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Heavy metals in urban soils of the Granada city (Spain)

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Urban soils (Anthrosols, Technosols, and the remaining natural patches) are essential components of the city ecosystems influencing the quality of life for people. Unfortunately, because of the high concentration of matter and energy that occurs in any city, these soils might accumulate potentially toxic pollutants such as heavy metals, organic compounds, pathogens, pharmaceuticals, and soluble salts. Contamination by heavy metals has been considered especially dangerous because they can affect human health via inhalation of dust, ingestion, or skin contact with soils. Children are the more exposed citizens in gardens and parks. Accordingly, our objective was to analyze the content of heavy metals in soils of the two most emblematic, extensive, and visited landscaped areas of the Granada city (Salón Garden, which dates back to 1612, and Federico García Lorca Park, opened since 1993) for assessing the health hazard. Using a composite sampling of 20-30 points chosen at random, we collected the upper soil (10 cm) of five representative plots for each landscaped area. We determined soil characteristics by routine procedures and metal elements using ICP-mass. From high to low concentration we found Mn, Ba, Pb, Zn, V, Sn, Cr, Cu, Ni, Sb, Y, As, Sc, Co, Th, Au, U, Mo, Be, Bi, Tl, Cd, and In; the first 10 metals ranging between 478 and 22 ppm. Mn, Ba, and other trace elements were strongly correlated with soil properties suggesting the inheritance as a possible source of metal variation, especially in the soils of younger Park, where the materials used to build gardens in the five sampled plots seemed to be more variable (carbonates: 10-40%, clay: 18-26%, pH: 7.6-7.9, organic matter: 3-7%, free iron 0.5-1.1%). The content of many other metals measured in the sampled plots, however, were independent of soil material and management. On the other hand, compared to agricultural and native soils of the surroundings, our urban soils had obviously greater content in organic matter and nutrients as a result of the garden management, but was unexpected the abundance of heavy metals of urban provenance. Especially the concentration in Pb (83-322 ppm) and Cu (37-48 ppm), common in the city fumes, was higher in the urban soils. Considering the total content of metals, the soils of Salón Gardens also had 200 ppm (45% in Pb) more than those of Federico García Lorca Park, with statistically significant differences ($P<0.05$) in Zn, Cd, and Pb, which could be explained by a longer metal accumulation time. In addition, it was noted that the Pb content in the ancient garden substantially increased from the inner parts (154 ppm) to the periphery (322 ppm) near streets with car traffic. This is noteworthy because the five Salón plots had soils extremely homogeneous (carbonates: 24-25%, clay: 18-19%, pH: 7.6-7.7, organic matter: 3-4%, free iron 0.6-0.7%). Despite this seeming soil contamination in Pb, Cr, Cu, Zn, and Cd from urban sources, there were no toxic levels according to European legislation and consequently, there should be no health risk.