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Impact of Heavy Metal Contamination on *Taxiphyllum Barbieri*: A Comprehensive Study of Physiological and Biochemical Responses

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INTRODUCTION & AIM

- Contamination of aquatic environments by heavy metals (HMs) poses a significant concern due to their potential toxicity and persistent accumulation in aquatic ecosystems.
- Various aquatic bryophytes have proven effective as bio-indicators due to their ability to accumulate substantial amounts of contaminants in water.
- The phytoremediation potential of Hypnales aquatic mosses remains insufficiently explored.
- Investigating the remediation capabilities of these mosses could unveil a valuable and sustainable approach to addressing heavy metal contamination in aquatic environments.

METHOD

A thorough review of available literature was conducted to identify the maximum concentrations of HM discharged in effluents by various industries.

Sl. No.	Heavy Metal	References
1.	Iron (Fe) – 25 mg/L	Al-Farraj et al., 2013
2.	Copper (Cu) – 6.5 mg/L	Islam, 2017
3.	Zinc (Zn) – 56 mg/L	Iloms et al., 2020
4.	Nickel (Ni) – 6.5 mg/L	Maheshwari, 2008
5.	Cadmium (Cd) – 6.5 mg/L	Maheshwari, 2008
6.	Chromium (Cr) – 4.9 mg/L	Islam, 2017

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Heavy metal contamination conditions were simulated. The moss (*Taxiphyllum barbieri*) was subjected in the HM for a period of three months.

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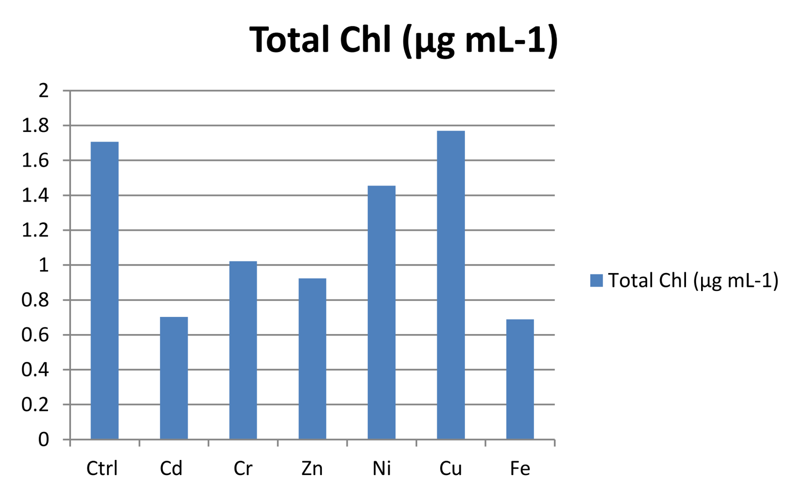
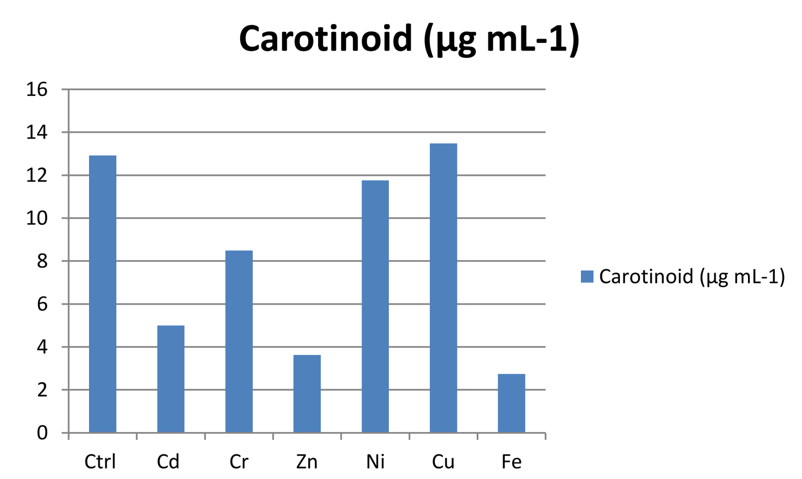
The moss's responses were analyzed with respect to total chlorophyll, carotenoid, protein, carbohydrate, proline, superoxide dismutase (SOD), malondialdehyde (MDA) and catalase (CAT).

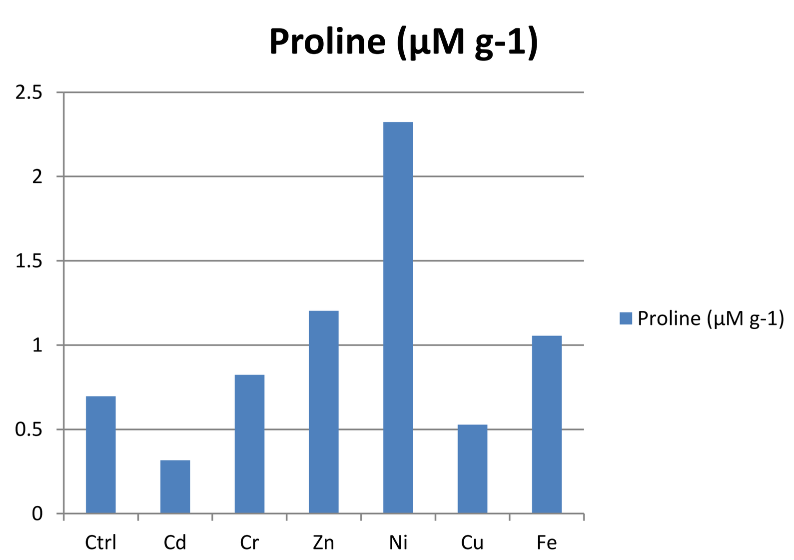
Sl. No.	Analysis	Method	References
1.	Total chlorophyll	Spectrophotometric	Porra et al., 2019
2.	Carotenoid	Spectrophotometric	Porra et al., 2019
3.	Proline	Spectrophotometric	Bates et al., 1973
4.	Protein estimation	Lowry's method	Lowry et al., 1951
5.	Total Carbohydrate	Phenol Sulphuric Acid Method	Krishnaveni et al., 1984
6.	Superoxide dismutase Assay	Spectrophotometric	Ginnopolitis and Ries (1977)
7.	Catalase	Spectrophotometric	Luck (1974)
8.	Lipid peroxidation (Malondialdehyde)	Spectrophotometric	Heath and Packer (1968)

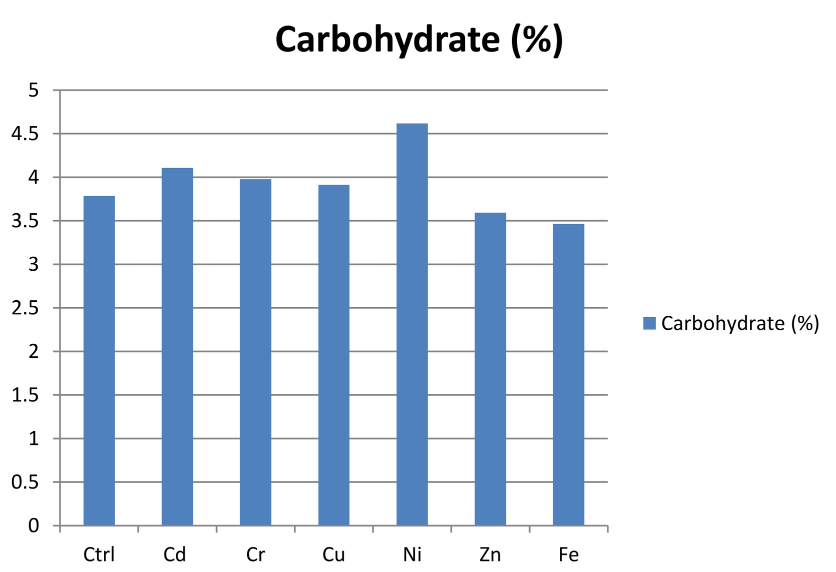
RESULTS & DISCUSSION



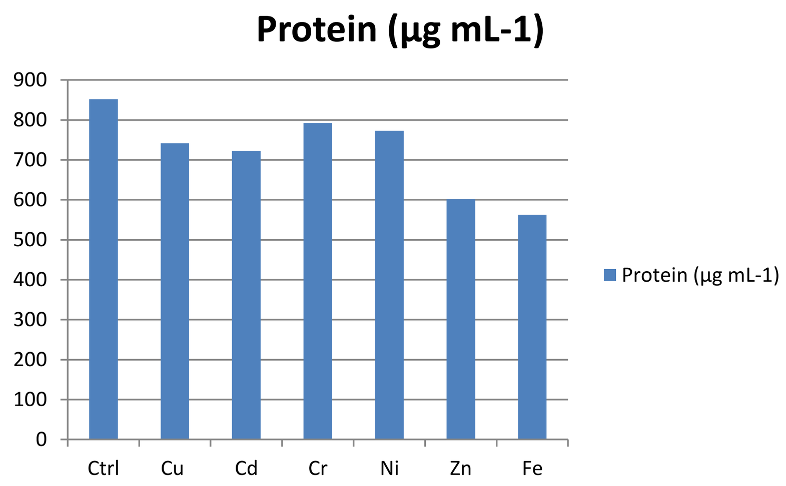


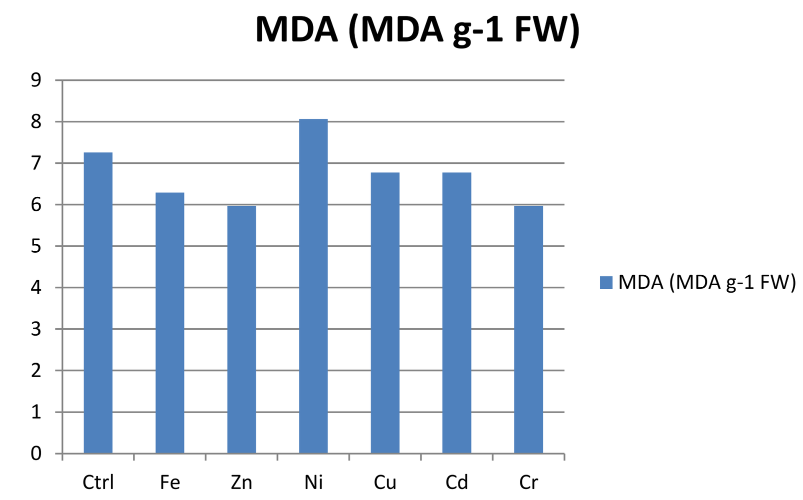
Copper (Cu) is known to play a crucial role in chlorophyll and carotenoid synthesis, enhancing the photosynthetic process. Iron (Fe) exposure, on the other hand, may have adverse effects on chlorophyll and carotenoid production, leading to reduced levels.



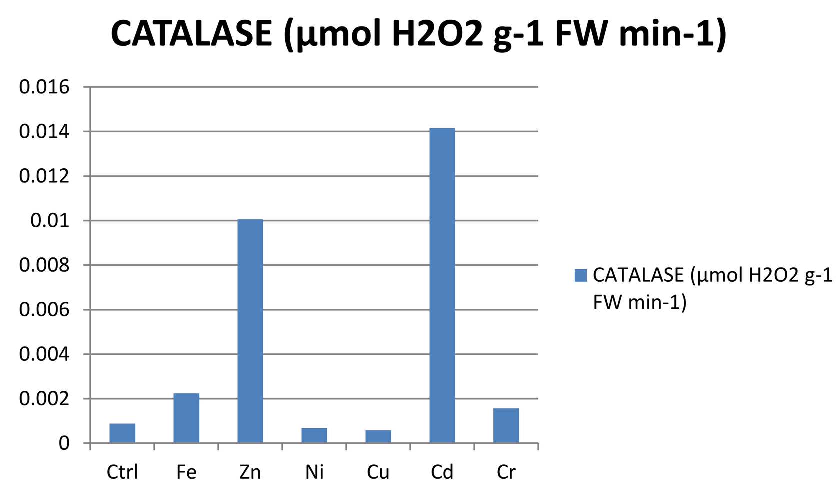


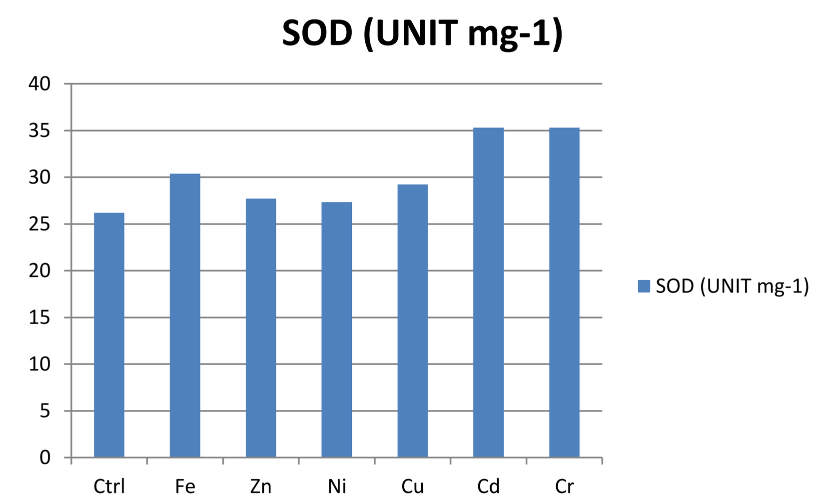
- Proline is a known stress indicator; its increased levels in the Ni-exposed sample suggest that the moss responded to nickel (Ni) stress by accumulating proline. Conversely, the lower proline content in the Cd-exposed sample may indicate a different adaptive response or lower stress intensity.
- The moss exhibited increased carbohydrate content in response to nickel (Ni) exposure, indicating a potential energy storage or metabolic response. Conversely, the lower carbohydrate levels in the Fe-exposed sample may be attributed to the inhibitory effects of iron on carbohydrate metabolism.





- Iron (Fe) exposure led to the lowest protein content, suggesting a possible disruption in protein synthesis or increased protein degradation. Heavy metals, especially iron, can interfere with cellular processes, impacting protein metabolism.
- The elevated MDA levels in the Ni-exposed sample indicate lipid peroxidation, suggesting oxidative stress. Nickel (Ni) is known to induce reactive oxygen species (ROS) production, leading to increased lipid peroxidation and MDA accumulation.





- Cadmium (Cd) exposure resulted in the highest catalase (CAT) activity, indicating an adaptive response to combat oxidative stress. Catalase is an enzyme involved in the breakdown of hydrogen peroxide, and its increased activity suggests an attempt to mitigate oxidative damage caused by Cd.
- The highest superoxide dismutase (SOD) activity in Cd and Cr-exposed samples suggests an intensified defense against oxidative stress. SOD is a key enzyme in the antioxidant defense system, and its increased activity reflects the moss's response to heavy metal-induced oxidative stress in these cases.

CONCLUSION

This study reveals that *Taxiphyllum barbieri*, exhibits a high tolerance towards HM. Notably, moss demonstrated a high tolerance to 4.5 mg/L of copper in comparison with other metals as well as the control sample without HM. The differential impact on physiological and biochemical parameters highlights the complexity of the plant's adaptive strategies, with metals like Cu positively influencing chlorophyll content, while others like Ni induce higher proline and MDA levels, indicative of stress responses. This enhanced tolerance resulted in enhanced growth, increased pigment levels, and elevated protein content. These findings underscore the phytoremediation potential of Hypnales aquatic mosses, suggesting a promising and sustainable approach for mitigating HM contamination in aquatic environments, with broader implications for environmental conservation.

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