



Assessment of Pb and Ni stress on the physiology and growth of *Rosa indica* L.

*Mukul Baghel, Rohan J. D'Souza

Department of Botany, St. John's College (Dr. Bhimrao Ambedkar University, Agra) UP, India

*Corresponding email: baghel.mukul39@gmail.com

ARTICLE INFO	ABSTRACT
<p>Research Article Received on August 20, 2023 Revised on September 19, 2023 Accepted on October 18, 2023 Published on October 28, 2023</p> <p>Article Authors Mukul Baghel, Rohan J. D'Souza</p> <p>Corresponding Author Email baghel.mukul39@gmail.com</p>	<p>Heavy metal pollution in the environment is a growing concern with far-reaching consequences for ecosystems and human health. This study provides an overview of the effects of heavy metal stress on aromatic plants, emphasizing physiological responses and potential implications. It focuses on Pb and Ni, two prevalent and toxic heavy metals. Aromatic plants, known for their diverse secondary metabolites, play a pivotal role in various industries, including pharmaceuticals, perfumery and culinary applications. The plant selected for this study was <i>Rosa indica</i> (common Indian rose). It was grown in controlled (without heavy metals) as well as contaminated soil (Ni and Pb treated). Aromatic plants are known for their ability to accumulate heavy metals within their tissues, but these heavy metals also have negative impact on plants physiology and their biomass production. The research showed that different Ni doses had less negative impact on plant height and biomass compared to different Pb doses.</p>
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Different external factors affect plants differently and they create challenging adverse conditions in their environment to survive. Changes in environmental conditions alter plants physiology and their growth. Any environmental change, which affects plant response adversely, might be considered stressful. Environmental stresses are a major threat to plants and their productivity. These stresses can be heavy metal toxicity, flooding, cold, heat, drought and salinity (Gaffar *et al.*, 2012). Heavy metals are metals of high density. Regardless of debate on their classification, the term HM, particularly in a biological sense, is more often used for those metals and metalloids with potential human and environmental toxicity (Tchounwou *et al.*, 2012).

Accumulation and enrichment of excessive heavy metals such as lead (Pb), cadmium (Cd), nickel (Ni), mercury (Hg) and arsenic (As) due to industrialization and modernization has not only devastated our ecosystem, but also posed a threat to global vegetation (Feng *et al.*, 2023). These metals affect plant growth and often lead to toxic effects. Both underground and aboveground parts of plants can absorb HMs, which directly or indirectly affect plant health. Heavy metal stress stimulates the production of excessive ROS that disrupt cellular redox homeostasis and ultimately leads to plant structural damages. Physiologically, heavy metal stress can affect the photosynthetic apparatus, leading to reduced chlorophyll content, decreased photosynthetic rates and impaired antioxidant defense mechanisms.

Sometimes aromatic plants, sensitive to heavy metal stress, exhibit distinct responses morphologically, physiologically when they are at high heavy metal stress. Plants exposed to high level of heavy metals, when present in plant tissues especially in roots and shoots, then reach to toxic level and resulting decrease plant growth and development (Hall, 2002). Heavy metals disturb the growth and metabolism by triggering secondary responses, which are oxidative damage, when heavy metals are absorbed and collect in plants at different places such as roots, shoots and leaves (Choudhary *et al.*, 2004).

Lead (Pb) is non-essential heavy metal, which mostly comes from industrial sources like smelters, mining and refining and once comes in the air, Pb can attach to airborne particles to form particulate matter. Lead can also settle into the soil and then be kicked up again by human activity or wind and leads to inhibition of plant health and growth at different levels such as decreased root/shoot length and their biomass too. At high concentration it produces reactive oxygen species (ROS) which affects a plant's photosynthetic processes to destroy or damage chlorophyll pigment

and suppresses overall plant growth (Najeeb *et al.*, 2014). Nickel (Ni) is one of many trace metals widely distributed in the environment, being released from both natural sources and anthropogenic activity. Combustion of coal, petroleum products are the cause of pollution by nickel. Nickel is a major problem in land near towns because such areas receive wastes such sewage sludge. While nickel is essential in small amounts, it can become toxic to plants at higher concentrations. Nickel toxicity can lead to symptoms such as leaf yellowing, stunted growth, and reduced flowering in aromatic plants.

Aromatic plants, often prized for their pleasant fragrances and culinary or medicinal properties, possess a remarkable ability to tolerate heavy metal stress, making them not only valuable for their aromatic compounds but also for their ecological significance in polluted environments. Aromatic plants often have a higher capacity to produce antioxidants, such as glutathione and superoxide dismutase, which help counteract the damaging effects of heavy metals on cellular structures, physiology and biomass.

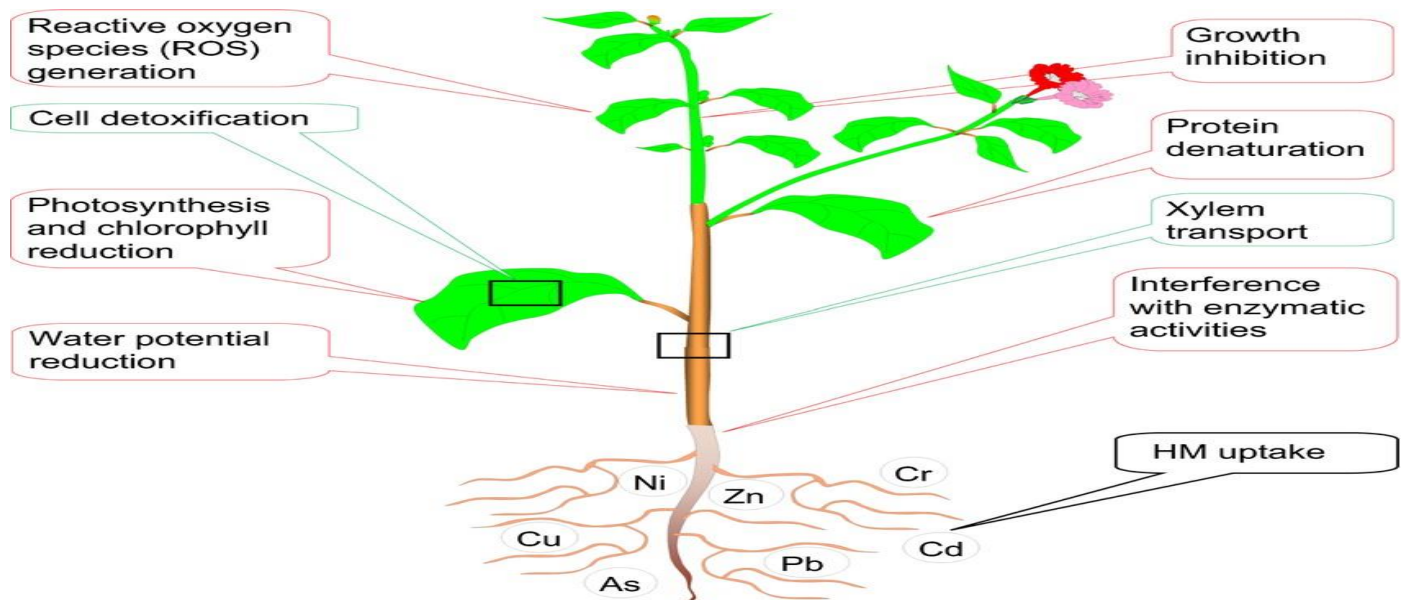


Fig 1. Possible effects of heavy metal stress on physiology and growth of a plant

Materials and Methods

Rosa indica cuttings were taken and allowed to mature for two months prior to the study. This was a preliminary screening to arise the tolerance and resilience of the species to Pb and Ni in the

rhizosphere in order to explore its potential use as a phytoremedial tool for these heavy metals. Phytoremediation is a clean green technology, which uses plants to absorb, contain or transfer pollutants from soil and/or water.

Experimental Design

The greenhouse study was conducted at the Department of Botany, St. John’s College, Agra. The plantlets were first transplanted in pots having Ni and Pb in different concentrations separately. The pots were kept in a random block design. Each treatment was set up with three replicates. Metals were applied to the pots in aqueous solution as Ni (SO₄.6H₂O) and Pb (NO₃)₂. The doses applied were 50 and 100 mg/kg of each HM. Control pots were set up with test plants without any metal treatment. The physiological/biochemical (chlorophyll and proline) and growth (plant height and biomass) parameters were investigated at 30, 90 and 180 DAT (days after treatment) in this study.

Statically analysis-data were expressed as mean and standard deviation. Total chlorophyll content was determined according to (Arnon, 1949) and expressed as mg kg⁻¹ fw. Total Proline content was determined according to (Bates *et al.*, 1973) and expressed as µg g⁻¹ fw.

Results and Discussion

Total chlorophyll content showed a dip in Pb and Ni treatments. This decrease was most pronounced at 30 DAT and the disparity was alleviated as the study prolonged. At 180 DAT, the chlorophyll content was in the general range of control readings though slightly lower in most cases.

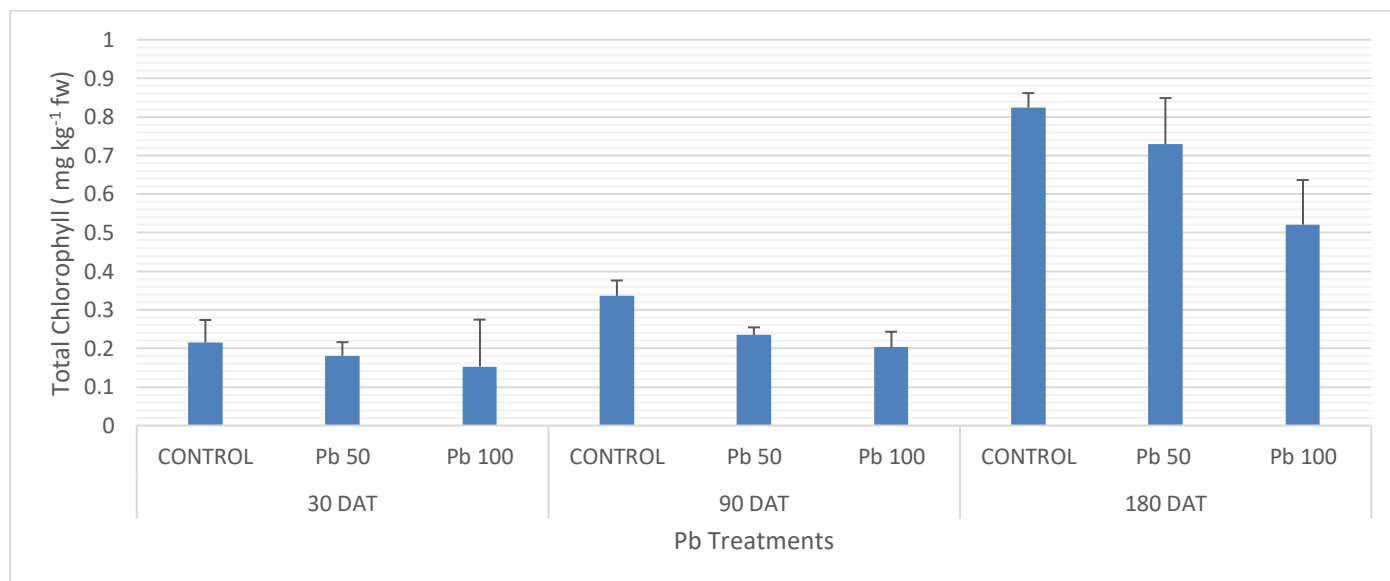


Fig 2. Total chlorophyll content in R. indica in response to Pb at successive days of study

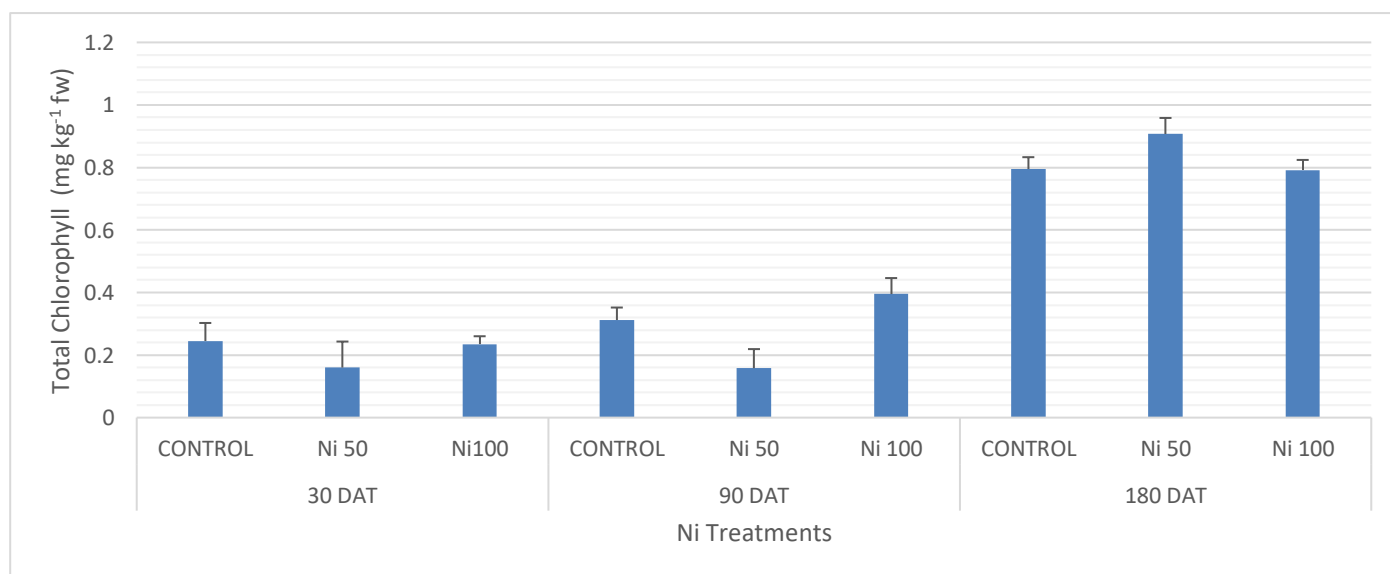


Fig 3. Total chlorophyll content in R. indica in response to Ni at successive days of study

Zengin and Munzuroglu (2006) studied the effect of HMs including Pb, Ni, Co, Cd and Zn on the chlorophyll content of *Phaseolus aureus* and *P. vulgaris* L. proved inhibition of chlorophyll content with increasing concentrations of heavy metals. Pb concentrations above 1.5 mM caused a reduction of total chlorophyll content. Oncel *et al.*, (2000) reported decreased chlorophyll in several plant species under the impact of heavy metals. Decreased chlorophyll content associated with heavy metal stress may be the result of inhibition of the enzymes responsible for chlorophyll biosynthesis. Sindhu *et al.* (2015) have reported that the chlorophyll content (a+b) in the leaves of wheat seedlings decreased significantly with the increase

as concentration. They noticed maximum reduction 150 mg/kg in chlorophyll content in the as treated plants. At 30 DAT, proline content in all treatments was higher than control. Highest proline content was observed at 90 DAT in both Pb and Ni treatments. As the study prolonged proline concentrations were seen to decline. Our research data showed that stress in plants has direct correlation with the concentration of proline. As stress in plant increases so does the proline content. It was also noted that stress due to the HMs was dose dependent. Pb seemed to produce greater stress as compared to Ni.

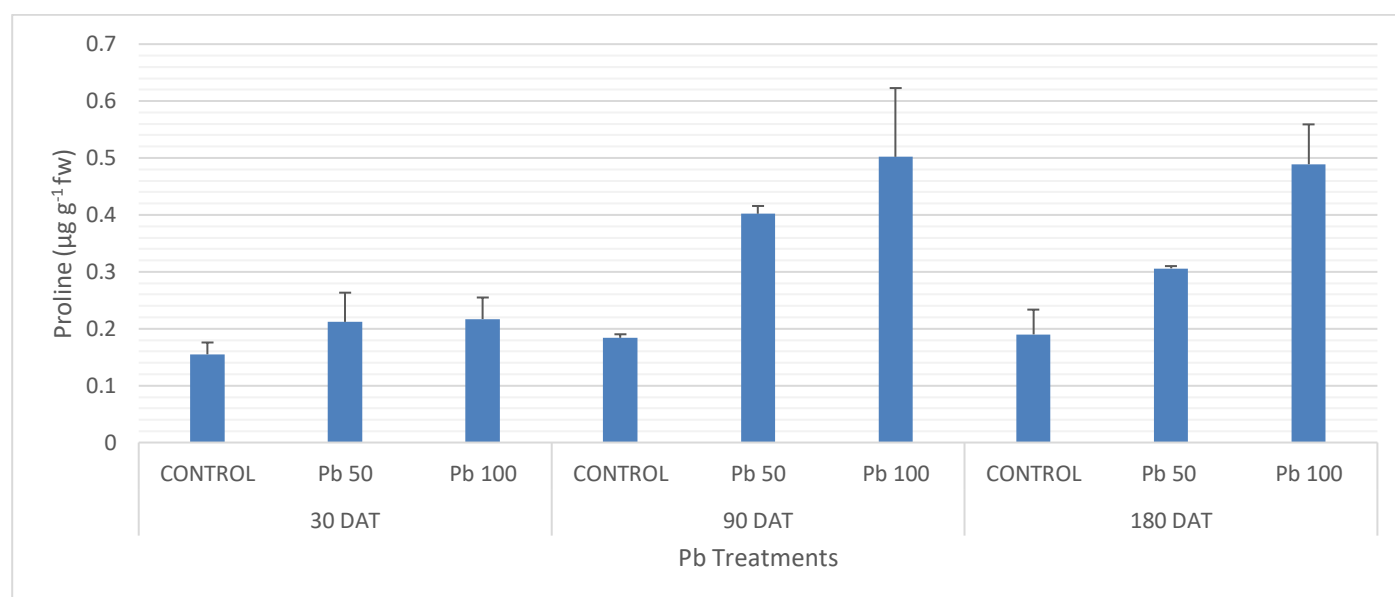


Fig 4. Proline content in *R. indica* in response to Pb at successive days of study

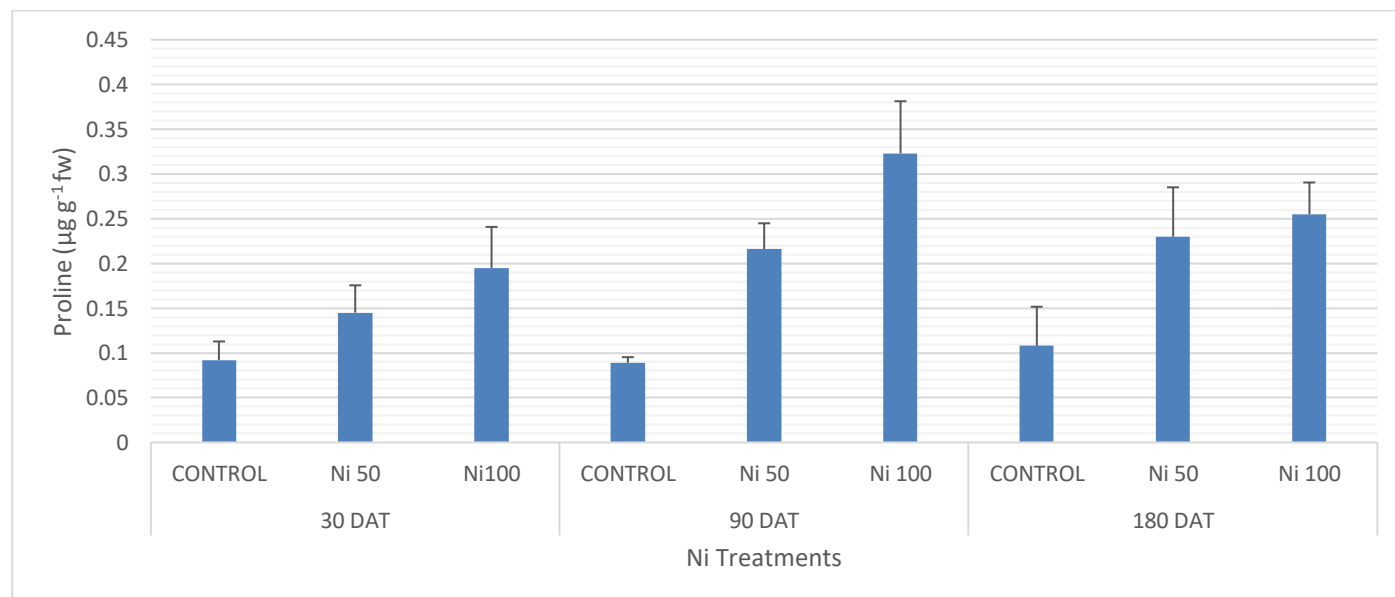


Fig 5. Proline content in *R. indica* in response to Ni at successive days of study

Treatments with HMs like Pb, Cu and Ni have been shown to increase proline content in *Phaseolus aureus* and *P. vulgaris* according to (Zengin and Munzuroglu, 2005 and Panda, 2003). Decrease in protein and increase in proline content has been reported in *Taxithellium sp.* when treated with Pd, Ni and Co at 2.5 mM. (Khadim, 2011). Karamooz *et al.*, (2016) study showed the great influence of Cd and Ni on the proline content of plant *Descurainia sophia* L. They found that with the oxidative stress of Cd and Ni and increasing concentration of these metals showed increasing accumulation of proline in the plant cells and tissues. Growth parameters such as plant biomass and height were also analyzed at 30, 90 and 180 DAT.

The data clearly indicates that HM content in rhizosphere had some negative effects on root/shoot biomass. The effect was more pronounced at 90 DAT for both HMs when compared to control. At 180 DAT, the effect was mitigated largely and root/shoot biomass was comparable to control. The effect of Pb was more pronounced when compared to that of Ni. Singh *et al.*, (2007), observed a reduction in germination percentage and early growth stage of wheat treated with Cu at 5, 25, 50 and 100 ppm. Treatment on *Leuceana leucocephala* with 25, 50, 75 and 100 ppm of Pb and Cd, showed a gradual reduction in seed germination and seedling growth (Shafiq *et al.*, 2008).

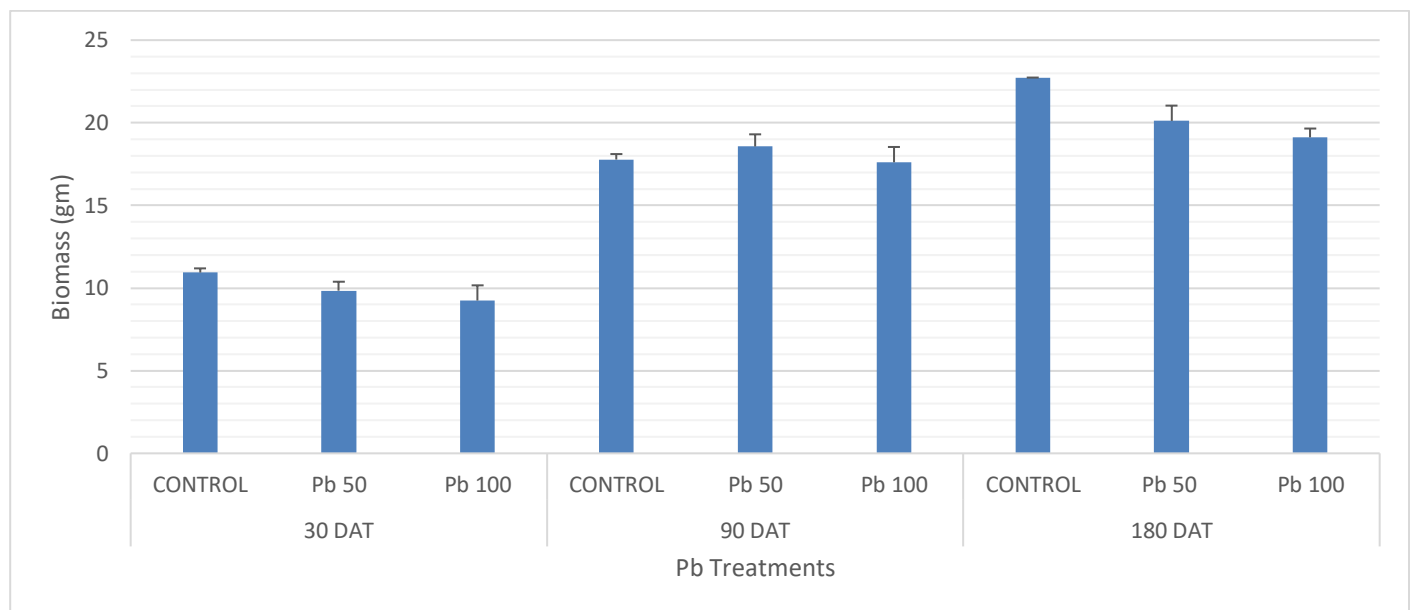


Fig 6. Biomass of *R. indica* in response to Pb at successive days of study

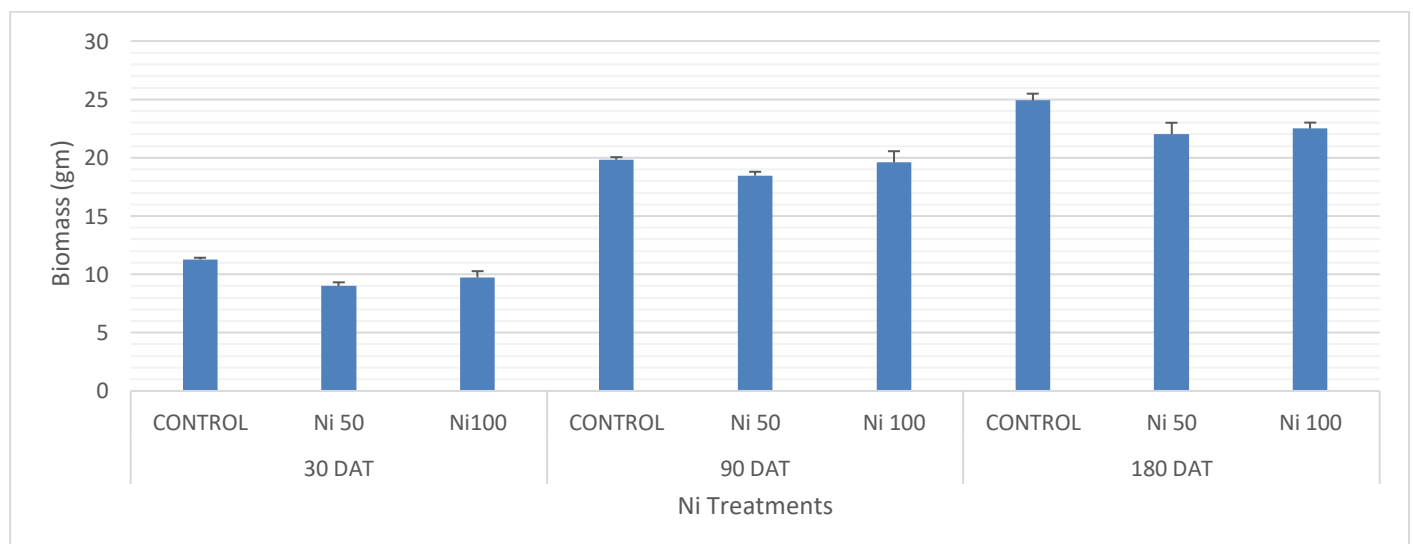


Fig 7. Biomass of *R. indica* in response to Ni at successive days of study

Thivya *et al.* (2014) also reported the negative effect of heavy metals (Cr and Co) on biomass of *Mentha spicata*. The shoot and root length of the treated plant were affected after treated with Pb and Ni. The growth matrix was seen to inhibit growth in terms of root and shoot length in all treated plants as compared to control. However, Pb was more inhibitive of growth.

Conclusion

Metal toxicity governs growth, germination and physiology of plants. The effect of pollutants such as HMs (Pb and Ni) on plants is dependent on the amount of HM concentrations taken up from the soil. Aromatic plants exemplify nature's resilience and adaptability in the face of environmental challenges. The internal defense mechanism of the test plant *Rosa indica* was able to tolerate the presence of Pb and Ni in the rhizosphere, at least at the doses applied. Thus, it can clearly lie grown on degraded/contaminated soils. These plants offer a natural and eco-friendly approach to withstand heavy metal pollution with the added benefits of cost-effectiveness and aesthetic enhancement. It is evident that these plants should be explored further to mitigate HM pollution too through phytoremedial efforts. Its natural potential to reduce bioavailable metal content in soil through uptake or stabilization needs to lie understood and possibly enhanced through eco-friendly agronomic amendments.

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