Cytotoxic and genotoxic effects of macro- and nano-form of heavy metals in *Pisum sativum* L. grown in soil

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INTRODUCTION

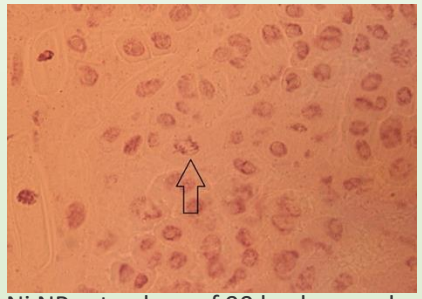
The accelerated applications of nano-forms of metals are one of the emerging concerns. Like other contaminants, the soil is the main sink for nanoparticles (NPs). Undoubtedly, in the last decade, metal NPs have been recognized for their numerous roles in research and development but due to their increasing amount in the environment, these emerging issues cannot be ignored.

METHODS

Pisum sativum L. was exposed to nano-disperse (30-50 nm) and macro-disperse (3-5 µm) forms of metal oxide viz., Zn, Cd, Ni, and Pb at the doses of 3, 30, and 90 background contamination (in mg/kg). After 3-4 days of exposure, the emerged roots were harvested, cleaned with distilled water, and fixed in Clark's fluid (aceto-alcohol) for further analyses. For microscopic observations, slides were prepared using the squash technique. In this work, the mitotic index and frequency of chromosomal aberrations were recorded to depict the extent of cytotoxic and genotoxic effects.

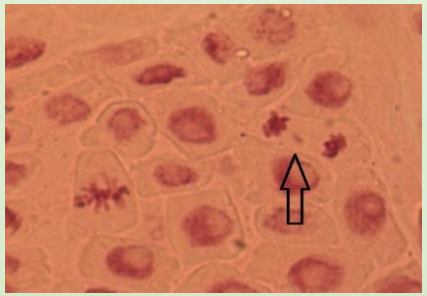
RESULTS

The experimental outcomes revealed that the maximal genotoxicity was found in all soil samples at the level of 90 background contamination, regardless of the macro- or nano-state of the metals.

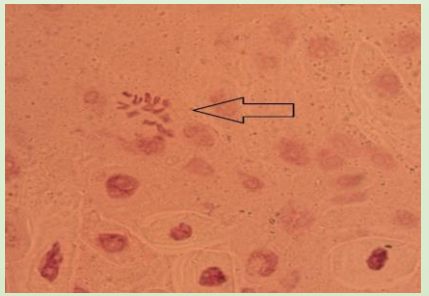


Ni NPs at a dose of 90 backgrounds

Zn NPs at a dose of 90 backgrounds

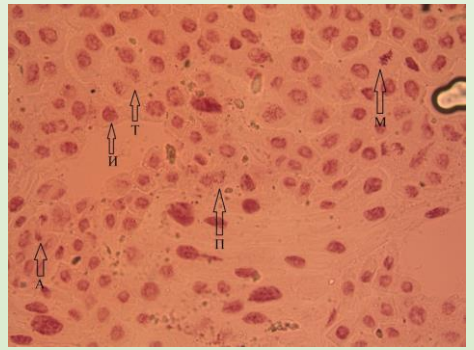


Pb NPs at a dose of 90 backgrounds



Cd NPs at a dose of 90 backgrounds

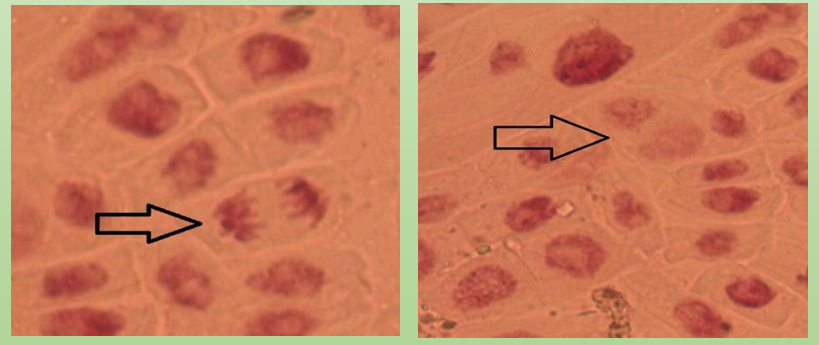
Besides, the commonly observed chromosomal aberrations were bridges and fragments. Also, cell ruptures at the metaphase stage, forming a metaphase plate was found but rarely.



Micrography of the cell division phase in the root meristem on a variant with the introduction of Zn nanoparticles at a dose of 3 background: assessment of the mitotic index. (И-interphase, П-prophase, M-metaphase, A-anaphase, T-telophase).

Late anaphase

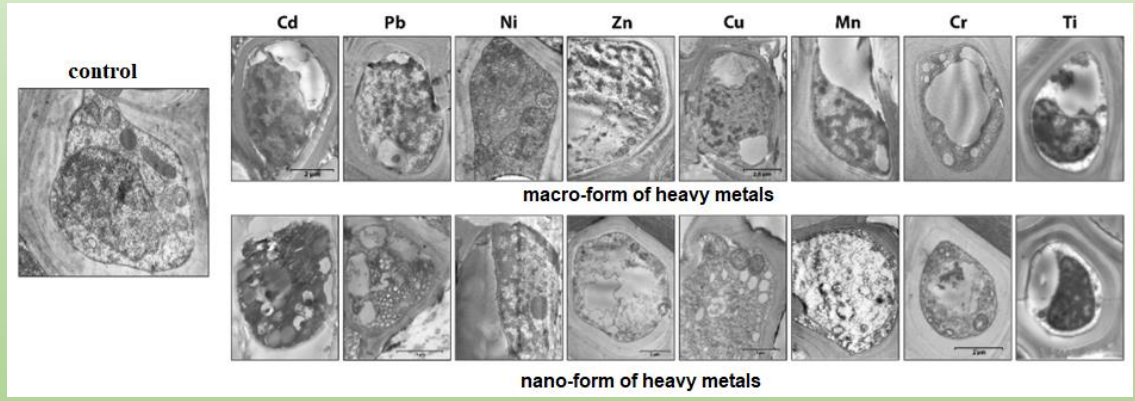
Early telophase



Introduction of Zn NPs in a dose of 3 background. Normal anaphase.

Electron microscopy data showed that the greatest changes compared with the control in the ultrastructure of root cells occurred in variants with the nanoform of all the metals studied.

Heavy metals caused the following ultrastructural changes: violation of the integrity of the cytoplasm, the presence of many small vacuoles, heterogeneity of the structure of mitochondria, etc.



Metal nanoforms have a greater negative effect on the genetic apparatus of plant root cells compared to macroparticles. The cytotoxicity results are consistent with the genotoxicity results. At the same time, the degree of ultrastructural changes can be called destructive.

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