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Fluoride toxicity and impact on Spider Plant leaves

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ABSTRACT

The work investigated the effects of fluoride toxicity on the leaves of spider plants (*Chlorophytum comosum*) grown under controlled indoor conditions. Overall, the study aimed to contribute to our understanding of fluoride toxicity. Yellowing of leaves, became more pronounced in the second week, and by the third week, the plants displayed increased yellowing and slight wilting. Moderate stress was observed in the first week, followed by the development of yellow spots on the leaves in the second week. By the third week, the plants exhibited brown edges. Stress levels, Brown spots appeared on the leaves, and by the second week, wilting became pronounced. Many leaves showed signs of wilting, and some had died. Concentrations of fluoride demonstrated a substantial negative impact on the Spider plants, leading to a decline in overall health. Wilting became a prominent feature, and by the second week, some leaves had died highlighting the severe impact of extremely high fluoride concentrations on the plants.

Key words: *Fluoride, Toxicity, Leaf burn, Wilting, Yellow spots, Brown spots, Dead leaves.*

Introduction

Nature has provided plenty natural (abiotic and biotic) resources to people, which are required to sustain all forms of life on Earth. Moissan, French chemist detected fluorine, a diatomic gas and also a naturally occurring element that is found in various places, such as rocks, minerals, water, and soil. Fluorine is the halogen with the highest electronegative property in the periodic table and is an essential component (number 13) in the Earth's crust with an average concentration of 625 mg kg^{-1}. The environment can be exposed to fluoride from geogenic and human-made sources (Kumari *et al.*, 2023). Heavy metal toxicity poses a significant threat to plant health and ecosystem integrity, as these non-biodegradable pollutants can accumulate in soils and plants over time, leading to adverse effects on growth, development, and physiological processes. Heavy metals such as Lead (Pb), Cadmium (Cd), Mercury (Hg), Arsenic (As), and Chromium (Cr) are of particular concern due to their persistence in the environment and potential for bioaccumulation in the food chain. Plants can absorb heavy metals from the soil through their root systems, as well as through foliar uptake from airborne pollutants (Schutzendubel, 2002; Noman and Aqeel, 2017). Once inside the plant, heavy metals disrupt essential biochemical and physiological processes, including photosynthesis, respiration, enzyme activity, and nutrient uptake. The mechanisms of heavy metal toxicity in plants involve the generation of reactive oxygen species (ROS), which cause oxidative stress and damage to cellular components such as lipids, proteins, and DNA (Schutzendubel, 2002; Noman and Aqeel, 2017). However, prolonged exposure to high concentrations of heavy metals can overwhelm these detoxification mechanisms, leading to physiological disorders, stunted growth, chlorosis, and ultimately plant death (Riaz *et al.*, 2021). Therefore, understanding the pathways of heavy metal uptake, accumulation, and detoxification in plants is essential for assessing the ecological risks of heavy metal pollution and developing strategies for phytoremediation and environmental remediation (Alengebawy *et al.,* 2021; Adrees *et al.,* 2015).

Scientific Classification of Spider Plant

Kingdom: Plantae
Order: Asparagales
Family: Asparagaceae
Genus: Chlorophyta
Species: *Chlorophytum comosum*

Fig. 1. Spider Plant

General Description: *Chlorophytum comosum* has become one of the most widespread and recognised houseplants. It becomes especially popular among beginners due to its ease of growth and propagation, tolerance of neglect, and ability to thrive in almost any environment. Its common name derives from its small plantlets that grow on long trailing stems and resemble spiders. This clump-forming, perennial herbaceous plant is native to South Africa's coastal areas and has narrow, strap-shaped leaves that emerge from a central point.

Leaves: The leaves can either be solid green or variegated with lengthwise stripes of white or yellow. The leaves of the plant are not flat, but rather channelled or folded down the centre. Plants grow 12-15 inches tall. The fleshy, thick rhizomes and roots developed to hold water, allowing it to withstand infrequent waterings. With its gracefully arching leaves adorned with vibrant stripes, the spider plant adds a touch of elegance to any indoor space while quietly purifying the air (Chataika *et al.*, 2020; Li *et al.,* 2001).

Propagation: Spider plants are quite easy to propagate by planting the "spiders" or plantlets that grow after the flowers in their own pots. Place the plantlet, still connected to its parent plant, on the surface of a pot filled with without soil potting medium and allow it to root before cutting the stem that connects it to the mother plant. A bent paper clip or a piece of wire can be used to keep the plantlet attached with the soil while it grows roots. Alternatively, choose a plantlet which has already begun to grow roots and pot it. Larger plants may also be separated. They can also be grown from seed, though the seedlings may not have identical leaf coloration as the parent.

Understanding how spider plants respond to fluoride toxicity is important for their own health. Spider plants, with their high transpiration rates and efficient pollutant uptake capabilities, have been suggested as potential candidates for improving indoor air quality by removing volatile organic compounds (VOCs) and other air pollutants. However, prolonged exposure to high concentrations of heavy metals can overwhelm these detoxification mechanisms, leading to physiological disorders, stunted growth, chlorosis, and ultimately plant death (Riaz *et al*., 2021).

Experimental Set-Up: In the following study, growing Spider plant was involved. Saplings were purchased from commercial source-Nursery, Charkhi Dadri. Task was to examine and estimate the effects of Fluorine ion concentration on the potted plants which were grown under environmental condition. After purchasing the saplings plants were transferred to pots and different concentration of fluorine ion water was poured as per requirement and were kept in observation. Morphological characters were studied by naked eyes. Pre liminary observations were made and symptoms on different parts of plants were also noted.

Results

The plants were initially observed to establish a baseline for their condition before the introduction of varying fluoride concentrations. The pots were chosen to provide adequate space for root development and to ensure proper drainage, preventing waterlogging. This initial potting phase aimed to create a uniform starting point for all plants, minimizing any potential variability arising from differences in soil composition.

Environmental conditions were carefully con-

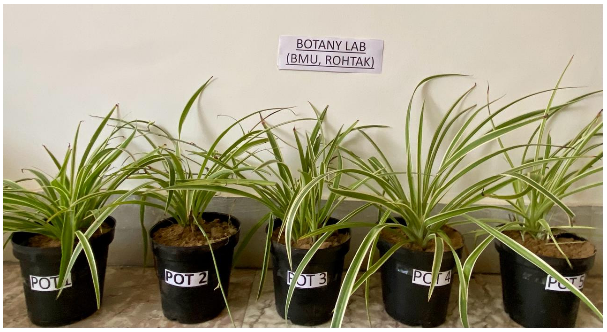

Fig. 2. Potted plants during experimental set-up.

trolled throughout the experiment. The temperature was maintained at 20 °C to simulate common indoor conditions for Spider plants. Regular monitoring with calibrated instruments ensured the stability of these conditions. The watering protocol involved providing each pot with a fixed amount of water (250 ml) at specified intervals. The water used for irrigation contained the designated fluoride concentration corresponding to the treatment group.

Observations were conducted at multiple levels. Morphological characteristics of the Spider plants were observed and recorded regularly by naked eyes. Weekly monitoring focused on changes in leaves, noting variations in colour, wilting, and the appearance of spots. Procedures were designed to minimize stress and harm, and adverse effects were closely monitored.

The results of the experiment investigating the effects of different fluoride concentrations on Spider plants revealed distinct patterns of plant responses over the four-week observation period.

Plot A, where the fluoride concentration was absent in water as distilled water was poured (0.00 ppm), the Spider plants exhibited robust and healthy growth throughout the entire study. Leaves remained green and vibrant, indicating that the absence of fluoride had no adverse impact on the plants.

Plot B (0.1 to1.5 ppm), subtle signs of stress became evident. In the first week, the plants remained healthy, but by the second week, slight yellowing appeared on the leaves. This yellowing intensified over the subsequent weeks, indicating a dose-dependent response to fluoride exposure.

Plot C (1.51 to 3.00 ppm), the Spider plants exhibited signs of stress early in the experiment, with slight stress observed in the first week. Yellowing became more pronounced in the second week, and by the third week, the plants displayed increased yellowing and slight wilting. This suggests that higher fluoride concentrations led to progressive negative effects on plant health.

Plot D (3.01 to 4.50 ppm), where moderate stress was observed in the first week, followed by the development of yellow spots on the leaves in the second week. By the third week, the plants exhibited brown edges, and wilting increased. This concentration demonstrated a noticeable impact on the overall health and morphology of the Spider plants.

Fig. 3. Symptoms Observed on Leaves of Spider Plant

Table 1. Observations (Effect of Fluoride concentrations on Spider Plant)

Sapling	F^-Conc.	Water Poured (ml)	Effect on Leaves Week 1	Effect on Leaves Week 2	Effect on Leaves Week 3	Effect on Leaves Week 4
Plot A	Distilled water	250	Healthy	Healthy	Healthy	Healthy
Plot B	0.1 to1.5	250	Healthy	Slight yellowing	More yellowing	Unchanged
Plot C	1.51 to 3.00	250	Slight stress	Yellowing	Increased yellowing	Slight Wilting
Plot D	3.01 to 4.50	250	Moderate stress	Yellow spots	Brown edges	Increased Wilting
Plot E	Above 4.51	250	High stress	Brown edges	Wilting, Dead leaves	Many dead leaves

Plot E (Above 4.51 ppm) showed a significant escalation in stress levels, with high stress evident in the first week. Brown spots appeared on the leaves, and by the second week, wilting became pronounced. In the third week, many leaves showed signs of wilting, and some had died. This concentration demonstrated a substantial negative impact on the Spider plants, leading to a decline in overall health. Wilting became a prominent feature, and by the second week, some leaves had died highlighting the severe impact of extremely high fluoride concentrations on the Spider plants.

Conclusion

In conclusion, the study on the effects of different fluoride concentrations on Spider plant saplings has provided valuable insights into the dose-dependent responses of these plants. The progressive morphological changes observed in the leaves, ranging from subtle symptoms at lower concentrations to severe stress and wilting at higher concentrations, underscore the sensitivity of Spider plants to varying fluorine ion levels. The controlled environmental conditions ensured that observed differences were primarily attributed to the fluoride concentrations, enhancing the reliability of the results. These findings contribute to our understanding of the threshold at which fluoride exposure can adversely impact Spider plants, offering implications for plant health and emphasizing the need for careful management of fluoride levels in environments where these plants are cultivated. Further research into the underlying physiological mechanisms will be crucial for developing strategies to mitigate fluoride-induced stress in plant species with varying sensitivities.

Conflict of Interest- None

References

Adrees, M., Ali, S., Rizwan, M., Zia-ur-Rehman, M., Ibrahim, M., Abbas, F., Farid, M., Qayyum, M.F. and Irshad, M.K. 2015. Mechanisms of silicon-mediated alleviation of heavy metal toxicity in plants: A review. *Ecotoxicology and Environmental Safety*. 119: 186-197. https://doi.org/10.1016/j.ecoenv.2015.05.011

Alengebawy, A., Abdelkhalek, S.T., Qureshi, S.R. and Wang, M.Q. 2021. Heavy Metals and Pesticides Toxicity in Agricultural Soil and Plants: Ecological Risks and Human Health Implications. *Toxics.* 9(3): 42. https://doi.org/10.3390/toxics9030042

Chataika, B.Y., Akundabweni, L.S.M., Achigan-Dako, E.G., Sibiya, J. and Kwapata, K. 2020. Utilization of Spider Plants (*Gynandropsis gynandra,* L. Briq) amongst Farming Households and Consumers of Northern Namibia. *Sustainability*. 12(16): 6604. https://doi.org/10.3390/su12166604

Kumari, S., Dhankhar, H., Abrol, V. and Yadav, A.K. 2023. Bioaccumulation of Fluoride Toxicity in Plants and Its Effects on Plants and Techniques for Its Removal. *Advanced Treatment Technologies for Fluoride Removal in Water*. 271-290. https://doi.org/10.1007/978-3-031-38845-3_15

Li, Y., Liang, C., Slemenda, C.W., Ji, R., Sun, S., Cao, J., Emsley, C.L., Ma, F., Wu, Y., Ying, P., Zhang, Y., Gao, S., Zhang, W., Katz, B.P., Niu, S., Cao, S. and Johnston, C.C. 2001. Effect of Long-Term Exposure to Fluoride in Drinking Water on Risks of Bone Fractures. *Journal of Bone and Mineral Research*. 16(5): 932-939. https://doi.org/10.1359/jbmr.2001.16.5.932

Noman, A. and Aqeel, M. 2017. miRNA-based heavy metal homeostasis and plant growth. *Environmental Science and Pollution Research*. 24(11): 10068–10082. https://doi.org/10.1007/s11356-017-8593-5

Riaz, M., Kamran, M., Fang, Y., Wang, Q., Cao, H., Yang, G., Deng, L., Wang, Y., Zhou, Y., Anastopoulos, I. and Wang, X. 2021. Arbuscular mycorrhizal fungi-induced mitigation of heavy metal phytotoxicity in metal contaminated soils: A critical review. *Journal of Hazardous Materials.* 402: 123919. https://doi.org/10.1016/j.jhazmat.2020.123919

Schutzendubel, A. 2002. Plant responses to abiotic stresses: heavy metal-induced oxidative stress and protection by mycorrhization. *Journal of Experimental Botany.* 53(372): 1351-1365. https://doi.org/10.1093/jexbot/53.372.1351