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Effect of ZnO Nanoparticle Concentration on Wheat Seed Growth

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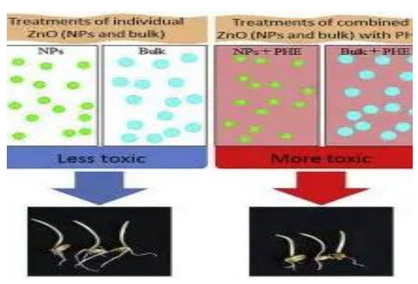
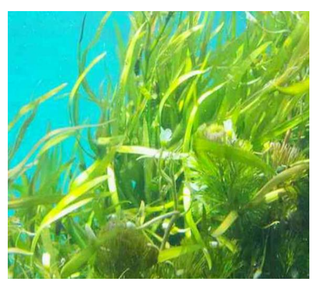
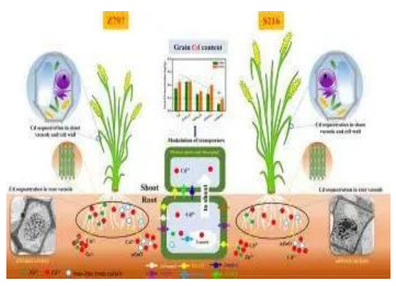
INTRODUCTION & AIM

ZnO nanoparticles (NPs) are widely used in photocatalysis, medicine, and electronics. However, their ecotoxicity remains poorly understood. Previous studies show reduced germination rates and growth inhibition in wheat at high NP concentrations.

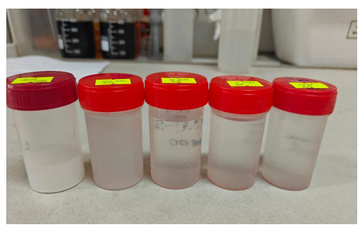
Goal: to evaluate the effects of zinc oxide nanoparticles (ZnO NPs) with different particle sizes (40 nm and 300 nm) and concentrations on wheat seed germination and root/shoot development, in order to assess their nanotoxicity.





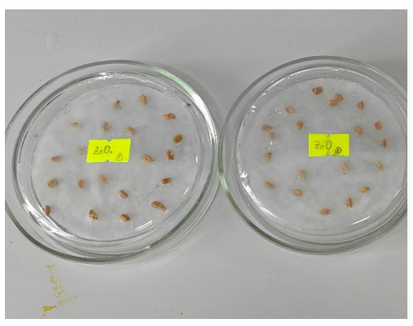


METHOD



- **Preparation of suspension:**

Concentration of NPs: 1–10 000 mg/L
Distilled water
Acculab ALC-110d4, ±0.0001 g
Ultrasonic treatment 15 min
ODA-LQ40 bath, 120 W



- **Seed soaking:**

seeds of the wheat "Trizo"
Tomsk Region, Russia, 2020
20 wheat Glass Petri dishes
7 mL of suspension
25°C, 72 h

- **Root morphometry:**

ImageJ
Root length measurement (**L, cm**)
Germination rate calculation (**G, %**)

$$G = \frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ seeds} 100\%$$

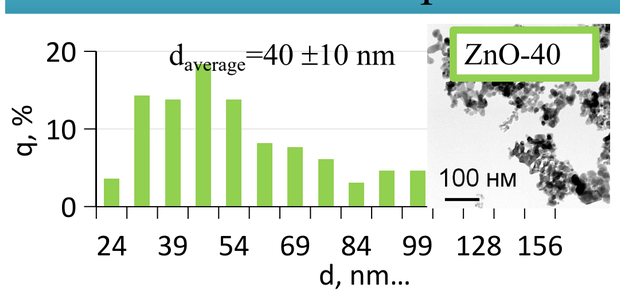
- **Shoot cultivation:**

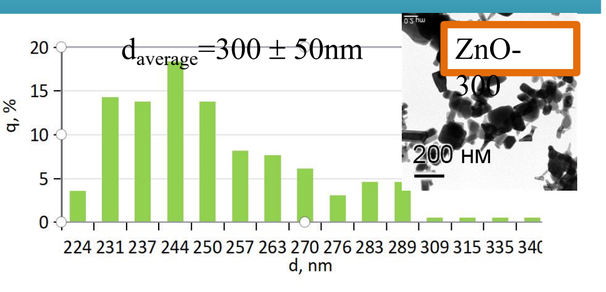
150 mL of distilled water
Light:dfrkness= 16:8 h
Root index (RI) calculation

$$RI = \frac{Mean\ root\ length}{Mean\ shoot\ length}$$

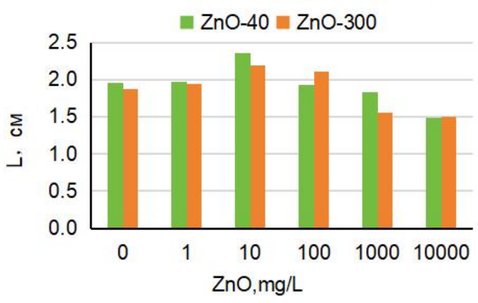
RESULTS & DISCUSSION

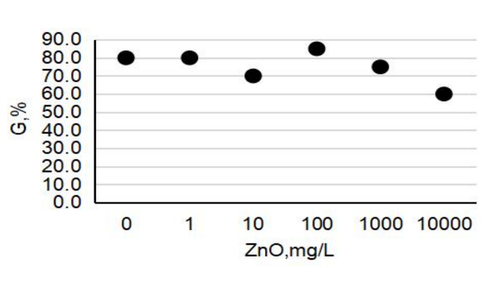
Nanoparticles characterization

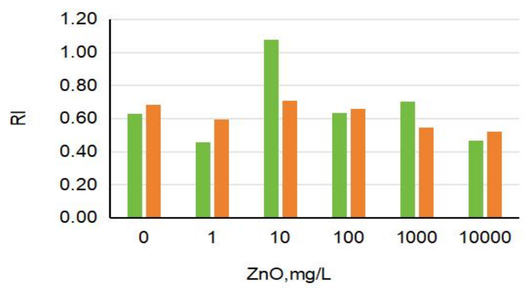




Morphology of seedlings







1. Dual concentration effect: 10 mg/L ZnO NPs suspension stimulated root growth up to 19%, while 10,000 mg/L caused significant inhibition (24%).

2. At concentrations 1–100 mg/L ZnO-40 NPs exhibited slightly stronger promotional effects on root and shoot growth compared to ZnO-300, suggesting that smaller particle size may mildly enhance bioactivity due to higher specific surface area. However, this difference diminished as concentration increased, with toxicity becoming dominant at high concentrations and no significant size-dependent effects observed.

3. Toxicity threshold: Concentrations exceeding 1000 mg/L consistently inhibited root development for both NP sizes (23-28% reduction in root index).

4. Concentration over size: NP concentration demonstrated a stronger influence on wheat growth than particle size (40 vs. 300 nm).

CONCLUSION

The key finding of this experiment is that the concentration of ZnO nanoparticles is a far more critical factor influencing seed germination and early seedling growth than their size (40 nm vs. 300 nm). While a minor size-dependent effect was noted at very low concentrations, high concentrations were universally toxic. This result underscores the importance of carefully controlling the dosage of ZnO nanoparticles in agricultural or environmental applications to avoid detrimental effects on plant development.