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Agricultural Land Pollution Survey in Kosovo

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Abstract

Kosovo is facing serious environmental issues. There are initiatives to improve the situation but the main concerns are from (i) industrial emissions and immissions into soil, air, surface and groundwater, (ii) the discharge of untreated wastewater and sewage into the rivers and streams. During the ex-Yugoslavia era, the expansion of heavy industries in Kosovo was a major focus for economic development. It was not common to take environmental aspects into consideration because it seemed incompatible with economic output. Ore mining concentrated upon chromium, nickel, copper, lead and zinc. Over the past two decades economic activity has continued with these extraction industries for the production of raw materials and semi-finished products (e.g. lead, coal, zinc and some textiles). The energy sector is also a source of pollution in Kosovo mainly impacting the air with CO_2, SO_2 and dust and especially for the neighbouring areas of Obiliq where the greater part of the electricity is generated from lignite-powered thermal plants. However, the environmental impacts from the current level of agricultural activity are considered low.

Keywords: Organo-pollutant parameters, Heavy Metals, Screening analyses, Soil pollutants

1. Introduction

Decomposition of rock and organic matter for many years has resulted in soil formation. Soils are critical environments where rock, air and water interface [1]. Chemical elements occur naturally in soils as components of minerals, though at certain concentrations some may be toxic. The chemical elements such as metals cannot break down, but their characteristics may change so that they can be easily taken up by plants or animals [1]. Bedrock composition, climate, and other factors have led to varying soil properties [2]. Soil can be said to be clean where the substances under environmental concern occur in concentrations equal to or lower than the value found in nature which is used as a reference and normally called the 'background concentration'. The background concentration is the total element concentration obtained from soils that have not been affected by human activity. However, certain actions such as past land use; current activities on the site, and nearness to pollution sources have all affected soil properties [2]. Such activities result in contaminations in various forms. According to Worksafe (2005) contamination refers to the condition of land or water where any chemical substance or waste has been added at above background level and represents, or potentially represents, an adverse health or environmental impact. It can result in a potential financial, social and environmental cost [3].

2. Material and Methods

2.1 Agriculture land and the sampling grid

The geographical area covered by the survey includes the17 Municipalities in Kosovo where most agricultural activities take place. These are shown in the map below (red dot).

Each Municipality was layered on a1km^2 grid reference using digitised maps. The sampling sites are clearly pinpointed using GPS equipment.

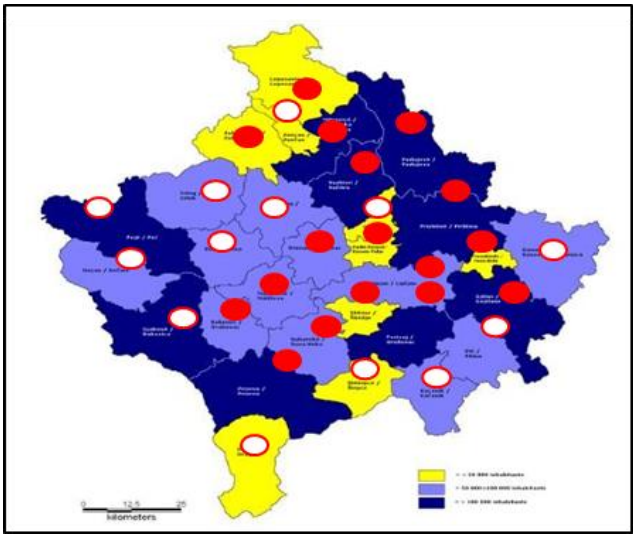

Figure 1. Kosovo Municipalities involved in survey

The total area of the 17 Municipalities selected is 4,101 km^2. Data from the Kosovo Cadastre Agency shows the agricultural arable land area and unused pasture land in these 17 Municipalities is 164,339 ha (April2013). At present, many Municipalities are in the process of data collection related to spatial planning and more accurate information will be made available during the next few years. Soil samples were taken across this whole agricultural area according to international standards and norms, unless it was already occupied by infrastructure

And also within a village, town or city building zone limits.

The background concentrations of elements that are used for reference to assess contamination level are taken from the Soil Contaminant Standard (SCS) threshold values of the revised 'Kosovo List'.

2.2. Sampling methodology, designation and sampling locations

The survey was guided by the relevant ISO/IEC norms, particularly ISO 17025:2005. It was designed and implemented according to international scientific practices which included the identification and screening of the point and non-point sources of pollution in Kosovo with particular focus on the heavy metals such as cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), zinc (Zn) and arsenic (As).

The procedure involved (i) taking soil samples from specific locations, (ii) conducting screening tests using Field Portable X-Ray Fluorescence Spectroscopy (FPXFS) equipment and also field test kits and (iii) the selection of samples for performing additional detailed chemical analysis carried out in accredited and certified laboratory conditions complying with ISO/IEC17025:2005.

Based on the Manual for Soil Sampling Procedure prepared especially by this project, 2,804 soil samples were taken from the 164,339 ha of agricultural arable land area and unused pasture land to perform the initial screening tests. This is an average of one sample per 0,586 km^2. However, other criteria were also used to sample some areas more intensely than others. This included the 'hotspots' from the Pedological Map of Kosovo (KEPA, 2013) where the intensity of sampling was higher.

For those Municipalities with 'hotspots' or close to 'hotspots' 1 sample/0.5km2 (50 ha) was taken. For those Municipalities out of these areas 1 sample/1km2 (100 ha) was taken.

The total agricultural arable land area and unused pasture land is some 164339 ha for the 17 Municipalities. The project determined that some 2500-3000 soil samples were to be taken to perform the initial screening analyses. This means that each sample represents an area of around 0.5–0.7 km^2. However, other criteria were also used. This included the 'hotspots' (from KEPA, 2013) and the Pedological Map of Kosovo where the intensity of Sampling was re-calculated.

In total some 2804 soil samples were taken based upon the Manual for Soil Sampling Procedure prepared especially by the project. These samples were then subjected to the screening test using FPXFS. The intensity and the level of pollution found including some specific soil chemical properties (i.e. samples considered 'suspicious') were subjected to further analyses by two (2) external ISO accredited laboratories from EU Member States of Italy and Slovenia.

2.3. Calibration and validation of data analysed by FPXFS

The prepared soil samples were subjected to X-rays for 60 seconds using a Bruker TRACER III–V+ system (FPXFS). Raw detector counts were translated into quantified measures of near-total heavy metal concentrations using a custom calibration curve created from a subset of 50 LRM samples analysed externally via ICP-AES following an itricaqua-regia digestion (3:1, v/v, HCl to HNO3) in a graphite heating block. This was carried out by the co-operating ISO/IEC accredited laboratory in Tuscia, Italy. Aqua-regia digestion has a recovery rate ranging from 70–95% for different heavy metals in soil due to the retention of each element at acid dissolution resistant alumina-silicate sites. Despite the potential underestimate of total element, the aqua-regia digestion provides the accuracy needed for environmental monitoring of heavy metals in soils. An additional 10 samples were also sent to the Tuscia Laboratory for ICP-AES analysis but especially for validation of the results.

3. Results and Discussion

Using the Field Portable X-ray Fluorescent Spectroscope (FPXFS) a total of 2804 soil samples were subjected to analysis for a spectrum of selected parameters (Al, Cr, Mn, Fr, Co, Ni, Cu, Zn, Hg, As, Pb, Mo, Cd, Se, Sr). The results show concentrations at individual sampling points distributed over a large area.

3.1. Chromium (Cr)

Chromium (Cr) was detected in many soil samples distributed over almost all the agricultural land. In more than 98% of the samples the concentration was below the Soil Contaminant Standard (SCS) threshold values of the revised 'Kosovo List'. However, in certain cases elevated levels were found and from the field visits, it can be assumed that the pollution is of geogenous origin. In some places anthropogenic influences can also be expected to play a role from mining and processing activities.

The concern for this element is related to the industrial /mining activity which takes place in some areas. It is suggested to carry out an environmental monitoring programme to ensure adequate protection for the local population in the site-specific areas.

As can be seen form the Figure 2, any pollution threat is localised

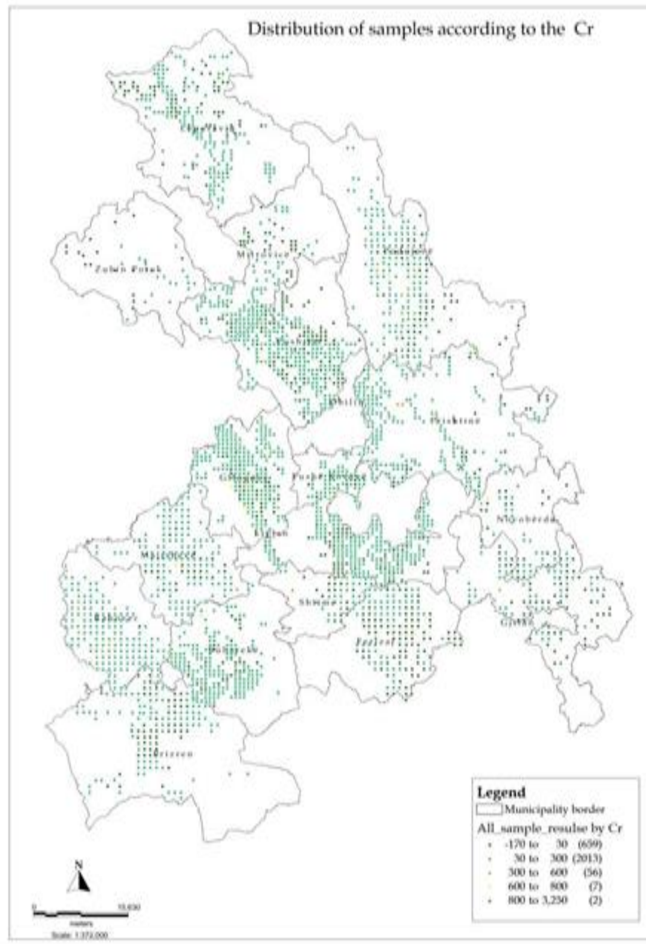

Figure 2. Distribution of samples according to the Cr

3.2. Nickel (Ni)

Nickel concentrations are similar to those observed for chromium, although the abundance and occurrence is less. Even in those cases where there are isolated elevated concentrations it can be assumed that as with chromium, the cause of the Nickel pollution is from geogenous origin and that it is increased through anthropomorphic activities such as mining and ore processing.

The correlation between chromium and nickel concentrations is high and elevated chromium concentrations were associated with higher nickel concentrations. This leads to the conclusion that chromium and nickel are from the same sources. It is recommended to follow up this correlation with a more detailed investigation because the ratio of chromium and nickel in samples can provide additional useful spectroscopic information.

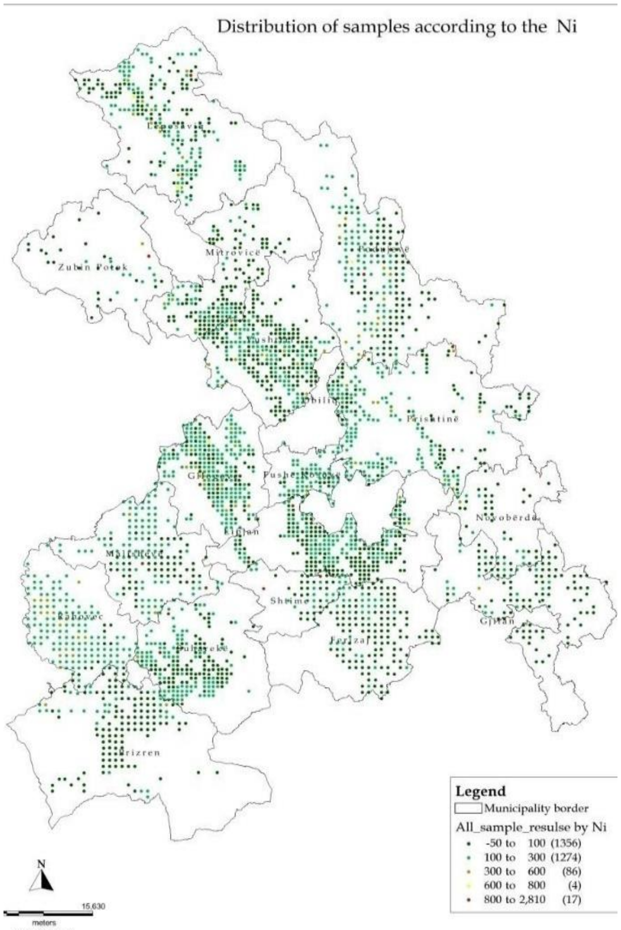

Figure 3. Distribution of samples according to the Ni

3.3. Cadmium (Cd)

Cadmium is a heavy metal with a high risk for human health if ingested through the consumption of crops. Moreover, it is a poison for many plants. Its concentration in soil samples did not indicate elevated levels compared with the SCS threshold values of the revised 'Kosovo List'. There are some elevated levels of Cd concentrations but they are small land site-specific. The sources of the increased concentrations found around some Municipalities like Drenas, Mitrovicë, Vushtri and Leposaviç may be connected to earlier industrial activities and also excessive fertilizer and pesticide use, irrigation, atmospheric deposition and pollution by waste materials.

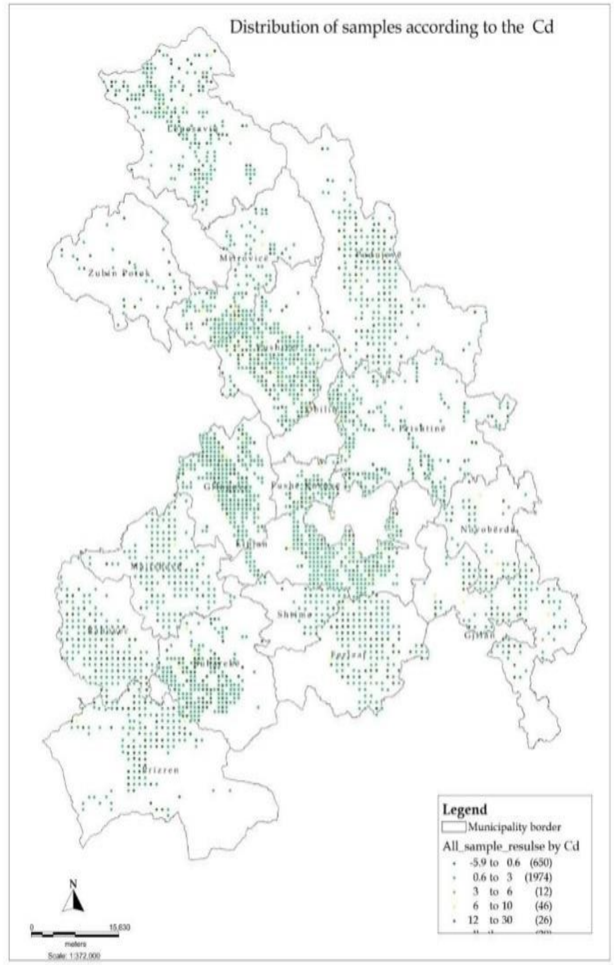

Figure 4. Distribution of samples according to the Cd

3.4. Lead (Pb)

The data show that lead concentrations in agricultural soil are more prevalent in areas around the industrial and mining regions of Mitrovicë, Leposaviç, Fushë-Kosovë and Vushtri. The presence of this element follows that of other elements like Cd, Cr, Zn and Ni. There are some elevated levels for samples such as No: 1283, 1298, 1305, 1324, 1334, 1348, 1349, 1377 and 1390 which are above the SCS threshold values of the revised 'Kosovo List'. However, when these locations were re-visited during the field visits to find out whether there were specific reasons for these concentrations, it was found that environmental conditions such as closeness to the main roads, mines and other industrial activities were the probable sources. More importantly the field visits indicated that the area was not in use for Agricultural purposes but was uncultivated and at some points in developed urban zones.

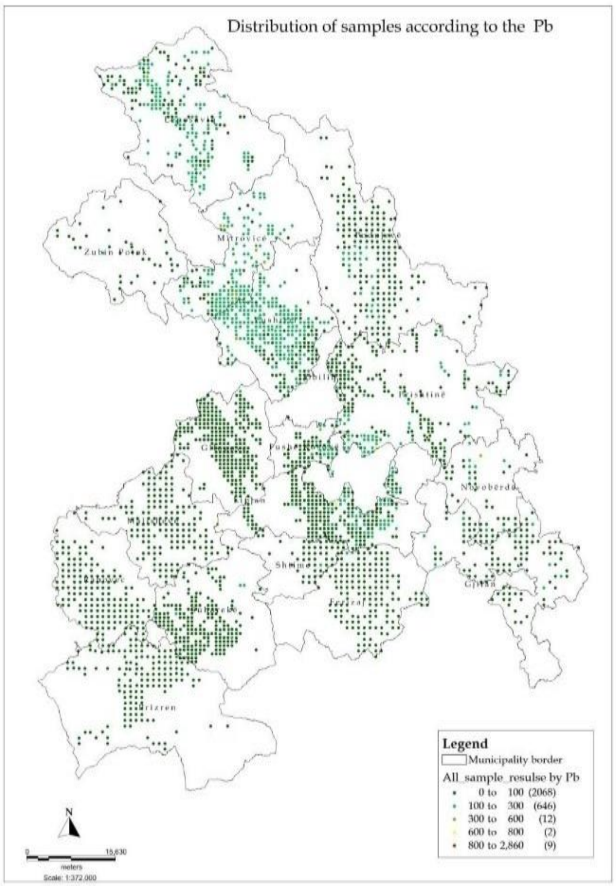

Figure 5. Distribution of samples according to the Pb

3.5. Arsenic (As)

In general the concentration of arsenic is below the SCSs from the revised ‘Kosovo List’. There are only 6 samples where the value is elevated but the soils were not used for agriculture purposes.

3.6. Other elements

In general, the concentrations of arsenic are below the SCSs from the revised ‘Kosovo List’.

In the majority of cases the heavy metal concentration levels of copper, cobalt, selenium, mercury and zinc do not exceed the SCSs in the revised ‘Kosovo List’. Elevated levels found in some soil samples are discussed below. The copper content is low for all samples. It is also noted that industrial units involved with copper mining and ore production are outside the agricultural production areas.

Zinc is a heavy metal that is found in several ores in Kosovo and it is mined in commercial mining operations such as Belo Brdo, Zuta, Prilna, Crnac, Stan Tërg, Artana, Hajvalia, Kishnica and Badovc. Geogenously, it is associated with lead and they are often mined together. Most zinc reserves are found in the Mitrovicë region. The zinc content is low and most soil sample concentrations are below the SCS threshold values of the revised ‘Kosovo List’. Only 8 samples have slightly elevated zinc levels.

The concentrations of selenium, mercury, strontium, molybdenum, manganese, cobalt and iron do not exceed the SCSs in the revised ‘Kosovo List’. In comparison with copper, mercury and selenium, the concentration of strontium in some locations exceeds the SCSs of the revised ‘Kosovo List’. This element is found mostly in Drenas and Fushë-Kosovë. The reason is mainly because of anthropomorphic activities such as coal and oil combustion. Strontium also commonly occurs in nature, forming about 0.034% of all igneous rock in the form of the sulphate mineral Celestine ($SrSO_4$) and the carbonate strontianite ($SrCO_3$). For most people, strontium uptake will be moderate and its ingestion is generally not known to be a serious risk to human health. However, strontium chromate is considered a risk even in small quantities. As far as molybdenum, aluminium, manganese and iron, even though they are not considered as heavy metals, their relative concentration is not high and does not exceed the SCSs in the revised ‘Kosovo List’.

4. Conclusions

Because no widespread agricultural land pollution was detected and elevated levels when found were site-specific, there is no need at this stage to recommend large-scale remediation measures to be applied. The decision for (high cost) site remediation depends upon land-use and public demand. Nevertheless, simple and cost-effective mitigation measure should be promoted through 'Good Agricultural Practices' (GAP). For example, to prevent the bio-availability of certain pollutants such as Cd, lime can be applied to increase the pH.

To date, 17 Municipalities have been surveyed. It is recommended to continue the detailed investigation of the remaining agricultural land in the other 21 Municipalities in Kosovo in order to have a full inventory of soil pollution. This will also identify the sources and pathways of pollution and include risk assessment as well as mitigation and/or remedial measures. Based on the results of the survey the following steps can be recommended for sustainable and environmentally sound management of agricultural land in the future: (i) to improve waste management in the whole of Kosovo as well as to commence the construction of waste water treatment plants for industry and households; (ii) to control and promote best available technologies (BAT) for mining and wastewater management as well as to check landfills for possible leakage; (iii) carry out additional surveys to identify and ring-fence 'hot-spots' and if needed, apply the appropriate remediation using BAT.

5. Acknowledgements

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