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Analysis of Heavy Metals and Determination of Physicochemical Parameters in Agricultural Soils as a Condition for the Cultivation of Wheat Varieties *Triticum Aestivum* and *Triticum Durum* in the Agro Ecological Conditions of Kosovo

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ABSTRACT

The purpose of the study is the determination of heavy metals in soil samples and their circulation in the food chain. In this study, the correlation between the presence of heavy metals in agricultural soils and the quality preservation of wheat, specifically *Triticum Aestivum* and *Triticum Durum*, was investigated. The results indicate that over 85% of the samples contain a high presence of metals compared to Kosovar standards. Land surveying was conducted at distances ranging from 20 m to 400 m from the highway. The results for Pb at a distance from 20 m showed a value of 2.11 $mg \cdot kg^{-1}$, while Zn varied with a value of 5.12 $mg \cdot kg^{-1}$. However, the amount of heavy metals in agricultural soil is not sufficient to determine their risk in the food chain. The samples studied from the wheat varieties exhibited the accumulation of metals in the wheat cultivated in the studied soils. Some wheat samples showed high levels of heavy metals, with Pb varying significantly with a value of 1.99 $mg \cdot kg^{-1}$, and Cr with a value of 6.12 $mg \cdot kg^{-1}$. In this study, the circulation of soil metals such as Pb, Cd, Cr, Fe, Cu, Zn, and Mn was monitored. The study then continued with the monitoring of soil physicochemical parameters as indicators of soil quality, such as organic carbon. The results showed variations depending on the distance and its concentration. The maximum protein value varied at 11.9%, gluten at 22.8%, moisture at 11.4%, etc., especially for *Triticum* E. and *Triticum* D. wheat varieties.

Keywords: soil, heavy metals, organic carbon, wheat.

INTRODUCTION

Land fulfills many environmental functions such as economic, social, and cultural ones. Land is a resource that cannot be consumed like other natural resources such as minerals that can be moved and processed in other places (Andrade et al., 2013). The land cannot be acted upon in that way, except in cases of its movement due to various natural disasters, such as those caused by erosion, landslides, and so on (Ahmadpour et al., 2012). The multiple functions of the earth are being threatened by the many pressures related to human activities, and physicochemical, and biological changes in the soil and of the ecosystem closer to the earth's surface (Hoxha et al., 2023). This can result in land degradation and the loss or reduction of the functionality of daily life. It is also observed that in many cases, human activities in daily life lead to physical loss of land because this is the most severe form of land loss which is called land destruction (Abdulrahman et al., 2016). This happens as a result of the surface exploitation of minerals for the construction of settlements and industrial departments and those of water accumulations and waste dumps. (Gashi et al., 2023). Environmental pollution is not only dumping waste in the wrong place or creating illegal landfills. Additionally, land can become polluted by contaminated water, particularly during irrigation (Gibbons et al., 2015). Then there is the case of the use of artificial fertilizers, where some of them are used by the plants while another amount is left in the soil, changing the chemical content of the soil and the microbiological processes in the soil (Shala et al., 2023). The most important factor affecting the complexity and uneven distribution of mineral resources is the chemical and mineralogical composition of the earth's crust (Taszakowski et al., 2016). Most of the composition of the lithosphere consists of non-metallic sources, while from metallic sources only iron and aluminum minerals are represented a little more often on Earth (Możdżer et al., 2017). Also, mineral substances are of natural origin as a product of complex geological processes that appear in the earth's crust, which are used and can be used as they are found in nature (Shala et al., 2023). Mineral resources are unevenly distributed in the world, and this phenomenon is a consequence of the long geological-historical processes of the formation of the earth's crust (Ahmadpour et al., 2012). The importance of wheat as an agricultural crop is in many directions, it is used as a raw material for the production of bread, fermentation, and production of alcoholic beverages, etc.

Natural resources represent the basis of all material goods, which are of special importance for the life and development of humanity. Sustainable management of natural resources, especially land, has become an imperative of contemporary society. The activity of humanity must be developed based on the principles of environmental sustainability with the aim of economic and social prosperity, environmental protection, and improvement of the environment polluted by human activity. Wheat is a food product that can contain high levels of heavy metals present in the soil where it is cultivated. These metals circulate in foods that are made from wheat. Wheat is a necessary food product for the human body, but the presence of heavy metals in the soil during cultivation increases their presence. The presence of metals in wheat increases the likelihood of various diseases, especially Alzheimer's and some other types of cancer, heart problems and decreased immune system. The decline in soil quality for wheat cultivation is attributed to high levels of metals in the water, which result from water pollution. This water is then used to irrigate agricultural crops. Recent reports indicate the presence of heavy metals and metalloids in wheat. The accumulation of metals in wheat is a consequence of polluted water with concentration values between 10 and 150 mg·kg^{-1} in some grains due to poor waste management. High toxicity from prolonged exposure or bioaccumulation in the body increases the risk of disease (Shala et al., 2023):

- Lead (Pb) – accumulates in the body, which has negative effects such as the destruction of various cellular enzyme systems, resulting in damage to the main tissues and organs of the human body. Allowed daily doses (0.0036 mgPb/kg/day), medium (2.61 mgPb/kg/day) and high doses (4.95 mgPb/kg/day) for 60 days are used.
- Cadmium (Cd) – usually accumulates in the body in a high concentration in the liver and kidneys, usually has negative effects on tissues, exposure to it increases estrous cycles and reduces fertility. Permissible daily doses (0.0005 mg Cd/kg/day), medium dose (0.2177 mg Cd/kg/day) and high dose (LD50-5% 0.1148 mg Cd/kg/day). Heavy metals have greater negative effects on humans than any other type of pollutant. WHO estimates that 85% of premature deaths from stroke and heart disease, 15% of deaths from chronic obstructive pulmonary disease or acute pulmonary disease, and 7% of deaths from lung cancer are related to air, water and land pollution with heavy metals. Careful use and good management of land are essential for the preservation and existence of mankind. This implies the use of natural resources in the concept of land regeneration. Good management of agricultural land and clean maintenance of the land for the future represents a good quality of food and safety for their consumption. This study, which analyzes the concentration of heavy metals and determines the physicochemical parameters of agricultural lands planted with wheat, represents an innovation for wheat cultivars. However, it is worth noting that the wheat crop is sensitive to soil impurities. Micronutrients are essential nutrients for plant development in agricultural soils. They play a vital role in metabolic processes, stress protection and crop productivity. Understanding soil micronutrient balance is a visual signs in plants such as chlorosis, necrosis or rust can indicate a

micronutrient deficiency. This is a quick method, but not always accurate. Rapid on-farm tests can give an initial idea of micronutrient levels. However, they cannot replace a thorough soil analysis in the laboratory.

- Iron (Fe) – is an essential trace element for plants, it plays a major role in the processes of photosynthesis, resp iration and chlorophyll synthesis. Its absence in the soil leads to chlorosis, poor growth and low yields of agricultural crops. Iron is found in many different mineral forms in agricultural soils, such as oxides, sulfates, and silicates. Its distribution depends on soil quality and geochemical factors. After absorption, iron is transported through the roots, pulp and leaves of plants, where it is integrated into life processes such as photosynthesis and respiration. Plants absorb iron mainly in the form of Fe2+ and Fe3+ ions through their roots (Dreshaj et al., 2022). This process is influenced by soil pH, temperature and nutrient availability. Iron is an essential mineral that plays an irreplaceable role in agricultural production and productivity. Adequate levels of iron in soil and plants can increase yields by up to 20%, improve the quality of agricultural products by up to 15%, and increase their durability and shelf life by up to 12%.
- Manganese (Mn) – is important for many plant life processes, including photosynthesis, carbohydrate metabolism and protection against oxidative stress. Its absence in the soil can cause deviations in growth and decrease in yields of agricultural crops.
- Zinc (Zn) – is a vital trace element for plant development. It plays an important role in chlorophyll synthesis, protein metabolism and enzyme activity. Zinc deficiency in the soil leads to stunted growth, flowering problems and low crop yields.
- Chromium (Cr) – is an important trace element that plays an important role in agricultural soils. It helps in the metabolism of carbohydrates, proteins and the conversion of sugars by plants. Chromium deficiency can cause slow growth and low productivity of agricultural crops.

The purpose of this study is to analyze the concentration of heavy metals in soil and their circulation in agricultural crops. Priority has been given to the two main wheat producing regions in Kosovo. Compared to the region-specific background values, five heavy metals (Pb, Cd, Cr, Fe, Cu, Zn, and Mn), represented the most serious pollutants in both regions and pollutant concentrations.

MATERIAL AND METHODS

The soil samples were collected in the Dukagjin Plain region, along the Pejë – Deqan road. Samples were collected at different distances from the main road 20 m, 30 m and 40 m, (check point 400 m), at depth (0–30 cm) in Table 2. The soil sampling method is done by mechanical drilling on both sides of the highways, then they are placed in plastic bags and transported to the laboratory of the Agricultural Institute in Peja (Dreshaj et al., 2023).

Soil samples were treated with aqua regia (3 parts HCl and 1 part HNO_3). For the analysis of heavy metals in agricultural soils, the method (ICP-OES), (induction coupled plasma – mass spectroscopy), (induction coupled plasma – optical emission spectroscopy) was used. (Dreshaj et al., 2022).

Analysis of heavy metals in wheat first, the sample grains are carefully cleaned to remove foreign impurities. They are then dried in a controlled environment to remove excess moisture. Further separation and grinding of the samples ensures sufficient homogeneity for analysis.

Wheat samples were microwave decomposed by treating with HNO3 and H2O2. Analysis of the composition of plants can indicate the levels of heavy trace elements in the soil. The standard method used for the analysis of metals in wheat samples is: ISO 15510:2017, MPAES Apparatus/Device (Comparative 1 H NMR Spectra of 2-MPAES-60 (OCH_3).

Determination of the concentration of organic carbon (TOC) is a type of test that is carried out in different areas of the soil. It is indicative of soil pollution with polluted water caused by synthetic organic compounds. Depending on the sampling distance, organic carbon concentration was also tested.

Organic carbon concentration testing was also conducted based on depth to analyze the variable of organic carbon concentration varying with depth (0–30 cm) in Table 1 and Figure 1.

RESULTS AND DISCUSSION

While wheat is primarily cultivated for human consumption, it also serves as an important food source for livestock and plays a significant role in various industries. It is one of the most important crops planted in Kosovo (Dreshaj et al., 2022). Wheat is cultivated to contain normal parameters of heavy metals, and necessary proteins or to contain albumins very valuable for the human

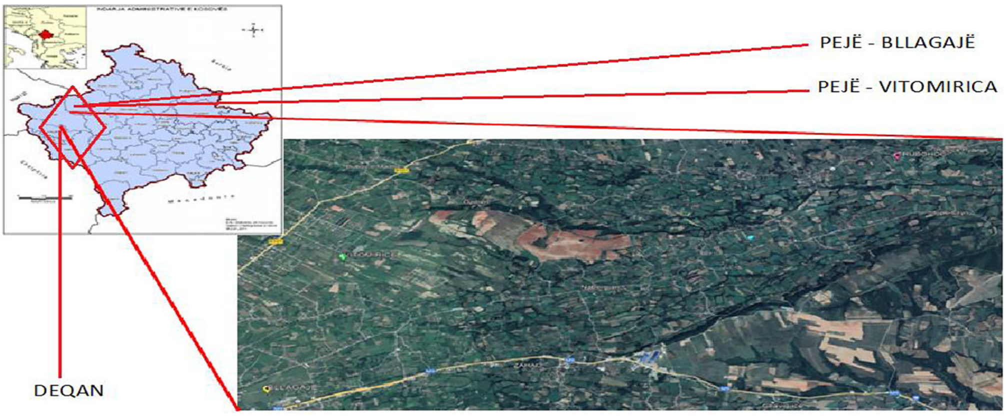

Figure 1. Study area

body, because they are rich in irreplaceable amino acids (Soong et al., 2004). Wheat contains 18 amino acids necessary for human nutrition, such as lysine, arginine, cystine, histidine, leucine, isoleucine, valine, tryptophan, etc. The presence of heavy metals contaminates the grain and reduces its quality (Nsaif et al., 2024).

Cultivation of agricultural crops is also necessary for the development of agriculture. Monitoring the concentration of organic carbon in the soil as a result of the quality of the agricultural soil is presented in Table 1. Through this work, the presence of heavy metals in the agricultural soil as a result of the cultivation of wheat in the Kosovar market is evaluated. Additionally, it identifies differences in physicochemical analyses among the studied wheat varieties. Monitoring of organic carbon concentration in agricultural soils was done depending on the distance, also different soil depth samples were taken at four positions starting from 0.cm to 30 cm depth in the two studied regions in Table 1. Monitoring and managing the normal maintenance of toxic metals and soil physicochemical parameters is a condition for soil quality, presented in Table 2. The cultivation of food products such as wheat and its varieties is the result of good soil management (Li et al., 2017). The soil was analyzed for organic carbon concentration, and the results revealed variability in concentration across the samples (Doughmi et al., 2024). The samples indicate that, on the soil surface, organic carbon concentration varies, with some cases showing lower concentrations depending on the distance of the analyzed samples (Sudarno et al., 2024). At a distance of 20 m and a depth of 10–15 cm, the minimum concentration of organic carbon varies by 0.39%. With an increase in distance to 40 m, the concentration of organic carbon also increases, with a value of 0.3%.

The variability in organic carbon concentration is attributed to the presence of heavy elements near highways. In the municipality of Deqan, the concentration of organic carbon in the analyzed soils ranges from a minimum of 0.38% to a maximum of 0.77%. This represents an increase in organic carbon content of 0.38%. At a distance from 400 m, the percentage of organic carbon is not favorable, ranging from the minimum value of 0.38%. In other sampling locations, the organic carbon content increases to 0.67%, with a change in organic carbon value of 0.29%. This lower value is attributed to the presence of acidic elements in the soil.

The presence of heavy metals in the soil is the result of the mismanagement of agricultural lands

Table 1. Percentage of organic carbon, at different depths of soil adjacent to the highway (Peja – Deqan)

Sampling point		Peja (Percentage of organic carbon) %				Deqan (Percentage of organic carbon) %			
Distance	Depth	0–10 cm	10–15 cm	15–20 cm	20–30 cm	0–10 cm	10–15 cm	15–20cm	20–30 cm
20 m		0.51	0.39	0.52	0.46	0.73	0.71	0.77	0.42
30 m		0.61	0.37	0.49	0.40	0.77	0.65	0.71	0.42
40 m		0.79	0.49	0.51	0.38	0.69	0.52	0.63	0.43
400 m		0.67	0.42	0.67	0.58	0.67	0.38	0.67	0.57

Table 2. Concentration of toxic metals in the soil at different depths, adjacent to the highway mg·kg^{-1}

Year		2023							
The municipalities studied		Peja/Depth (0.15–0.5 m)				Deqan/Depth (0.15–0.5 m)			
Distance	Elements	Pb	Cd	Zn	Cr	Pb	Cd	Zn	Cr
20 m		2.11	0.14	5.12	0.84	1.45	0.08	4.22	0.71
30 m		0.83	0.12	3.82	0.59	0.99	0.02	3.88	0.54
40 m		0.52	0.13	2.91	0.49	0.61	0.07	2.79	0.33
400 m		0.19	0.09	0.45	0.09	0.04	0.03	0.44	0.02
Year		2022							
20 m		2.81	0.15	5.12	0.78	2.32	0.09	4.44	0.49
30 m		1.99	0.07	3.43	0.61	1.29	0.08	3.55	0.39
40 m		0.88	0.04	2.31	0.49	0.50	0.07	1.71	0.33
400 m		0.05	0.11	0.29	0.03	0.03	0.04	0.39	0.04

in the Dukagjin Plain. The use of land for wheat cultivation is necessary due to good climatic conditions. The Drini Bardh basin is the largest in Kosovo R., from this basin all crops are irrigated. Poor management of industrial and urban waste, pesticides, and herbicides, cause this basin to often contain heavy metals above normal parameters. Cultivars use water for irrigation and during the use of this water, there is a content of heavy metals in the water and the presence of heavy metals in the soil also increases. The analyzed samples show the presence of metals depending on the distance and geological soil.

In some locations of the region of Peja, the presence of Zn varies with the highest value of 5.12 mg·kg^{-1}, the value of Zn decreases with increasing distance up to 400 m, with a value of 0.29 mg·kg^{-1} with a difference in the reduction of the value 4.83 mg·kg^{-1}.

Pb metal at a distance from 20 m has a maximum value of 2.81 mg·kg^{-1} as a result of sampling near highways, while the minimum value at a distance from 400 m has a value of 0.05 mg/kg and the difference value. of 2.76 mg·kg^{-1}. The land studied in the Deqan Municipality has shown results for Pb, Cd, Zn, and Cr, their values are smaller because in these regions the studied lands are far from highways, lack industry, and are known as rural areas.

The presence of Pb varies from a maximum value of 1.45 mg·kg^{-1}, while the minimum value at a distance from 400 m has a value of 0.03 mg·kg^{-1} with a difference in values of 0.65 mg·kg^{-1} in Table 2.

In this study, the physicochemical parameters of *Triticum* E. and *Triticum* D. wheat were determined, and the results showed the presence of proteins with the best percentage in *Triticum* D. wheat with an average percentage of 14.3%. The moisture concentration in Adelaide was analyzed with a higher percentage of 11.4% than the other varieties of wheat studied with a difference of 0.7%. The presence of gluten in the analyzed Cobato wheat has an average value higher than 29.7% higher than the other studied varieties. Analysis of other varieties with a gluten variability of 7.1% in Cobato wheat.

All four wheat varieties were analyzed, and the results showed that they are good for their organoleptic properties. The starch content in the studied samples of the AGB-28 wheat variety is the highest at 72.2%. – wheat with a value of 66.5% with a value difference of 5.7% higher than other varieties in wheat AGB-28, are as average values in Table 3.

Physicochemical parameters of wheat *Triticum* E. in the varieties of AGB-28 and Adelaide varieties of these varieties were analyzed at the time of wheat harvest at the agricultural institute of Peja. The protein analysis of Adelaide wheat has the highest value compared to AGB-28 wheat with a value of 0.73% as the average value. The gluten value varies by 0.02%. As for other physicochemical parameters of these varieties, they remain within normal values according to national standards.

Statistical data show for the Adelaide-3 wheat varieties the highest parameters: hectoliter mass has the value 83.4, dirt 2.5, broken grains 2.5, absolute grain weight 45.83 in Table 4.

Heavy metals are the most dangerous pollutants for the environment and human beings. Once heavy metals enter the soil, water or air, they can cause risks to human health through the consumption of food crops grown in these contaminated environments. The statistical results of the study

Table 3. Physico-chemical analysis of wheat varieties *Triticum* E. mean values for protein, moisture, starch control, ash control, gluten

Cultivar	Protein %	Humidity control %	Starch control %	Ash control %	Gluten %
Bisanzio -1	11.7	10.7	71.1	1.820	22.8
Bisanzio -2	11.6	10.7	71.1	1.818	22.4
Bisanzio -3	11.7	10.7	70.6	1.821	22.7
Average	11.66	10.7	70.9	1.819	22.6
Triticum durum -1	14.3	11.0	66.8	1.868	28.8
Triticum durum -2	14.3	11.0	66.4	1.869	29.5
Triticum durum -3	14.5	11.0	66.4	1.863	29.3
Average	14.3	11.0	66.5	1.866	29.2
Agb-28	10.9	11.2	71.9	1.639	20.2
Agb-28	11.0	11.2	72.2	1.636	20.5
Agb-28	11.1	11.2	72.0	1.638	20.7
Average	11	11.2	72.0	1.637	20.4
Adelaide-1	11.7	11.4	69.6	1.780	22.4
Adelaide-2	11.6	11.4	69.6	1.786	22.1
Adelaide-3	11.9	11.4	69.1	1.782	23.2
Average	11.73	11.4	69.43	1.782	22.5

Table 4. Physico-chemical analysis of wheat varieties *Triticum* E. average values for hectoliter mass, impurities, broken kernels, absolute weight of wheat

Cultivar	Hectoliter mass %	Impurity %	Broken kernels %	Absolute weight of wheat %
Bisanzio -1 Bisanzio -2 Bisanzio -3	77.1	2.2	2.2	40
	77.2	2.5	2.5	39
	77.7	2.2	2.2	41
	77.3	2.3	2.3	40
Triticum durum -1 Triticum durum -2 Triticum durum -3	70.7	2.3	2.3	35
	72.3	2.3	2.3	33
	73.2	2.3	2.3	36
	72.7	2.3	2.3	39
Agb-28 Agb-28 Agb-28	80.9	2.1	2.1	41
	81.0	2.0	2.0	42
	81.2	2.1	2.1	40
	81.0	2.0	2.0	41
Adelaide-1 Adelaide-2 Adelaide-3	83.2	2.5	2.5	46.5
	83.6	2.5	2.5	45
	83.6	2.5	2.5	46
	83.4	2.5	2.5	45.83

show that in the grain analyzed, the metal heavy iron metal in samples M4 min and M5 max varies with an average value of 17.1 mg·kg^{-1}. Metal Pb in this study in some samples has a higher value compared to other analyzed samples, samples M1 max and M7 min have a difference value of 1.01 mg·kg^{-1} in Table 5. Statistical results show that lead and chromium have higher values, while the other studied metals are within normal parameters. Ingestion of contaminated food is one of the main routes through which heavy metals enter the human body. Also, for the human body, some heavy metals are essential for biological systems as structural and catalytic components of proteins and enzymes. The results show that over 85% of the samples contain high presence of metals compared to Kosovar standards. Land surveying was carried out at distances ranging from 20 m to 400

Table 5. Concentration of toxic metals in wheat varieties mg·kg^{-1}

No. of wheat samples analyzed	Pb	Cd	Cr	Fe	Cu	Zn	Mn
M1	1.99	0.29	6.12	35.30	4.37	30.70	33.91
M2	1.67	0.33	4.12	32.46	4.16	27.30	38.20
M3	1.55	0.31	2.91	33.47	4.01	28.02	37.90
M4	0.99	0.21	1.45	28.90	3.54	16.50	45.90
M5	1.81	0.19	6.11	46.00	4.52	43.10	39.50
M6	1.91	0.17	3.67	45.22	4.66	42.90	40.90
M7	0.98	0.09	2.33	36.50	4.27	34.30	29.30
M8	1.24	0.19	1.29	35.70	5.03	35.10	36.20
M9	1.38	1.10	2.34	34.40	4.57	27.50	34.50
M10	1.89	2.10	4.33	40.50	4.66	28.90	33.30
M11	1.77	1.11	4.27	38.99	4.99	20.18	33.46
M12	1.91	1.23	4.56	38.43	4.64	23.31	41.38

m from the highway. The results for Pb at a distance from 20 m showed a value of 2.11 mg·kg^{-1}, while Zn varied with a value of 5.12 mg·kg^{-1}.

Some wheat samples showed high levels of heavy metals, with Pb varying significantly with a value of 1.99 mg·kg^{-1} and Cr with a value of 6.12 mg·kg^{-1}. In this study, the circulation of soil metals such as Pb, Cd, Cr, Fe, Cu, Zn and Mn was monitored.

The results showed variations depending on the distance and its concentration. The maximum protein value ranged to 11.9%, gluten to 22.8%, moisture to 11.4%, etc., especially for the wheat varieties *Triticum* E. and *Triticum* D.

CONCLUSIONS

Analytical results showed that the percentage of organic carbon in the analyzed soil decreases with increasing soil depth. These results are evident in samples of wheat varieties *Triticum* E. These results are decisive based on the analysis of toxic metals of the studied soil and the tested plant, on the structure of the soil, such as water capacity, infiltration rate, aeration and porosity of the soil. Organic matter is considered as a single parameter of soil productivity.

A combination of compost and chemical fertilizers proved beneficial in increasing soil organic carbon levels. Pollution of air, water, road transport is the main source of soil pollution. Moreover, in this research it is observed that toxic substances are easily taken up by plants through the leaves. Epidermal cells absorb Pb from the leaf surface. The results show that 95% of the Pb in the leaf material was due to the accumulation of Pb in the wheat leaves. Pb levels accumulate from burning gasoline, motor oil, tire wear, and traffic density. The concentration of Cd and some other studied elements generally decreases with increasing distance along the highway, and the Cd content decreases with increasing depth. Cd from plants grown in the tested agricultural soil accumulates first in the roots; then, it is transported in smaller amounts to the stems and seeds of the wheat plant.

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