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Microplastics Reduce Earthworm (Eisenia fetida) Biomass and Impact Behavior

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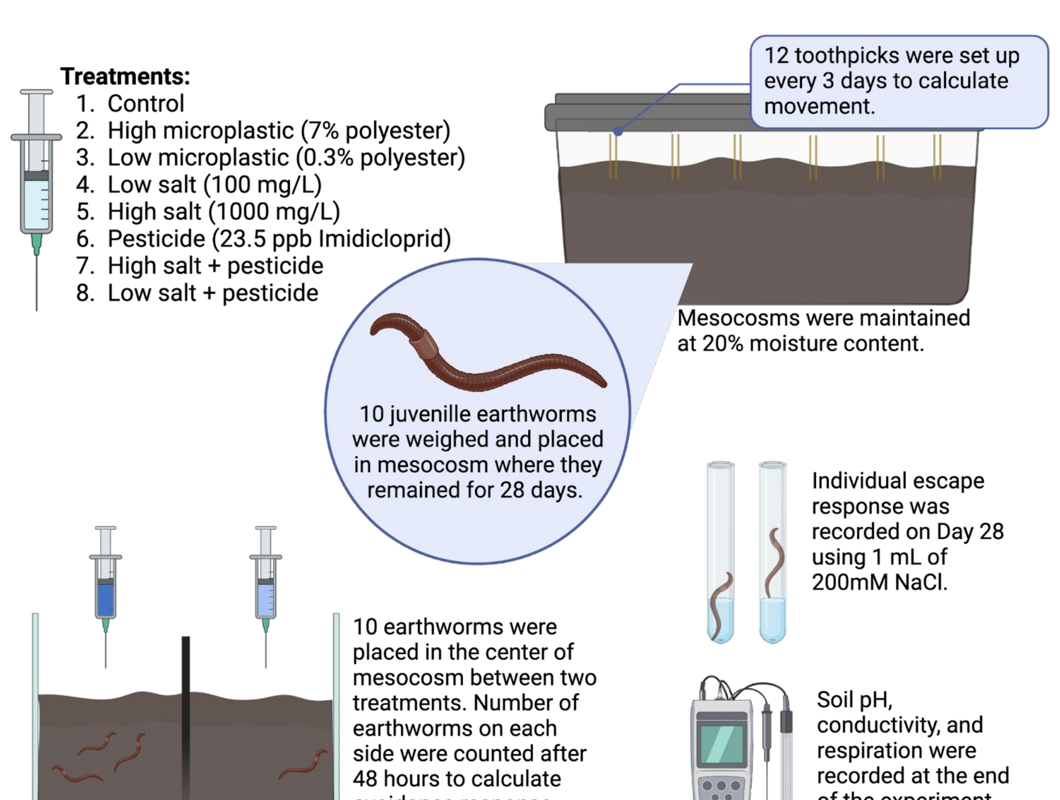
Introduction

- Microplastics, pesticides, and salts accumulate in soils impacted by human activity (1-3).
- Microplastics (particles <5mm) are a threat to marine ecosystems by harming organisms and affecting their biological functions. However, the impacts of microplastics on terrestrial environments are less clear (4-6).
- Imidacloprid has shown to be highly toxic to non-target invertebrates. Since this pesticide has a long half-life in soil, excessive use can cause soil salinization and alter the structure and properties of soil ecosystems (2-3).
- Earthworms are ecosystem engineers that contribute to soil structure and nutrient availability. These invertebrates are at risk of ingesting pollutants which can interfere with their biomass accumulation and behaviors (1,4-5).
- Soil pH and conductivity are affected by pollutants, which alters the physiological function of the species living within that soil (7).

Questions

- Do microplastics, pesticide, and salinity affect biomass, escape response, movement activity, and avoidance behavior in *Eisenia fetida*?
- Do microplastics, salinity, and pesticide affect soil pH and conductivity?
- Does the combined treatment of salinity and pesticide have a compounding effect on earthworm and soil variables?

Methods



Results

Earthworm Responses

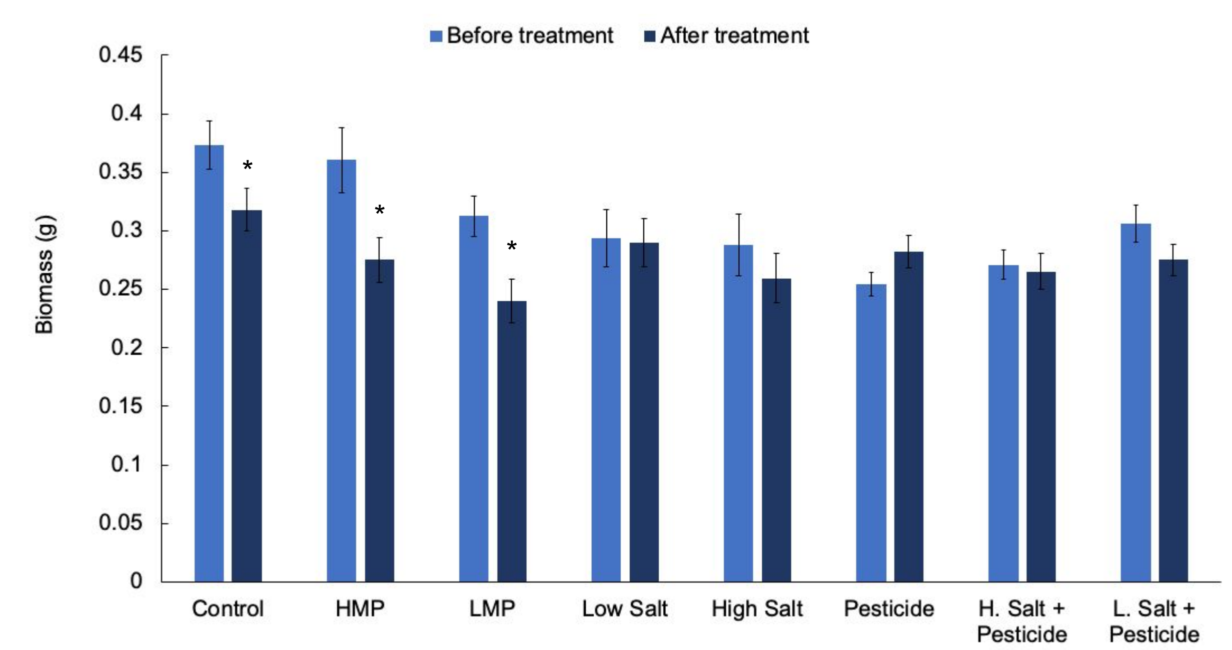


Figure 1. The average biomass ± SE of earthworms before and after each treatment. The Calculated p-values for the treatments found to significantly affect biomass were 0.044 for Control, 0.006 for high microplastic concentration, and 0.006 for low microplastic concentration. The * indicates significant difference in biomass.

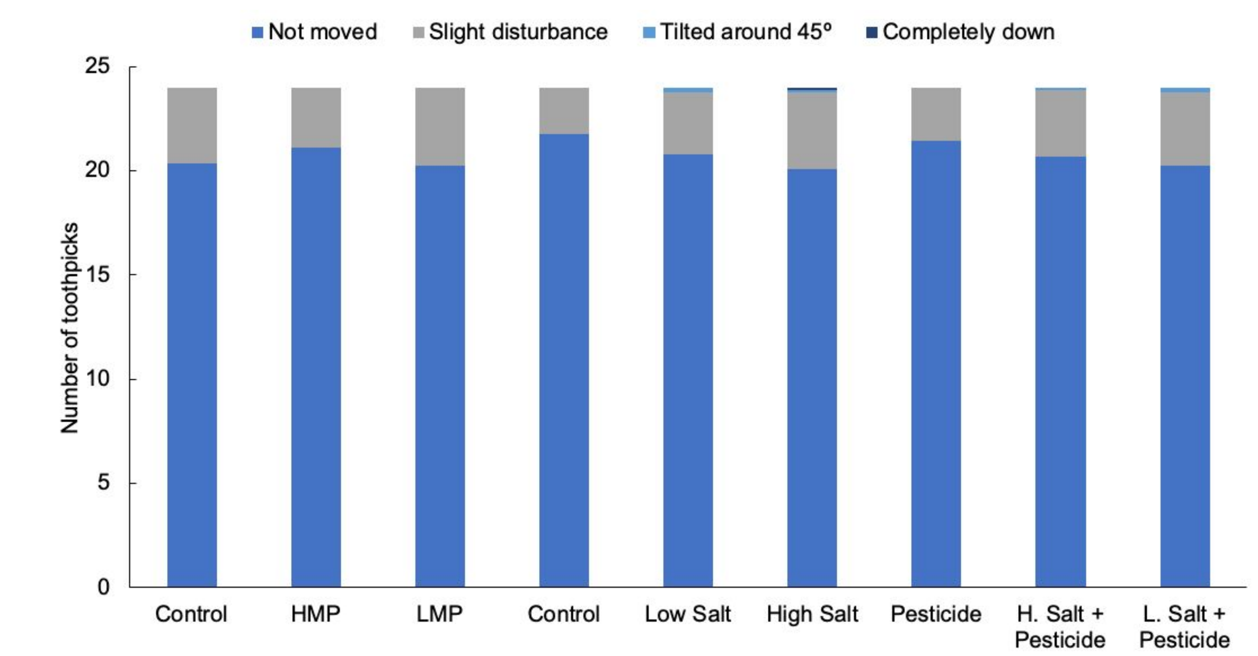


Figure 2. The average number of toothpicks per category of movement for each treatment. The average for each category was calculated based on two recordings per week for three weeks.

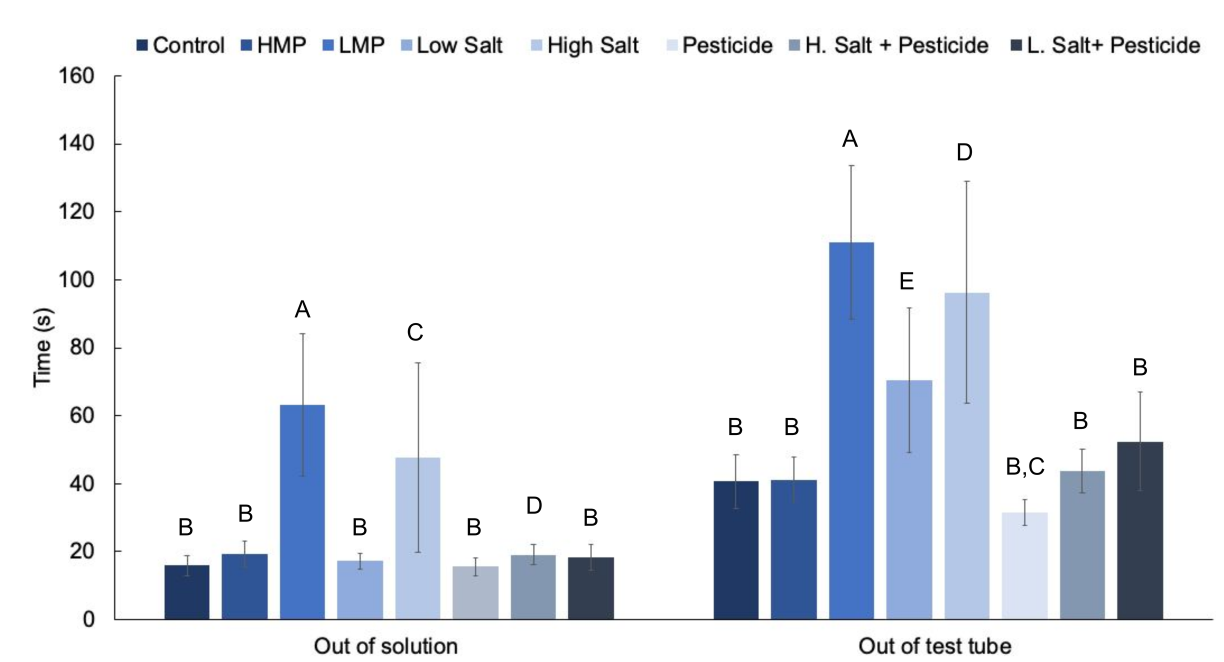


Figure 3. The average time ± SE to escape the solution and the test tube for each treatment group. The average was calculated from ten recordings. Out of solution Kruskal Wallis p<0.05 and out of test tube Kruskal Wallis p<0.05. Letters indicate significant differences between treatment groups.

Table 1. Avoidance Behavior Pilot. Percent avoidance was calculated using the formula $(n_c - n_t)/N * 100$, where n_c is the number of worms in the control, n_t is the number of worms in the treatment, and N is total worms used.

Trial #	Treatment	Number of worms in control	Number of worms in treatment	Percent Avoidance (%)
1	HMP	2	8	-60
2	LMP	2	8	-60
3	High Salt	5	5	0
4	Pesticide	8	2	60
5	High Salt + Pesticide	4	5	-11.1

Soil Characteristics

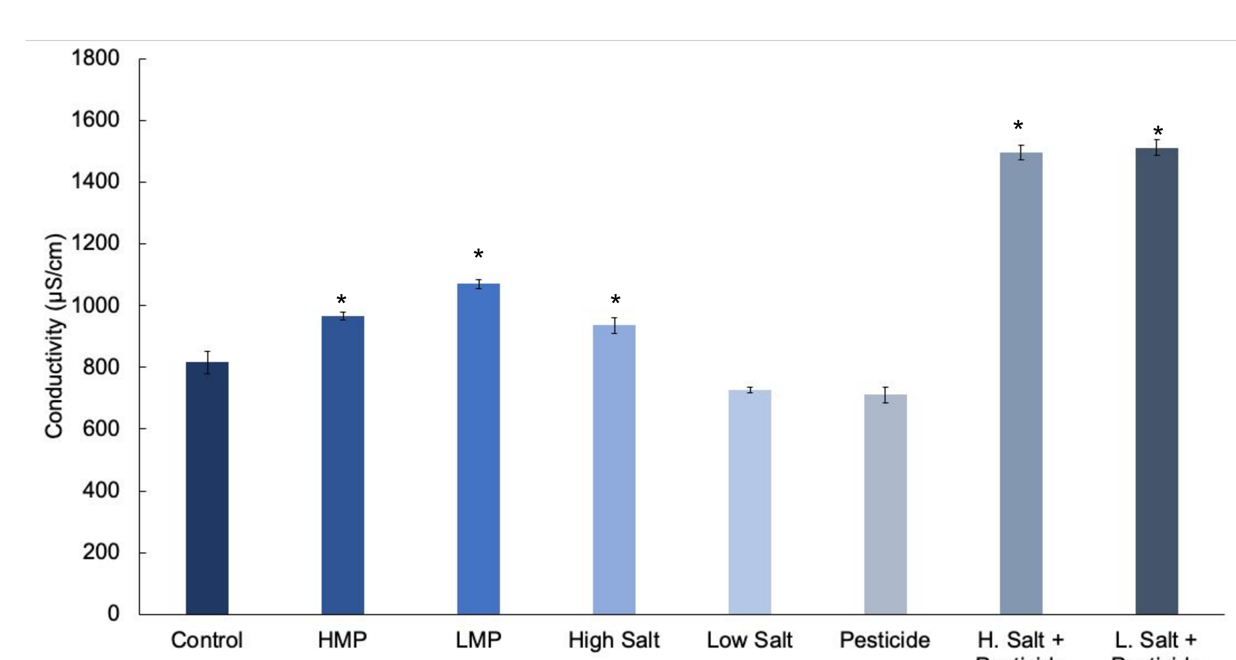


Figure 4. The average conductivity ± SE of each treatment was recorded at the end of the experiment. Preliminary data analysis suggest significant difference between the control and high microplastic, low microplastic, high salt, high salt + pesticide, and low salt + pesticide. The * indicates a significant difference from the control group Tukey's pairwise p<0.05.

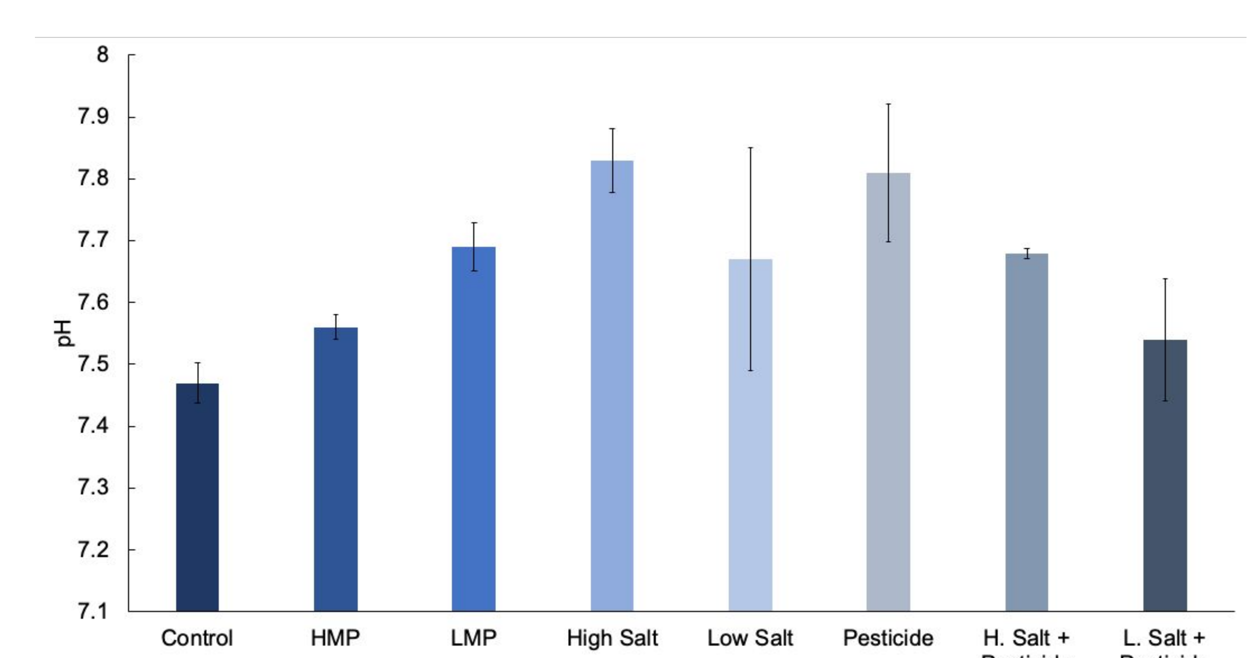


Figure 5. The average pH ± SE of each treatment group was recorded at the end of the experiment. Average was calculated from four recordings for all treatments. ANOVA p>0.05.

Discussion

- The decrease in biomass for control and microplastic treatment groups may be attributed to biological tradeoffs and microplastic accumulation in the gut and stomach, respectively, which interferes with biomass accretion (8).
- Escape responses were significantly longer in low microplastic and high salt treatment groups. The data suggests there is a trend between increased escape times and low biomass.
- Results from the avoidance behavior pilot suggest that microplastics can attract earthworms supporting the 'peanut butter on the cracker' hypothesis (5).
- Increased conductivity in high microplastics and low microplastics may be attributed to decreased bulk density in the soil. The interactions between the salt and pesticide may have led to increased conductivity as a result (9-12).
- Overall, these pollutants can create unfavorable soil ecosystems which can lead to a general decrease in fitness of *E. fetida*.

Future Research

- Investigate the impact treatment groups have on reproduction and mortality in *E. fetida* to assess biological tradeoffs.
- Identify metabolic perturbations caused by microplastics, such as changes in gut microbiota and oxidative stress responses, to investigate their effects on biomass.
- Measure the total amount of microplastics digested by analyzing and dissecting casts to provide insight on how *E. fetida* act as transport agents in soils.

Literature Cited

Acknowledgements

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