Heavy metal (As, Cd, Cr, Cu, Ni, Pb, Zn) determination with the ICP-AES technique in the vicinity of Kosovo's power plants

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Abstract

Coal, when used as an energy source, has the ability to interfere with the quality of the atmosphere, water and particularly soil. It does so by increasing the presence of pollutants – in the case of soil, in the form of increased amounts of deposits.
Most of Kosovo's electricity supply is produced at a coal-powered plant complex in Kastriot, roughly 10 kilometers away from the capital, Prishtina. Due to the use of coal, among other factors, this region as well as a wide range is believed to be heavily polluted.
The aim of this study is to give a clear picture of pollution in the areas surrounding these power plants. In order to accomplish this, we have determined the presence of heavy metals in soil samples collected in various spots around the plants. We ensured the proximity of the samples to be varied, so that a correlation between the distance from the plant and level of pollution can be roughly established.
We measured the concentration of heavy metals in the soil samples by using inductively coupled plasma-atomic emission spectrometry (ICP-AES). They were treated in teflon vessels with diverse acid treatments, including HNO_3, $HClO_4$, HF and HCl according to the ISO 14869-1 standard. The referring sample that was used for comparison was collected at a pollutant-free spot, about forty kilometers away from the power plant.
It was thereby concluded that the concentration of heavy metals, with a special focus on As, Cd, Cr, Cu, Ni, Pb and Zn in most areas are in high levels and that they – as expected – exceed the upper concentration limit for soil pollution with heavy metals according to Dutch standards.
Stated succinctly, this zone is highly contaminated and we support this through the measurements of heavy metals, which in most cases exceed the tolerated upper limit.

Key words: *soil, heavy metals, coal, contamination.*

Introduction

The human impact on the biosphere has been very broad and complex, and often has led to permanent changes. The human made modifications disturb the natural balance of each ecosystem that has been formed evolutionarily over a long period of time [1].

Heating systems which are coal-powered have the ability to trigger negative effects on the environment, as well as on health. During the process of coal burning, a number of hazardous substances are released; these include acidic gases, benzene, dioxins and furans; formaldehyde, lead, arsenic, mercury; polycyclic aromatic hydrocarbons (PAH) and radioactive materials [2].

The Kosovo Energy Corporation (abbreviated as KEK in Albanian) is the largest corporation which is responsible for addressing Kosovo's electricity needs. In order to do so, it produces energy through two power plants: Kosovo A and Kosovo B, both of which are coal-powered. During our study, we measured the concentration of heavy metals (As, Cd, Cr, Cu, Ni, Pb, and Zn).

Materials and Methods

Study area description

The environment of Kosovo is irreversibly linked to the consequences stemming from the electric generation facilities located in Kastriot, a few kilometers away from the capital city.[3]

The Kosovo A power plant is a lignite power station operating with five units in Kastriot, Kosovo. It is the second largest power station in Kosovo with a capacity of 449 MW, second to Kosovo B power station. It is described as the worst single-point source of pollution in Europe and is expected to be closed by 2017.[4] Kosovo B power station is a lignite-fired system consisting of two units with 290 MW generation capacity, which share a 183 meters (600 ft) tall chimney with 6.8 meters diameter at the top. Figure 1 shows a map of Kosovo, with Kastriot – the studied zone – encircled in black.

Fig. 1 Map of Kosovo with the zone of study encircled in red

Soil treating

Soil samples were collected on the surface layer from 0 to 30 cm, in the region of Kastriot. Samples were taken from different locations by using the Global Positioning System (GPS). Each sample represented the composite material collected using probes. The composite material of each sample (about two kilograms) was placed into plastic bags.

After the soil samples were dried in air temperature, they were ground down to 75 micrometers. The samples were digested and treated according to ISO 14869-1 [5].

Experimental data

All analyzed elements were determined by atomic emission spectrometry with inductively coupled plasma, ICP-AES (Varian, 715-ES) applying ultrasonic nebulizer CETAC (ICP/U-5000AT) for better sensitivity.

Results and Discussion

The following table presents the lowest and highest concentrations of heavy metals of the measured samples. The concentration of these metals in all samples exceed the permitted maximum allowed by comparison with the Dutch National Standards for soil [6].

Table 1. The measurements of heavy metal concentration with ICP/AES technique

Elements	Lowest	Highest
	mg/kg	mg/kg
As	52.8	119
Cd	1.15	12.6
Cr	105	204
Cu	37	273
Ni	37	228
Pb	110	425
Zn	208	1557

Diagram 1 shows the graphical interpretation of the data presented in Table 1. For comparison purposes, we used the Dutch List of standards (Table 2). [6]

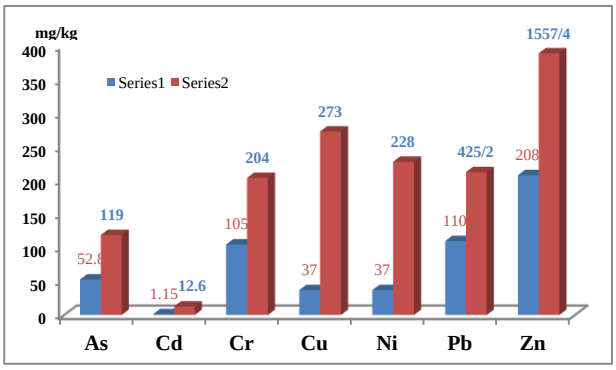

Diagram 1. The comparison of lowest and highest concentrations of heavy metals

Table 2. Target and intervention values of the contents of elements in the soil according to the Dutch National standard

Dutch list	**Elements, in mg kg^{-1}**						
	As	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**
Target	29	0.8	100	36	35	85	140
Inter ve-ntion	55	12	380	190	210	530	720

In this study, it is indicated that the pollution with As measured using the ICP/AES technique is the lowest at 52.8 mg/kg and highest at 119 mg/kg (Table 1), while the maximum allowed concentration of arsenic is 29 mg/kg (Table 2).

The highest concentration of Cd is 12.6 mg/kg with and the lowest 1.15 mg/kg, whereas the maximal permitted concentration of Cd (Table 2) is 0.8 mg/kg, thereby leading to the conclusion that highest concentration exceeded the upper limit for around 16 times.

The concentration of Pb is around minimal values of 110 mg kg-1 to 425.1 mg kg-1 (Table 1), while the maximum concentration of Pb according to Dutch Nationals Standard for soil is 85 mg/kg.

Zinc is an essential trace element involved in various biological functions, such as hormone control , DNA synthesis, gene expression, enzymatic reactions, and cell proliferation [7] [8] Intracellular free Zn^{2+} levels are tightly regulated; spikes in intracellular free Zn^{2+} are toxic to most cells, with a particular emphasis on neurons.[9][10] The concentration of zinc in our samples varied from the lowest of 208 mg kg-1 to 1557 mg kg-1, while the comparison value (Table 2) shows that maximum permitted value to be 140 mg kg-1.

The content of chromium was over the target value of 100 mg kg^{-1} (Table 2) from the minimum value of 105 mg kg^{-1} up to the maximum value of 204 mg kg^{-1}. The target concentration of copper in the soil under the Dutch National Standard is 36 mg kg^{-1}. In the samples analyzed, copper levels range from the minimum value of 37.0 mg kg^{-1} to 273 mg kg-1 as a result of the pollution from anthropogenic activities.

Nickel is considered to be an essential element in animals, microorganisms, plants, as well as enzymes and proteins.[11] Although it occurs naturally, concentrations found in the environment may also be triggered by anthropogenic input, including depositions from the burning of fossil fuels [12] energy supplying power plants (fueled by coal, petroleum, nuclear decomposition, or high tension lines),[13] chemical industries and the like.

Conclusion

1. This research is based on measurements of pollutants emitted in agricultural soils from coal-fired power plants in Kosovo. This study, which utilized the ICP/AES technique, presents the concentration of heavy metals in the area, including As, Cd, Cr, Cu, Ni, Pb, and Zn.
2. According to the obtained results, it can be inferred that the studied zone around the power plants is highly contaminated due to coal being used as a fossil fuel for the purpose of generating heat.

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