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A study on the assessment of lead and copper elements in a designated areas of agricultural soil in the city of Benghazi, Libya

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ABSTRACT

This study investigates the concentrations of lead and copper in soil samples collected from different locations, analyzing the potential contamination of heavy metals and their implications for the environment. Statistical analysis revealed significant differences in lead concentrations between the samples (ranging from 9.45 mg/kg to 24.75 mg/kg) with the highest concentration observed in sample number 6. These levels exceed permissible limits in several countries, suggesting potential soil contamination, which warrants further evaluation of the impact on plant growth and agriculture. Additionally, copper concentrations ranged from 5.65 mg/kg to 15.10 mg/L, with significant differences observed at a probability level of less than 0.001. These findings are consistent with previous research indicating that high levels of copper accumulation can lead to soil toxicity and hinder plant nutrient absorption. The study highlights the importance of monitoring and mitigating heavy metal pollution in soil to prevent adverse effects on ecosystems, agricultural productivity, and human health.

1 Introduction

Heavy metals in soil represent a significant environmental concern, impacting both human health and ecosystems. Elements like lead, cadmium, and mercury can enter the soil from multiple sources, including industrial emissions, mining operations, and agricultural activities (Alloway, 2013). The extraction of minerals through mining operations is a major source of these contaminants, resulting in extensive ecological damage and raising significant concerns for human health (Setia et al., 2023).

Human activities are the leading cause of heavy metal accumulation in soils. Industrial processes release substantial quantities of these metals into the environment, where they persist and accumulate over time. Furthermore, the application of fertilizers and pesticides in agriculture introduces additional heavy metals into the soil, further exacerbating contamination levels (Kabata-Pendias, 2010).

Over various historical periods, the primary sources of atmospheric lead emissions have been coal combustion, the use of leaded gasoline, and non-ferrous metal smelting. Furthermore, the transportation sector, particularly automotive transport, has contributed to air and soil pollution by releasing heavy metals such as chromium, copper, lead, cadmium, zinc, and others (Karn et al., 2021).

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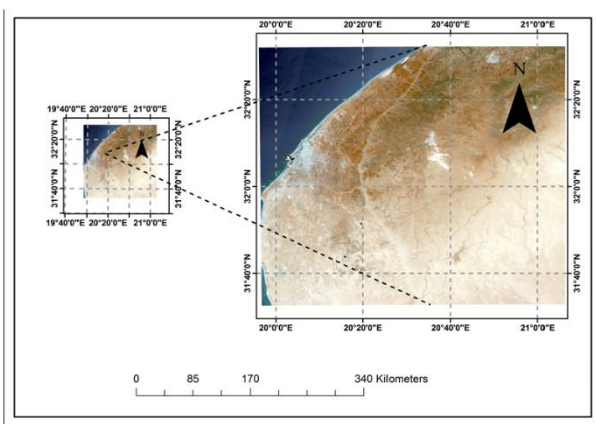
The presence of heavy metals in soil presents serious health hazards. These metals can enter the food chain through crops cultivated in contaminated soil, potentially causing health problems such as neurological disorders and cancer in humans. In addition, heavy metals adversely impact soil biology, decreasing fertility and damaging both plant and animal life (Tchounwou et al., 2012).

Soil contamination by heavy metal ions presents serious environmental risks, including soil and water pollution, disruption of ecosystems, and the release of harmful substances into the environment (Li et al., 2023). This study was conducted to assess and compare the concentrations of lead and copper at different sampling locations in the agricultural soil of Benghazi, Libya. Positive results indicate the extent of the contamination of the soil by these metals.

2. Materials and Methods

2.1 Study area

Samples were collected for this study in October 2024 from farms in the Sidi Khalifa region, Benghazi. The coordinates shown in Map 1 show the sampling areas.



Map 1: shown the sampling locations.

2.2 Heavy Metal analysis

Samples of surface soil were collected using shovels and placed in polyethylene bags from each site. The samples were then labeled at each site and transported to the laboratory. The soils were dried at room temperature and passed through a 2-mm sieve. The samples were stored in a dry place until the necessary analysis could be performed.

Approximately 1.0 g of the dried soil sample was digested in 15 mL of a hydrochloric acid-nitric acid mixture (HCl: HNO_3, 3:1) for 4–5 hours using an electric heater at a temperature of about 110°C. The digested solution was then cooled, filtered through Whatman No. 42 filter paper, and transferred to a 50 mL flask. The filtrate was diluted to the mark with deionized water. The soil samples are now ready to be analyzed using atomic absorption spectrophotometry (Jones et al., 2002). The atomic absorption method was employed to measure lead and copper concentrations using a Philips PU 9100X atomic absorption spectrophotometer (AAS), equipped with a Slotted Tube Atom Trap (STAT) unit, under the following operating conditions:

Operating conditions	**Lead**	**Copper**
Wavelength nm	217	324.75
Lamp current M A	108	15
Slit width nm	0.5	0.7
Flow Rate Fuel/Air Acetylene/L	0.9-1.2	1.5-5.0

3. Results and Discussion

Table 2: The mean concentrations of heavy metals (Lead and Copper) in agricultural soil in the city of Benghazi

Sample number	Pb mg/kg Mean ±SD	Cu mg/kg Mean ±SD
1	12.95 ±0.02	11.65±0.001
2	12.00±0.01	12.25±0.004
3	12.65±0.01	13.20±0.002
4	13.45±0.01	11.40±0.004
5	9.45±0.02	10.30±0.002
6	24.75±0.03	5.65±0.003
7	12.15±0.01	10.25±0.001
8	9.55±0.02	12.90±0.002
9	12.25±0.04	8.50±0.003
10	11.6±0.02	10.05±0.0001
11	14.20±0.02	10.45±0.001
12	16.90±0.02	9.35±0.002
13	16.80±0.03	11.55±0.001
14	15.80±0.02	10.60±0.003
15	17.50±0.02	12.40±0.001
16	17.97±0.04	12.65±0.003
17	16.75±0.02	11.40±0.003
18	19.70±0.012	15.10±0.004
19	18.90±0.02	11.80±0.001
20	21.40±0.013	10.70±0.002

The statistical analysis of these results confirmed significant differences between sample collection locations in terms of lead concentration, with a probability level of less than 0.05. The concentrations of lead range from 9.45 mg/kg to 24.75 mg/kg. The highest lead concentration is 24.75 mg/kg (sample number 6), while the lowest concentration is 9.45 mg/kg (sample number 5).

These levels are considered high compared to the permissible limits in some countries, where the maximum allowable lead concentration in the soil ranges from 5.00 to 15.00 mg/kg (according to the World Health Organization). This suggests that the soil may be contaminated with lead, warranting further evaluation of potential impacts on plants and agriculture. Noticeable fluctuations in the concentrations are observed between the samples, which may indicate intermittent pollution or environmental or industrial influences (Kabata-Pendias, 2011).

A study by Adriano (2001) showed that lead is one of the most harmful heavy metals to the environment. It can accumulate in the soil for extended periods, affecting plant growth and posing a threat to the health of animals that feed on contaminated plants. A study by Duruibe & Ogwuegbu (2007) discussed the effects of lead contamination in soil on the agricultural environment, highlighting that high concentrations of lead tend to lead to the degradation of soil properties and negatively impact plant growth.

According to Adriano (2001), such concentrations can affect the chemical interactions in the soil, leading to a reduction in the availability of nutrients for plants. Additionally, lead may enter the food chain through contaminated plants, exposing animals and humans to the risk of poisoning.

Smith et al. (2018) found that Pb concentrations in urban soils ranged between 10 and 25 mg/kg, which is similar to the values seen in this study. The variation in Pb levels could be linked to local industrial activities or vehicle emissions, as Pb is often a byproduct of such processes

Jones et al. (2020) reported Pb levels in contaminated agricultural soils in a region near a mining site, where concentrations ranged from 5 to 30 mg/kg. This comparison suggests that the levels observed in your samples are within typical ranges, though potentially higher levels can indicate areas of heavy pollution.

Brown et al. (2017) investigated Cu levels in agricultural soils and found typical concentrations ranging from 8 to 15 mg/kg, which aligns with the findings in this study. They noted that Cu is often linked to agricultural practices, particularly the use of Cu-based pesticides and fungicides.

There are highly significant differences in terms of the copper levels at a probability level of less than 0.001. Copper concentrations range from 5.65 mg/kg to 15.10 mg/kg. Sample number 6 contains the lowest copper concentration, while sample number 18 contains the highest concentration. This is consistent with the concentrations measured in other studies in the soil surrounding industrial areas. A study by Saiyasitpanich et al. (2014) showed that high copper accumulation can lead to toxicity in the soil, causing issues with nutrient absorption by plants. The concentrations recorded in this study may affect plant growth in this soil. Copper accumulation in the soil could lead to negative impacts on agricultural land, such as reducing its ability to support healthy plant growth (Manta et al., 2002).

5. Conclusions

Based on the statistical analysis of the results, significant differences were found between the sample collection locations in terms of lead and copper concentrations, indicating potential soil contamination with heavy metals. The lead concentrations ranged from 9.45 mg/kg to 24.75 mg/kg, levels which are considered high compared to permissible limits in some countries, highlighting the need for further assessment of the impact of this contamination on plants and agriculture. Additionally, the copper concentrations ranged from 5.6513 mg/kg to 15.10 mg/kg, consistent with previous studies that have shown that high copper accumulation can lead to soil toxicity, affecting nutrient absorption by plants.

Studies indicate that lead and copper contamination in soil can degrade soil properties and negatively affect plant growth. Moreover, contaminated plants may transfer these metals into the food chain, posing a risk of poisoning to animals and humans. Therefore, the results suggest the urgent need for measures to reduce heavy metal pollution in soil, as well as further studies to evaluate the broader environmental and public health impacts.

Conflict of interest:

I declare that there are no conflicts of interest.

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