ppm by weight of the human body, but does not have any recognized essential biological role. Human exposure to Sr is primarily by the oral route (via fruits, vegetables, and drinking water), although inhalation exposures are also possible [16,17,60].

Cr is known as carcinogenic; can cause carcinoma and is one of the leading kidney failures causing agents [9,38,39,45,46]. Its concentrations in the haffirs proved to be higher than their PLs (100 ppm) [10] in each haffir and each tested soil depths. The concentration of Cr in Tarfa haffir was significantly ($P \leq 0.05$) higher than that of Azaza. Elkafay haffir at surface and up to 30 cm showed significantly ($P \leq 0.05$) higher concentrations than those of Azaza and Tarfa.

Ni is accused of being a causal agent for breast cancer; however, its concentration in these haffirs was significantly higher than the PLs (50 ppm) [10]. The concentration of Ni in Elkafay haffir was significant ($P \leq 0.05$) higher than those of Azaza and Tarfa haffir. Ni has been considered to be an essential trace element for human and animal health. In living systems, it is associated with DNA and RNA molecules and also a regulatory element for the various enzyme systems [37,43,46-48].

Finally, it is worth noting that the registry of the East Cancer Center for Tumor Therapy, GS and from Dr. Haidar Mahmoud Center for Dialysis and Kidney Transplant [1] showed the number of cancer cases (25 types) admitted by the center for both sexes was 1,038 (1.44% of Gedarif Population) for 2017. The renal problems in the state were mainly renal failure (67), inflammations (1,470) and stones (514).

Conclusions: HMs concentration exceeding the PL in the 3 soil tested layers:

- a) Azaza haffir: 7 elements, viz. Pb, Fe, Zn, Mo, Ti, Cr and Ni, especially Zn, Fe, Co, and Mo.
- b) Tarfa haffir: 10 HMs, viz. Pb, Cu Zn, Fe, Mo Ni, Ti, Sr, Cr and Ni, i.e. very much higher, especially Zn, Fe, Mo and Ti.
- c) Elkafay haffir: 9 HMs, i.e. Pb, Cu Zn, Fe, Mo Ni, Ti, Sr, Cr and Ni, especially Zn, Fe, Mo and Ti.

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