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Estimation of soil pollution with wastewater by measuring the content of heavy elements in some vegetables grown in it

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Abstract: This research was conducted to estimation of soil pollution with wastewater by measuring heavy metals (Lead, Chromium, Copper, Zinc and Manganese) in Samples of imported vegetables (from Egypt), and the vegetables that we sampled are: cucumbers, tomatoes, eggplants, zucchini, onions and carrots, collected from the central vegetable market in Tobruk City. The samples prepared by dry-ashing digestion method and the concentrations of heavy metals were determined by using atomic absorption spectroscopy (AAS). The results showed a significant increase in the levels of heavy metals that were measured in the samples.
Keywords: pollution, wastewater, vegetables, heavy metal.

Introduction

Environmental pollutants are substances or energy introduced into the environment that have adverse effects, or adversely affects the usefulness of a resource. These can be both naturally forming (i.e., minerals or extracted compounds like oil) or anthropogenic in origin (i.e., manufactured materials or byproducts from biodegradation). Pollutants result in environmental pollution or become public health concerns when they reach a concentration high enough to have significant negative impacts [1].

Untreated wastewater is a term used to describe wastewater that has not been treated to remove harmful pollutants. This type of wastewater can contain a variety of contaminants, including bacteria, viruses, parasites, heavy metals, and other chemicals. The use of untreated wastewater to irrigate vegetable fields is a common practice in many parts of the world. This is because wastewater is a readily available source of water, and it can be used to grow crops throughout the year. However, the use of untreated wastewater can also pose a number of risks to human health and the environment [2,3].

Growers are often unaware of the health risks associated with growing vegetables on sewage and industrial effluents, which can lead to a buildup of heavy metals in the food chain [4].

Heavy metal pollution in water and soil is a serious problem that is of great concern to both the public and scientists, as these metals can be extremely toxic to human health and biological systems [5].

Research has shown that the rate at which plants absorb metals increases as the concentration of metals in the soil increases. In soils with low levels of metals, there is often a linear relationship between the concentration of metals in the soil and the concentration of metals in plants. For example, a study found that the concentration of Zn and Cd in bean leaf tissue increased with the amount of metals added to the soil through sludge applications. The concentration of metals in the plant tissue reached a maximum level, however, and did not increase further with additional applications of metals [6,7].

Urban agriculture can introduce new risks to public health, but it is also exposed to environmental hazards that can affect producers, traders, and consumers. These hazards are not unique to urban agriculture, as other activities in urban areas can also expose people to contamination. The list below summarizes the potential health hazards associated with urban agriculture, as identified by regional researchers in Africa, Asia, and Latin America [8].

1. Contamination of crops grown on polluted soils or irrigated with river water contaminated with industrial and chemical byproducts.
2. Microbial and heavy metal contaminants in untreated or improperly treated urban waste and human and animal excreta used in agriculture.
3. Zoonotic diseases associated with urban livestock keeping.
4. Encouragement of vector breeding sites.

The urban food system is at risk from industrial and chemical byproducts that can pollute crops, soil, and water. These pollutants can cause health problems for people of all ages, but children are especially vulnerable. Heavy metals are a major source of pollution in soils, and they can enter the food chain through irrigation, solid waste disposal, fertilizer and pesticide application, and atmospheric deposition [9].

Hardoy and Satterthwaite argue that chemical pollution is a major environmental concern in urban areas. Industrial and chemical pollutants are often disposed of in local bodies of water or vacant land without adequate measures to protect human health. This can lead to a variety of health problems, including respiratory problems, cancer, and reproductive disorders [10]. They claim that "reports from Third World Cities of severe health problems arising from human contact with toxic or hazardous wastes are increasingly common".

Urban agriculture is a major source of heavy metal exposure for people living in urban industrial areas. This is because urban agriculture often takes place on contaminated land, and the produce grown on this land can contain high levels of heavy metals. The World Health Organization (WHO) and Polish researchers have found that 60-80% of heavy metal toxins found in human bodies in urban industrial areas are the result of consuming contaminated foods, rather than air pollution. [11].

Heavy metals are of considerable environmental concern due to their toxicity and cumulative behavior [12]. Trace quantities of certain heavy elements, such as Cr, Co, Cu, Mn, and Zn, are essential micronutrients for higher animals and for plant growth [13]. On the other hand, they are easily assimilated and accumulate in plants and animals' bodies [14]. Vegetables absorb heavy metals from the soil as well as from surface deposits on the parts of vegetables exposed to polluted air [14]. Moreover, the presence of heavy metals in fertilizers contributes an additional source of metal pollution for vegetables [15].

MATERIALS AND METHODS

Samples of the edible vegetables that were imported from Egypt collected from Tobruk Central Vegetable Market in April 2023, the samples were randomly collected included: Cucumber, Tomato, Eggplant, Zucchini, Carrots and Onion.

The vegetables were first washed in fresh running water to remove any dirt, dust, or parasites. They were then washed with distilled water to remove any remaining contaminants. The vegetables were then sliced and dried in an oven at 90 degrees Celsius for 48 hours. After drying, the vegetables were ground into a fine powder [16].

Also, we measured all sample wight before and after dried to determine the moisture content in all vegetable samples.

Two grams of dry matter for each sample was weighed in a porcelain crucible and burn it on hot-plate at 120°C. After burning, ash was obtained at 550°C in a muffle furnace for four hours [17]. Then the ash was dissolved with 5ml 1N Nitric Acid and after 2 hours the solution transferred to a 100-ml calibrated flask and filtered with filter paper and fill to 100 ml with same diluted acid.

Concentrations of heavy metals (Zn, Cu, Pb, Cr, Mn) were measured by Drawell DW-AA320N Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The moisture content in all vegetable samples is shown in table 1:

Table1: Moisture and solid contents in samples

Sample / Content	Zucchini	Eggplant	Carrots	Cucumber	Onion	Tomato
% moisture	93%	94.2%	89.1%	95.7%	89%	93.9%
% solid	7%	5.8%	10.9%	4.3%	11%	6.1%

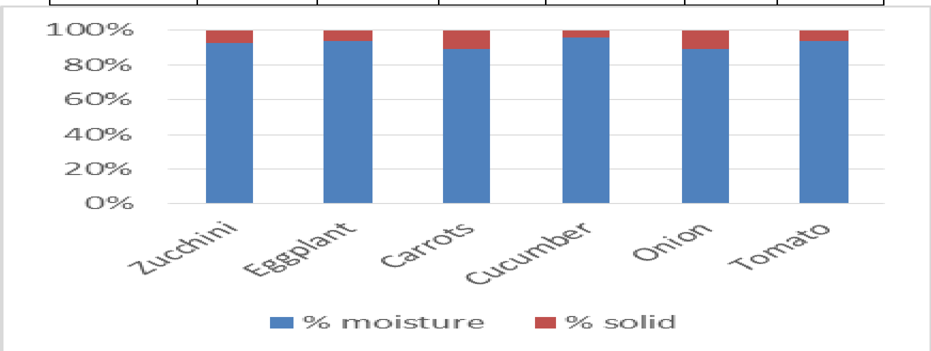

Figure 1: Comparing % of Moisture and solid contents in samples

Trace elements are essential in very small amounts for all life forms. However, they can also be toxic in higher concentrations, especially when they are present in organic compounds. Lead is a good example of a trace element that can be highly toxic, even in small amounts. It can cause a variety of health problems, including damage to the kidneys, liver, heart, and vascular and immune systems [18]. The presence of heavy metals in vegetables can be influenced by a number of factors, including the soil, fertilizers, and the proximity of industries or highways. It is important to be aware of the potential for heavy metal contamination in vegetables, as it can pose a health risk to humans, animals, and plants [19].

Copper and zinc are two trace elements that are essential for human health. They are required for a variety of biological functions, including the formation of enzymes and the maintenance of redox balance. However, even these essential nutrients can be toxic in high doses. It is important to consume copper and zinc in moderation, and to be aware of the potential for contamination in food [20].

The mean values of Zn, Pb, Mn, Cu, and Cr concentrations in 6 vegetable samples (Cucumber, Tomato, Eggplant, Zucchini, Carrots and Onion), are given in table 2 (Concentration mg/kg).

Table2: Concentrations of heavy elements in samples

Sampl / Metal	Zucchini	Eggplant	Carrots	Cucumber	Onion	Tomato
Pb	0.771	0.962	3.13	1.132	1.329	0.66
Cr	0.218	0..818	4.7	0.449	0.271	2.929

Zn	7.4	2.562	9.133	5.388	6.98	3.824
Mn	0.504	1.479	3.144	1.378	1.313	0.732
Cu	N D	0.017	6.677	0.969	N D	N D

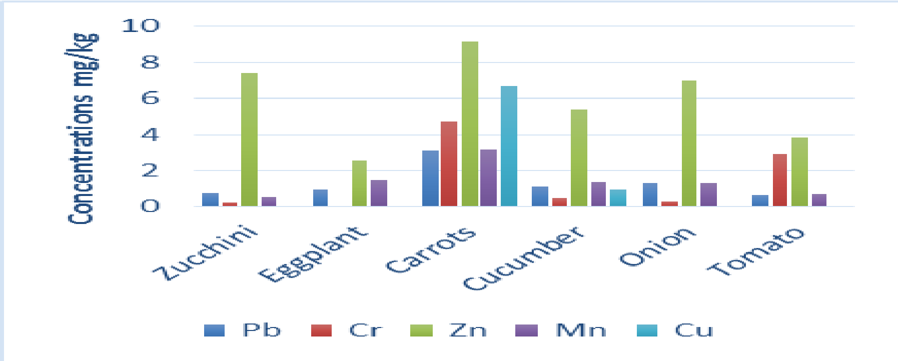

Figure 2: Concentrations of heavy elements in samples

The comparison between the main values of heavy metals in the samples with the values of the maximum normal value according to the Food and Agriculture Organization (FAO) [21], are in tables and figures 3, 4, 5, 6 and 7.

Table3: Lead concentrations in the samples and the maximum permissible value.

Sample \ Value	Value of Pb in sample	Normal value (Maximum)
Zucchini	0.771	0.1
Eggplant	0.962	0.1
Carrots	3.13	0.1
Cucumber	1.132	0.1
Onion	1.329	0.1
Tomato	0.66	0.1

Table4: Chromium concentrations in the samples and the maximum permissible value.

Sample \ Value	Value of Cr in sample	Normal value (Maximum)
Zucchini	0.218	0.1
Eggplant	0.818	0.1
Carrots	4.7	0.1
Cucumber	0.449	0.1
Onion	0.271	0.1
Tomato	2.929	0.1

Table5: Zinc concentrations in the samples and the normal value.

Sample \ Value	Value of Zn in sample	Maximum Normal value
Zucchini	7.4	8.3
Eggplant	2.562	1.6
Carrots	9.133	2.4
Cucumber	5.388	1.5
Onion	6.98	1.7
Tomato	3.824	1.7

Table6: Manganese concentrations in the samples and the normal value.

Sample \ Value	Value of Mn in sample	Maximum Normal value
Zucchini	0.504	2
Eggplant	1.479	2.3
Carrots	3.144	1.8
Cucumber	1.378	0.9
Onion	1.313	1.3
Tomato	0.732	1.2

Table7: Copper concentrations in the samples and the normal value**.**

Sample \ Value	Value of Cu in sample	Maximum Normal value
Zucchini	N D	1
Eggplant	0.017	0.9
Carrots	6.677	0.6
Cucumber	0.969	0.7
Onion	N D	0.4
Tomato	N D	1.8

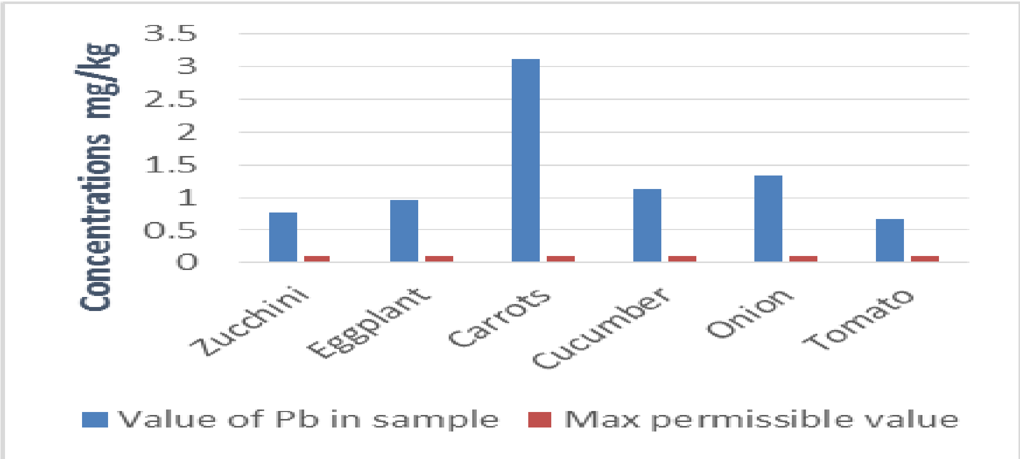

Figure3: Comparison of lead concentrations in the samples with the maximum permissible value.

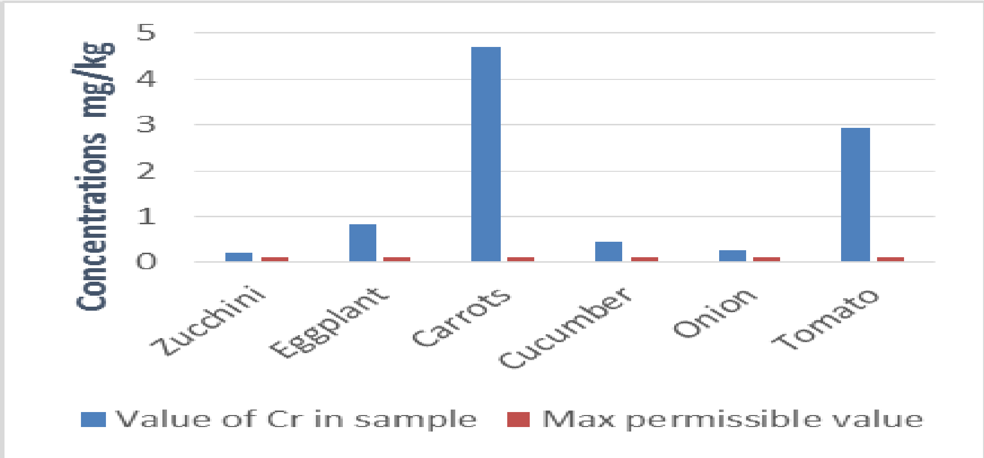

Figure4: Comparison of Chrome concentrations in the samples with the maximum permissible value

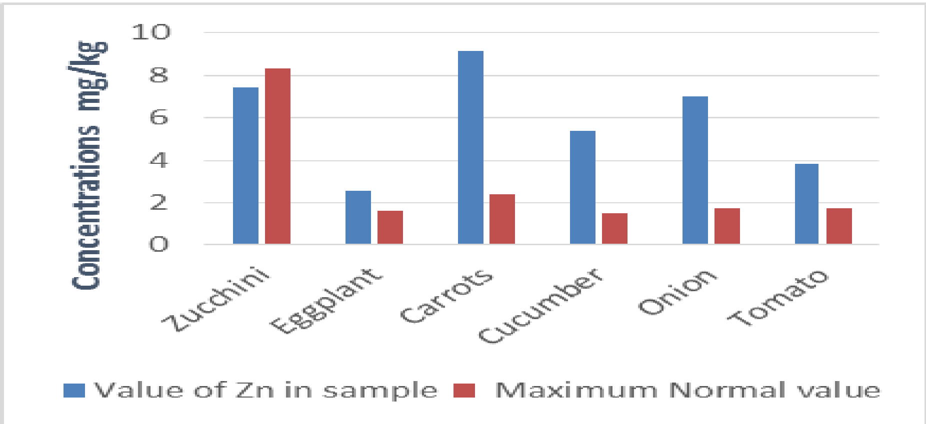

Figure5: Comparison of Zinc concentrations in the samples with the maximum normal value

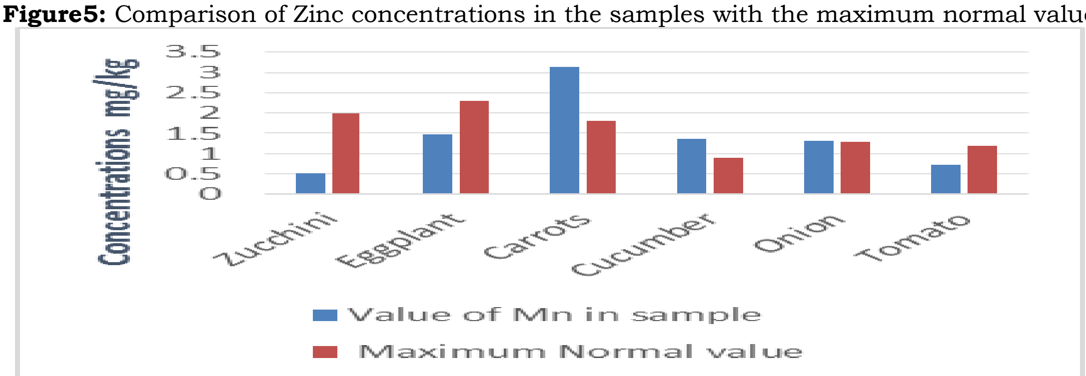

Figure 6: Comparison of Manganese concentrations in the samples with the maximum normal value

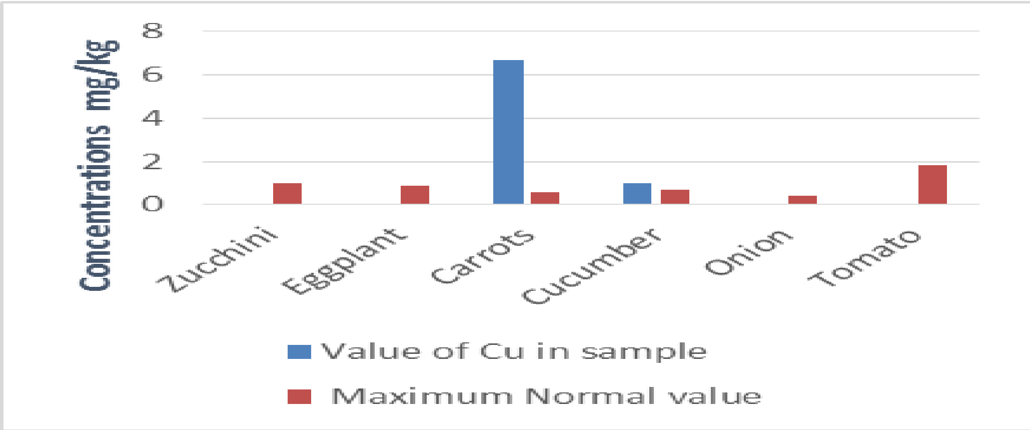

Figure 7: Comparison of Copper concentrations in the samples with the maximum normal value

From tables and figures 3, 4, 5, 6 and 7, we can see:

- Lead values recorded very high percentages in all samples when compared to the maximum permissible values, reaching more than 31 times the permissible rate in the carrot sample.
- Chromium values also recorded rises in all samples, some of which had a very high chromium percentage, as the carrot sample recorded a rise of 47 times the permissible value.
- Zinc, manganese and copper recorded high values in some samples, but they are not very high compared to lead and chromium, where zinc recorded the highest value in the onion sample which is 4.1 times the normal rate, while manganese recorded the highest value in the carrot sample and it reached only 1.74 times higher than the normal rate, while copper recorded readings in only three samples, one of which was in the carrot sample, and it was very high, as the rate of rise reached 11.1 times the normal rate.

Conclusion

The values of heavy metals in the samples recorded an increase in 22 out of 28. Lead and chromium, all of its readings recorded very high values, above the maximum allowable rate.

The large increase in the values of the heavy metal readings indicates a significant contamination in the soil used in cultivating the samples. This pollution in the soil leads us to the conclusion that its pollution was not only through the air, but there must be other reasons that increased the percentage of pollution, perhaps the most prominent of which is wastewater pollution, especially industrial wastewater that pollutes the water used in agriculture in that soil, which led to the occurrence of accumulation and high Levels of heavy metals in the soil with time. This could explain the high levels of minerals such as lead and chromium (and copper in some samples) to very high levels.

In the end, it must be notes that the continued absolute dependence of the Libyan markets on imported vegetables contaminated with these high levels of heavy metals, without a strict mechanism to control quality standards in order to import this type of food, will lead to many public health problems for the citizen in the near future.

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