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Heavy metals contamination in soils and their transfer to common wheat (*Triticum aestivum* L.): a case study

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At several sites all over the world, both in industrialized and in developing countries, farmlands are located in the proximity of industrial plants and major roads; moreover, they can be affected by many other sources of heavy metals (e.g. use of fertilizers and pesticides, amendment with sewage sludge). Heavy metals, after entering the soil system, can represent a risk for human health. In this work we focus on the transfer of potentially toxic elements through the food chain, and especially on plant uptake from soil through the root system and translocation to the aerial part.
The study area is located in the proximity of an industrial district (mainly tanneries, but also chemical industries and smelters) and along a highway in North-East Italy. Wheat (*Triticum aestivum* L.) is one of the most widespread crops in the area.
Eight sampling locations were chosen, for each site the following samples were collected: topsoil (0-20 cm), subsoil (45-70 cm), mature wheat. Soil samples were sieved to 2 mm and analyzed for the determination of: pH, carbonates, organic carbon, cation exchange capacity, texture. Total concentration of some major and minor elements (K, Ca, Mg, P, S, Al, Fe, Mn, Cr, Pb, Ni, Zn, Cu) in soils and plants were determined by ICP-OES after complete acid digestion in the microwave.
Pedological characteristics present little variations among different sites; average values are: pH 8.1; $CaCO_3$% 20%; organic carbon 14 g Kg^{-1} for topsoils and 11 g Kg^{-1} for subsoils; cation exchange capacity 43.9 cmol Kg^{-1}. Texture is loamy, silty loamy or clayey loamy.
Only two metals (Cr, Cu) present concentrations above the Italian legislation limits for residential and green areas; Cr is above the threshold in 7 samples of 16 and very close to the limit in 4 more samples. Cr contamination of soil is due to the activity of the tannery industries, which use it in their productions. Cu exceeds the limit only at one site (two samples), probably owing to the vicinity of a vineyard, where $CuSO_4$ is usually utilized as fungicide. No recognizable gradient of the elements content in soil is present in relation to the distance from the highway.
Top enrichment factor (TEF = metal content in topsoil/metal content in subsoil) was calculated for the considered elements. If TEF $>>1$ it is likely an anthropogenic enrichment of the topsoil.
Metal concentration in wheat seeds is lower than in roots for all the metals considered, whereas for some nutrients (eg. K, P, S) concentration in seeds is higher than in roots. Potentially toxic metals content in seeds is lower than toxicity thresholds proposed by some authors in all samples. Metal distribution inside the plants follows two different pathways: for some essential micronutrients (e.g. Cu, Zn) root>seed>straw, while for other elements (e.g. Fe, Ni, Cr) root>straw>seed.
Translocation factor (TF = concentration in seeds/concentration in roots) was calculated for each element. Cr, Al, Ni and Fe are almost completely immobilized in the roots, thus suggesting a barrier effect.
Regarding the case study considered, there is no health risk for wheat consumption, even though the contents of some elements in soil (Cr, Cu), are above legislation limits.