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The Effect of Aggregate-Size Fractions on the Availability of Cu in Some Contaminated Soils with Heavy Metals

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Introduction: In recent years, because of the presence of industrial factories around the Isfahan province of Iran and high concentrations of heavy metals in the vicinity of them, and the gradual accumulation of heavy metals from various sources of pollution in urban areas over time, including gasoline combustion, and use of urban waste compost and sewage sludge as fertilizer, there has been widespread concerned regarding the human health problems with increasing heavy metals in soils around the Isfahan city. The variation of composition in the soil matrix may lead to variation of composition and behavior of soil heavy metals. Soil is a heterogeneous body of materials and soil components are obviously in interaction. Studies tacking this complexity often use aggregate measurements as surrogates of the complex soil matrix. So, it is important the understanding soil particle-size distribution of aggregates and its effects on heavy metal partitioning among the size fractions, the fate of metals and their toxicity potential in the soil environment. Therefore, the present study aimed to determine the Cu release potential from different size fractions of different polluted soils by different extractants and their availability for corn plant.

Materials and Methods: Five soil samples were collected from the surface soils (0–15 cm) of Isfahan province, in central of Iran. The soil samples were air-dried and ground to pass a 2-mm sieve for laboratory analysis. Air dried samples fractionated into four different aggregate size fractions 2.0–4.0 (large macro-aggregate), 0.25–2 (small macro-aggregate), 0.05–0.25 (micro-aggregate), and <0.05 mm (mineral fraction) by dry sieving. The available Cu in soils and aggregates was extracted with DTPA-TEA, Mehlich-1, 0.01 M $CaCl_2$ and distilled water. In a pot experiment, 3 kg of air-dried soil transferred into a plastic pot. Five germinated seeds (*Zea mays L.*) planted at a depth of 0.5 cm in the soil in each pot, which was fertilized with 100 mg N kg^{-1}, 100 mg P kg^{-1}, and 100 mg K kg^{-1}, in a greenhouse. After 1 week, the seedlings were thinned to 3 per pot. This experiment was performed for all 5 soils in triplicate in a completely randomized design. Sixty days after the seedling thinning, the plant shoots were cut at the soil surface and soils were sieved to remove the roots. The roots and shoots were oven-dried at 70°C for 48h, weighed, and dried samples were finely ground for analysis.

Results and Discussion: The results showed that in the studied soils, the aggregate-size fraction was dominated by 0.25 to 2 mm and these aggregates had the highest contribution in total Cu of soils. There were remarkable differences in extracted available Cu from soil and various aggregate-size fractions. The DTPA-TEA was the most aggressive extractant for removing Cu from the soil, and the amount of extracted Cu decreased in the following order Mehlich-1, $CaCl_2$ and H_2O. The distribution of Cu in the aggregate-size fractions showed that there were significant differences in the extractable Cu with different extraction methods in each fraction and Cu were not homogeneously distributed over the various aggregate-size fractions, suggesting that aggregate size have a significant influence on the partitioning of Cu. Available Cu was highest in the <0.05 mm fraction, followed by the 0.05 to 0.25, 0.25 to 2 and 2 to 4 mm fractions. The greatest shoot and root Cu uptake were observed in S4 with the highest concentration in bulk soil, indicating that the increase in Cu uptake by corn was mainly attributable to the increase in extractable Cu in soil. The higher Cu concentrations observed in the roots (compared with the shoots) revealed the restriction of Cu to this part of the plant. This plant defense mechanism coincidentally generally restricts the transmission of heavy metals to the edible parts of plants. The bioavailability of Cu in soils and aggregates to corn was evaluated by correlation studies showed that the available Cu in 0.05 to 0.25 mm aggregate fractions and plant indices had the highest correlation. Therefore, 0.05 to 0.25 mm aggregate fractions had a higher contribution in supplying Cu for corn.

Conclusion: The investigated soils located in Isfahan province because of the presence of industrial factories and use of waste compost and sewage sludge and gasoline combustion are highly polluted with Cu. Aggregate-

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size in studied soils, were dominated by the 0.25 to 2 and 2 to 4 mm size fractions and large proportions of total Cu were attached to 0.25 to 2 fraction. Cu concentration in corn shoots and roots were significantly correlated with DTPA-TEA extractable Cu in micro-aggregates (0.05 to 0.25 mm). Therefore, the results of this research showed that micro-aggregates had an important role in supplying Cu.

Keywords: Aggregates-Size Fraction, Available Cu, Chemical extractants, Corn