Environmental risks associated with soil contamination by copper based nanoparticles

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It is well known that soil contains natural nano-sized minerals/particles, and soil biota has evolved along with them but not together with engineered nanoparticles (NPs, size ≤100 nm). The physiochemical properties and behaviour of NPs are different as compared to bulk materials. Due to specific characteristics, the applications of NPs are fast increasing, and raise the concern for the environment as well as for human health. More than three thousand of nano-based products are available in the market, and many more could appear in the near future embedded with specific features. Most of used NPs are not bio-degradable, thus, they remain in the environment, especially in soil. NPs can enter soil with atmospheric precipitation, sedimentation in the form of dust and aerosols, direct soil absorption of gaseous compounds, application of nano-pesticide and fertilizers, abscission of plant leaves or as a result of anthropogenic activity. Therefore, the accurate determination of these NPs in the environment is imperative to assess the real-time scenario of toxicity to soil biota and risks associated with human health.

Due to wide range of applications of Cu based NPs in various fields (from consumer products to agriculture, medicines, coatings, cosmetics, chemicals, electronics and optics, environmental remediation, fuel additives, energy, textile and paints), the lab and field, in-situ and ex-situ experiments were conducted on CuO NPs along with bulk materials to observe the toxicity on barley, a widely grown crop in the South of Russia. The results in hydroponic conditions were more expressive than the soil medium due to the fast dissolution of CuO NPs. The experiments were conducted at various concentrations of CuO NPs, i.e., 300, 2,000, 10,000 mg L^{-1} along with bulk CuO. The commercial grade CuO NPs (particle size 30-50 nm) was used. The stability and hydrodynamic sizes of NPs in suspension were monitored by zeta potential analyzer. Twenty-five sterilized seeds were placed on filter paper in clean Petri dishes, and 5 ml of the distilled water with or without CuO NPs was applied and placed in a growth chamber at 28°C. After successful germination, seedlings were transferred to plastic vessels (100 x 60 x 50 mm). In each vessel 10 seedlings were placed in 50 ml solution and kept in the growth chamber at 25 ± 2°C with a 16 h light and 8 h dark cycle.

Newly formed leaves and middle roots were collected and prepared for transmission and scanning electron microscopy analysis. The morphometric and physiological parameters are recorded at various intervals throughout the experiment. After 30 days of barley growth in NPs solution the relative root lengths remained one-third (35%) and shoot length reduced up to 10% as compared to untreated plants. The 5.7 and 6.4-folds higher Cu accumulated in the roots and leaves of the treated plant than the control, respectively. The CuO NPs also altered the physiological process by decreasing photosynthesis and transpiration rate, disturbed the integrity of cellular, sub-cellular organelles and affects plant growth and performance. The decreases in quantum yield of photosystem II and transpiration rate were noted. The microscopic observation showed effects on stomatal aperture, and root morphology especially root-hairs, vascular bundles, and changes in cellular (size and integrity of plastids and mitochondria) and sub-cellular organelles (plastoglobules, starch granules, protoplasm) and membranes.

Our results indicate that the CuO NPs could be toxic to plants and accumulate in edible tissues, and consequently impose a threat to human health. Thus, the series of safety evaluation and toxicological risk assessment standards must be formulated before the unlimited use of these NPs. The future researches should conduct on the appropriate application of small amounts to achieve maximum benefits without posing a threat to the living organisms.

This work was supported by RFBR according to the research project №19-29-05265 mk.

Динамика восстановления биологических свойств дерново-карбонатных почв Адыгеи после вырубки леса

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Цель работы – исследование динамики восстановления биологических свойств дерново-карбонатных почв Адыгеи после вырубки леса. Территория, на которой проводились исследования, расположена в нескольких километрах от пос. Гузерипль (Адыгея) на высоте 1200-1600 м над уровнем моря. Возраст вырубок на момент наблюдения составлял 8 лет. Почвы исследуемой территории – дерново-карбонатные (рендзины), выщелоченные на элювии известняков. Исследования выполнены в 2010-