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Research Article

Studies on Water-Harvesting Ponds (Haffirs) in Gedarif State, Eastern Sudan: IV. Registry of Cancer Cases and Kidney Problems Reported in Gedarif State and their Relations to the Detected Pollutants

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Abstract

The water harvesting ponds (haffirs) are used for drinking, agriculture, domestic needs and activities. These haffirs are designed to store water to be used during the dry-season in Sudan. The objectives of the series of the 4 previously published studies were to investigate the possibility of pollution hazardous materials like heavy metals (HMs), pesticides and hydrocarbons (HCs) and relate them to the registry of cancer and renal problem cases of Gedarif State (GS), Eastern Sudan. Three haffirs, representing 3 regions within the state, were subjected to the investigations, viz. Azaza, Tarfa and Elkafay. The HMs results showed that levels of several of them were higher than the WHO permissible levels (PLs) in the soil and water. The herbicide 2,4-D, and the insecticides carbaryl, lindane, their degradation products, in addition to some hydrocarbons were detected. 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 required attention by all stakeholders.

Keywords: *Water-Harvesting; Heavy Metals; Carbaryl; Lindane; 2,4-D; Cancer; Renal Problems; Gedarif State; Sudan*

Introduction

Gedarif State (GS) is located in the eastern Sudan (33 - 36°E and latitudes 13 - 16°N). It covers an area of 71.000 km^2 and consists of 5 localities, bordered in the east by the Ethiopian Frontier, In the south and the west Rahad River, and in the north-east by the Atbara River. The region is a flat plain, with almost no relief other than small, scattered hills and seasonally flowing water recourses [1-3]. However, the rural people in Eastern Sudan, store rainwater in water-storage ponds (haffirs), which are excavated areas of land where rain -water and run-off water is harvested during the rainy-season (June to October). This harvested water is intended to be stored for human and animal consumption, in addition to other activities during the dry-season (November to June). The size of haffirs varies, depending on the location, hydrology, soils, rainfall; it ranges between 5,000 and 30,000m^3. Haffirs are divided into traditional and standard. Traditional haffirs go back to > 100 yr. Standard haffirs are developed using modern engineering design; the components of standard haffirs include: stilling pool, inlet and outlet valves, energy dissipater, embankments, pump units, filters and drainage canal [1]. Winds and water runoff carry soil particles and water from different areas, e.g. agricultural fields, industrial areas, mining, etc. Particles and wash water will go directly to the haffirs water. For instance: from the agricultural areas plant nutrients, e.g. Phosphorus, nitrogen, and potassium in the form of fertilizers, manure, sludge, different types and categories of pesticides can find their way to the haffirs. Moreover, crop residues, animal feces and urine, from farms and pasture can also find their way to the haffirs. Heavy metals (HMs), e.g. Hg, Pb, Cd, Zn, Cr and Cu, at higher concentration they can lead to severe poisoning [1-3].

HMs have a crucial role in the metabolic processes of the biota. However, due to the excessive use and dumping at high concentrations, they become toxic to both human and microbes [1-10]. Areas of limited and intensive pesticides use showed measurable residue levels, indicating the movement of organochlorine pesticides (OCP) residues by various environmental factors [11,12]. Lindane is an OC insecticide widely used throughout the world and considered as Persistent Organic Pollutant (POP). Due to the deleterious effect of POPs on environment and human health, the use of many of them has been reduced or even banned in developed countries, but they are still widely used in a few of the developing nations. Others are banned, because they persist for decades (viz. OCPs) [1,13].

Moreover, people around the haffirs used to wash their tractors, lorries, trucks, cars, etc. near or inside the haffirs. This could be source for oils, lubricants, HMs, detergents, etc. One would also expect polyaromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs), dioxins and furans (PCCD/F) and other POPs and persistent toxic substances (PTS) [14,5].

Objective of the Study

The overall objective of this series of studies was to investigate the expected health effects of the detected pollutants in the soil, sediments and haffir water of GS and relate them to the registered cancer cases and renal problems in the area around these Haffirs.

Materials and Methods

The materials and methods used for the detection and the determination of the levels of the HMs, pesticides and PAHs were reported in the previous papers [1-4]. The cancer cases were collected from the East Cancer Center for Tumor Therapy, Gedarif State (GSCDTT), whereas the renal data was collected from Dr. Haidar Mahmoud Center for Dialysis and Kidney Transplant (DHMDKT).

Results and Discussion

Cancer

The number of cancer cases admitted by the center for both sexes was 1,038 (Table 1). Approximately 17.1% of all cases were diagnosed as breast cancer in both sexes, whereas 18 cases were reported to have stomach cancer (both sexes). The reported pancreas cancer patients were 16. All types (50 types) were reported in the table 1, e.g. pineal body tumor, anal, chorionic, tongue, uterus, bone-marrow, eye, endometrium, brain, sarcoma, malignant melanoma, mandible, fibrosarcoma, vulva, Hodgkin, lymphoma, small bowel, tongue, myelofibrosis, larynx, mandible, neuroblastoma, retinoblastoma. Number of these cases were about 15 /case. Bone cancer (20 cases), whereas Leukemia, multiple myeloma, skin cancer, and thyroid cancer cases were 16 each. Nephroblastoma cancer and soft tissue cancer (17cases). Rectum cancer and stomach cancer registered 18 cases each and kidney cancer 19 cases, bladder cancer and colon cancer 21cases each, and ovary cancer 22 cases. However, breast cancer and cervix cancer, 24 cases each, while liver cancer registered 27 cases, moreover, prostate cancer registered the highest number of cases (31).

Renal diseases

Table 2 showed the reported types (2,051 case) of renal diseases in the state, for both sexes, and the severity based on the total population of the state. The renal problems in the state are mainly renal failure (67), inflammations (1,470) and stones (514). Regarding inflammations in the capital town (Tarfa haffir area) proved to be ca. 81.12%, Galabat East (14.14%) and Galabat West (3.12%; Elkafay

Serial	Cancer type	No, of cases	Serial	Cancer type	No. of cases
1	Pineal body tumor	15	26	Myelofibrosis	15
2	Anal Canal	15	27	Mouth	18
3	Leukemia	16	28	Nasopharynx	17
4	Basal cell carcinoma	15	29	Nephroblastoma	17
5	Bladder	21	30	Neuroblastoma	15
6	Bone	20	31	Oral Cavity	18
7	Early detection	178	32	Osteosarcoma	16
8	Breast	24	33	Pancreas	16
9	Cervix	24	34	Ovary	22
10	Bone-marrow	15	35	Parotid gland	15
11	Eye	15	36	Polythycemioavera	15
12	Colon	21	37	Prostate	31
13	Endometrium	15	38	Rectum	18
14	Esophagus	39	39	Retinoblastoma	15
15	Brain	15	40	Rhabdomyosarcoma	15
16	Sarcoma	15	41	Seminoma	15
17	Hodgkin' lymphoma	15	42	Skin	16
18	Hypopharynx	17	43	Small bowel	15
19	Kidney	19	44	Soft tissue sarcoma	17
20	Larynx	15	45	Thyroid	16
21	Liver	27	46	Stomach	18
22	Lower lip	15	47	Tongue	15
23	Malignant melanoma	15	48	Lung	16
24	Mandible	15	49	Uterus	15
25	Multiple Myeloma	16	50	Vulva	15
Total		1,038			

Table 1: *Number and types of cancer patients diagnosed.*

Source: University of Gedarif and Ministry of Health.

haffir area) and Gedarif Central (1.6%), i.e. Azaza haffir area. Regarding the kidney stones, the capital registered 88.7%, Galabat East 16.6% and Galabat West (2.91%) and Gedarif Central (1.75%). The Renal failure data was 61.12%, Galabat East 22.4% and Galabat West 4.48% and Gedarif Central 4.48%., following the same order.

Locality	Renal failure	Inflammations	Stones
Gedarif Town	41 (61.12%)	1,193 (81.12%)	368 (88.70%)
Gedarif Central	3 (4.48%)	23 (1.6.0%)	9 (2.17%)
Galabat East	15 (22.4%)	208 (14.14%)	69 (16.6%)
Galabat west	3 (4.48%)	46 (3.12%)	15 (1.21%)
Total	67 (100%)	1,470 (100%)	514 (100%)

Table 2: *Renal problems registry.*

HM-contamination of water resources is of great concern, because of the toxic effect to human beings, animals, plants even at very low concentrations. Since HM ions are not biodegradable in nature; effective removal of HM ions from water through new technologies (physical or chemical) is important. 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 [16]. Exposure to certain HMs has been linked to an increased risk of cancer and renal problems. Cd exposure is associated with an increased risk of lung, prostate, and kidney cancers. Prolonged exposure to Cd can lead to kidney disease, as the metal accumulates in renal tissues, causing damage over time. However, regarding Pb, some studies suggested a potential link between Pb exposure and certain cancers, though the evidence is not conclusive. Renal problems resulting from Pb exposure has been implicated as a risk factor for renal cell carcinoma. Hg exposure has been associated with an increased risk of certain cancers; can cause kidney damage, leading to conditions, e.g. nephrotic syndrome. Arsenic (As) is a well-known carcinogen linked to cancers of the skin, bladder, lungs, and liver. Chronic exposure to As can lead to kidney disease. Hexavalent chromium [Cr(VI)] exposure is considered hazardous and can cause cancer in humans and can lead to renal illness. It is important to note that the degree of risk associated with these metals depends on factors, e.g. the level and duration of exposure, as well as individual susceptibility [5-10].

As in table 1, about 50 types of cancer, in both sexes, were reported in the State. The esophagus, prostate, liver, breast, cervix, and ovary cancers were the leading cases. Three types of renal diseases, i.e. failure, inflammations and stones were also reported within the same period (Table 2). Inflammation diseases in the capital (Tarfa haffir) were by far higher than those in other studied regions of the 2 other haffirs. The stones cases, followed the same trend. However, the renal failure in the capital (Tarfa) was by far higher, but at a lower percentage (61.12%) than the percentages of inflammation and the stones (81 - 88%).

Accumulated 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. These metals tend to accumulate to a critical level, when they enter into the food- chain. This is considered the most important impact of soil pollution [5-10]. HMs toxicity can lower energy levels and damage the functioning of the brain, lungs, kidney, liver, blood composition and other important organs [17]. 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 [17]. 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 [18]. Beryllium, Pb, Hg, Al, titanium, antimony, tungsten, bismuth and Fe are reported as carcinogens or potentially carcinogenic [19].

In the present work, the concentrations of Pb proved to be higher than their PLs, according to WHO [20], in all haffirs water and soil samples taken from the surface or 30 and 60 cm depth. The surface soil concentration in Azaza haffir was significantly higher than those of Tarfa and Elkafay haffirs [1-4]. The high concentrations could also be resulting from anthropogenic activities, e.g. vehicles emissions resulting from the heavy traffic on this interstate highway [21] or natural reasons, since this element is one of the naturally -occurring HMs. The presence of Pb in drinking water, even at low concentration, may cause diseases, e.g. anemia, encephalopathy, hepatitis and nephritic syndrome [22]. Pb poisoning in humans causes severe damage to kidney, nervous system, reproductive system, and liver. The high incidence of renal failure in the area could be attributed to high levels of Pb in water and soil.

No significant difference on Cu concentration between the depths soil of Azaza and Tarfa haffirs. But, at surface and 30 cm soil depth, the concentration in Elkafay haffir was significantly higher than that of the Tarfa and Azaza haffirs [1-4]. Cu can cause cirrhosis, nausea, vomiting and diarrhea [23]. Cu occurs naturally in rock, soil, water, sediment, and air. The high concentration in some sites in several countries could be a result of burnt vehicles along the major roads, because copper is commonly found in electrical wirings.

Rain water release Zn into environment from soil and rocks. In the present work, Zn concentration in Azaza and Elkafay haffirs was significantly higher than that of the Tarfa haffir at surface soil and 30 cm soil depth. The concentration in some countries was attributed to the number of trucks and emissions that pass through these roads. Regarding the water samples taken from the 3 haffirs, both Azaza and Elkafay water samples proved that Zn concentration was lower than the PL (0.2 ppm) [1-4]. However, Elkafay haffir Zn concentration exceeded by far the PL; it registered 0.37ppm. Too much Zn, however, can also cause health problems. 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 HDL cholesterol [24].

Fe is the most abundant metal, and is believed to be the 10th most abundant element in the universe. The element causes production of free radicals that are generally toxic to cells, binds avidly to virtually all bio- molecules, so it will adhere nonspecifically to cell membranes, nucleic acids, proteins, etc. Excess Fe in the body causes liver and kidney damage (hemochromatosis). Some Fe -compounds are suspect carcinogens [25]. The concentrations of Fe in soil sample were higher than their PLs (50,000 ppm) for the 3 haffirs (50,041 - 69,433 ppm), except at 60 cm soil depth of Tarfa haffir (49,633 ppm). Fe water concentration in Azaza was 2.45 ppm, Tarfa 9.09 ppm and Elkafay 2.09 ppm, all by far higher than the 0.5 ppm, which is the PL [1-4].

Vanadium (V) PL in soil is 310 ppm and in water 0.0003 ppm. The concentration in the soil samples (154 - 207 ppm). The levels were always higher in Elkafay haffir soil samples. Water concentrations (0.002-0.0029 ppm) by far higher the PL in all haffirs [1-4]. The concentration of V in water is largely dependent on geographical location and ranges from 0.2 to > 100 µg /L in freshwater [24]. 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. [26].

Mn occurs naturally in many surface water and groundwater sources and in soils that may erode into these waters. However, human activities are also responsible for much of Mn contamination in water in some areas. In surface waters, manganese occurs in both dissolved and suspended forms, depending on such factors as pH, anions present and oxidation-reduction potential. The CNS is the chief target of manganese toxicity [24]. The concentration of Mn^{+2}, Mn^{+5} ions, were lower than their PLs (2,000 ppm) in soil in the 3 haffirs and the 3 soil depths (538.3 - 1369 ppm), except in Tarfa surface soil samples, which registered 8,732 ppm of Mn^{+5} ions. The Mn^{+2}. PL in water is 0.4 ppm. The levels in the samples taken from the 3 haffirs from July to February were significantly higher than the PL. Azaza 2.19 ppm, Tarfa 1.51 ppm and Elkafay 1.13 ppm [1-4].

Strontium (Sr) is a natural and commonly occurring element. Sr can exist in 2 oxidation states: 0 and +2. Under normal environmental conditions, only the +2-oxidation state is stable enough to be important. Rocks, soil, dust, coal, oil, surface and underground water, air, plants, and animals all contain varying amounts of Sr. Typical concentrations in most materials are a few ppm. Sr ore is found in nature as the minerals celestite ($SrSO_4$) and strontianite ($SrCO_3$). After the Sr is extracted from strontium ore, it is concentrated into $SrCO_3$ or other chemical forms by a series of chemical processes. Sr compounds, e.g. $SrCO_3$, are used in making ceramics and glass products, pyrotechnics, paint pigments [24], fluorescent lights, medicines, and other products. Sr is found nearly everywhere in small amounts, and one can be exposed to low levels of Sr by breathing air, eating food, drinking water, or accidentally eating soil or dust that contains Sr. Food and drinking water are the largest sources of exposure to Sr. There are no harmful effects of stable Sr in humans at the levels typically found in the environment. The only chemical form of stable Sr that is very harmful by inhalation is Sr chromate, but this is because of toxic Cr and not Sr itself. Problems with bone growth may occur in children eating or drinking unusually high levels of Sr, especially if the diet is low in Ca and protein [24]. The concentration of Sr was higher than their PLs (240 ppm) in almost all soil samples taken during the study period. The concentration of Sr in Azaza haffir concentration was higher than Tarfa and Elkafay haffir at surface soil. However, at 30 and 60 cm depths, the concentration in Tarfa haffir was significantly higher than that of Azaza haffirs. The PL in water is 0.02 ppm. Azaza water Sr concentration was 4.37 ppm, Tarfa 1.267 ppm and Elkafay showed the lowest concentration (0.14 ppm) [1-4].

Cr is a naturally-occurring element found in rocks, animals, plants, and soil, where it exists in combination with other elements to form various compounds [24,26]. Cr can also be found in air, soil, and water after release from industries that use Cr, e.g. industries involved in electroplating, leather tanning, textile production, and the manufacture of Cr-based products [17]. Cr can also be release into the environment from the burning of natural gas, oil, or coal [18]. Cr does not usually remain in the atmosphere, but is deposited into the soil and water. Cr can change from one form to another in water and soil, depending on the conditions present [17,18]. This metal is carcinogenic to humans and long-term exposure has been associated with lung cancer in workers exposed to levels in air that in the order of 100 to 1,000x higher than usually found in the environment [18]. Cr concentration, in the present work, was higher than their PLs (100 ppm) in soil, in all analyzed soil samples, e.g. surface samples showed 133.8, 273.5 and 269.7 ppm, respectively, for Azaza, Tarfa and Elkafay. At 30 cm, concentrations were even higher. However, at 60 cm only Azaza increased than its former levels. The PL for water is 0.05 ppm. All water sample were by far lower than that level [1-4].

Ni is found naturally in the earth's crust in various forms, e.g. nickel sulfides and oxides and is present in small quantities in soils, aquatic environments, and vegetation [27]. Excessive exposure to Ni may cause health effects on the blood, lung, nose, kidney, reproductive system, skin and the unborn child. In prolonged and direct contact with skin, nickel may cause an allergic reaction on Ni sensitized people. The metal is also toxic to aquatic life. However, hazards depend on the form and bioavailability of Ni. Large amount of Ni can cause lung and nasal sinus cancers. The Ni carcinogenicity is probably caused by Ni replacing Zn and Mg ions on DNA-polymerase [27]. Ni levels in the present work was higher than their PLs (50 ppm) for all haffirs and soil depths [1-4]. The concentration in Elkafay haffir was significantly higher than those of Azaza and Tarfa haffir at the 3 depths levels. Regarding water, the PL is 0.07 ppm. The concentration in Azaza haffir was 0.049 ppm, almost doubled in Tarafa haffir (0.085 ppm), and very low in Elkafay haffir (0.0076 ppm).

Co is a naturally-occurring element that has properties similar to those of Fe and Ni. Small amounts of Co naturally found in most rocks, soil, water, plants, and animals, typically in small amounts. The element is usually found in the environment combined with other elements, e.g. O, S, and As [28]. Co even found in water in dissolved or ionic form, typically in small amounts. People exposed to 0.007 mg Co/m^3 at work have also developed allergies to Co that resulted in asthma and skin rashes [28]. The concentrations of Co were lower than their PLs (50 ppm) in all tested soil samples of the haffirs, with no significant differences in concentrations at the 3 soil depths of each haffir. PL for water is 0.0003 ppm. The 3 haffirs water concentration was identical, i.e. 0.0018. It is 6x higher than the PL.

Mo occurs in natural waters, and may be present in concentrations of several hundred μg/L or higher in ground and surface water near mining operations or ore. A long- term inhalation, bioassay of molybdenum trioxide in mice yielded "some evidence" of carcinogenicity [29]. One case-control study suggested a possible link between occupational exposure to Mo and lung cancer [29]. The PL in soil is 250 ppm. The concentrations in the soils of the 3 haffirs and the 3 soil depths were 3-4x higher than the PL. Elkafay registered the highest levels. The PL in water is 0.07 ppm. The water samples from all haffirs showed a range of 0.051 - 0.064 ppm [1-4].

Ti is the 9th most abundant element in the Earth's crust. Ti exposure may be harmful to the brain. Ti nanoparticles can enter directly into the hippocampus region of the brain through the nose and olfactory bulb. Titanium dioxide had a toxic effect on glial cells in the brain, suggesting that exposure to titanium dioxide may cause brain injury and be a health hazard [30]. Titanium dioxide causes adverse effects by producing oxidative stress, resulting in cell damage, redness, and immune response [31]. Ti in Elkafay haffir was significantly higher than those of Azaza and Tarfa haffir in all soil samples tested. However, the PL in water is 0.001 ppm, and the concentration in Azaza, Tarfa and Elkafay were 4x, 7x and 6x, respectively, higher than the PL.

Persistent pesticides, such as OCs, were used for cotton and sugarcane production prior to their restriction and later banning for agricultural use since 1983 in the Sudan [11-13]. Endosulfan was the only OCP permitted for use in cotton production and constituted at least 50% of the annual cotton spray regime. No more endosulfan is introduced to the country for the last 5 yr. Lindane, in the present work, weas detected in the different samples of water and soil from July to January. The lowest levels were detected in November [1,3], while the highest was detected in the July. OCP were not detected in the Tarfa and Elkafay haffirs water and soil. Lindane also has long-term effects on human health, including anemia, as well as liver, testicular, bone marrow, and kidney damage [32].

The soil concentrations of Azaza and Tarfa haffirs were significantly higher than Elkafay haffirs concentrations for carbaryl insecticide [1,3]. The concentrations in the soil were 2.40, 0.04 5.25 ppm for Azaza, Tarfa and Elkafay haffir, respectively. Tarafa 1-nephthanol levels, i.e. the degradation product of carbaryl, and carbaryl levels indicated that the haffir water concentration was significantly higher than that of Azaza and Elkafay haffirs. High concentration of 1-naphthanol of the Azaza and Tarfa haffirs was detected. However, the concentration of carbaryl was high in Azaza and Tarfa haffirs. The result in showed that the concentrations of 1-naphthanol were 8.05, ND, 0.891,7.15 ppb; 6.12, 8.23, 9.199, 7.651 ppb, and 2.9, ND (for the rest of the months) ppb in July, September, November and January, respectively, for Azaza, Tarfa, and Elkafay haffirs [1,3]. Carbaryl concentrations in Azaza haffir water were 1.0 0, 258, 0.254, 0.25 and 4.4.27 ppb. Tarfa concentrations were 1.599, 5.453, 025 and 4.27 ppb; and Elkafay 1.81, 4.27, 1.60 and 0.95 ppb, respectively for July, September, November and January. Acute occupational exposure of humans to carbaryl has been observed to cause cholinesterase (ChE) inhibition, which impairs CNS function, resulting in nausea, vomiting, bronchoconstriction, blurred vision, convulsions, coma, and respiratory failure [33-35]. Acute carbaryl exposure in humans may also cause eye and skin irritation [36]. Carbaryl is used by the farmers to protected their harvested sesame plants in the fields and in the stores for more than 20 yr now.

According to Ghassemi., *et al.* [37], in the aqueous environment, 2,4-D is most commonly found as the free anion The amine salt formulations dissociate to the anion and, ester formulations hydrolyze to the anion, usually within one day. The rate of hydrolysis is pH-dependent, with the hydrolysis half- life at pH 9 much shorter than the half-life at pH 6. Therefore, the persistence of the 2,4-D anion is of primary concern. Residues of 2,4-D can enter ponds and streams by direct application or accidental drift; by inflow of herbicide previously deposited in dry stream beds, pond bottoms, or irrigation channels; runoff from soils; or by leaching through the soil column [38-40]. The last two reason could be behind detection of the herbicide in the study haffirs. Groundwater contribution of 2,4-D residues into ponds and streams is dependent upon soil type, with coarse-grained sandy soils with low organic-content expected to leach 2,4-D into groundwater [41,42]. Transport losses from forest soils to water bodies are expected to be less than losses from agricultural soils, due to factors, e.g. reduced surface runoff, adsorption to forest litter, absorption by plants, and possible greater organic material and microbial activity in forest soils [43]. In soil, 2,4-D esters and salts are first converted to the parent acid prior to degradation. The rate of the ester hydrolysis decreases with decreasing soil moisture and with increasing molecular weight of the alcohol portion of the ester. The fate of 2,4-D may be affected by several processes, including runoff, adsorption, chemical and microbial degradation, photodecomposition, and leaching. Water solubility and the soil adsorption coefficient (Koc) indicate the potential mobility of a chemical in soil; while the aerobic and anaerobic soil metabolism, hydrolysis half-lives, and field dissipation rate indicate the persistence of a chemical in soil [38-43]. In the present study [1,3], only Elkafay haffir showed significantly higher levels of acetic acid over of the other haffirs, and Azaza haffir was significantly higher than Tarfa haffir. However, for 2,4-D (acetic acid) the concentration was not detectable for July, September and November and 1.85 in Azaza haffir, and 4.98, 2.94, 2.24 ppm and ND, respectively, for the same order of months, and 1.78, 4.2, 1.13 and 1.29 ppm, in Elkafay haffir. In terms of propionic acid, Tarfa haffir concentrations were significantly higher than the acetic acid butyl. The concentrations of propanoic acid in Azaza haffir were 3.06, 17.52 ppm, for July and September and ND in November and January. Tarfa haffir showed 5.25, and 5.16 ppm in September and November only, whereas Elkafay showed 13.03 ppm during September only. Exposure to this herbicide might result in fatigue, weakness, anorexia, perhaps nausea, vomiting and diarrhea. Chronic exposure may lead to CNS defects in the control of motor function [42,43]. This herbicide is the most commonly used in the state for controlling broad-leaved weeds for at least the last 10 yr.

Contamination of soil with oil spills is another major concern. Contaminated soil is a serious, often lethal hazard to the health of humans. Oil spills cause pollution of ground water, environmental problems, decreases overall productivity of agricultural land [14]. HCs concentration in Azaza haffir water (benzene compounds), were 0.871, 4.3, 2.8 and 0.26 ppm, and of the alcohols was 4.8, 0.87, 0.3 and 0.0 ppm, for July, September, November and January, respectively [1,3]. As for Tarafa haffir, the of concentrations were 0.23, and 0.29 ppm for Elkafay haffir. No significant differences between hexadecane and undecane compounds. The concentrations were 0.55 and 4.2% for hexadecane and undecane at July and September, respectively. These levels pose severe immediate and long-term influence, since many HCs constituents are toxic in nature. These pollutants persist in soil and water for a very long time often decades. HCs (mostly due to toluene) may cause a metabolic acidosis, leading to renal tubular acidosis, urinary calculi, glomerulonephritis, hyperchloremia, and hypokalemia. Abuse may lead to both proximal and distal tubular injury [44].

Conclusion

It is concluded that the levels of some of these pollutants might be behind and potentiating each other to cause the reported cancers and the renal failure/inflammations cases in the area, especially Tarafa haffir. The study recommended that haffirs site selection, design, facilities, logistics and protection must be given the required attention by all stakeholders.

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