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Spatial and temporal variability of Cadmium and Lead in Urban Soils of Thessaloniki (northern Greece).

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Abstract: In this study, an investigation was carried out to record, document and monitoring the pollution caused by heavy metals in soil surface soils in the urban fabric of the city of Thessaloniki. During the years 2021 & 2022, surface soil samples were collected in the spring and autumn of each year. Soil and chemical analyses were conducted to determine the physicochemical properties of soil samples. The available and pseudo-total concentration of cadmium (Cd) and lead (Pb) was determined and the mean values for the two years of the study were calculated. Using Geographical Information Systems (GIS), thematic maps were built in order to study the spatial and temporal distribution of each metal. The statistical tools used should provide useful guidance for pollution surveillance and identification of potential sources of pollution in the study area.

Keywords: Urban spatial environment; Heavy metals; Potentially toxic elements.

1. Introduction

Environmental pollution by organic and inorganic pollutants, such as polycyclic aromatic hydrocarbons and heavy metals, respectively, has become a major challenge (Tóth et al. 2018). In the last decades, the study of soil pollution has been intensively carried out, as soils are a reservoir of persistent pollutants, and through this, long-term pollution is being visualized (Golia et al. 2021). It is well known that heavy metals are naturally present in the earth, as they are bound in minerals and soil rocks. Heavy metals, despite their geochemical origin, are a product of human activities. They can enter the plant, animal, and human tissues through inhalation, diet, and manual manipulation as well (Yang et al. 2022). Common sources are mining and industrial waste, vehicle emissions, lead batteries, fertilizers, paints, treated wood, aged and damaged water infrastructure, and microplastics floating in the world's oceans (Rodrigues et al. 2010; Peana et al. 2022).

The study of urban and peri-urban land-based pollution is also a subset of the pollution study of interest to humans, as such areas pose a direct risk to people's health due to their habitation and daily activities. The primary objective of the present study was to record and monitor heavy metal pollution in the urban fabric of Thessaloniki. As urban areas are densely populated and industrialized, the environmental quality of urban soil is closely linked to human health and well-being (Tsakaldimi & Ganatsas 2015). Urban soils, especially in areas of public parks, can have a direct impact on public health, mainly due to direct human contact. In addition, soils reflect long-term pollution and therefore it is considered of particular importance to study the levels of pollutant concentrations within the soil environment.

Thessaloniki is a coastal city and the largest port in Northern Greece. Numerous heating installations, coal or crude oil used for domestic heating, leaded petrol, and exhaust gases from diesel vehicles are some of the possible sources of urban soil pollution and are major problems in the city of Thessaloniki. In addition, the presence of an extensive industrial area is likely to affect soil quality in the city center (Burliva et al. 2017).

2. Materials & Methods

In two distinct seasons, Spring and Autumn of 2021 & 2022, 68 soil samples were collected from the center of Thessaloniki. The soil samples were selected from small green areas, the area adjacent to the port, the city and intercity bus station, the railway station, near major avenues, inside the parks located in the city center, and playgrounds.

The physicochemical composition of the soil samples was measured, using the methods described in Golia et al. (2021): particle size distribution (Bouyoucos hydrometer), pH and electrical conductivity (EC) (1:1, soil: H_2O), organic carbon (wet oxidation according to Walkley and Black) and $CaCO_3$ (Bernard calorimeter).

Total and available concentrations of Cd and Pb and Zn were determined by Aqua Regia and DTPA extraction methods, respectively. Analytical results were checked for systematic differences between batches and for outliers. Subsequent statistical analysis was performed by

calculating the basic descriptive statistics for the measured parameters, including minimum, maximum, mean, median, and standard deviations. The thematic maps dependent on the distribution of metals in the city of Thessaloniki were created using Geographical Information Systems techniques. Geostatistical analysis and spatial distribution of the data were also carried out using GIS (g GIS v.8.3.2) tools.

3. Results & discussion

Significant differences were observed between samplings at the two times of the year. Both the available concentration of cadmium and lead were significantly lower in the soil samples collected during the autumn sampling, compared to the summer one.

Among the pseudo total metal concentrations, no statistically significant differences were observed between the two years of the study. Also, the values of metal concentrations were lower than the total concentration value set by the European Union and the country of Canada as a safety limit for agricultural and urban soils respectively. Figure 1 shows the pseudo-total and available concentrations of the two metals in the study during the November samplings. Cadmium's concentrations are a percentage of total from 3.8 to 52.6%, while in the case of lead the corresponding rates are 5.5 to 50.4%.

4. Conclusions

The present study constitutes a valuable guide for the continuous future monitoring of pollution in the study area. The database constructed during the study can be updated and upgraded, being a useful tool for identifying the most polluted areas, estimating the contribution of parent materials and anthropogenic activity to the local level of pollution leading to assessment of risks both to the environment and citizens of Thessaloniki city (Northern Greece).

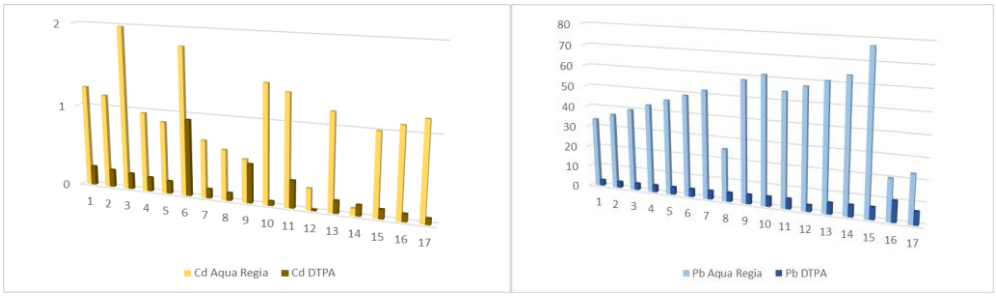

Figure 1. Pseudo-total and extractable Cd and Pb concentrations (mg kg $^{-1}$) in soil samples during autumn sampling (mean values of the two years of the study)

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