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# Determination of Heavy metals Concentration in Soil and Its Impact on Humans and Environment

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## Abstract

A few investigations have been done to detect the heavy metals concentration in Al-Shabanat farm south of Riyadh near a group of different factories in order to determine its environmental impacts. The heavy metals were measured by using ICP-MS. The Results indicate that soil of Al-Shabanat farm has different concentrations of heavy metals. In this research the metals have been measured ware: Pb, Cd, Ni, As, Cr, Zn and Cu. The result of the concentration was within the permissible rang. The direct impact of heavy metals on humans and animals has been recognized that these metals didn't pollute the soil due to the use of some factors that reduce the pollution rate, such as using fertilizers, in acceptable limits.

**Keywords:** Heavy metals determination • Soil; Adsorption • Separation • Inductively coupled plasma mass spectroscopy

## Introduction

Metals and rocks have an important role in our lives due to their numerous benefits to humans, especially that they are included in all industrial, agricultural and economic needs [1]. Soil pollution of heavy metals has become a major and acute problem in many regions of the world because of its direct and indirect impact on human health [1]. Their presence in the soil also indicates the toxicity of foods caused by human activities and natural processes, which lead to an increase in their concentration in agricultural soil. Soil pollution is considered one of the most dangerous types of pollution as it is difficult to observe, since it's colorless and odorless In addition to its stability and lack of biological decomposition, toxicity, diffusion in water, air and soil. Although heavy metals are naturally present in the soil, their concentrations may increase due to several natural factors and external influences, for example: metal smelting, burning fossil fuels, the use of fertilizers and pesticides, agricultural waste inputs, industrial emissions, wrongful disposal of industrial waste by burying it, erosion, decomposition and transportation of exposed rocks due to rain, floods, winds, etc [2]. Saudi Arabia's agricultural soil has a poor quality, due to lacking sufficient amounts of nutrients, organic matter, and moisture, However Saudi Arabia has good soil in 1980s, but using huge amounts of water resources and fertilizers, to the accumulation of organic and inorganic contaminants in soil. Most of the heavy metals present in high concentrations in the soil have toxic effects that may pose a threat to human, animal and plant health. There are many heavy metals that carry risks in their core, and each metal has a different harm than the other, for example lead, despite its importance in human activities, but it is toxic and causes disorders in the nervous system and brain damage, and among the harmful heavy metals is also chromium. In industry,chromium is important in the industrial field. However, the presence of chromium in high concentrations can cause many damages, including kidney failure, irritation and dermatitis [2]. Arsenic, cadmium, lead, manganese, zinc, uranium and others. are some of the most harmful and toxic heavy metals to the environment Exposure to these heavy metals have a significant health damages to humans such as cadmium, when enters the human body, 70% of it attacks the liver , kidneys and remains in the bones , as it is difficult to get rid of, it leading to many diseases and health complications, including osteoporosis, since it causes lung damage and endocrine disorders (Table 1).

| Metal | Effect on human health | Effect on soil and plants | Effect on animals |
|---|---|---|---|
| As | Affects essential cellular processes such as oxidative phosphorylation | Reduces fruit yield; and decreases in leaf fresh weight | irritation to lung, stomach and intestine, skin disturbances, and decreases formation of RBCs and WBCs |
| Cd | Affects calcium regulation in biological systems, lung damage and fragile bones | Reduces shoot growth; inhibition of root growth | can damage kidneys cause bone fractures and reproductive problems |
| Ni | Allergic skin diseases such as | Decreases enzyme activity | - |

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| | | | |
|---|---|---|---|
| | itching, cancer of the lungs and hair loss | which affected Calvin cycle and CO2 fixation | |
| Pb | Short-term memory loss, excess exposure in children causing impaired development | Decreases in plant protein content | kidney damage, reproductive/ fertility problems and brain or nervous system damage |
| Cr | Hair loss | Decreases in plant nutrient acquisition | - |

**Table 1:** Toxic effect of some heavy metals on human health plants and soil.

Researchers in China conducted a study on agricultural soils over the period (2005-2013) showed that about 82% of the soil contains toxic inorganic pollutants such as, Pb, Cd, Cr, As, while the soil contamination with lead reached 1.50%. Moreover, researchers in Congo-Brazzaville studied the concentrations of 5 heavy metals (Pb, Zn, Cu, As, and Mn) in 2011. the soil samples are collected from different depths and the results of concentration levels in the soil are listed in the following order: Pb > Mn > Zn > As > Cu, as shown in figure 1.

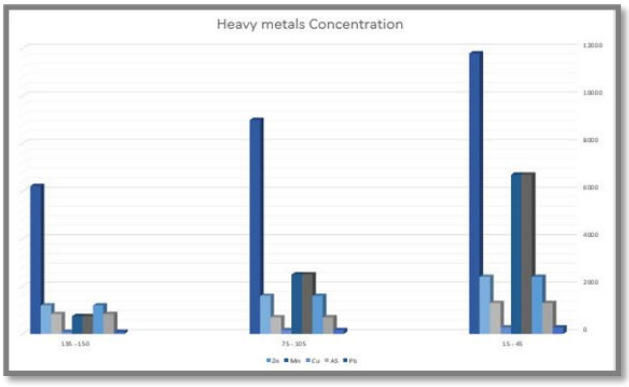


**Figure 1:** Graph shows the levels of heavy metals concentration.

Also, in wadi jazan the researchers were measured heavy metals by using ICP-MS. Results shown that soil of Wadi Jazan area has many different concentrations of heavy metals.The most extremely soil pollution at Wadi Jazan was by Cd, where all analyzed samples have higher concentration than the maximum permissible concentration by the World Health Organization. In the soils around Perlis were studied 5 heavy metals concertation (Cu, Cr, Ni, Cd, Pb). Samples were collected at depth of 0-15cm in eighteen station around Perlis. The concentration of heavy metals in the soil ware as the following decreasing trend: Cu>Pb>Cr>Ni>Cd. From this result, the level of heavy metals in soil near centralized Chopping industrial areas give maximum value compared with other location in Perlis. The main objective of the research is to determine the concentration of heavy metals in agricultural soils. The Shabanat area was chosen for its proximity to the industrial areas. And because industrial zones have bad effects on human, animal and plant health, the release of fumes, gases and residues has led to environmental disturbances and health concerns have increased due to the accumulation of heavy metals. There must be knowledge and awareness of the extent of harm and danger of heavy metals and reduce their accumulation by treating polluted soil in environmentally friendly ways. As mentioned earlier, the main goal of the research is to measure the concentrations of heavy metals and to ensure that they do not exceed the permissible limit in order not to cause harm to the environment. And to ensure that the soil is not damaged by pollutants surrounding the farm, as well as to ensure that treatment methods are followed, and pollution is reduced. In this research, the concentrations of some heavy elements in agricultural soils and the effect of depth and distance factor on increasing or decreasing concentrations of these minerals have been studied to discuss their impact on humans and environment, where we focused in this study on measuring the following minerals (Pb, Cd, As , Cr , Cu , Zn and Ni). Three samples were collected from different sides of the Al-Shabbanat farm on the Al-Kharj road nearby a group of factories with different activities as shown in figure 2 and 3, at the following depths: (10 -15 cm), then three points were placed with different dimensions around the farm, then at the depths of 10 cm and 15 cm were measured for each area and called (Point A), (Point B) and (Point C). Each region contains a different plant and a different fertilizer [3].


**Figure 2:** Location map of the factories which are A, B, C, D nearby Al-Shabanat farm


**Figure 3:** Location of the soil samples A, B and C

Soil contains mixed fertilizers from the above-mentioned industrial fertilizers and organic fertilizers. The soil is watered from well water, as the well depth reaches 180 cm and the water depth reaches 115 cm, as shown in Figure 4 and 5.

**Figure 4:** Picture of well watered the soil in farm.

The concentrations of these heavy elements were measured by the two instruments: ICP-MS Nuclear Science Research Institute (NSRI) in King Abdulaziz City for Science and Technology.

## Methodology

### Study area

Since Region A, contains organic (animal) fertilizer, the date palms are planted in. As for Region B, it contains industrial fertilizers imported from Optimal company, accordingly, the types used are, granular NPK -18-18-5, granular NPK 12-12-17, and the last imported from SABIC and its types used are, granular urea N 46%. While Region C, includes Diammonium Phosphate DAP 18: 46: 0.

### Samples collection

Laboratory procedures are of great importance, as this is one of the important steps. If the sampling is performed incorrectly, the results can become difficult to interpret. When taking samples, they must be placed directly in plastic bags to prevent contamination, so samples must be kept from contamination to ensure the accuracy of the analytical results. Soil samples should be taken with tools made of stainless steel. Glass or plastic items should be soaked in weak inorganic materials [4]. Samples are collected at the following depths, Sample A at 10 cm, 15 cm, Sample B at 10 cm, 15 cm, Sample C at 10 cm, 15 cm. Chemicals materials are $HNO_3$ Acid 69%, HCL Acid 37%, and HF Acid 48%. Reference material is (IAEA-soil-7).

### Physicochemical parameters analysis

A sample weight of 0.5 g was taken and humidity's measured. Then a 10 g weight was taken with a distilled water of 50 ml was added in glass jars., and put in a rocking water bath to shake the samples and wash the sample well for an hour at 24.4 ˚C. Then measured the pH, after that it was placed in plastic boxes with a volume of 50 ml and placed in a centrifuge (which is used for the process of separating liquids from solid materials where they precipitate at the bottom) for a10 min as it rotates at 4000 /minute. Then the total dissolved solids "TDS" and electrical conductivity "COND" were measured.

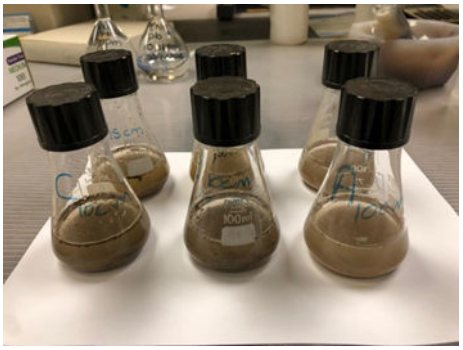

**Figure 5:** Samples after placing them in the rocking water bath.

Then put it in the oven at 45 ˚C for 24 hrs. until samples are dried. The samples are then sifted by sieves of 250 µm size to separate the larger from the smaller ones [5]. The samples were digested afterwards using a microwave program by taking a weight of 0.1 g of the samples with the reference sample IAEA-SOIL-7 taken from a Teflon incubator tube 120 ml. Furthermore 5 ml of 69% nitric acid, 2 ml of Hydrochloric acid 37 %, and 2 ml of 48% HF were added for 49 minutes and were allowed to cool for half an hour in cold water. The result was added from the digestion process of the polypropylene bottle and the addition of distilled water DDW until we reach 30 ml and 1 ml from samples was taken, 0.1 ml of radium was added and then 1 ppm was combined to all samples and dilution to 10 ml with 1% HNO3. Standard have been prepared with 10, 50, 100 ppb.

## Results and Discussion

### Heavy metals concentration assessment

Chemical analysis has been done for 6 selected samples from Al-Shabanat farm. The chemical analysis has been done at NSRI, -Riyadh - by using Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) from Perkin- Elmer ELAN 90. In general, the comparison was between depths and the concentrations of these 7 heavy metals.

The results show all elements, as follow, generally Zn has the highest value, while Cd has the lowest value. The results of concentrations levels in the soil depth 10 and 15 cm in samples A are listed in the following order: Zn > Cr > Ni > Cu > Pb>As>Cd., sample B results are listed by ordering: Zn > Cr > Ni > Cu >Cd. As concentration result in sample C at the depth 10 cm, is high, however, Pb is high in sample C at depth 15 cm. Quality assurance: standard reference materials, (Soil 7) (IAEA) from the internarial Atomic Energy Agency, Vienna, Austria was used. The quantitative analysis result is shown in figure 6.

| Element | Recommended Value mg/kg | 95% Confidence Interval mg/kg | N* |
|---|---|---|---|
| Na | 2400 | 2300 – 2500 | 33 |
| Mg | 11300 | 11000 – 11800 | 24 |
| Cr | 60 | 49 – 74 | 41 |
| Ni | 26 | 21 – 37 | 30 |
| Cu | 11 | 9 – 13 | 34 |
| Zn | 104 | 101 – 113 | 44 |
| As | 13.4 | 12.5 – 14.2 | 25 |
| Cd | 1.3 | 1.1 – 2.7 | 18 |
| Pb | 60 | 55 – 71 | 31 |
| Co | 8.9 | 8.4 – 10.1 | 32 |
| Mo | 2.5 | 0.9 – 5.1 | 5 |
| Hg | 0.04 | 0.003 – 0.07 | 5 |

**Figure 6:** Shows the range value for each element in reference soil

The results values show that there is no pollution in that soil based on soil reference for example, sample C at 10 cm was 9.28 ppm, however in soil reference between 12.5-14.2 ppm (Figure 7).

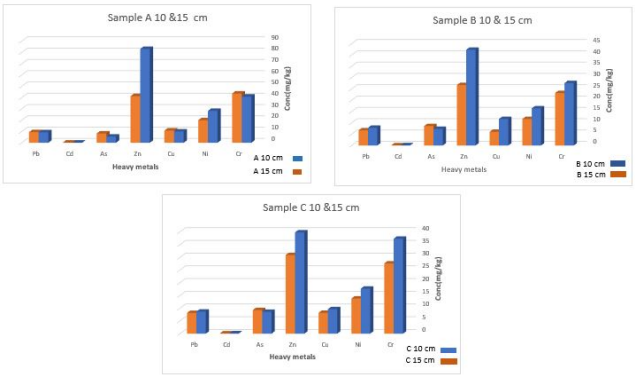


**Figure 7:** Shows the concentrations value for metals in each sample with different depths.

## Treating contaminated soils

There are different methods for treating contaminated mineral soils. They range from physical and chemical methods to biological methods. Most physical and chemical methods(such as packaging, hardening, persistence, electrical electricity, glazing, steam extraction, soil washing and cleaning) are expensive and do not make the soil suitable for plant growth.

On the other hand, a biological approach (biological treatment) encourages the regeneration of plants on contaminated soil. It is an environmentally friendly approach because it is achieved through natural processes. Biological therapy is also an economical treatment technique compared to other treatment methods. Biological treatment is an effective method for treating soil contaminated with heavy metals. It is a widely accepted method and is mostly implemented on site; thus it is suitable for creating / recreating crops on treated soil. Microorganisms and plants use various mechanisms for the biological repair of contaminated soil. Using plants to treat contaminated soils is a more common method of treating soils contaminated with heavy metals, and ensures a more efficient cleaning of soils contaminated with heavy metals. However, the success of this approach is largely dependent on the types of organisms involved in the process.

## Physico chemical properties of soil

The moisture content is higher, because the area present in sample B is a greenhouse. It is called greenhouse cultivation, it is a unique and specialized form of agriculture, which enables some control of wind velocity, moisture, temperature and it works for improving crop productivity in this region. As for samples A and C present in an open environment, influenced, due to the climate factors, which is still among the greatest constraints in crop production in it, temperatures that are either too hot or too cold, moisture deficiencies or excesses. As for the different moisture content between samples A and C is that sample A is more exposed to the sun directly, that makes them less moisture content, as for sample C, it is less exposed, and therefore it has higher moisture content of A. The moisture content in the depths differs from depth, in the samples B and C whenever the depth, increases moisture content. The first depth in the sample B is (15.472) and the second depth is (15.716). As for the sample C its first depth is (12.121) and second depth is (13.545), which mean that (SMC) increases with increasing soil depth, where the reason attributed to the soil in the first depth more exposed to air, sunlight and heat and this leads to loss of moisture compared to other depths. There is a direct relationship between the depth of the soil and moisture content, where the moisture increases with increasing the soil depth.

## pH measurements

Most soils have pH values between 3.5 and 10. In higher rainfall areas the natural pH of soils typically ranges from 5 to 7, while in drier areas the range is 6.5 to 9. The correct balance is where the soil pH is between 5.5 and 7.5, so every effort should be taken to check soil pH levels regularly. Early identification of soil pH problems is important as it can be both costly and difficult to correct long-term nutrient deficiencies. As it shows in sample A and B, the rate of pH raises as the depth increases, while its almost the same in both depths of sample C, probably due to soil mixture, so they almost the same, except in 0.1 degree that may attribute due to procedural error. But for both samples A and B, they show the same difference, except sample B shows bigger difference between the depths, perhaps because of the effect of the greenhouse of region B. Some fertilizers can change soil pH and increase or reduce the amount of nutrients available to plants. Fertilizers such as crushed sulfur and some ammonium-based nitrogen fertilizers lower pH and make soil more acid. Therefore, they are useful for soils with problems caused by high pH (Figure 8).

| Sample name | pH |
|---|---|
| A 10 cm | 7.4 |
| A 15 cm | 7.8 |
| B 10 cm | 7.3 |
| B 15 cm | 8.3 |
| C 10 cm | 7.8 |
| C 15 cm | 7.7 |

**Table 4:** Results of pH measurements

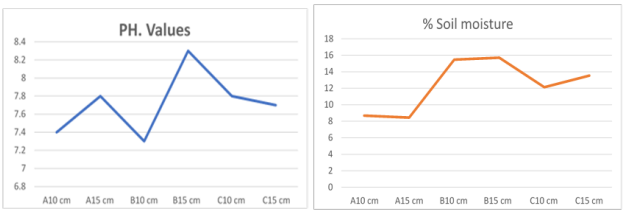


**Figure 8:** Graph shows the levels of Soil moisture and pH for each sample.

## Conductivity and TDS

Quantity of soluble salts (TDS). It is the group of positive and negative ions present in the soluble soil, and its source in the soil is an organic compound resulting from human or inorganic activities resulting from the melting of sulfates, carbonates, sodium and

chlorides, and this depends on the concentration of each of the Electrical conductivity (E.C):

conductivity It is a measure of the ability of the aqueous solution to conduct electrical current, and soil conductivity is related to the concentration of dissolved mineral salts in it, as they are directly proportional. It is a quick way to determine the amount of salts and dissolved solids. Acids, bases and inorganic salts dissolved in water are good conductors of electric current, while organic salts and acids are poorly conductive of electrical current. The relationship between them is direct, The greater the total amount of soluble salts, the greater the electrical conductivity. The value of conductivity is almost twice the value of total dissolved salts approximately.

### Explanation

The proportions of salts in the samples differed due to the methods of irrigation and fertilizers used: Sample(A) , The percentage of salts in the surface is less than the depth due to the fact that the irrigation was sprayed by mixed water first on the surface, and the salts are deposited in the surface and then irrigation is carried out with stagnant water to pass the salts through the soil avoiding the formation of a salt layer on the surface that in turn prevents the plant from growing, Less than the rest of the samples To use compost Organic. The sample(B), the percentage of salts in the surface more than the depth due to irrigation, the tubes were buried with filtered water ten centimeters deep in order to reach the roots of the plant before mixing it with soil, and fertilizers industrial on the surface. Sample(C), The percentage of salts in the surface is less than the depth due to the aforementioned irrigation method mentioned in Sample A, but the proportions of salts are more than the rest of the samples in it due to the use of unfiltered water a mixture of industrial and organic fertilizers.

## Conclusion

This study indicates that it was confirmed that all the samples that were studied did not contain pollution rates because of the factors that were used to reduce the pollution rate and the average heavy metal contents of the fertilizers are within the acceptable limits. On the other hand, the farm may have been biologically treated and the soil is renewed from time to time to ensure that it is not contaminated. This method may reduce the concentration of heavy metals. Furthermore, this may be due to factories regulations and controls that waste does not leak into the surrounding environment.

## Recommendations

Ensuring heavy metal concentrations in agricultural soils, especially in industrial areas, is extremely important to reduce health risks that pose a threat to human, animal and plant health, to ensure the health of agricultural production, to enhance food security, and to reduce pollution. During the study, a suitable site surrounded by pollutants must be chosen to ensure that the soil is healthy and free from harmful effects, and take care to choose the most appropriate method of analysis to obtain reliable results

## References

1. Li, Fengxu, Zhang Jiquan, Cao Tiehua, and Li Sijia, et al. "Human health risk assessment of toxic elements in farmland topsoil with source identification in Jilin Province, China." Int J Environ Res 15, (2018): 1040.
2. Dixit, Ruchita, Malaviya Deepti, Pandiyan Kuppusamy, and B Singh Udai, et al. "Bioremediation of Heavy Metals from Soil and Aquatic Environment: an Overview of Principles and Criteria of Fundamental Processes." *Sustainability* 7, (2015): 2189-2212.
3. Chibuike, Grace U, and C Obiora Smart. "Heavy Metal Polluted Soils: Effect on Plants and Bioremediation Methods." Appl Environ Soil Sci. 2014.
4. Ellison, Katherine. "The Nature of Farms." *Front Ecol Environ 4,(2006): 280-280.*
5. Carey, Edward E, Jett Lewis, J Lamont William, and T Nennich Terrance, et al. "Horticultural crop production in high tunnels in the United States: A snapshot." HortTechnol 19, (2009): 37-43.

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