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Detoxification of Heavy Metals from Leafy Edible Vegetables by Agricultural Waste: Apricot Pit Shell

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Abstract

Soil contamination by heavy metals, though restricted to surface horizons, based on soil texture are occluded, organically complexed, modified and specifically adsorbed based on anthropogenic sources, resulted in toxicity ramification on human health, has been in vogue as a serious environmental problem for last few decades. A laboratory study was planned due to reduction of Lead, Cadmium and Nickel toxicity by a low-cost soil amendment. Apricot (*Prunus armeniaca* L.) pit shell an abundant and low cost natural resource in Iran was used to adsorbing some heavy metals from contaminated soil of vegetable farmlands. Different adsorption parameters like adsorbent dose, particle size of adsorbent and time of growing vegetable were studied. Composite soil sample were collected from four randomized farmland locations at three agricultural fields (each one more than 10 hectares), in Yazd county in Yazd Province. Cultivated Leafy vegetables were grown under controlled similar physical conditions, including pH, light and demonized watering. Leaves, roots and soil samples were examined, analyses and studied, at various frequencies for heavy metals.

Keywords: Apricot shell; Heavy metals; Leafy vegetables; Adsorption; Contaminated soil

Introduction

Soil contamination by heavy metals, specially originated from anthropogenic sources, as a result of their toxicity ramification on human health, has been known as a serious environmental problem for last few decades [1-18]. Bioavailability, mobility, and activity of heavy metals are greatly affected by waste deposition which leads one of the most important factors resulting in environmental degradation. The soil contaminated [4,6] with heavy metal [5,19-25] waste deposition becomes affects seriously the future ecosystems. The environmental sustainability of the human society principally relays on our administration of the natural environment and the ecosystems that establish the platform upon which our civilization is based. Waste management programs in developing countries are often unsatisfactory and the disproportionate disposal of waste is a major issue worldwide. One the other hand, traditional methods for soil remediation are mostly expensive and energy consuming and the elevated costs involved in removal of toxic substances from contaminated [4,13,16,18,24] soils prevent remediation from being carried out; especially in areas of little economic value [15]. Historical evidence suggests that compost tea (CT) were used in agriculture by Romans and ancient Egyptians. Nowadays the environmental pollution with toxic and heavy metals has become a multinational crisis by affecting agriculture and subsidizing to bioaccumulation and bio exaggeration in the food chain.

Adsorption is considered to be entirely alluring in terms of its performance of removal from dilute waste solutions [26]. Despite the fact that the use of common materials such as activated carbon, chitosan, zeolite, clay is still completely recognized in order to the high adsorption capacity, they lead to overpriced process, too [1]. Along these longs, there is a growing demand to find relatively efficient, low-cost and easily ecofriendly and available adsorbents for the adsorbing process of heavy metals [5,19,20,21,25], particularly if the adsorbents are the wastes from agricultural or food industries.

The new orientation is occurred towards no expensive adsorbents by researches. However, there is a lack of literature dealing with the possible application of agricultural waste materials as an economic and ecofriendly by their unique chemical compositions and also availability in abundance, renewable, low in cost applied for amendment and remediation of heavy metals contaminated soil of farmlands [27-30]. There are many efficient various methods and processes have been investigated to remove or eliminate heavy metals from contaminated soil, water and wastewater, such as phytoremediation, addition of the biodegradable chelating agent, physical removing of heavy metals, reverse osmosis, electrochemical treatment, chemical precipitation, membrane processes, ionic exchange and active carbon based adsorption [3,4,8,13,19,26]. Despite the fact that these conventional techniques have their own integrated limitations such as: less achievements, responsive operating precedence and extra costly disposal affair, another impressive technology is heavy metals adsorption [1,19,20,21]. The adsorption process could be recommended to be one of the most resourceful methods in consideration of its easy procedure, adjustability, adsorption [3,13,26] of metals by high performance, recovery of heavy metal contaminants and transcribe and even restate /reuse of the applied adsorbent [1,19,20,25].

Probably toxic and harmful heavy metal contents in soils may drive from not only by bedrock itself, but also from anthropogenic sources like solid or liquid waste deposits, agricultural inputs and sludge industrial waste materials and urban emissions [12,16,18,19,21,24]. Excessive accumulation in agricultural soils may propagate in soil contamination and has also emanation to food quality and safety.

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Therefore, it is indispensable to screen and monitor food safety, given that plant uptake is one of the major pathways through which heavy metals invade to the food chain [5,25].

The hard shells of some nuts recycle in a variety of different ways. Various nutshell powders have been used for centuries in folk medicine in many countries. Walnut shell powder could be easily purchased today and even many individuals buy it in large scale due to add it to their beauty skin products. Nowadays agricultural waste materials is known profitable and ecofriendly as a result of their renewable, unique chemical composition, abundant availability, economical and simply organized are seem to be applicable option for heavy metal remediation [5,15,19-21]. Studies reveal that various agricultural waste materials such as rice [6] bran and husk, wheat bran, wheat husk, saw dust of various plants, bark of the trees, groundnut shells, coconut shells, black gram husk, hazelnut shells, walnut shells, cotton seed hulls, waste tea leaves, Cassia fistula leaves, maize corn cob, apple, banana, orange peels, soybean hulls, grapes stalks, water hyacinth, sugar beet pulp, sunflower stalks, coffee beans, shell nuts, cotton stalks etc. has been tried. These auspicious agricultural waste materials could be utilized in the removal of metal ions either in their natural form or after some physical or chemical modification and treatment.

According to FAOSTAT, Iran has the second rank of the top producers of apricots (in tons) in 2013 [11,30]. Apricot trees can grow over the world and production level exceeds 2 million tons. Turkey, Iran, Australia, France, Hungary, Italy, Morocco, Spain and Tunisia can be regarded as important apricot producer countries. Apricot (*Prunus armeniaca* L.) is classified under the Prunus species of *Prunodae* sub-family of the *Rosaceae* family of the Rosales group. This type of fruit is a cultivated type of Zerdali (wild apricot) which is produced by inoculation. Vegetables and fruits are the most important components of human diet and it is well known that consumption of these food items on a regular basis is one of the possible health improving practices [22,28,31-37]. In human nutrition, apricot has an important point, and can be used as fresh, dried or processed fruit. As known in Iran and other countries the fruit of apricot is not only consumed fresh but also used to produce dried apricot, juice, nectar, jam, jelly, marmalade, pulp, frozen apricot, extrusion products, etc. Moreover, the kernels of apricot fruit are being used in the production of oils, benzaldehyde, cosmetics, active carbon, and aroma perfume. Average concentration of all the heavy metals was observed to be higher in leafy vegetables as compared with fruit vegetables, root vegetables, and fruits [37]. Usually, heavy metal concentration varied among different vegetables and fruits depending on the different accumulation capacities and variation in the soil properties [22,30].

Apricot is not indigenous to Armanestan, this fruit is originally from China which there are evidences that about 4000 years ago was planted in China. The genus prunus has many species (*P. armeniaca*, *P. manchurica*, *P. sibirica*, *P. brigantina*) which the most famous is *P. armeniaca*. Three of those species are so called Asian-Iranian type. According to statistics the total dried apricot production every year is 10-12 thousand tons of which 6 000 tons are exported every year. Apricot as a fresh fruit has got its place in the market with a rather high price.

Cadmium (Cd) and Lead (Pb) accumulation in soil are among the main environmental concerns [9,18,26]. Cd is highly toxic to animals and plants. In plants exposure to Cd causes reductions in photosynthesis, water and nutrient uptake. When Cd concentration exceeds 100 mg kg^{-1} the plant growth rate decreases. The soil permissible Cd concentration is about 0.5 mg kg^{-1}. The permissible concentration of Cd in soil which doesn't adversely affect plant growth and quality and EW application to agricultural land is 3 mg kg^{-1}. Mobility of Cd in soils are toxic to plants as they accumulate and redistribute in plant organs, resulting in plant injuries, changes in plant protective enzymes, or changes in photosynthetic sensitivity of plants at different growth stages.

Hard rock mining sites are sites where the desired mineral must be extracted from rock hosts. Examples of common hard-rock derived metals include Fe, Zn, Pb, cobalt (Co), Cu, gold (Au), and Mo, although some of these are mined from sedimentary deposits as well. The desired metal is present at an elevated concentration in a mineral matrix (ore) that is sufficiently above background to make extraction of the metal economically viable. In addition to the mined ore, hard rock mining sites must move large amounts of non-mineralized rock (overburden) to get to and remove the ore. These sites can include open pit and underground mining operations. In both cases, overburden or waste rock with low mineral concentration frequently makes up a large portion of the waste material onsite. Adjacent soil also may be contaminated from fluvial deposition or, in some instances, the use of historical irrigation practices. For most of these sites, overburden or waste rock, which often is acidic and has elevated contaminant concentrations, is the material left that needs to be re-vegetated [4]. Since much hard rock mining sites generate acidic soil conditions in their overburden and waste rock, addition of liming materials is usually an essential first step to site remediation. However, there are limitations associated with lime treatment of acid-forming mine waste. Problems achieving adequate mixing are commonly encountered in excessively rocky materials. Iran in fact holds 7% of the total world's minerals, the biggest global zinc reserves, some of the biggest copper deposits and is a very significant supplier of iron ore and chromite globally. There are approximately 5,000 mines in operation in Iran, with 12 metals and 36 non-metal ores currently being exploited.

Yazd province is one of arid regions of Iran with limitation of water resources. Utilization of industrial wastewater on agriculture lands can somehow compensate the lack of water [12]. The vicinity of an ancient abandoned copper, Lead and Zinc mines located on the Yazd and vicinal provinces was assessed for the dispersion of Nickel, Copper, zinc, lead, and cadmium [2,9,18,26] into the surrounding environment. Leafy Vegetables easily take up HMs and accumulate them in their edible and non-edible parts at aggregate high adequate to induce clinical problems to both animals and human beings [31-37]. Present study was performed aiming to investigate effective strategy to remove toxic heavy metals by Apricot residues. On the whole the main aim of the current study is to: Assess the applicability of *Prunus armeniaca* L. in removing heavy metals: Pb, Cd and Ni from the contaminated soil and edible vegetables grown in this soil [7,24]. Due to need only a little processing before use of low cost and economical [15,29] natural adsorbents which are abundant in nature or being a by-product or waste material from another industry seems logical for heavy metal removing from food chain, therefore it becomes very crucial to consider all possible agricultural and food industry waste materials based on inexpensive adsorbents to be analyzed and their expediency and potential for the removal of toxic heavy metals to be investigated [19,21]. The main objective of current study is to assign that if hard shell of apricot as an abounding safe and low cost adsorbent and its utilization possibilities for removing/ decreasing the heavy metals from vegetable farms and also from edible and common leafy vegetables [5,7].

Experimental

Soil sampling

The soil sample was collected from four randomized farmland locations at three agricultural fields (each one more than 10 hectares), in Yazd county in Yazd Province in the late of September 2016 (Figure 1) in Iran (3°53′N 54°27′E)which is shown in Figure 1. The soil samples were filled in several plastic bags and carried to a laboratory at the Islamic Azad University, Pharmaceutical Sciences Branch, Nutrition and Food Sciences Research Center, Tehran-Iran [14]. The heavy metal contaminated soil samples, so collected were safely transported in clean self-sealing quart-size polyethylene freezer bag to the Tehran laboratory. Four common popular edible vegetable were similarly transported: Parsley (*Petroselinum crispum*) [31]; holy basil (*Ocimum tenuiflorum*) [32]; *Coriandrum sativum* [33] and Cress (*Lepidium sativum*) [35], hosted in 80 vases of 27 × 13 × 16 cm size and grown in the same conditions as those cultivated in Yazd.

A set of laboratory tests were performed on the samples to determine the physical properties of soil samples such as particle size, maximum dry unit weight and optimum water content. All experiments were conducted according to ASTM, D 421; D 4138; and D 698 respectively. Grain-size distribution curve of the soil was obtained in accordance with ASTM D422. At the beginning of study, soil profile characteristics were observed and recorded by a packet penetrometer (Cl-700A, soil Test Inc., USA). Soil samples were mixed, homogenized and separated into three parts, 1/3 of each samples was air-dried and pass through a 2 mm sieve in order to determine p and k content, pH and electrical conductivity and particle-size distribution. The other 2/3 was passed through a 2 mm sieve without drying and 1/3 of it used to determine heavy metals concentration by Atomic Absorption Spectroscopy (AAS) after digestion with aqua-regia. The samples were analyzed by an Atomic Absorption Spectrophotometer Model AA-6200 (Shimadzu, Japan) using an air-acetylene flame for heavy metals: Chrome, Nickel, Lead and Cadmium [2,9,19,26], using at least five standard solutions for each metal [7]. All necessary precautions were taken to avoid any possible contamination of the sample as per the AOAC guidelines. Chemical composition and the geotechnical index properties of the soil are summarized in Tables 1 and 2, respectively. Each soil sample analyzed were a combination of 5 to 10 subsamples taken from the soil area of each farmland and mixes them together to obtain the final sample. Representative channel samples were taken from 0-35 cm depth from each farmland location. These sites targeted the main concern, especially in this region, of unregulated grey water discharge [8]. This comprises raw sewage additions and mixing with fresh water to extend utility of this very limited fresh water resources. This adulterated ‘grey water' causes 'irreversible' damage to agricultural lands and the environment. Initially soil profile characteristics were observed and recorded by a pocket penetrometer (Cl-700A, soil Test Inc., USA). Soil samples were mixed, homogenized and riffle split into three parts. One third of each sample was air-dried and passed through a 2 mm sieve in order to determine p and k content, pH and electrical conductivity and particle-size distributions. The other 2/3 was passed through a 2 mm sieve without drying. One third was put in control samples and in one third rest (tested group) Apricot shell of 1% and 3% (w/w) as trial heavy metal adsorbent were mixed with the heavy metal contaminated soils collected, and along with untreated soils as controls, placed in 80 vases [10].

All samples were analyzed to determine heavy metals concentration by Atomic Absorption Spectroscopy (AAS) after digestion with aqua-regia. The samples were analyzed by an Atomic Absorption Spectrophotometer Model (ALPHA 4, Chem Tech Analytical, England) using an air-acetylene flame for heavy metals: Nickel, Lead and Cadmium, using at least six standard solutions for each metal [18]. All necessary precautions were taken to avoid any possible contamination of the sample as per the AOAC guidelines.

Apricot shell sampling

Apricot (20 Kg) (ripped completely) were purchased in October 2016 from 2 gardens of Yazd city in the central of Iran. In order to investigate the influence of apricot shell as an amendment on remove or decrease of chemical forms of Cd, Pb and Ni. In this study the soil of farmlands and even the apricot shells gathered from Yazd as the city of Yazd is the economic and administrative capital of the province and therefore the most heavily populated. The samples were (Fine, mixed, mesic, Fluventic Calcixerepts) in Oct 2016. Particle size distribution was determined by the hydrometer method. The pH values of the soil were measured in a 1:1 soil- water and electrical conductivity (EC) was measured in the soil paste extracts. Cation exchange capacity (CEC) and organic matter (OM) were determined by replacing cations with NaOAc and Walkley-Black method, respectively. The calcium carbonate equivalent (CCE) was determined by neutralization with HCl [13].

Cultivated Leafy vegetables were grown under controlled similar physical conditions, including pH, light and demonized watering. Leaves, roots and soil samples were examined, analyses and studied, at various frequencies for heavy metals, as it influences human health by modifying the cell cycle, suppress apoptosis (programmed cell death), and alters the expression of various genes. Cooking of plants, has very limited impact on reducing heavy metals concentration. The

Figure 1: Yazd province in Iran.

Soil texture	Sand (%)	Silt (%)	Clay (%)	Field Capacity (%)	$CaCO_3$ (%W)	OC (%W)	OM %	CEC cmol/kg)	pH	EC ds/m
Clay	40	18	42	51.2	6.49	1.03	1.77	45.1	7.56	6.12

Table 1: Selected chemical and physical properties of studied soil.

heavy metals pollution also arises due to the increased uses of fertilizers and other chemicals to meet food production demands [10,28]. Metal contents were detected by Atomic Absorption Spectrophotometer by wet digestion method in the Food Science & Technology Research Laboratory within the Pharmaceutical Sciences Branch, Department of Food Sciences & Technology (IAUPS) [14].

Lead, cadmium and nickel determination

For Lead, Cadmium and Nickel analyses, vegetable samples were vigorously washed with distilled water to eliminate suspended particles. Leaves were collected from all samples and cleaned with demonized water repeatedly. These leave samples were oven dried at 65°C for about 4 hours and ground with a grinding mill until all passed through a 60 mesh sieve. The samples were stored in clean, dry, high density polyethylene bottles of 100 ml capacity with screw caps, without metal contaminating liners. Bottles were prewashed with 10% nitric acid, rinsed with de-ionized water, dried and tested for contamination by leaching with 10% nitric acid. Samples were precisely weighed (1.000 ± 0.001 gram each) and ground in a mortar followed by wet digestion with HNO_3:HCl (3:1) in a conical flask for 2-3 hours on a shacking sand bath. Some 10 ml of H_2SO_4 was added. Digested samples were filtered with 0.45 µm pore size cellulose nitrate membrane filter paper (Millipore) and the volume was increased to 100 ml with double distilled water. Bottles were stored for up to 3 days until flame atomic absorption spectrophotometry was performed. The samples were analyzed by an atomic absorption spectrophotometer (ALPHA 4, Chem Tech Analytical, England) using an air-acetylene flame for the 3 heavy metals: Pb, Cd and Ni, using at least six standard solutions for each metal. A certified standard reference material (Alpha – Line, Chem Tech Analytical, England) was used to ensure accuracy, and the analytical values were within the range of certified values. All recoveries of the metals studied were greater than 95%. Based on the average concentration and the average consumption of edible vegetables, estimates of the amount of each heavy metal consumed were calculated. The daily intake of heavy metals through the consumption of the vegetables tested was calculated according to the given equation:

Daily intake of heavy metals (µg/day)=[Daily vegetable consumption × vegetable heavy metal concentration]

Health risk assessment and daily (or weekly) intake of heavy metals through vegetables was made by comparing the concentration of the contaminants recorded with national and international safe limit standards [10,17,28]. The percent contributions to dietary intake of heavy metals of the vegetables tested were calculated by dividing the daily consumption rates of the heavy metals with the values of provisional tolerable daily intake (FAO/WHO) [11]. The heavy metal content in the various samples were investigated by collecting it at field condition.

Mineral elements	mg/kg DW ± SD
Fe	372.32 ± 0.11
Mn	176 .11 ± 0.15
Zn	399.87 ± 23.16
Cu	74.83 ± 0.15
Ni	58.38 ± 0.19
Cd	3.12 ± 0.26
Se	2.46 ± 0.05
Pb	5.82 ± 0.80
Cr(VI)	73.21 ± 3.17

Table 2: The mean content of Mineral elements (mg/kg DW ± SD) in the studied soil.

Results and Discussion

Data of heavy metal concentrations were checked for homogeneity of variance and normality. The data of heavy metal concentrations in all analyzed samples across the various farming sites were subjected to two-way analysis of variance (ANOVA) to assess the significance of differences in heavy metal concentrations by site, Sample type and their interaction. Pearson correlation analyses were also carried out to assess the relationships of soil and metal concentrations. All statistical analyses were computed with SPSS software version, the physical properties of the soil profile before planting 4 edible vegetables: Parsley (*Petroselinum crispum*) [31]; holy basil (*Ocimum tenuiflorum*) [32]; *Coriandrum sativum* [33] and Cress (*Lepidium sativum*) [35,36] is shown in Table 1. The mean content of some mineral elements such as Fe, Mn, Cr(VI), Zn, Cu, Se, Pb and Nickel (mg/kg DW ± SD) in Yazd farmland 's soil after 3 replicates of 5 subsamples is shown in Table 2. Vegetables samples during 40 days were studied in pH=5.6-7.1, as plant availability of certain heavy metals depends on soil properties such as soil and contains exchange capacity and on the distribution of metals among several soil fractions. All the soil data are expressed on a dry basis.

Results showed the high zinc and Iron contents as it would be predictable according to the vicinity of some mines in Yazd province. Plant availability of certain heavy metals depends on soil properties such as soil pH and contain exchange capacity and on the distribution of metals among several soil fractions. The fractionation of lead and nickel in 4 edible leafy vegetables cultivated in control soil) untreated by apricot hard shell) and in soils treated by natural adsorbent in different percentage of hard nutshell is completely determined due to find out the adsorption ability of heavy metals by agricultural waste in contaminated soil samples. In Figures 2-5, the treating contaminated

Lead Content (mg/kg) DW ± SE)	Day=1	Day=10	Day=20	Day=30	Day=40
Parsely (*Petroselinum crispum*) cultivated in untreated soil	3.82 ± 0.03[a]	3.70 ± 0.08[a]	3.63 ± 0.11[a]	3.55 ± 0.15[a]	3.48 ± 0.07[a]
Parsely (*Petroselinum crispum*) cultivated in treated soil by 1% Apricot shell	3.27 ± 0.12[a]	2.31 ± 0.15[b]	1.04 ± 0.09[c]	0.41 ± 0.08[d]	0.27 ± 0.13[e]
Parsely (*Petroselinum crispum*) cultivated in treated soil by 3% Apricot shell	3.28 ± 0.07[a]	2.22 ± 0.16[b]	0.96 ± 0.08[c]	0.37 ± 0.05[d]	0.19 ± 0.08[d]
Holy basil (*Ocimum tenuiflorum*) cultivated in untreated soil	3.80 ± 0.21[a]	3.72 ± 0.09[a]	3.61 ± 0.16[a]	3.52 ± 0.17[a]	3.44 ± 0.37[a]
Holy basil (*Ocimum tenuiflorum*) in treated soil by 1% Apricot shell	3.22 ± 0.34[a]	2.51 ± 0.27[b]	1.59 ± 0.26[c]	0.52 ± 0.23[d]	0.33 ± 0.16[d]
Holy basil (*Ocimum tenuiflorum*) cultivated in treated soil by 3% Apricot shell	3.20 ± 0.27[a]	2.01 ± 0.13[b]	0.87 ± 0.11[c]	0.37 ± 0.09[d]	0.24 ± 0.11[d]
***Coriandrum sativum* cultivated in untreated soil**	3.68 ± 0.27[a]	3.60 ± 0.29[a]	3.45 ± 0.16[a]	3.38 ± 0.15[a]	3.33 ± 0.06[a]
***Coriandrum sativum* cultivated in treated soil by 1% Apricot shell**	3.33 ± 0.18[a]	2.45 ± 0.27[b]	1.39 ± 0.15[c]	0.65 ± 0.13[d]	0.38 ± 0.09[d]
***Coriandrum sativum* cultivated in treated soil by 3% Apricot shell**	3.43 ± 0.16[a]	1.98 ± 0.06[b]	0.99 ± 0.19[c]	0.49 ± 0.07[d]	0.26 ± 0.03[d]
Cress (*Lepidium sativum*) cultivated in untreated soil	3.86 ± 0.27[a]	3.76 ± 0.42[a]	3.54 ± 0.36[a]	3.39 ± 0.29[a]	3.11 ± 0.25[a]
Cress (*Lepidium sativum*) in cultivated treated soil by 1% Apricot shell	3.11 ± 0.06[a]	2.00 ± 0.22[b]	0.97 ± 0.11[c]	0.41 ± 0.16[d]	0.11 ± 0.05[e]
Cress (*Lepidium sativum*) in cultivated treated soil by 3% Apricot shell	3.09 ± 0.18[a]	1.43 ± 0.06[b]	0.65 ± 0.19[c]	0.24 ± 0.08[d]	0.11 ± 0.04[d]

Table 3: Removal yields of Lead contents of 4 edible vegetables using Apricot Shell.

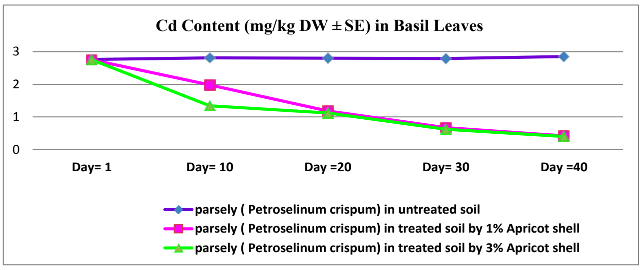

Figure 2: Removal yields of Cadmium contents in *Ocimum tenuiflorum* using Apricot Shell (Adsorbent dose=1 g/100 g and 3 g/100 g), temperature=24°C, during 40 days studding.

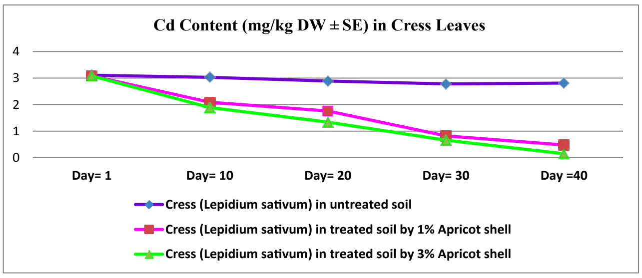

Figure 3: Removal yields of Cadmium contents in *cress* using Apricot Shell (adsorbent dose=1 g/100 g and 3 g/100 g), temperature=24°C, during 40 days studding.

soil trend by hard shell of apricot indicates that dried plant parts in the soil which is enriched soil by mineral elements and vitamins, it can be consider as a suitable method for rescuing soil by its relatively large ratio of biomass concentration of the contaminant to the soil concentration (Table 3).

Mean scores with different small letters are significantly different in each row (p<0.05) Lead in *Coriandrum sativum* in untreated soil on day 1, 10, 20, 30 and 40 are 3.41, 3.23, 3.19, 3.14, 3.15 (mg/kg DW ± SD); There is a remarkable decrease in the content of lead in *Coriandrum sativum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 3.33, 2.45, 1.39, 0.65, 0.38 (mg/kg DW ± SD). The condition changes when the apricot shell treatment is increased in dosage, the lead in *Coriandrum sativum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are appreciably controlled 3.43, 1.98, 0.99, 0.49, 0.26 (mg/kg DW ± SD).

Lead in *Ocimum tenuiflorum* in untreated soil on day 1, 10, 20, 30 and 40 are 3.19, 3.25, 3.16, 3.19, 3.1 (mg/kg DW ± SD); There is a significant decrease in the content of lead in *Ocimum tenuiflorum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 3.22, 2.51, 1.59, 0.52, 0.33 (mg/kg DW ± SD); The situation changes when the apricot shell treatment is increased in dosage, the lead in *Ocimum tenuiflorum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are noticeably controlled 3.2, 2.01, 0.87, 0.37, 0.24 (mg/kg DW ± SD).

Lead in *Lepidium sativum* in untreated soil on day 1, 10, 20, 30 and 40 are 3.19, 3.16, 3.14, 3.09, 2.98 (mg/kg DW ± SD); There is a remarkable decrease in the content of lead in *Lepidium sativum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 3.11, 2, 0.97, 0.41, 0.11 (mg/kg DW ± SD); The condition changes when the apricot shell treatment is increased in dosage, the lead in *Lepidium sativum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are significantly decreased 3.09, 1.43, 0.65, 0.24, 0.11 (mg/kg DW ± SD).

Lead in *Petroselinum crispum* in untreated soil on day 1, 10, 20, 30 and 40 are 3.82, 3.7, 3.33, 3, 2.98 (mg/kg DW ± SD); There is a notable decrease in the content of lead in *Petroselinum crispum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 3.27, 2.31, 1.04, 0.41, 0.27 (mg/kg DW ± SD); The condition changes when the apricot shell treatment is increased in dosage, the lead in *Petroselinum crispum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are considerably controlled 3.28, 2.22, 0.96, 0.37, 0.19 (mg/kg DW ± SD) (Table 4).

Mean scores with different small letters are significantly different in each row (p<0.05) Nickel in *Coriandrum sativum* in untreated soil on day 1, 10, 20, 30 and 40 are 2.83, 2.81, 48.91, 48.01, 46.59, 45.78, 46.19 (mg/kg DW ± SD); There is a remarkable decrease in the content of nickel in *Coriandrum sativum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 48.33, 30.81, 25.01, 23.07, 19.46 (mg/kg DW ± SD); The condition changes when the apricot shell treatment is increased in dosage, the nickel in *Coriandrum sativum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are considerably decreased 46.72, 29.44, 16.15, 14.33, 13.29 (mg/kg DW ± SD).

Nickel in *Ocimum tenuiflorum* in untreated soil on day 1, 10, 20, 30 and 40 are 43.11, 40.98, 41.12, 42.28, 41.22 (mg/kg DW ± SD); There is a notable decrease in the content of nickel in *Ocimum tenuiflorum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 43.09, 31.22, 26.5, 22.8, 20.81 (mg/kg DW ± SD); The circumstance changes when the apricot shell treatment is increased in dosage, the nickel in *Ocimum tenuiflorum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are appreciably controlled 42.38, 35.67, 29.88, 23.44, 22.06 (mg/kg DW ± SD).

Nickel in *Lepidium sativum* in untreated soil on day 1, 10, 20, 30 and 40 are 66.51, 64.29, 64.08, 63.19, 60.18 (mg/kg DW ± SD); The situation changes when the apricot shell treatment is increased in dosage, the nickel in *Lepidium sativum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 65.78, 40.21, 29.07, 25.11, 21.13 (mg/kg DW ± SD); There is a remarkable decrease in the content of nickel in *Lepidium*

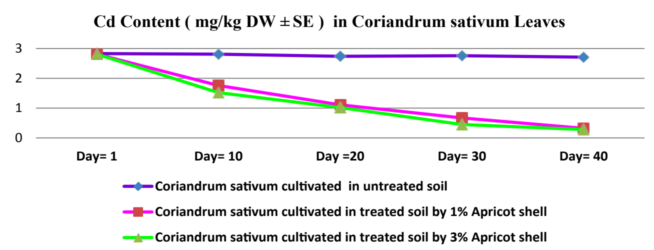

Figure 4: Removal yields of Cadmium contents in *Coriandrum sativum* using Apricot Shell (adsorbent dose=1 g/100 g and 3 g/100 g), temperature=24°C, during 40 days studding.

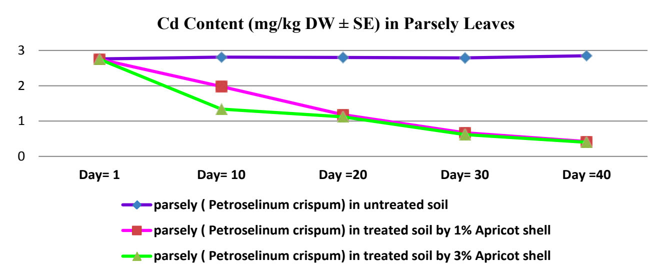

Figure 5: Removal yields of Cadmium contents in *Petroselinum crispum* (parsley) using Apricot Shell (adsorbent dose=1 g/100 g and 3 g/100 g), temperature=24°C, during 40 days studding.

sativum in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are noticeably depicted 67.01, 43.9, 31.02, 26.47, 23.21 (mg/kg DW ± SD).

Nickel in *Petroselinum crispum* in untreated soil on day 1, 10, 20, 30 and 40 are 52.75, 50.14, 50.01, 51.33, 50.02 (mg/kg DW ± SD); There is a significant decrease in the content of nickel in *Petroselinum crispum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 52.31, 44.09, 29.61, 23.11, 20.06 (mg/kg DW ± SD); The condition changes when the apricot shell treatment is increased in dosage, the nickel in *Petroselinum crispum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are substantially dropped 52.34, 40.11, 20.17, 19.04, 18.28 (mg/kg DW ± SD); Apricot Shell treatment in heavy metal contaminated soil of *Ocimum tenuiflorum*; indicate 10 days sample looks promising on Cd on leaves (Figure 2). In Basil leaves the Cd concentration depletion during the initial 10 days is faster and thereafter it straightens. The treatment of Apricot Shell nurtures the rehabilitation of soil by balancing (3 g/100 g has a faster rate of reaction) with the existing soil conditions. The observed values establish the band of Cd stabilizing across increased time period. The rate of reaction is varied in leaves with high Cd concentration only up to 20 days, later up to 40 days the impact does not significantly reduce Cd concentration.

Cadmium in *Coriandrum sativum* in untreated soil on day 1, 10, 20, 30 and 40 are 2.83, 2.81, 2.74, 2.76, 2.71 (mg/kg DW ± SD); There is a major decrease in the content of Cadmium in *Coriandrum sativum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 2.81, 1.76, 1.11, 0.67, 0.32 (mg/kg DW ± SD); The condition changes when the apricot shell treatment is increased in dosage, the Cadmium in *Coriandrum sativum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are appreciably decreased 2.81, 1.52, 1.02, 0.45, 0.28 (mg/kg DW ± SD).

Cadmium in *Ocimum tenuiflorum* in untreated soil on day 1, 10, 20, 30 and 40 are 3.01, 3.06, 2.98, 3.01, 3 (mg/kg DW ± SD); There is a significant decrease in the content of Cadmium in *Ocimum tenuiflorum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 3, 2.32, 1.11, 0.42, 0.19 (mg/kg DW ± SD); The condition changes when the apricot shell treatment is increased in dosage, the Cadmium in *Ocimum tenuiflorum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are substantially controlled 3, 2.06, 0.98, 0.47, 0.17 (mg/kg DW ± SD).

Cadmium in *Lepidium sativum* in untreated soil on day 1, 10, 20, 30 and 40 are 3.11, 3.03, 2.89, 2.78, 2.81 (mg/kg DW ± SD); There is a substantial decrease in the content of Cadmium in *Lepidium sativum* in 1% Apricot shell treated soil from the 1st day to the 40th day are 3.08, 2.09, 1.76, 0.82, 0.48 (mg/kg DW ± SD); The condition changes when the apricot shell treatment is increased in dosage, the Cadmium in *Lepidium sativum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are significantly decreased 3.08, 1.89, 1.34, 0.66, 0.15 (mg/kg DW ± SD).

Cadmium in *Petroselinum crispum* in untreated soil on day 1, 10, 20, 30 and 40 are 2.76, 2.81, 2.8, 2.79, 2.85 (mg/kg DW ± SD); There is a significant decrease in the content of Cadmium in *Petroselinum crispum* in 1% Apricot shell treated from the 1st day to the 40th day are 2.75, 1.98, 1.18, 0.67, 0.42 (mg/kg DW ± SD); The situation changes when the apricot shell treatment is increased in dosage, the Cadmium in *Petroselinum crispum* in 3% Apricot shell treated soil on day 1, 10, 20, 30 and 40 are considerably dropped 2.75, 1.34, 1.12, 0.62, 0.4 (mg/kg DW ± SD).

In *Lepidium sativum* [35,36] the Apricot Shell treatment of the heavy metal contaminated soil indicates that Cd concentration in the Cress leaves is appreciably depleting as the time passes, even up to 40 days of observation. In initial 10 days the Cd concentration depletion is very fast compared with the remaining 30 day period, observed and analyzed on a 10 day interval. The treatment of Apricot Shell nurtures the rehabilitation of soil by balancing (3 g/100 g has a faster rate of reaction compared with that of the 1 g/100 g mixture). The observed values establish the band of Cd stabilizing across increased time period. The rate of reaction is continuous in Cress leaves; the Cd concentration drops significantly as the mixture concentration of Apricot increases and the days prolong.

Apricot Shell treatment in heavy metal contaminated soil of *Coriandrum sativum* [33]; indicate appreciable decrease in Cd concentration within the initial 10 days in leaves. In Coriander leaves the Cd concentration depletion continues as downward trend as the treatment of Apricot Shell nurtures the rehabilitation of soil by balancing with the existing soil conditions. The observed values establish the band of Cd stabilizing across increased time period. The rate of reaction is varied in leaves with high Cd concentration only up to 30 days, later up to 40 days the impact does not significantly reduce Cd concentration.

Apricot Shell treatment in heavy metal contaminated soil of *Petroselinum crispum*; indicate 10 days sample looks promising on Cd on leaves. In leaves the Cd concentration depletion during the initial 10 days is faster and thereafter it straightens. The treatment of Apricot Shell nurtures the rehabilitation of soil by balancing (3 g/100 g has a faster rate of reaction) with the existing soil conditions. The observed values establish the band of Cd stabilizing across increased time period. The rate of reaction is varied in leaves with high Cd

Nickel Content (mg/kg DW)	Day=1	Day =10	Day =20	Day=30	Day =40
Parsely (*Petroselinum crispum*) cultivated in untreated soil	57.75 ± 0.34^{a}	54.14 ± 0.27^{a}	53.01 ± 0.19^{a}	52.33 ± 0.43^{a}	51.02 ± 0.35^{a}
Parsely (*Petroselinum crispum*) cultivated in treated soil by 1% Apricot shell	52.31 ± 0.44^{a}	44.09 ± 0.32^{b}	29.61 ± 0.27^{c}	23.11 ± 0.16^{c}	20.06 ± 0.11^{c}
Parsely (*Petroselinum crispum*) cultivated in treated soil by 3% Apricot shell	52.34 ± 0.34^{a}	40.11 ± 0.65^{b}	20.17 ± 0.26^{c}	19.04 ± 0.14^{c}	18.28 ± 0.09^{c}
Holy basil (*Ocimum tenuiflorum*) in untreated soil	59.11 ± 0.11^{a}	57.98 ± 0.19^{a}	56.12 ± 0.18^{a}	52.28 ± 0.20^{a}	51.22 ± 0.37^{a}
Holy basil (*Ocimum tenuiflorum*) in treated soil by 1% Apricot shell	43.09 ± 0.55^{a}	31.22 ± 0.29^{b}	26.5 ± 0.22^{c}	22.80 ± 0.19^{c}	20.81 ± 0.14^{c}
Holy basil (*Ocimum tenuiflorum*) in treated soil by 3% Apricot shell	42.38 ± 0.18^{a}	35.67 ± 0.27^{a}	29.88 ± 0.19^{b}	23.44 ± 0.16^{b}	22.06 ± 0.11^{b}
***Coriandrum sativum* in untreated soil**	58.91 ± 0.11^{a}	58.01 ± 0.09^{a}	56.59 ± 0.27^{a}	55.78 ± 0.26^{a}	53.19 ± 0.09^{a}
***Coriandrum sativum* in treated soil by 1% Apricot shell**	48.33 ± 0.18^{a}	30.81 ± 0.22^{b}	25.01 ± 0.26^{c}	23.07 ± 0.37^{c}	19.46 ± 0.18^{c}
***Coriandrum sativum* in treated soil by 3% Apricot shell**	46.72 ± 0.25^{a}	29.44 ± 0.26^{b}	16.15 ± 0.19^{c}	14.33 ± 0.18^{c}	13.29 ± 0.16^{c}
Cress (*Lepidium sativum*) in untreated soil	56.51 ± 0.37^{a}	54.29 ± 0.27^{a}	54.08 ± 0.45^{a}	53.19 ± 0.47^{a}	50.18 ± 0.22^{a}
Cress (*Lepidium sativum*) in treated soil by 1% Apricot shell	65.78 ± 0.33^{a}	40.21 ± 0.28^{b}	29.07 ± 0.37^{c}	25.11 ± 0.11^{c}	21.13 ± 0.05^{c}
Cress (*Lepidium sativum*) in treated soil by 3% Apricot shell	67.01 ± 0.15^{a}	43.90 ± 0.14^{b}	31.02 ± 0.04^{b}	26.47 ± 0.07^{c}	23.21 ± 0.04^{c}

Table 4: Removal yields of Nickel contents of edible vegetables using Apricot Shell.

concentration only up to 20 days, later up to 40 days the impact does not significantly reduce Cd concentration. The established methods for quantifying the analytical component of the uncertainty is to compare the components that arise from the process of primary sampling, therefore analysis of variance (ANOVA) is applied to estimate the total measurement uncertainty and also to quantify the contributions to that uncertainty which arise from the process of sampling and analysis. ANOVA One-way for statistical comparison between various elements adsorption showed that there is a significant difference in the heavy metals adsorption percentage by the kind of leafy vegetables and the percentage of apricot shell percentage that had the best removal rate for Cd, removal in 3% waste addition. Similar research studies, but with mango had through FTIR analysis revealed that carboxyl and hydroxyl functional groups were mainly responsible for the adsorption of Cd^{2+}. Various metal-binding mechanisms are thought to be involved in this process including ion exchange, surface adsorption, chemisorption and adsorption [1,3,26].

Results showed agricultural waste material adsorption for all heavy metals (Cd, Ni and Pb) in treated soil were affected significantly by dried adsorbent content and the adsorbent not only affected on contaminated soil and can adsorb Cd, Ni and Pb after 20 days ($p<0.001$) more than other studied but also adding apricot hard shell have reduction and rescue effect in taking up heavy metals especially in bio-adsorbing Cadmium [2] and Nickel more than other heavy metals studied in short time and it keeps edible vegetable safe for eating.

Conclusion

Heavy metals contamination is more prevalent due to inefficient food regulatory policies, inadequate environmental monitoring, and enforcement strategies. The health implications of trace elements and the toxic consequences of heavy metals necessitate effective monitoring of food products to ensure the public health safety. Apricot shell is an attractive and inexpensive option for the removal of dissolved metals. This study investigated removal yields of Lead, Nickel and Cadmium contents of edible vegetables using Apricot Shell. Thus, detoxification of heavy metals in plants, a serious issue before being used for food processing and human consumption, finds a better treatment process with Apricot. Heavy metal related illnesses and chronic degenerative conditions can be avoided in various plants Parsley (*Petroselinum crispum*) [31]; holy basil (*Ocimum tenuiflorum*) [32]; *Coriandrum sativum* [33,34] and Cress (*Lepidium sativum*) [35,36] using Apricot Shell treatment in Soil. The scope of this project extents to calculation of the risk in leafy and root vegetables, fruits are to determine a designated order such as Leafy vegetables>Root vegetables>Fruit vegetables>Fruit. Further even among metals which of the carcinogenic heavy metals, contributed to risk percentage in fruit vegetables, root vegetables, leafy vegetables, and fruits can be analyzed. This can even lead to identifying the most dominant carcinogen and thus attention to be paid to control its exposure to environment to save the population from risk can also be analyzed. Herbal health restoration in plant growth facilitates safety food production for direct consumption and assimilation. Even very little processing after harvest, can retain the best natural minerals and ensure quality of health in life. This research opens more scope for further research incorporating various plant waste mixture treatments. Public acceptance of green ecofriendly environmental technologies is generally higher than that of industrial processes [12]. The responsible organizations should stimulate research to upgrade existing soil treatment by implementing more properly adsorbents especially from food waste industry and agricultural waste materials and demonstrating their reliability to the public.

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