DOI: 10.46991/JISEES.2025.SI1.064

Features of Copper Accumulation in Macro- and Nanodispersed Forms in Haplic Chernozem

Anatoly Barakhov*, Saglara Mandzhieva, Tatiana Bauer, Elizaveta Bogomaz, Valeria Malieva, Alina Badmaeva

Federal State Autonomous Educational Institution of Higher Education "Southern Federal University"

ABSTRACT

Cu contamination of soils is a critical environmental concern, as this metal exhibits high toxicity and can progressively accumulate in biological systems. Nanoparticles are of particular concern because their increased specific surface area and reactivity result in higher bioavailability and greater migratory activity compared to macroparticles, necessitating special attention in ecological risk assessments. In a model experiment, the comparative mobility of macro- and nanodispersed Cu forms was studied in haplic carbonate chernozem (Rostov Region, Russia). The soil had the following physicochemical properties: physical clay content – 53.1%, silt – 32.4%, organic carbon (Corg) – 3.4%, cation exchange capacity (CEC) – 37.1 cmol(+)/kg, and pH 7.3. We placed 50 g of air-dried soil into Petri dishes, cleared of plant residues and sieved through a 3-mm mesh. The soil was artificially contaminated with Cu oxides (Alfa Aesar) in nano- (30-50 nm) and macro-dispersed (3-5 μm) forms at doses equivalent to 3, 30 and 90 times the background concentrations (123, 1233 and 3699 mg/kg, respectively). The samples were incubated for 30 days at 60% of field water-holding capacity. The experiment was conducted in triplicate. The content of mobile Cu forms was determined by AAS after extraction with 1M ammonium acetate (pH 4.8). The results showed that nanodispersed Cu exhibited higher mobility than macrodispersed Cu in all treatments. In control samples, the total content of mobile Cu was 0.3 mg/kg, corresponding to background levels for this soil type. At the 3× background dose, the mobile Cu content was 6 mg/kg for the macroform and 8 mg/kg for the nanoform. At 30× background, these values reached 89 and 115 mg/kg, respectively, while at 90× background, they increased to 353 and 441 mg/kg. Our research demonstrates that nanodispersed Cu is significantly more ecotoxic than macrodispersed Cu at all tested concentrations.

Keywords: mobility of metals, ecotoxicological assessment, polydisperse forms of Cu

Acknowledgement: The study was carried out with the financial support of the Ministry of Science and Higher Education using the equipment of the Center of Collective Use «Soil Bioengineering» (Agreement No. 075-15-2025-667 and FENW-2021-0014) and by the Strategic Academic Leadership Program of the Southern Federal University ("Priority 2030").

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***Corresponding Author:**

Barakhov Anatoly, Youth Laboratory of Regenerative Agriculture, Southern Federal University, 344090, Rostov-on-Don, Russia.
Email: tolik.barakhov@mail.ru