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Microorganisms and heavy metals presence in the soil of central Albania and their impact on food crops

Anila Jançe [1, *], Adea Bajri [2] and Admir Jançe [3]

[1] *Nursing - Physiotherapy Department, Medical Sciences Faculty, "Barleti University", Tirana, Albania.*

[2] *"Turgut Ozal" High School, Tirana, Albania.*

[3] *Imaging Department, Technical Medical Sciences Faculty, "European University of Tirana", Tirana, Albania.*

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Abstract

This scientific paper details the presence of heavy metals and microorganisms (primarily bacteria) in the subsurface layers of Tirana, the capital city of Albania, which is in the middle of the country. We can infer some significant conclusions from the data if bacteria and heavy metals are present in sufficient amounts to be regarded as variables contributing to soil pollution.

This study's primary goal was to illustrate the potential link between soil contamination caused by chemicals and microorganisms and the resulting harm to the general public's health. To accomplish this goal, six soil samples collected in June 2024 at a depth of 0.5 m were used. We call attention to the fact that Tirana has been linked over time to considerable air pollution caused by heavy metals and microorganisms.

Through statistical analysis of the data, we were able to derive conclusions about the chemical components that might be responsible for soil contamination.

In summary, we discover that the soil has been chemically contaminated by nickel, which is present in an amount that is roughly 2.2 times higher than what the EU Regulatory Acts have set as acceptable. This is predicated on a qualitative examination of the outcomes in relation to the EU's permitted pollution levels.

We think that the primary causes of Tirana's soil pollution are farmers' overuse of chemical and organic fertilizers, the relevant municipal authorities' poor handling of wastewater, and the disrespectful actions of heavy and light industries operating within the city.

Keywords: Microorganisms; Heavy Metal; Soil Pollution; Nickel; Food Crops; Tirana

1. Introduction

Heavy metal poisoning in the soil near industrial areas has had devastating effects on pastures, woodlands, and agricultural land.

Researchers from the country's universities and research facilities have investigated the heavy metal pollution of Tirana's mines, enrichment plants, and industrial facilities.

* Corresponding author: Anila Jançe

Along with trace elements, some heavy metals are essential for maintaining life and the body's metabolism, including copper, zinc, and selenium [1, 2].

The deposition, and even more the concentration on the rates of heavy metals such as nickel, zinc, cobalt, lead, copper, arsenic, cadmium, and selenium in agricultural lands near areas with a developed industry, is a factor for a considerable change to the whole plant community.

All the above-mentioned chemical elements are part of heavy metals, which are also naturally present in the Earth's crust.

Some of the negative factors that affect the quality of healthy soil are the presence of macro- and microplastics in the soil, excessive use of pesticides, deforestation primarily caused by humans, excessive fertilizer application to agricultural lands by farmers, and the presence of heavy metals above permissible levels [5, 6, 7, 8, 9, 10].

In general, heavy metals are dangerous even in small amounts, and for this purpose, for the benefit of the plant community, but not only, it is important to achieve their elimination through different processes. They have detrimental effects on living things when ingested in small amounts through food, drink, and the air [3, 4, 5, 6, 7, 8, 9, 10].

In cases where the presence of heavy metals is in parameters higher than the respective maximum limit allowed for each of them, the poisoning of the animal world through the food chain can also occur. Heavy metals are dangerous because of their tendency to bioaccumulate [6, 8].

Numerous diseases, such as typhoid, influenza, tuberculosis, and numerous fungal infections that impact plants or animals, can be easily spread through the air [11, 12, 13, 14, 15].

Boaccumulation is the process by which chemical components become concentrated over time in a biological organism as opposed to their concentration in the environment [11, 12, 13, 14, 16].

In the natural world, they are not as focused. Conversely, high concentrations of heavy metals have detrimental effects on human health and the environment in polluted areas [5, 6, 7, 8, 9, 10, 16].

Plants that are exposed to heavy metals experience damage to their cell membranes, abnormal growth of roots and shoots, reduced CO_2 uptake, reduced transpiration, and reduced stomatal conductance [5, 6, 7, 8, 9, 10, 16].

In addition to the primary output, industrial operations produce solid, liquid, and gaseous secondary products, which necessitates continuous management and environmental observation [5,6,7,8,9,10, 16].

pH, redox potential, organic matter, and total metal content are a few examples of the factors that influence the concentration of metals in soil [17, 18].

The soil contamination that existed in a few locations in Tirana in June 2024 is extensively detailed in this essay. To investigate the microbiological and heavy metal level pollution in Tirana, six monitoring locations have been identified in the city's east, north, and southwest way.

1.2-1.4 km distance was observed between each sampling station, far from the city center.

From the processing of the obtained data, we came to the conclusion that the concentrations of almost all heavy metals analyzed such as zinc, arsenic, cadmium, chromium, cobalt, copper and lead are within the normal values determined by the EU, and the only the element that makes an exception is nickel, which is present in the analyzed soils in an amount 2.2 times higher than the maximum allowed parameters.

It is also established that food crops are cultivated in every land that was analyzed. The main crops grown there are fruit trees, wheat, maize, and fodder items [11, 12, 13, 14].

The scientific work undertaken by us aims to contribute to providing preliminary knowledge about the identification of possible factors as well as their impact on soil pollution with heavy metals and microorganisms.

To achieve the above goal, we have analyzed the soil samples taken at the predetermined stations in the Tirana region, determining the presence and number of different microorganisms and heavy metals.

2. Materials and Methods

In June 2024, six soil samples are collected at a depth of 25 to 50 cm in the Tirana area.

Diphenyl carbazide, a colorimetric technique, was used to determine the speciation analysis in water soil extracts [5, 6, 7, 8, 9, 10, 19].

Following that, 25 ml of demineralized water and 2.5 g of soil samples were mixed and left for roughly two hours. After centrifuging the water for 10 minutes at 3500 rpm, a 0.45 μm Millipore filter was used to filter the water [17].

Following extraction, the sample was immediately acidified with a drop of concentrated ultrapure HNO_3 to lower the pH to less than 2.

The sample was suspended in 25 ml of demineralized water containing 10 g of soil after 30 minutes of magnetic stirring, and the pH of the soil was determined using a standard calibration at pH 4 -7 [19].

Numerous investigations revealed that the silt to sand fraction contained over 90% of the soil sediments. There was roughly 9% clay in the mixture.

To determine the grain size, 10 g of the sample were treated with H_2O_2 to release organic material, oxalic acid to release iron, and HCl to remove calcareous material.

3. Results and Discussion

Based on the treatment and laboratory examination carried out, the statistical analyzes obtained as well as the analytical processing of the results obtained on the soil samples collected in six predetermined stations in the Tirana area, for the period of June 2024, we have managed to identify the microbiological presence and heavy metals in these soil samples. Meanwhile, we emphasize that the only chemical element found with a presence beyond the permitted rates that identifies it as a soil pollution factor, is nickel.

The results obtained for each of the six analyzed samples are combined and compared as a common average with the basic parameters predetermined by the EU, with the aim of accurately identifying the level of soil pollution taken in the study.

On Table 1 are given the *Enterococci* and *Coliform bacteria* presence as the main soil microorganisms.

Table 1 Microbial analysis summary for each of the six examined stations

<table>
<tr><th>No.</th><th colspan="2">Index Microbiological</th><th colspan="2">Average (weight of 100 grammes of dry soil)</th><th colspan="2">Overall (%)</th></tr>
<tr><td>1</td><td colspan="2">Enterococci</td><td colspan="2">23912</td><td colspan="2">22.1</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Coliform bacteria (group)</td><td>Coliform bacteria – without E. coli</td><td>62668</td><td rowspan="2">84254</td><td>57.9</td><td rowspan="2">77.9</td></tr>
<tr><td>E. coli</td><td>1586</td><td>20</td></tr>
<tr><td colspan="3">Total bacterial groupings</td><td colspan="2">108166</td><td colspan="2">100%</td></tr>
</table>

The required content and an analysis of the presence of heavy metals at each of the six stations in June are shown in Table 2.

Table 2 The mean concentration of heavy metals in the six stations under analysis

No.	Heavy metals	Average *(mg/kg)*	Suggested content *(mg/kg)*
1	Arsenic (As)	0.92	30
2	Cadmium (Cd)	1.24	3
3	Chromium (Cr)	68	200
4	Cobalt (Co)	31	75
5	Copper (Cu)	52	140
6	Lead (Pb)	69	300
7	Nickel (Ni)	166	75
8	Zinc (Zn)	76	300

All elements except nickel, which show values much above the allowed rate, are within the allowed range.

Arsenic (As) is evaluated at 0.92 mg/kg, the acceptable limit set by European directives being 30 mg/kg, indicating that its presence may be normal. Poisonous soil is defined as 20–40 mg/kg, while normal soil is measured at 5 mg/kg.

When *cadmium* (Cd) content is less than 0.1 mg/kg, it is considered normal; when it surpasses the maximum limit of 3–8 mg/kg set by the EU, it is considered poisonous; and when it is less than 1.24 mg/kg, it is considered almost normal.

The current value of *chromium* (Cr) is 68 mg/kg, which is less than the 200 mg/kg maximum allowed by the Directives. Over 5 mg/kg of Cr is considered part of the normal soil content; over 75–100 mg/kg, the soil is considered poisonous. Its presence is still regarded as being somewhat near but below the allowed level because it is European.

Cobalt (Co) content in soil between 31 mg/kg and 75 mg/kg, the maximum amount allowed by the EU, can be considered almost normal. Cobalt content of 10 mg/kg is considered normal; 40 mg/kg is considered poisonous.

Since *copper* (Cu) is currently tested at 52 mg/kg rather than the 140 mg/kg allowed limit by European laws, its presence can be considered normal. Copper (Cu) has a unit of measurement of 2 mg/kg for normal soil, while poisonous soil has a unit of measurement of 60-125 mg/kg.

Lead (Pb) is present in soil in normal amounts at 69 mg/kg of the maximum 300 mg/kg allowed by the EU, but at 100 mg/kg the soil is considered toxic. Lead (Pb) is a normal component of soil at a level of 10 mg/kg.

Zinc (Zn) levels in our soil (76 mg/kg) are deemed normal since they are below the 300 mg/kg legal limit set by European laws. Zinc, however, is added to normal soil contents at a rate of 10 mg/kg, and 100 mg/kg of zinc is regarded as poisonous soil.

- A concentration of 10 mg/kg of *nickel* (Ni) in soil is considered normal; a concentration of 70–400 mg/kg is considered harmful. At 166 mg/kg of 75 mg/kg, it is found to be 2.2 times higher than the European Union standard and the maximum allowed by European Directives.

Soil contamination can come by heavy metal contamination from industrial waste dumped on the ground or bacterial factors from sewage discharge.

The soil microbial communities in contaminated sites have been demonstrated to contain a significant number of different microbial taxa, such as fungi, actinomycetes, aerobic bacteria, and nitrogen-fixing agents [2, 4, 18].

The presence of heavy metals in the environment is dedicated to and comes mainly from the activities of the smelting and refining industries, the plastic and rubber industry, the technological processes that accompany the melting of ores and metals, as well as the burning of waste that is rich in these elements. They can enter the food chain by ingestion of food, suction from the air, and access to potable water [20].

Excessive levels of heavy metals in the environment can expose humans and other animals to dangerous substances through ingestion, dust inhalation, or the food chain. It is anticipated that food crops contamination will become more serious and widespread in the future, primarily because of the growing trend of globalization regarding the primary food supply sources. As a result of daily ingestion of tainted meat, fruits, and vegetables, the body's level of toxic metal presence will rise.

The fact that 20% of the average calorific consumer goods for every person in the world come from sources other than the earth and the remaining 80% come from crops cultivated directly in the soil serves as further evidence of the phenomenon [21].

Animal waste is used to make organic manure, which is used to fertilize land. However, heavy metal contamination may be present in the remaining feed that the animals eat [17].

Tirana, which is also the capital of Albania and now fully transformed into a real metropolis, is considered one of the most polluted cities in the country. We are mainly of the opinion that this significant pollution is due to factors such as: the rather dense population of Tirana, the numerous and multi-store buildings that have occupied the former green spaces, the road infrastructure and extremely heavy traffic, as well as the increase of the productive activity of the industries operating in the area by not respecting the appropriate measures against environmental pollution, unfortunately accompanied by the lack of proper technical control by the relevant Albanian authorities towards these companies.

It is generally acknowledged that traffic is the source of nickel pollution in the environment [5, 6, 7, 8, 22, 23, 24, 25], primarily from refinery emissions and industrial waste. We think that this elevated concentration of nickel is caused in part by the lithology of the surrounding terrain, which also shows that nickel pollution arises from natural nickel dispersion in the area under study [5, 6, 7, 8, 26, 27].

Even though nickel in excess can be dangerous to human health, nickel is an essential part of urease. Soil-food crop/vegetable systems provide a well-known example of abiotic-biotic interactions in the environment. When nickel levels are too high, it can have a negative direct and indirect impact on crops and human health [28].

In the Tirana region, nickel contamination was discovered in the soil during the analysis period.

4. Conclusion

- Almost ideal parameters are found for each component of heavy metals and microorganisms.
- Of the heavy metals found in the soil around Tirana, the only element that shows pollution at levels about 2.2 times higher than those mandated by the EU is nickel.
- Tirana is considered to have contaminated soil due to the high concentration of nickel; The main source, in our opinion, is the deposit of raw material from the production processes carried out by the light and heavy industries of the city.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest for the presented study.

References

[1] Lacatusu R. Appraising Levels of Soil Contamination and Pollution with Heavy Metals. In: Land Information System for Planning the Sustainable Use of Land Resources, European Communities, Luxembourg, 1998; 393–402.

[2] Censi P, Spoto E, Saiano F, Sprovieri M, Mazzola S, Nardone G, Di Geronimo SI, Punturo R, Ottonello D. Heavy metals in coastal water system. Chemosphere, 2006; 64(7): 1167-1176.

[3] Mantovi P, Bonazzi G, Maestri E, Marmiroli N. Accumulation of copper and zinc from liquid manure in agricultural soils and crop plants. Perugia: Journal of Plant and Soil. 2003; 249-257.

[4] Wolfenden PJ, Lewin J. Distribution of metal pollutants in flood plain sediments. Catena, 1977; 4: 309-317.

[5] Jance A, Jance A. Assessment of Chemical and Bacterial Pollution in Soil Samples from Industrial Areas of Elbasan, Albania. International Journal of Agriculture and Animal Production (IJAAP), 2024; 4(03): 26-32.

[6] Jance A, Jance A, Bogoev V. Underground Distribution of Heavy Metals in Central Albania. International Journal of Advanced Natural Sciences and Engineering Researches (IJANSER), 2024; 8(4): 180-184.

[7] Jance A, Jance A, Bogoev V. Quantitative Data on Microorganisms and Heavy Metals in Middle Albania Soil. International Journal of Advanced Natural Sciences and Engineering Researches (IJANSER), 2023; 7(6): 432-435.

[8] Jance A, Jance A, Bogoev V. Nickel Dispersion in Soil and its Effects on Agricultural Culture in Elbasani town, Albania. Plant Cell Biotechnology and Molecular Biology (PCBMB), 2021; 22(1-2): 18-24.

[9] Jance A, Bogoev V, Jance A. Description of soil impurity for Elbasan city - Albania. GSC Biological and Pharmaceutical Sciences (GSCBPS), 2020; 13(02): 240-244.

[10] Jance A, Bogoev V, Jance A. Soil pollution caused by heavy metals presence, in Elbasani town, Middle Albania. Journal of Multidisciplinary Engineering Science and Technology (JMEST), 2020; 7(11): 13018-13021.

[11] Jance A, Jance A. Paleopalynological Analysis of Primulaceae Family Evolution during the New Holocene Period in Elbasan, Albania. Journal of Environmental Impact and Management Policy (JEIMP), 2024; 4(03): 1-7.

[12] Jance A, Jance A, Kapidani G. Holocene Distribution of Boraginaceae Plants in Central Albania. International Journal of Advanced Natural Sciences and Engineering Researches (IJANSER), 2024; 8(4): 175-179.

[13] Jance A, Jance A, Kapidani G. Holocene Data on Fossil Pollen of Dipsacaceae Plants, Central Albania. International Journal of Advanced Natural Sciences and Engineering Researches (IJANSER), 2023; 7(6): 428-431.

[14] Jance A, Jance A, Kapidani G. Pteridophyta landscape through Holocene epoch in Elbasan, Albania. Plant Cell Biotechnology and Molecular Biology (PCBMB), 2021; 22(15-16): 34-40.

[15] Jay JM, Loessner MJ, Golden DA. Modern Food Microbiology. Food Science Text Series, 7th edition, Springer US, 2006; 790.

[16] Kenarova A, Bogoev V. Heavy metal tolerance of water microorganisms from natural and metal-polluted habitats, Reports of Bulgarian Academy of Sciences, 2001; 54(8): 87-90.

[17] McBride MB. Environmental Chemistry of Soils. First ed., Oxford University Press, New York, 1994; 416.

[18] Flint SJ, Enquist LW, Krug RM, Racaniello VR, Skalka AM. Principles of molecular Biology, pathotegenensis and control, ASM Press, Washington DC, 2000; 804.

[19] Gee GW, Bauder JM. Particle size analysis.In: Klute A. (Ed.), Methods of soils analysis, Part 1. Physical and Mineralogical methods, American Society of Agronomy and Soil Science Society, Madison, 1986.

[20] Gazso LG. The Key Microbial Processes in the Removal of Toxic Metals and Radionuclides from the Environment. A review. Hungary: Central European Journal of Occupational and Environmental Medicine, 2001; 7(3): 178 – 185.

[21] Weggler K, McLaughlin MJ, Graham RD. Effect of Chloride in Soil Solution on the Plant Availability of Biosolid-Borne Cadmium. Journal of Environmental Quality, 2004; 33(2): 496-504.

[22] Bastianelli D, Bonnal L, Jaguelin-Peyraud Y, Noblet J. Predicting feed digestibility from NIRS analysis of pig feces. Animal, 2015; 9: 781-786.

[23] Barbafieri M. The importance of nickel phytoavailable chemical species characterization in soil for phytoremediation applicability. International Journal of Phytoremediation, 2000; 2: 105-115.

[24] Mcllveen WD, Negusanti JJ. Nickel in terrestrial environment. Sci. Total Environ. 1994; 148: 109-138.

[25] Cempel M, Nikel G. Nickel: A review of its sources and Environmental Toxicology. Polish J. of Environ. Stud. 2006; 15(3): 375-382.

[26] Bencko V. Nickel: A review of its occupational and environmental toxicology. J. Hyg. Epidem. Micro. Immun. 1983; 27: 237-247.

[27] Gajewska E, Skłodowska M, Słaba M, Mazur J. Effect of nickel on antioxidative enzyme activities, proline, and chlorophyll contents in wheat shoots. Biologia Plantarum, 2006; 50(4): 653-659.

[28] Yong X, Baligar VC, Martens DC, Clark RB. Plant tolerance to nickel toxicity. 1. Influx transport and accumulation of Ni in four species. J. Plant Nutr., 1996; 19: 73-78.