

Concentration of Toxic Metals in Agricultural Land and Wheat Culture (*Triticum Aestivum* L.)

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ABSTRACT

Concentrations of heavy metals in the soil such as: (Pb, Cd, Zn and Cr), play a role in contamination of agricultural crops such as wheat (*Triticum aestivum* L.). Roads in the Republic of Kosovo are congested with traffic; in addition, over 55% are more than 20 years old. The agricultural land near roads in Kosovo is cultivated with agricultural products, especially wheat. This study aimed to investigate the concentration of toxic metals in soil and wheat crops due to vehicle emissions. In this research are examined the physico-chemical factors that affect the mobility of metals in the soil of the research area as: pH, concentration of organic carbon and heavy metals such as: (Pb, Cd, Zn and Cr). Analytical research shows that the content of toxic metals decreases with increasing distance or along highways. The concentration tests of toxic metals near roads and lands planted with analyzed agricultural crop of corn showed that heavy metal deposits also depend on atmospheric conditions and emissions from vehicle traffic.

Keywords: toxic metals, national roads, wheat, and vehicle pollution.

INTRODUCTION

The level of environmental pollution in the Republic of Kosovo significantly exceeds the norms of the European Union. Recent measurements show a high level of air pollution from dust particles. The pollution exceeds the EU norms by 19% (Andrade et al., 2013). Environmental experts claim that the increase in the level of pollution in the cities of Kosovo affects: vehicle traffic, construction without urban plans and ways of cleaning cities. As the level of pollution increases, so does the level of health concern of citizens, as they are non-essential metals that are not required for any vital function, neither by plants nor by animals (Ahmadpour et al., 2012). Heavy metals are transported or released during various road transport operations such as: combustion of petroleum products, leakage of liquids and corrosion of metals (Bartkowska, 2015). Heavy metals such as: (Pb, Cd, Zn and Cr), are the main pollutants in the environment; they impact food

products, are released from fuel combustion, tire wear, oil leakage, corrosion of industrial batteries, as well as metal parts, etc. Kosovo’s roads are overloaded with a high percentage of old vehicles. All roads in Kosovo are characterized by heavy traffic load, while vehicles use low quality diesel fuel, with high amounts of lead in gasoline. Excess metal contaminants deposited in the soil, can be transported to vegetation by plants, passing to animals and human beings. Soil pollution with heavy metals on the sides of highways, along the roads as well as accumulation of heavy metals on the side land near the highways, have impact on the quality of agricultural crops. Due to high urban development accompanied by an exponential increase in the number of vehicles on highways that do not have effective pollution control standards, the emission of emissions from vehicle traffic increases the environmental uncertainty (Bryzzhev et al., 2015). Inadequate public transport system has led to an increase in the concentration of heavy metals from public transport

as well as the amount of heavy metal emissions from vehicles.

Lead: its saline form is poisonous. Its passage into the atmosphere comes from the combustion of gasoline with tetra ethyl lead. The large amount of lead in the soil, increases the accumulation in human bones from the consumption of agricultural products, and causes a decrease in Ca, in the body. It has a detrimental effect on blood enzymes, respiratory system, cardiovascular system and cellular system (Taszakowski et al., 2015). Lead exposure can occur from the contact with lead in the air, household dust, soil, water, and commercial products contaminated with lead. Plants, including those consumed as food, absorb lead from soil, water and air. Lead enters the body with food (more than 0.2 mg), with water consumption (0.1 mg), and with inhaled air powder (about 0.1 mg) (Sheoran et al., 2011).

Cadmium: The average concentration in the Earth's crust is between 0.1–0.5 ppm. Cadmium use is generally declining because it is toxic (it is specifically listed under the European Union directive on the restriction of hazardous substances). The most dangerous form of cadmium exposure is the the absorption of fine dust and smoke. The human exposure to cadmium mainly results from the burning of fossil fuels.

METHODOLOGY

The plant samples (*Triticum aestivum* L.) were collected in the region of Dukagjini Plain, along the highway Peja - Pristina, in each area were taken from 8 soil samples and 4 wheat samples for testing (with three repetitions). The samples were collected at different distances from 10 m, 20 m

and 30 m (500 m control site), at depth (0–15 cm and 15–30); these samples were transported to the laboratory for further analysis. At each distance (15 cm and 15–30 cm), mechanical drilling was employed for sample collection on both sides of the highway; the harvested samples were placed in clean plastic bags and transported to laboratory. Road transport is responsible for more than two-thirds of the emissions of nitrogen oxides (NO_x), and 10% of the total emissions of other metal pollutants into the environment. Road transport in particular continues to account for the bulk of major air pollutants (excluding sulphur oxides).

RESULTS AND DISCUSSIONS

The percentage of organic carbon and concentration of heavy metals such as: (Pb, Cd, Cr and Zn), in soil and plant samples analyzed (*Triticum aestivum* L.), calculated average for two years 2020/21, are given in Tables 2–5.

The high content of these toxic metals is observed at a distance of 10 meters along the Peja / Klina highway and tend to decrease with increasing distance from the highway.

The pH and organic carbon values in the soil samples show the average pH and organic carbon levels in relation to the depth and distance from the highway.

The pH value ranged from 7.52 to 7.86 and the percentage of organic carbon ranged from 0.35% to 0.58%. The maximum pH value of 7.86 is observed from the Peja area at a depth of 0–15 cm and 20 m distance along the highway, while the minimum pH value varies from 7.45 to 7.99 and was found at a depth of 15–30 cm and distance of 30 m (Table 2).

Table 1. Motor and non-motor vehicles registered during the years 2011–2019 (KAS-Transport 2019)

Years	2011	2012	2013	2014	2015	2016	2017	2018	2019
Vehicles	170,321	176,398	222,537	236,145	281,847	260,291	273,862	280,422	291,295
Vehicle trans. 3.5 and over 3.5 t	10,877	11,547	15,532	15,769	18,330	17,963	18,559	33,889	35,153
Vehicle trans. below 3.5 t	17,901	18,225	24,659	26,949	30,846	31,285	32,299	19,371	19,379
Minivans	2,698	2,520	1,570	1,697	3,212	2,841	2,535	2,917	2,977
Bus	1,117	1,298	1,570	1,697	2,124	1,916	1,949	2,326	2,135
Motorcycles	546	809	1,488	1,540	1,849	1,790	1,690	2,308	2,087
Tractors	39	137	776	1,036	941	613	523	1,791	1,851
Trailer under 3 t	101	117	217	250	286	288	288	572	681
Trailer 3.5 and over 3.5 t	1,766	1,800	2,283	2,281	2,707	2,628	2,735	305	271
Total	205,366	212,581	272,107	288,828	342,142	319,615	334,440	343,631	355,829

The maximum percentage of organic carbon has the value of 0.56% analyzed from the regional area of Peja at a depth of 0–15 cm and a distance of 20 m, while the minimum percentage of organic carbon with a value of 0.36%, in the regional area of Klina at a depth of 15–30 cm and distance 30 m (Table 3).

All pH values and organic carbon content differ from the place of control of the samples, also a decrease of pH is observed in the soil after the use of organic materials. The production of organic acids (amino acids, glycine, cysteine and humic acid), during mineralization (ammonization and ammonization), of organic materials by heterotrophs and nitrification by autotrophs reduce the pH value of the soil. Moreover, soil pH affects the solubility of minerals. In all test areas, the pH value of the tested soil decreases with increasing depth, due to the increasing salt concentration.

Living organisms obtain organic carbon from their environment. When they die, organic carbon is returned to the living environment. However, the concentration of carbon in living a matter is about (18%), i.e. roughly 100 times higher than the concentration of carbon in the soil which has a value of (0.19%). The uptake of organic carbon into living organisms and its return to the environment are not in balance.

The concentration of toxic metals in soil and plant samples along the highway is as follows: lead has an average concentration value in agricultural land of $2.99 \text{ mg}\cdot\text{kg}^{-1}$, wheat plant has a value of $0.28 \text{ mg}\cdot\text{kg}^{-1}$ (Table 4, 5). Table 3 shows that the highest Pb concentration in the soil has the value of $2.99 \text{ mg}\cdot\text{kg}^{-1}$; it was detected at the sampling site in the Peja region at a distance of 10 m and 0–15 cm. The lowest Pb concentration value of $0.41 \text{ mg}\cdot\text{kg}^{-1}$ was detected in the Klina area, at a distance of 30 m and 15–30 cm depth, while the highest Pb concentration value of $2.29 \text{ mg}\cdot\text{kg}^{-1}$ from the control samples in distance 500 m with the value of $0.08 \text{ mg}\cdot\text{kg}^{-1}$ was observed along the highway. Table 5 describes that the highest Pb

concentration in wheat samples with a value of $0.21 \text{ mg}\cdot\text{kg}^{-1}$ was detected in the Klina area at a distance of 10 m and with a lower value of $0.15 \text{ mg}\cdot\text{kg}^{-1}$ observed from the Peja area in a distance of 30 m. The most likely source of lead involves the particles emitted by gasoline vehicles, which sediment not far from the highway. As the distance from the road increases, the Pb levels at all sampling points decrease. The soil pollution with Pb can reach a length of up to 100 m from the main road. Table 3 shows that the highest concentration of Cd in the soil has the value of $0.19 \text{ mg}\cdot\text{kg}^{-1}$; it was detected in the Klina area at a distance of 10 m and 0–15 cm depth, while the lowest value of Cd concentration with a value of $0.05 \text{ mg}\cdot\text{kg}^{-1}$ was detected in the Klina area at a distance of 30 m and a depth of 15–30 cm. The highest concentration of Cd, from the control samples at a distance of 500 m was observed with a value of $0.07 \text{ mg}\cdot\text{kg}^{-1}$ in the Klina area along the highway. Table 4 describes that the highest concentration of Cd, in wheat samples with a value of $0.16 \text{ mg}\cdot\text{kg}^{-1}$ was detected in the Peja area, at a distance of 10 m and the lowest with a value of $0.06 \text{ mg}\cdot\text{kg}^{-1}$ was observed in the Klina area at a distance of 30 m.

The pollutants that accumulate in the atmosphere, as a result of natural and anthropogenic processes, are deposited again on the surface of the earth, after their transport far or near to the source and their discharge. Therefore, the earth, or rather the surface of the earth, is the place where atmospheric pollutants accumulate. The distribution of heavy metals (MR) in the soil reflects the influence of anthropogenic factor on the morphogenesis of soils, i.e. their anthropogenic, lithogenic or pedogenic origin.

The exchange of matter in the ecosystem, the earth undergoes a system of natural purification, which means that the withdrawal or uptake of different amounts of toxic substances. Their binding and removal, depending on the type of matter and the properties of the soil, is partly

Table 2. pH level, at different depths of the soil adjacent to the highway

Distance	Peja				Klina			
	2020		2021		2020		2021	
	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
10 m	7.67	7.52	7.86	7.74	7.50	7.45	7.75	7.84
20 m	7.64	7.45	7.99	7.61	7.60	7.43	7.76	7.83
30 m	7.63	7.32	7.40	7.82	7.69	7.52	7.72	7.80
500 m	7.53	7.47	7.40	7.66	7.59	7.62	7.72	7.85

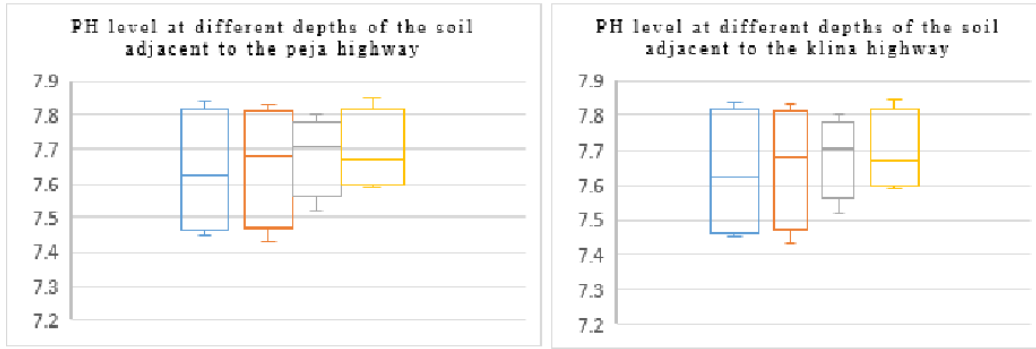


Figure 1. Graphic representation of pH level at different depths of the soil adjacent to the highway

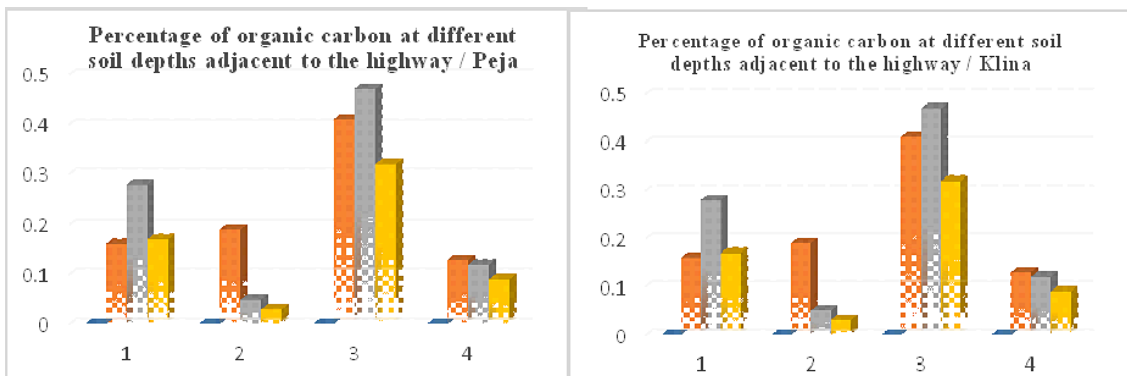


Figure 2. Graphic presentation of the concentration of organic carbon, at different depths of soil adjacent to the highway (Peja – Klina)

Table 3. Percentage of organic carbon, at different depths of soil adjacent to the highway (Peja – Klina)

Distance	Peja (Percentage of organic carbon) %				Klina (Percentage of organic carbon) %			
	2020		2021		2020		2021	
	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
10 m	0.55	0.35	0.41	0.35	0.61	0.51	0.69	0.53
20 m	0.56	0.36	0.45	0.39	0.64	0.55	0.63	0.52
30 m	0.58	0.39	0.46	0.35	0.62	0.59	0.61	0.53
500 m	0.59	0.46	0.57	0.48	0.48	0.47	0.59	0.49

Table 4. Concentration of toxic metals in the soil at different depths, adjacent to the highway (mg·kg⁻¹)

Years		2020								2021							
Distance		0–15 cm				15–30 cm				0–15 cm				15–30 cm			
Distance	Elements	Pb	Cd	Zn	Cr	Pb	Cd	Zn	Cr	Pb	Cd	Zn	Cr	Pb	Cd	Zn	Cr
10 m		1.61	0.05	5.98	0.73	1.57	0.09	5.51	0.69	2.29	0.19	7.19	0.79	0.07	6.09	0.45	0.59
20 m		0.72	0.06	4.85	0.63	0.90	0.03	3.78	0.58	1.66	0.17	5.21	0.66	0.08	4.11	0.40	0.56
30 m		0.41	0.03	3.99	0.53	0.54	0.09	2.20	0.40	0.89	0.15	4.94	0.49	0.09	3.50	0.36	0.41
500 m		0.02	0.08	0.45	0.06	0.03	0.02	0.31	0.04	0.11	0.03	0.45	0.03	0.08	0.42	0.03	0.06
10 m		2.99	0.11	5.67	0.63	2.27	0.07	4.37	0.45	2.16	0.19	5.17	0.71	0.11	3.95	0.73	0.49
20 m		2.17	0.05	4.49	0.64	1.14	0.09	3.99	0.33	1.73	0.05	4.16	0.96	0.03	5.08	0.51	0.31
30 m		0.72	0.09	2.59	0.48	0.49	0.06	1.89	0.21	0.97	0.09	2.50	0.21	0.34	3.32	0.44	0.43
500 m		0.03	0.08	0.31	0.02	0.07	0.03	0.33	0.02	0.03	0.07	0.32	0.11	0.21	0.65	0.04	0.22

back to the closed cycle of matter exchange. High deposition of toxic substances in the soil has dangerous consequences, both for plants and animals in the food chain and on humans. Earth,

as part of the ecosphere, between the atmosphere and the hydrosphere, assumes the functions of a filtration and buffer system, in the face of anthropogenic influences.

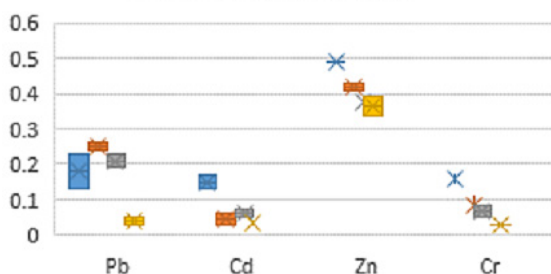
Table 5. Average value of toxic metal content in harvest samples, adjacent to the Peja-Pristina road (12–20 km) ($\text{mg}\cdot\text{kg}^{-1}$)

Town	Distance	Elements / 2020				Elements / 2021			
		Pb	Cd	Zn	Cr	Pb	Cd	Zn	Cr
Peja	10 m	0.16	0.19	0.41	0.13	0.28	0.15	0.45	0.19
	20 m	0.28	0.05	0.47	0.12	0.24	0.08	0.41	0.04
	30 m	0.17	0.03	0.32	0.09	0.23	0.04	0.34	0.03
	500 m	0.06	0.06	0.39	0.02	0.02	0.02	0.35	0.02
Klina	10 m	0.11	0.17	0.51	0.17	0.21	0.16	0.52	0.19
	20 m	0.19	0.06	0.38	0.05	0.17	0.12	0.58	0.04
	30 m	0.18	0.04	0.52	0.03	0.15	0.05	0.42	0.01
	500 m	0.01	0.02	0.30	0.07	0.01	0.02	0.45	0.02

Table 6. Average value of toxic metal content in harvest samples, adjacent to the Klina – Pristina highway (16–35 km) ($\text{mg}\cdot\text{kg}^{-1}$)

Town	Distance	Elements / 2020				Elements / 2021			
		Pb	Cd	Zn	Cr	Pb	Cd	Zn	Cr
Peja	10 m	0.13	0.13	0.49	0.15	0.23	0.17	0.49	0.17
	20 m	0.24	0.03	0.41	0.11	0.26	0.06	0.43	0.06
	30 m	0.19	0.07	0.38	0.08	0.23	0.05	0.37	0.05
	500 m	0.05	0.04	0.34	0.03	0.03	0.03	0.39	0.03
Klina	10 m	0.15	0.21	0.58	0.13	0.29	0.19	0.58	0.17
	20 m	0.20	0.07	0.32	0.06	0.14	0.16	0.54	0.07
	30 m	0.17	0.03	0.59	0.05	0.18	0.07	0.47	0.02
	500 m	0.02	0.01	0.34	0.07	0.01	0.03	0.41	0.04

Average value of toxic metal content in crop samples adjacent to the Peja / Prishtina road (mgkg^{-1})



Average value of toxic metal content in crop samples adjacent to the Klina / Prishtina road (mgkg^{-1})

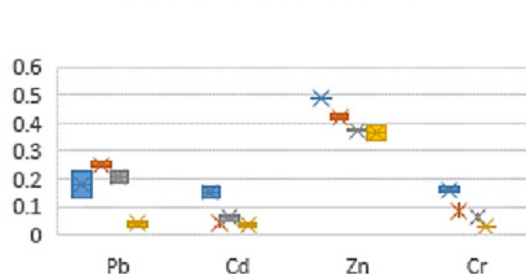
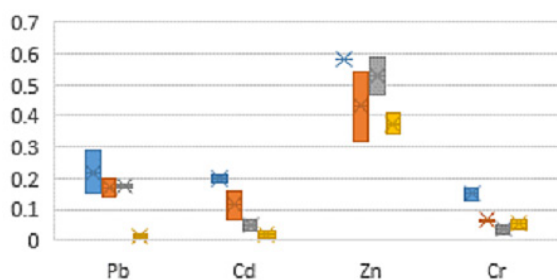


Figure 3. Graphic representation of the average value of toxic metal content, in the crop samples adjacent to the Peja-Pristina road (12–20 km) ($\text{mg}\cdot\text{kg}^{-1}$)

Average value of toxic metal content in harvest samples adjacent to the highway Klina - Pristina (16Km) (mgkg^{-1})



Average value of toxic metal content in harvest samples adjacent to the highway Klina - Pristina (32Km) (mgkg^{-1})

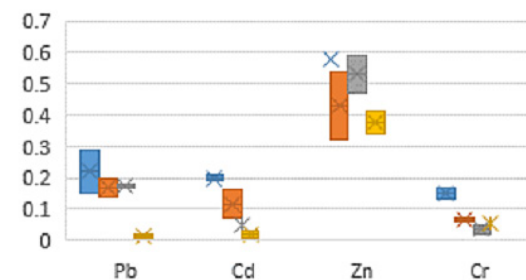


Figure 4. Graphic representation of the average value of toxic metal content in crop samples adjacent to the Klina – Pristina highway (16–35 km) ($\text{mg}\cdot\text{kg}^{-1}$)

CONCLUSIONS

Analytical results showed that the percentage of organic carbon in the analyzed soil decreases with increasing soil depth, these results are also visible in the samples of wheat analyzed. The analytical results are crucial, based on the factors of toxic elements of the soil and the tested plant, in the soil structure, such as: water holding capacity, infiltration rate, aeration and soil porosity. Organic matter was considered as a single parameter of soil productivity. It was observed that both levels of composting, resulted in an increase in the concentration of organic matter in the soil. A combination of compost and chemical fertilizers proved useful in increasing the level of organic carbon in the soil. Lead in the air is a major source of soil pollution and its transport to the tested wheat plant, resulted road transport and heavy vehicle traffic outside international standards. Moreover, in this research it is noticed that the toxic substances are easily taken from the plants through the leaves. Epidermal cells absorb Pb deposited on the leaf surface. The results show that 90–99% of Pb in the leaf material was due to the accumulation of Pb in the wheat leaves and mainly from the emission of vehicles along the road. The Cd concentration generally decreases with increasing distance along the freeway, across the sampling site, and the Cd content decreases with increasing depth; these results are similar to those analyzed. The Pb levels in the emissions of toxic substances were related to lead with the composition of gasoline, engine oil, tire consumption and waste disposal of these materials, on the side of the road, traffic density also plays a role. The results of this study showed that the uptake of Cd from plants cultivated on the tested agricultural soil accumulates first in the roots; then, it is transported in smaller quantities to the stalks and seeds of the wheat plant.

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