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**The impact of modified nano-carbon black on the earthworm *Eisenia fetida*
under turfgrass growing conditions: Assessment of survival, biomass, and
antioxidant enzymatic activities**

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HIGHLIGHTS

- SCB and NCB exhibited a certain degree of toxicity to earthworms.
- SCB and NCB significantly decreased the biomass and survival of *E. fetida* after 35- and 60-d exposures.
- The induction of oxidative stress was observed in earthworms exposed to three modified nano-CBs.
- Five percent modified nano-CB is potentially harmful to earthworms and deserves special concern.

ABSTRACT

Modified nano-carbon adsorbents have been employed in the immobilization of heavy metals in soil due to their good adsorption capabilities regarding metal ions. However, an assessment of their risks has not been extensively performed with soil organisms. To assess the toxic effects of three types of modified nano-carbon black (CB) on soil organisms, a laboratory test was conducted to expose the earthworm *Eisenia fetida* to artificial soil supplemented with 5% H₂SO₄-, HNO₃- and KMnO₄-modified nano-CB (SCB, NCB and KCB, respectively) under turfgrass growing conditions. The tested earthworms were systematically investigated for survival, biomass and the activities of antioxidant enzymes, including superoxide dismutase (SOD), peroxidase (POD), and catalase (CAT). SCB and NCB were found to be more toxic and ecologically dangerous to *E. fetida* because significant decreases in biomass and survival were observed after 35- and 60-d exposures and the survival rate showed a tendency to decrease with exposure duration. The activities of SOD, CAT and POD were inhibited in all treatments with modified nano-CBs at 35- and 60-d, which indicated that oxidative stress was induced by modified nano-CBs. The

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