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ECOTOXICOLOGICAL IMPACTS OF COPPER AND MANGANESE SALTS ON LEMNA MINOR: GROWTH INHIBITION AND BIOCHEMICAL ALTERATIONS

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Abstract: *A comprehensive study was conducted to assess the ecotoxicological effects of four metal salts—copper chloride ($CuCl_2$), copper sulfate ($CuSO_4$), manganese chloride ($MnCl_2$), and manganese sulfate ($MnSO_4$)—on the aquatic plant Lemna minor (common duckweed). Plants were exposed to five different concentrations of each compound under controlled laboratory conditions. Growth inhibition tests were performed to evaluate the impact on plant development, and the study was complemented by biochemical analyses including measurements of fresh weight, chlorophyll content, and the concentrations of reducing sugars and proteins. All tested compounds exhibited ecotoxic effects at higher concentrations, leading to significant inhibition of duckweed growth. Based on EC_{50} values, all four metal salts were classified as highly toxic. In terms of biochemical responses, fresh weight was strongly reduced at higher concentrations of all compounds. Chlorophyll content decreased significantly with exposure to copper salts, but was not strongly affected by manganese salts. Protein concentration declined notably under all concentrations of $MnCl_2$ and at higher levels of $CuSO_4$ and $MnSO_4$. Reducing sugar levels were generally unaffected by most treatments, except for a slight increase observed at the lowest concentration of $MnSO_4$*

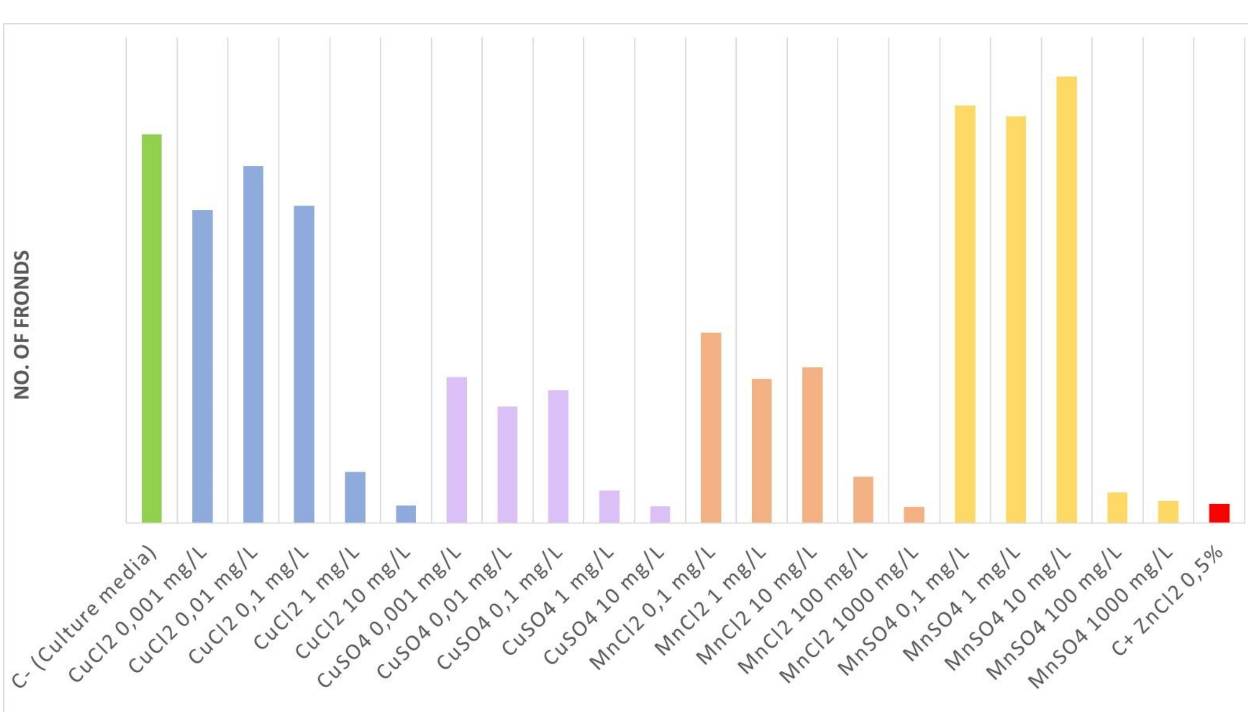
• Introduction

- Heavy metals like copper and manganese, commonly introduced into aquatic environments through industrial and agricultural activities, can be toxic to aquatic plants even at moderately elevated concentrations.
- This study uses Lemna minor as a model to evaluate the ecotoxicological effects of four metal salts through growth and biochemical responses, providing insight into their toxicity profiles.

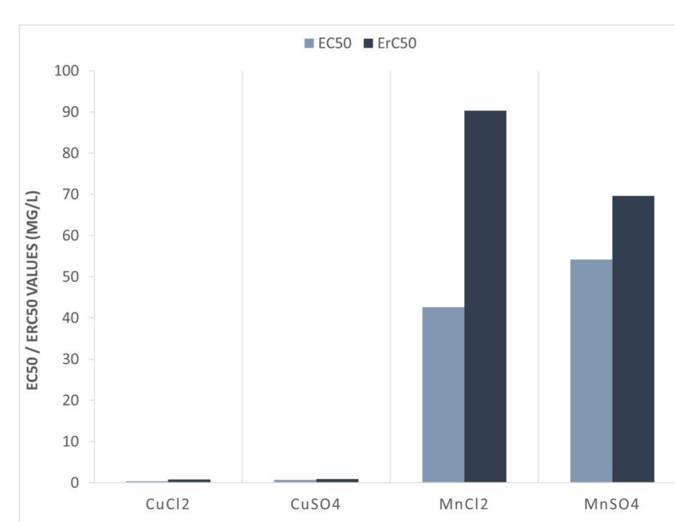
• Material and method

- a duckweed growth inhibition test was carried out by exposure to two salts of Cu and Mn, namely chloride and sulphate, at three concentrations each
- the plants obtained at the end of the test were used to obtain two types of extracts necessary for the determination of biochemical parameters such as:
  - Chlorophyll content
  - Reducing sugars concentration
  - Protein concentration

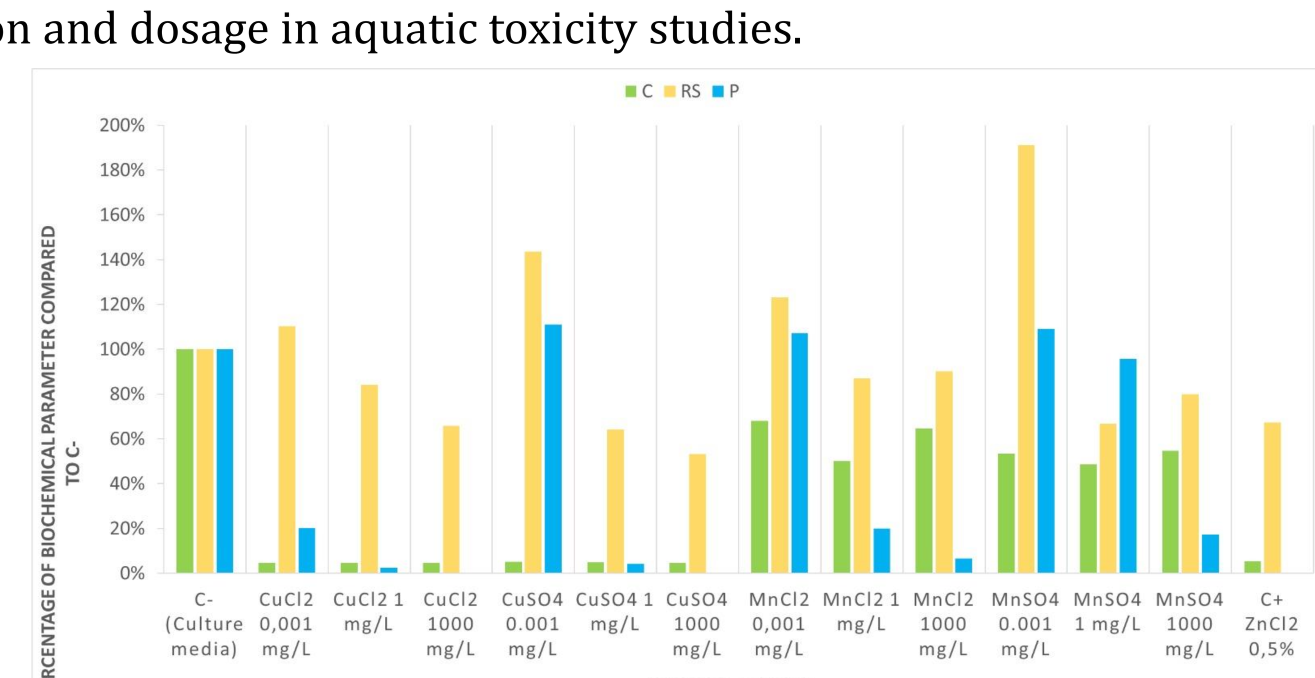
• Results and discussions



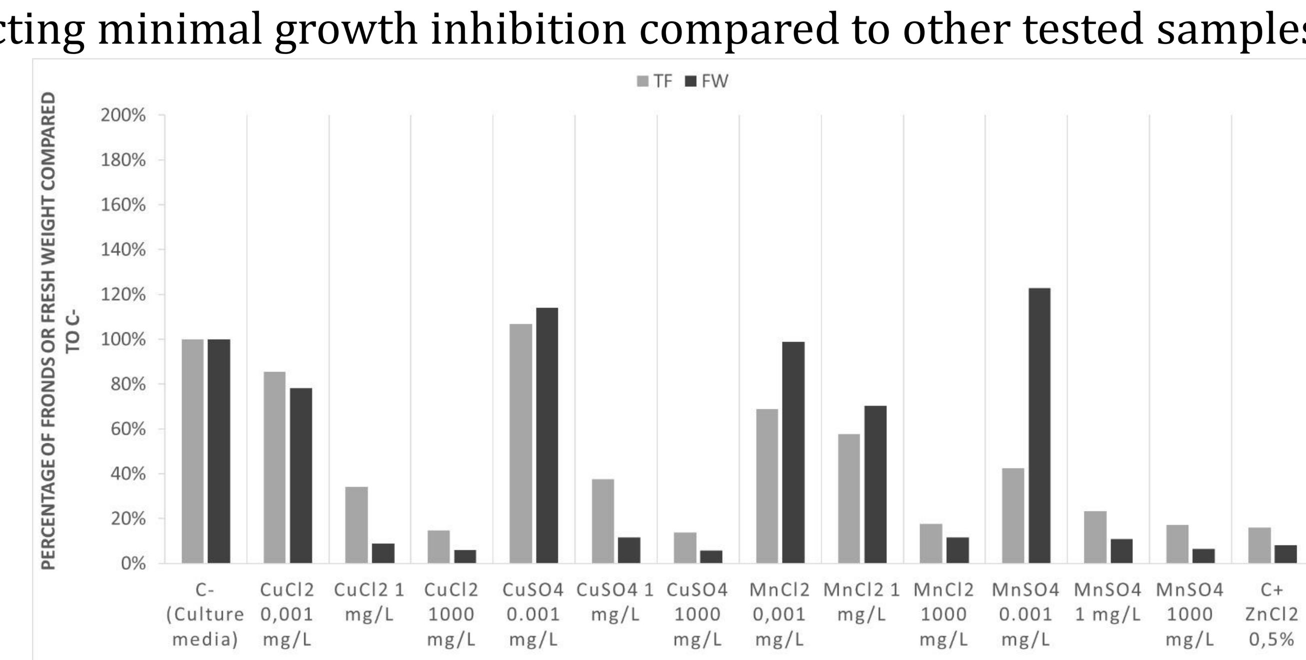
Metal type and concentration significantly influence duckweed growth. Low levels of $MnSO_4$ may be beneficial, while high concentrations of all metals, particularly $ZnCl_2$ and Cu salts, are detrimental. This highlights the importance of metal speciation and dosage in aquatic toxicity studies.



This bar chart illustrates the EC50 (median effective concentration) and ErC50 (median effective concentration for growth rate) values for four analyzed metal salts: $CuCl_2$, $CuSO_4$, $MnCl_2$, and $MnSO_4$, expressed in mg/L. Copper-based compounds ($CuCl_2$ and $CuSO_4$) exhibit significantly lower EC50 and ErC50 values (close to 0), indicating high toxicity. In contrast, manganese-based compounds ($MnCl_2$ and $MnSO_4$) show substantially higher values, suggesting lower toxicity. Notably, $MnCl_2$ has the highest ErC50 value (~90 mg/L), reflecting minimal growth inhibition compared to other tested samples.



Copper treatments, even at low doses, are detrimental to duckweed's photosynthetic pigment. Manganese, especially as $MnSO_4$, can enhance biochemical activity at low concentrations, while high concentrations of any tested metal salt negatively affect overall plant biochemistry. Zinc at 0.5% is highly toxic, nearly abolishing biochemical function.



Low levels of $MnSO_4$ enhance biomass accumulation, making it a potentially beneficial micronutrient at sub-toxic concentrations. In contrast, copper and zinc, particularly at higher concentrations, show strong inhibitory effects on both frond proliferation and biomass production.

• Conclusions

Copper and zinc salts exhibit high toxicity to duckweed, even at low concentrations, as evidenced by very low EC50 and ErC50 values. These metals strongly inhibit photosynthetic pigments, frond proliferation, and biochemical function, emphasizing their environmental risk in aquatic ecosystems. Manganese compounds, particularly $MnSO_4$, show low toxicity and may enhance duckweed growth at sub-toxic levels. Their higher EC50/ErC50 values and positive effects on biomass accumulation suggest potential as beneficial micronutrients when carefully dosed.