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Detoxification Capacity and Protective Effects of Medicinal Plants against Heavy Metals in Polluted Human Systems

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Abstract

The main objective of the present study was to indorse specific herbal formula as supplements in polluted human societies to minimize the harmful effect of the prevailing heavy metals. The concentration of different heavy metals in Abu Qir, Amreyya and Abis districts was determined and the different methods by which these metals were introduced to the body system was recognized. An herbal assemblage (ACOSTU) was prepared based on the types of heavy metals and their concentrations. The results of the application of the herbal assembly for six sustained months showed a significant improvement in the medical examined cases recorded in the study areas. The study concluded that initiation of health care specific programs for the human living in polluted districts is urgently necessary as a part of a sustainable development plan to save endangered rural communities.

Keywords: ***Heavy metals; Detoxification; Herbal formula; Hyperaccumulator species; Human health***

1. Introduction

Detoxification is a type of alternative-medicine which aims to free the body of unspecified toxins that have accumulated in the body and have undesirable short-term or long-term effects on individual health [1]. Modern research has shown that a wide range of plants can neutralize or detoxify toxins and protect the body from the toxic effects of drugs, chemicals and environmental pollution [2].

Several physical, chemical, and biological methods have been developed for detoxification of heavy metals [3]. However, each treatment has its own limitations, as the treated product should be safe and the nutrient contents of the treated product should not be reduced [4,5]. There are many ways by which heavy metals can be broadcasted into the body such as ingesting of foods,

beverages, skin exposure and inhaled air [6]. To minimize the detrimental effects of metal exposure and their accumulation in human societies, specific herbal formulas have evolved detoxification mechanisms based mainly on chelation and subcellular compartmentalization [7].

Climate change affects the overall health of humans through the uncontrolled change of environmental factors surrounding human societies. This is done by influencing the main component of environmental pollutants, especially heavy elements, which are considered dangerous effects on human health [8]. Hazardously, some pathogens feed on heavy metals and transform it into a neurotoxin capable to moveable throughout the body and cause greater demolition on the central nervous system. Laboratory assessments for lupus, rheumatoid, arthritis and many other autoimmune disorders start to lose their accuracy when the bloodstream becomes full of neurotoxic and pathogen waste. These neurotoxins can even cross the blood-brain barrier, where they short route our neurotransmitters. This can trigger depression and other mood disorders, memory loss and a variety of other cognitive injuries [9].

Rationally, reducing the dangerous effects of industrial pollutants does not mean the closure of the factories or industrial centers. This is unacceptable to affect the national economy of the country but may include recent technologies and strategies to reduce the emission of such materials and to create impressive and safe solutions depending on the practice and application of some biological agents.

2. Objectives

The main objective of the present study was to approve specific herbal formula as supplements for inhabitants in polluted human societies to minimize the harmful effect of the prevailing heavy metals.

3. Material and Methods

3.1 Study sites

Two industrial and one residential polluted sites were selected at Alexandria governorate, Egypt. The three sites are located at Abu Qir (Site I), Amreyya (Site II) and Abis (Site III) (FIG. 1). The three sites are being about 20 km, 27 km and 23 km from Alexandria city respectively.

Abu Qir (Site I) is an industrial area; it is a complex for several factories such as fertilizer and chemicals industries company, agricultural pesticides as well as paper company. Amreyya (site II) is an industrial area for petrochemicals and carbon black company while Abis (site III) is a residential area surrounded by agricultural spots and road network.

3.2 Determination of total suspended particulate matter (TSP)

Total suspended particulates **(**TSPs) in ambient air of the three selected sites and their relevant control were collected using a high-volume sampling technique for subsequent heavy metal analysis. Twenty-four samples were collected during summer with a flow rate of 60 L/min on Whatman GF/A glass microfiber filter of 47 mm diameter and 99% collection efficiency for particles of 0.3 microns placed at 1.7 m above the ground and TSP concentration was determined using the following equation:

$$\boldsymbol{TSP\ (Conc.)\ =\ \Delta w/\ (\Delta f\ X\ \Delta t\ )\ (\mu g/m3)}$$

Where: Δw**:** is the weight of filter paper after sampling – weight before sampling

Δf: is the average of flow rate (initial flow rate + final flow rate) / 2

Δt**:** is the sampling time (finial time – initial time)

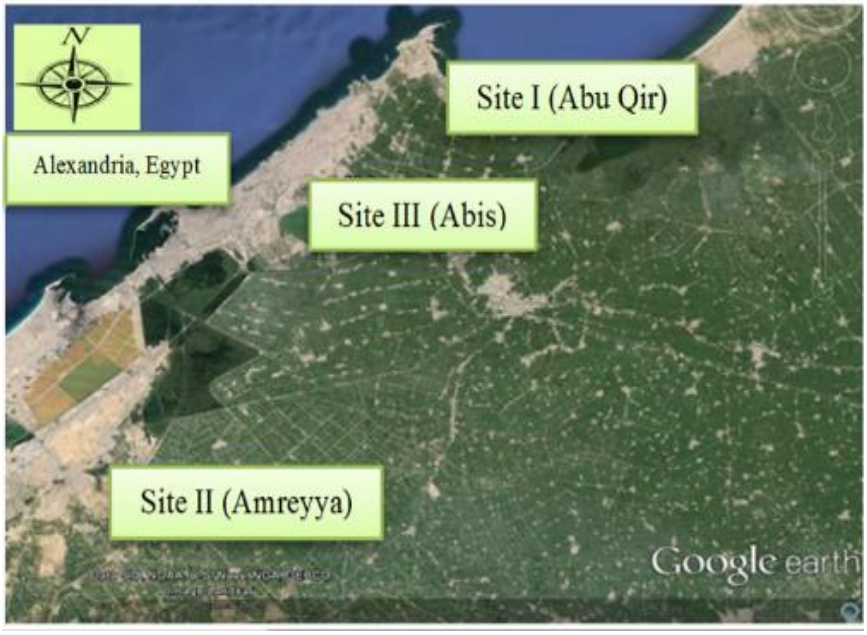

FIG. 1. **Map indicates the location of the study sites.**

3.2.1 Analysis for some selected heavy metals

Six trace metals; Fe, Pd, Cd, Zn, Mg and Mn were extracted by digestion the matter in HNO_3 facilitated by heat and then adding a mixture of HNO_3 and HCl (1:1) followed by extraction. The resultant solution was diluted and analyzed for trace metals by Perkin Elmer atomic absorption spectrophotometer. Blank and standard solutions, provided by Perkin Elmer, were prepared for routine check for the estimation of all metals. All the procedures were according to Jalees MI & Asim Z [10].

3.3 Health situation and care

The health condition of a sample of inhabitants was evaluated through well designed questionnaire. The questionnaire used included parameters about the types of medically diagnosed diseases These parameters include the number of chronically sick family members in the previous year, days lost by illness, number of visits to the health center and the amount of family income that was spent on treatments. Data obtained was compared and confirmed by population records in health centers for each site.

3.4 Herbal formula

An herbal formula (TABLE 1) has been assembled that is believed to act as chelating compounds to alleviate toxicity for heavy metals. The formula was administrated among the selected samples inhabit the study areas. About daily 10 g on twice dose per day (each 5 g every 12 hrs half an hour before meal as herbal tea) were administrated for each selected person continuous for six months. Thereafter, the type and severity of the diagnosed diseases were tabulated.

TABLE 1. **Proposed list of medicinal plants to detoxify the heavy metals.**

Medicinal plant	Botanic Family	English name	Organ used	Sharing %	Reference
Arctium lappa L.	Asteraceae	Burdock	Root	20	[11]
Coriandrum sativum L.	Apiaceae	Coriander	leaves	10	[12]
Olea europaea L.	Oleaceae	Olive	leaves	15	[13]
Silybum marianum L.	Asteraceae	Milk thistle	fruits	20	[14]
Tribulus terrestris L.	Zygophyllaceae	Puncture vine	shoot	20	[15]
Urtica dioica L.	Urticaceae	Stinging nettle	shoot	15	[16]

3.5 Statistical analysis

Results were reported as the average of three repetitions ± SE (standard error). The data subjected to standard one-way ANOVA using the COSTAT 2.00 statistical analysis software [17].

4. Results

4.1 Heavy metal concentrations

The mean concentration of some heavy metals (HM) in the different sites was presented in FIG. 2. Data showed that all heavy metals in the polluted sites have concentrations higher than those occurred in control sites. High concentrations of Zn, Mg and Mn were achieved at Abu Qir site (Site I) while those of Pd and Cd were obtained at Amreyya site (Site II). On the other hand, Abis site (Site III) exhibited the highest concentration of Fe. The highest, *sample: control ratios* (4.25 and 5.02) were for Pd and Zn at Abu Qir (Site I) and Amreyya sites (Site II) respectively.

4.2 Health situation and care

FIG. 3 showed the mean values of family health situation in the sample and control sites. Obviously, all considered parameters in all sites are significantly higher in the first relevant to second sites. At the end of the study period, all these parameters were significantly ($p \leq 0.05$) improved upon administration of the herbal material for six continual months (TABLE 2). The percentage of improvement was ranged from about 29% to 53% among all examined parameters.

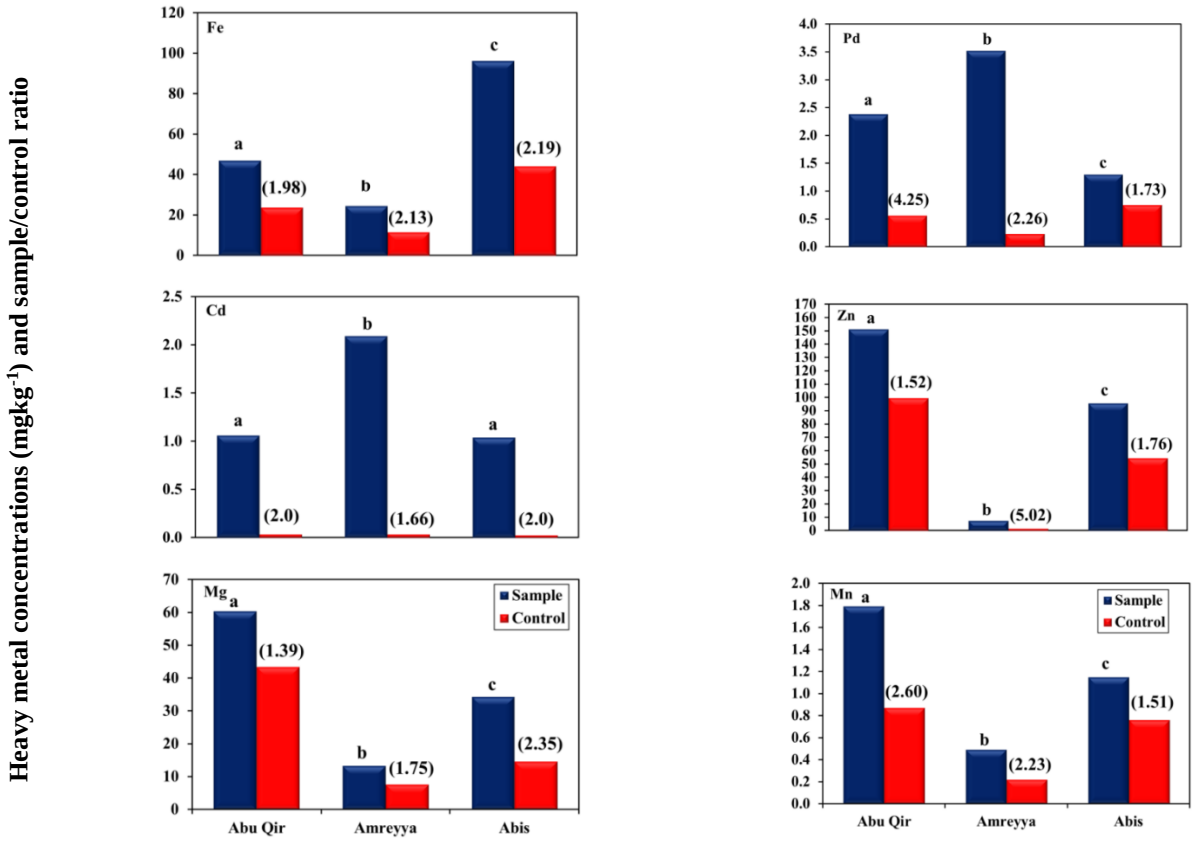

FIG. 2. **Average heavy metal concentrations of TSP (mgkg^{-1}) and their relevant control during summer season at the studied sites. Numbers between bracts indicate *sample: control ratio*. Different letters among sample columns indicate the significant difference as evaluated by One-Way ANOVA test.**

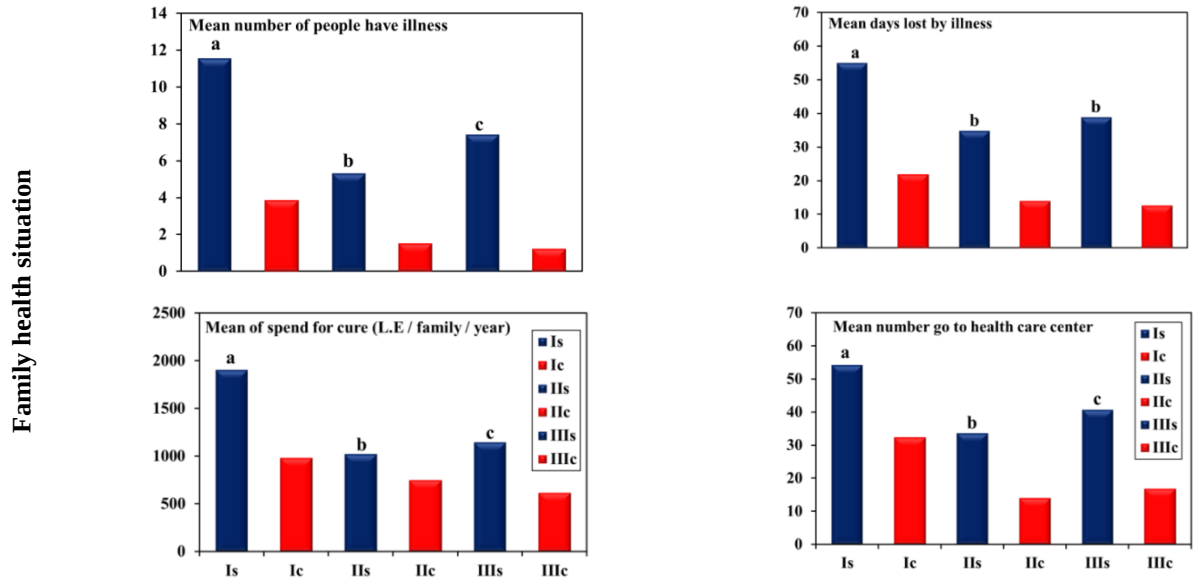

FIG. 3. **Mean values of family health situation in the sample sites (Is, IIs, IIIs) as well in the control sites (Ic, IIc, IIIc). Different letters among sample columns indicate the significant difference as evaluated by One-Way ANOVA test.**

TABLE 2. **Mean values of family health situation in the sample sites (Is, IIs, IIIs) as well in the control sites (Ic, IIc, IIIc) after administration of the herbal formula for six continual months and their percentages of improvement.**

Disease	After administration			Improvement (%)		
	Is	IIs	IIIs	Is	IIs	IIIs
Mean number of people have illness	6.4[a]	2.5[b]	4.13[c]	44.63[a]	53.39[b]	44.41[a]
Mean days lost by illness	29.7[a]	22.4[b]	18.4[c]	45.99[a]	35.63[b]	52.66[c]
Mean of spend for cure (L.E / family / year)	110[a]	700.18[b]	650[b]	42.26[a]	29.83[b]	43.23[a]
Mean number go to health care center	33.12[a]	23.6[b]	24.67[b]	38.90[a]	29.76[b]	39.34[b]

Different letters within each row indicate the significant difference as evaluated by One-Way ANOVA test.

Data in FIG. 4 showed that nearly 96.7% of the population had food poisoning and around 93.3% were diagnosed with lung disease in Site II (Amreyya). The values for these diseases were much lower for the population in the control site. On the other hand, Kidney diseases attained a percentage of 45% in site III (Abis). Moreover, liver and other diseases achieved percentages of 65 and 81 respectively at Abu Qir (Site I). TABLE 3 showed a significant improvement range from about 12% to 60% in the factors associated with the diseases among inhabitants present in the study area.

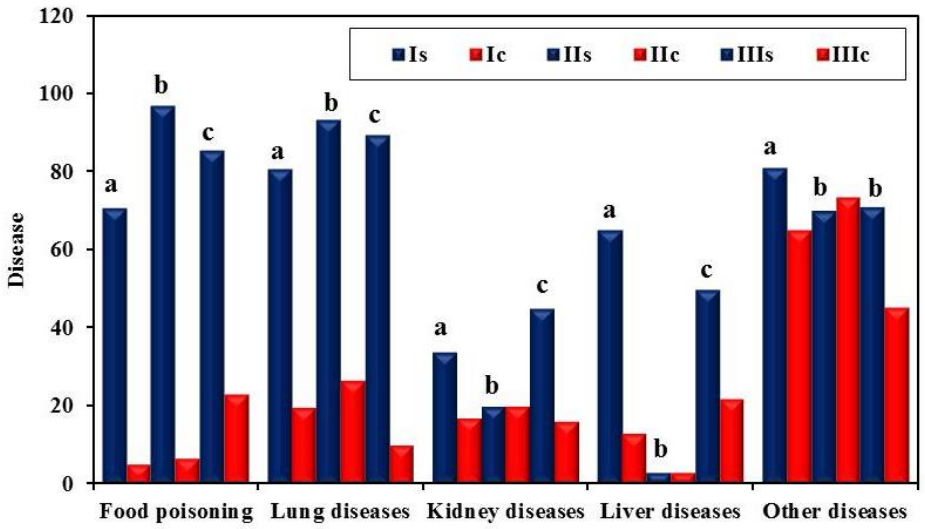

FIG. 4. **Mean values of some common diseases among inhabitants in control (Ic, IIc, IIIc) and sample sites (Is, IIs, IIIs). Different letters among sample columns indicate the significant difference as evaluated by One-Way ANOVA test.**

TABLE 3. **Mean values (%) of some common diseases among inhabitants in the study sites (Is, IIs, IIIs) after administration of the herbal formula for six continual months and their percentages of improvement.**

Disease	After administration			Improvement (%)		
	Is	**IIs**	**IIIs**	**Is**	**IIs**	**IIIs**
Food poisoning	44.76[a]	66.7[b]	65.43[b]	36.74[a]	32.02[a]	23.41[b]
Lung diseases	59.45[a]	73.3[b]	67.23[c]	25.99[a]	21.43[b]	24.65[a]
Kidney disease	19[a]	12[b]	31[c]	44.11[a]	40.0[a]	31.11[b]
Liver diseases	42a	1.3[b]	31[c]	35.38[a]	60.66[b]	38.0[a]
Other diseases	71[a]	54[b]	48[b]	12.34[a]	22.85[b]	32.39[c]

Different letters within each row indicate the significant difference as evaluated by One-Way ANOVA test.

5. Discussion

Our environment is flooded with chemicals that fill our air, our water, our food, and ourselves. Toxin-related cancers, neurological diseases, autoimmunity, reduced immune function, allergies, and the newer diagnoses of multiple chemical sensitivity, chronic fatigue syndrome, and fibromyalgia are most dominant examples. Once the presence of these toxics are recognized, proper environmental treatment is needed. Such treatment is composed of three phases: 1. Avoidance of further toxic exposure. 2. Supplementation to replace nutrient deficiencies, prevent further toxic damage, and assist in cleansing. 3. Cleansing to reduce body stores of toxins.

Agricultural policy is based on the use of the natural qualities and capacities of some plant species, namely metallophytes and their efficiency in rotation and breakdown of the heavy metals in their ecosystems [18]. For leaching out of the different heavy metals in the studied sites, the following plant species are recommended to cultivate in these ecosystems. For example, *Brassica juncea, Helianthus annuus, Plantago lanceolata, Lotus corniculatus, Thymus serpyllum, Rumex acetosa, Solanum lycopersicum, Cucurbita melo, Cucurbita pepo* and *Cynara scolymus*. These species are considered as hyperaccumulator species which may contribute to the alleviation of the harmful effect of a portion of the last-mentioned pollutants [19-21].

Excess toxins and waste in the body can lead to depression, lack of energy, skin conditions, weight gain, joint pain, headaches, muscle-aches, chronic fatigue, allergies, gastrointestinal distress, and irritability [22]. An attempt to remove the toxicity resulting from exposure to contaminants from various organs of the human body, using some dietary supplements and herbal formulas of some medicinal plants [23]. Toxic metals such as arsenic, cadmium, lead, and mercury are ubiquitous, have no beneficial role in human homeostasis, and contribute to non-communicable chronic diseases [7]. The nervous system is the principal target for many toxic metals. Lead-containing dust both within and outside the home was elevating children's blood lead to toxic levels. The source was not only leaded paint but industrial emissions (Site I and III in the present study). Excess accumulation of *manganese* (Site I) in the *brain* results in a neurological disorder. Chronic Mn exposure *produces* dopamine neuron degeneration and Idiopathic *Parkinson's disease* (PD) is a progressive [9]**.**

Most of the body's impurities are removed through the liver, kidneys, lungs, lymph nodes, intestines and skin. A detox diets or herb can help with a variety of symptoms, such as: lack of energy, headaches, acne, brittle hair or nails, minor aches, restlessness, weight loss, hair falling out, digestive issues and some allergies [24]. Some believe in detoxifying the body once a year, while others recommend ongoing methods of eliminating toxins. Many people prefer to take herbs as part of their daily vitamin and nutrient routine. Herbs are effective for eliminating toxins from the body [4].

The first step in lowering your toxic load is avoiding exposure to new toxins as much as possible. Eating herb is a great way to start. Spring is the perfect time to cleanse our body from the inside out. Some herbs having potent cleansing abilities and are commonly used for detoxifying the body. The herbal formula applied in the present study (ACOSTU) is of six potent and effective herbs. For example, *Arctium lappa*, *Coriandrum sativum*, *Olea europaea, Silybum marianum*, *Tribulus terrestris,* as well as *Urtica dioica* are of powerful action as detox herbs [25,4]. Many of these herbs can also be found in teas which you can drink on a regular basis. It was documented that *A. lappa* purifies the blood, aids the removal of the body's toxins making it an efficient detoxifier. *C. sativum* rids the body from heavy metals, protects against oxidative stress, prevents urinary tract infections, settles digestive upset, and protects against food poisoning. *O. europaea* leaves have a rich history of medicinal uses [26]. Cadmium is a class I carcinogen displaying adverse effects on many organ systems such as bones, lungs and kidneys [27]. The kidney is the major organ at risk of damage from chronic exposure to cadmium as a contaminant in food, water and air (Site II). Indeed, olive leaves represent a natural source of bioactive phytocompounds. It is a promising in preventing cadmium toxicity in environmentally and occupationally exposed populations or in habitual tobacco smokers who are chronically exposed to cadmium [28]. Furthermore, olive leaves, considered waste from olive groves and the olive oil industry, might be potentially applied in bioremediation programs. Additionally, [4] stated that *S. marianum*, *C. sativum* are active in excretion of Pd (Site II) while *S. marianum* was specific for Fe (Site III). *S. marianum* is one of the most well-known liver herbs. Its active flavonoid, silymarin, protects hepatic cell membranes (its protective action against amanitin), provides powerful antioxidant activity, and helps regenerate damaged liver cells. It also has a mild choleretic action, providing more toxic bile release [29]. *T. terrestris* exhibited protective effect against Cd-induced testicular damage (Site II). The protective effect appears to be mediated through inhibition of testicular tissue peroxidation by antioxidant and metal chelators activity and also, may be indirectly by stimulating the testosterone production from leyden cells [30]. *U. dioica* has been shown to reduce heavy metal content in soil up to less 8% for Zn, Pb and Cd [31]. It also considered as a kidney herb to support the function of this organ during the cleansing period [32]. Herbs in the formula elicited significant decrease in the severity of the documented cases in the study sites.

The increase intake of polyphenols may support to detoxify the body. The richest sources of polyphenols include cloves, star anise, peppermint, oregano, flaxseeds, cocoa powder, dark chocolate, green tea, strawberries and plums [33]. A lesser-known fact about dietary polyphenols is that they enhance the production of metallothionein, a major antioxidant enzyme. This enzyme is responsible for metabolizing and detoxifying heavy metals [34]. Polyphenol-rich beverages like red grape juice, green tea increased metallothionein production in the human body. Eating more polyphenol-rich foods will help you on your way to detoxifying your body of heavy metals. To go through with this, foods rich in sulfur include cruciferous vegetables like broccoli, kale, spinach, watercress, cabbage, and cauliflower as well as garlic and onions can help in body detoxification [35].

The food poisoning in Site II could be attributed to the fact that the families close to the carbon factory consume almost 50% of their food from their farm products which are heavily affected by the carbon pollution as indicated by the amount of residues present in these crops. This was also supported by the medical diagnosis of the cause of the poisoning. As mentioned by the interviewed families, their conditions were diagnosed as carbon poisoning by the physicians.

6. Conclusions

In Conclusion, the problem of pollution with heavy elements is a global problem and also local to some Arab countries. It is a means of seriously affecting the economy, whether directly or indirectly, by affecting human health. Therefore, the study recommends the need to find technical and biological solutions to this problem in line with the 2030 Agenda. The study recommends the continuous monitoring of the heavy metal concentrations in the study area and consequently can modified the herbal formula and dose.

7. Conflict of Interest

The authors declare that they have no conflicts of interest.

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