STUDIES CONCERNING THE INFLUENCE OF INORGANIC POLLUTANTS ON THE QUALITY OF AGRICULTURAL SOILS

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Abstract

In order to evaluate the impact of the main pollutants emitted by the industrial settlements on agriculture, their levels were monitored in the most widespread cultures along with the root soil. The goal of this research was to determine the levels of heavy metals in agricrops as carrot and potato, grown in agricultural soils of different contamination origin. Vegetable and soil samples were analyzed for inorganic content by x-ray fluorescence spectrometry method. The quality assurance of the measurements was realized by the etalons of wheat RJI and soil СП-3. Mn, Fe, Ni, Cu, Zn, Pb and Mo were the common metals detected in the agricrops studied. The enrichment of those inorganic components was due to local diffuse sources other than micronutrients or fertilizers.

Keywords: inorganic pollutants, XRFS, croplands, agricultural soils, vegetables

Introduction

In order to evaluate the quality of the crop in terms of its ecological health it is necessary first of all to know the quality of soil in which its root is growing. Local contamination from inorganic pollutants reflecting on the quality of agricultural soils is a serious problem recognized everywhere around the word. The main sources of trace elements to plants are their growing media, as soil-water-air ecosystem from which those nutrients are taken up by the root to the foliage. Heavy metals occur naturally in soil at low concentrations. At the background levels, they do not present any known hazard in crop production. Their concentrations in agricultural soils however may rise over time due to inputs from anthropogenic sources in connection with technological development of the society. Knowledge on the contamination of crops with inorganic pollutants from different soil environments is not well established in Romania.

The purpose of this study was to determine the level of heavy metals in selected agricrops namely carrot and potato along with the root soil.

Bioavailability of inorganic pollutants in the food chain

The bioavailability of inorganic elements to plants is influenced by many factors associated with geomorphological characteristics of soils, the climatic conditions, plant genotype and agronomic management. The main geomorphological characteristics altering the metal availability are soil pH, clay content and organic matter content. The plants accumulate necessary nutrients (i.e. N, P, K, Zn, Cu) as well as toxic metals as Pb, Cd and As. The ingestion through diet of vegetables grown in agrisoils contaminated with heavy metals

poses risk to human health as such elements are not biodegradable and can accumulate in human organs during the human life.

Then the determination of heavy metals in agricultural crops is frequently required in health-related environmental studies, because of high toxicity of trace amounts of such elements for human organism. Only in Europe, the effects of environmental pollution on natural vegetation and crops are under observation of scientists from 32 countries reunited in different national and international organizations and laboratories.

Experimental

Sample collection and preparation

The environmental samples were collected from the agricultural area surrounding two towns in Romania, namely Turnu and Oradea, of different industrial profiles. The same types of samples were recorded from a rural remote area chose as a clean spot.

The types of vegetables selected for this very study were carrot and potato for storage roots. Sampling was done randomly with five replicates. A representative amount of 1 kg from each crop material and root soil was collected in a perforated polyethylene bag. Prior to analysis the crop samples were rinsed with distilled water to remove the adhering particles from soil and/or atmospheric deposition. For each type of crop, an average sample was prepared by mixing the samples collected from a site (three pieces). Then the samples were air dried for about one month and later by 48 hours at 400C in the thermostat until constant weight. Amounts of 50 g were homogenized in an agate mortar. The analyses were carried out on the vegetation pieces and grain fractions < 2 mm. Aliquots of about 2 g of each sample were used for XRF analysis. The fresh/dry mass ratio determined for crops were 7.62 and 8.36 for carrot pulp and respectively, potato pulp.

The aim of this study was to investigate the trace-element polluting effect of 2 industrial areas on the agricultural crops, in particular for this very study, potato and carrot were chosen. For their assay, the x-ray fluorescence spectrometry method was used. XRFS using the ^{109}Cd (E_γ=22.16 keV) and ^{241}Am (E_γ=59.57 keV) radioisotop irradiation sources offers a reliable approach of providing a rapid multielemental analysis of various samples in ppm range, supposing as well the preservation of the samples. Multielemental XRFS analysis of environmental samples was accomplished at the x-ray fluorescence facility of the FLNR. The x-ray fluorescence spectra by an x-ray fluorescence detection system with a Si(Li) detector of 200 eV resolution at Fe K_α (6.4 keV) were measured. The measurements were accomplished by the technique of simultaneous determination in saturated substance layers of the all inorganic constituents, by their radioisotopes, using a unique calibration curve. The detection limits of XRF method were situated between $5 \cdot 10^{-1}$ mg/kg (for K) and $2 \cdot 10^{-4}$ mg/kg (for Zr). For example, the spectra of potato pulp and of its root soil are shown in Figures 1 and 2.

The analysis of the measured spectra were performed using the SPM software developed in FLNR using a nonlinear least squares fitting routine which approximates characteristic x-ray peaks with Gaussian curves of various types of background depending on the spectrum region and calculates intensities of x-ray peaks.

Quality control results

The analytical approach used is appropriate to measure concentrations of heavy metals in crop samples. Suggested methodology mostly gives lower concentrations than in standard samples, high concentrations can be received in 2-3 cases from 5 for Cr, Cu, Ni. Only 58,9%

and 80% of standard concentrations are determined for Pb and La using the above methodology. Maximum determined concentrations of Pb and La were 63 % and 88% from standards.

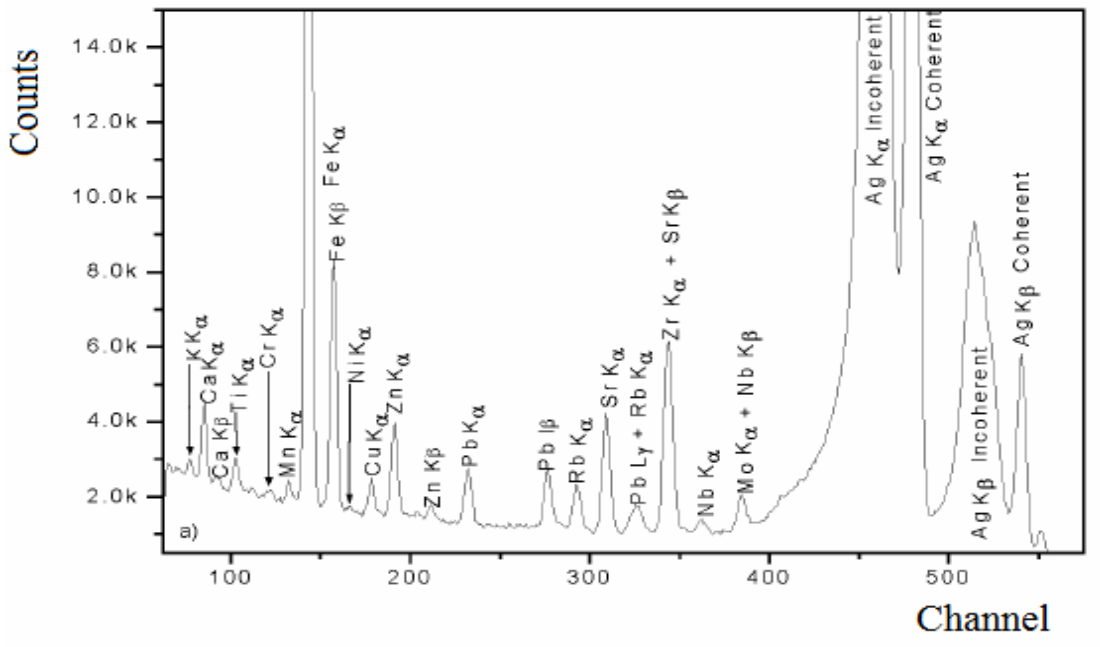

Figure 1. XRF soil spectra excited by ^{109}Cd isotope source

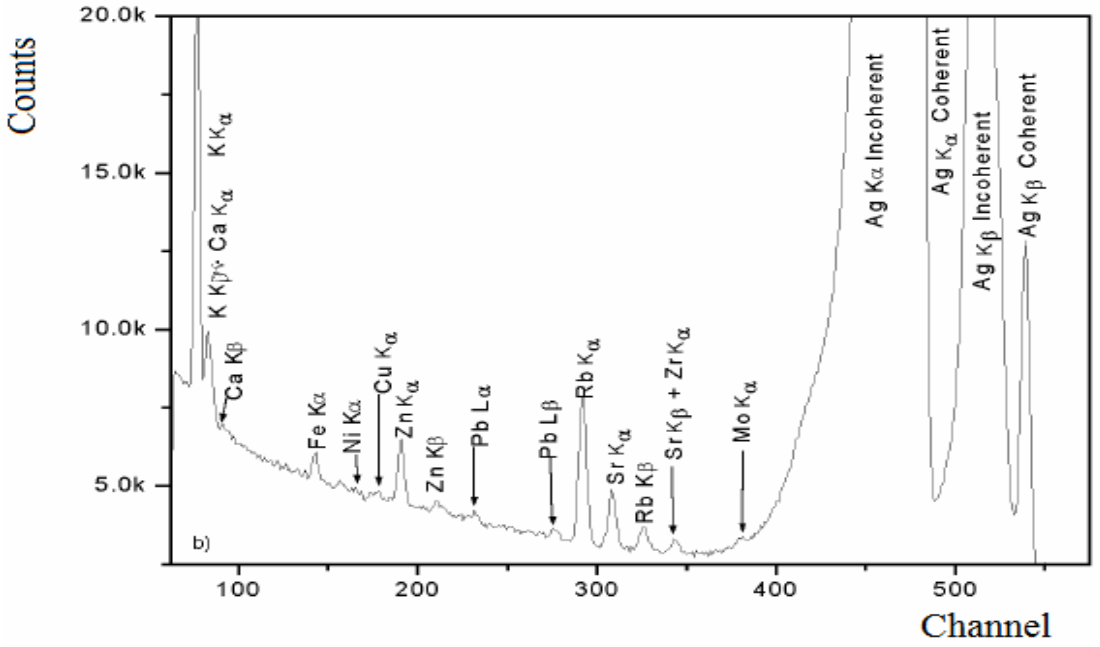

Figure 2. XRF spectra of the potato pulp excited by ^{109}Cd source

Results and discussion

Element ratios for crop and corresponding soil samples collected in the same sampling spots were calculated relative to those for control samples. Further the concentration factors

were assessed for crop relative to host soil (Figures 3 and 4). Relative to the control zone, significantly higher concentrations were found for various elements in carrot and potato grown on the polluted areas. Fe, As, Sb, Cs, and REEs, concentrations in carrot pulp, as well as Fe, Sb, and REEs, in potato pulp were found to exceed the normal levels. Cr, Ni, Zn, and Pb concentrations in potato and carrot pulp were found to be lower than the maximum allowable levels in Romania (except for Cr in carrot pulp which was 1.5 times higher).

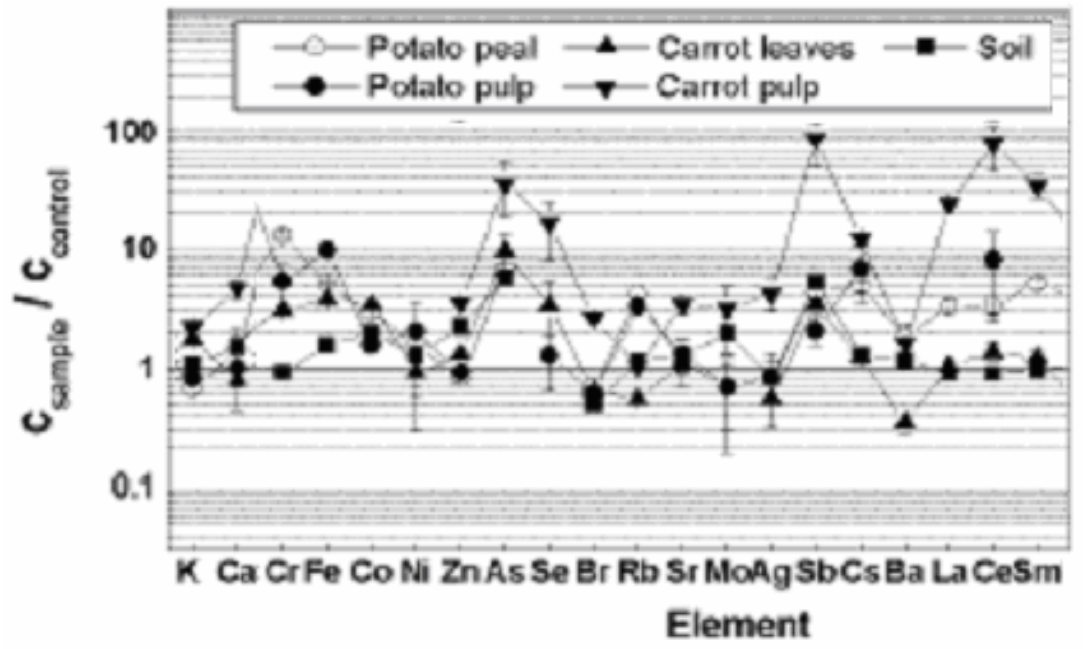

Figure 3. Element ratios polluted sample-to-control sample for crops and soil (Turnu Plant)

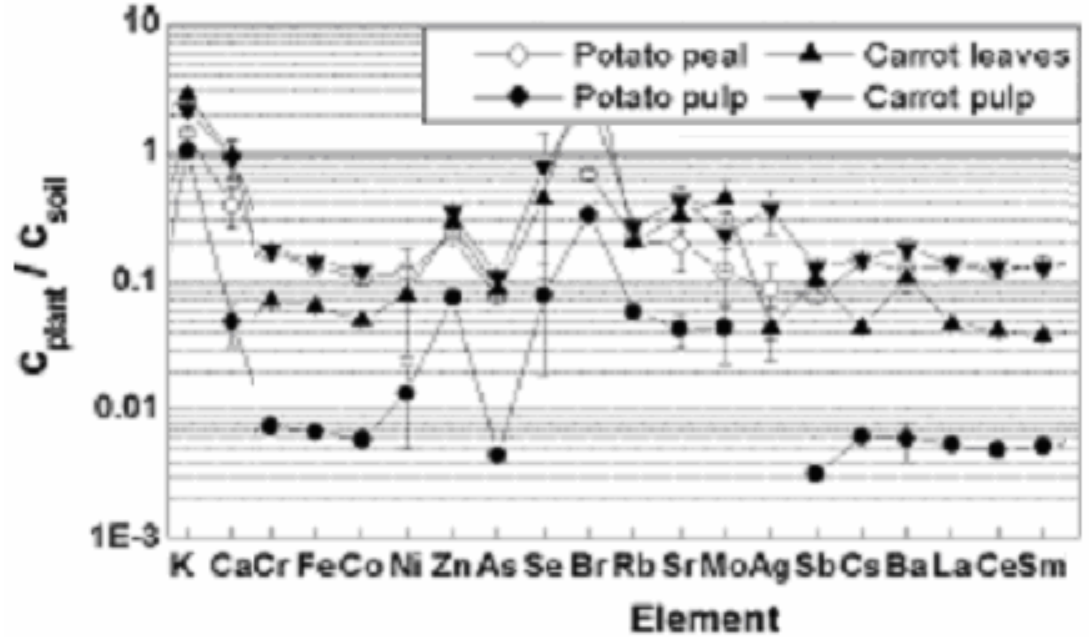

Figure 4. Element concentration factors in plant-soil near the Oradea town

Higher As, Sb and REEs concentrations were found in crop samples in Turnu area were the local environment is affected by the phosphorous fertilizer industry emissions. In Oradea area the increased availability of K, Se and Br is due to the local nonferrous and chemical industry and also to power plants emissions. It seems that lead concentrations in vegetables were because of the increased air pollution and traffic in this area.

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Root and leafy crops were found to accumulate As, Cr, Cu and Ni from soil much more efficiently than their fruit part.

Conclusions

XRFS analyses of samples of vegetables and root soil collected in agricultural lands to ascertain inorganic constituents in the samples have been performed. The study gives an indication of uptake trends of the elements in crops grown in different polluted environments.

In all cases the metal concentrations found in the vegetables studied are lower than maximum limit (MAL) as permitted by the European Commission Regulation. Therefore they are safe for the human dietary consumption. It should be noted that the own characteristics of the root soil as pH value and clay content determines the solubility of metals in the soil and their uptake by vegetables. Agricultural soils from the areas studied were also less polluted than the critical (MAL) levels.

This kind of studies is very requested regarding the vegetable meant for human dietary.

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