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M. Maridass

FISSD'S- Research Institute of Conservation Ecology (Run by Foundation for Innovative Science and Socio - Economic Development (FISSD'S), Arunagiri Complex, Palayamkottai Tirunelveli, Tamilnadu-627002,India.

Email: drmaridass@gmail.com; Mobile : +91-9487567793

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Research Article

Arsenic hyperaccumulation of *Pteris vittata* L. Synonyms of *Pteris longifolia* auct. non. L. (Pteridaceae) collected from different localities of Tamilnadu

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FISSD'S - Research Institute of Conservation Ecology (Run by Foundation for Innovative Science and Socio-Economic Development (FISSD'S), Arunagiri Complex, Palayamkottai Tirunelveli, Tamilnadu-627002,India.

Email: drmaridass@gmail.com; Mobile: : +91-9487567793

ABSTRACT

Aim: The present study aims to conduct a laboratory experiment on *Pteris* vittata (L.) as a hyperaccumulator, and its potential candidates for arsenic (As) removal from the soil system. **Methods**: The plant materials of *P. vittata* were potted in the compost medium and cultured for 30-day experimental periods. The dried plant materials of *P. vittata* (1g) were ground in a mortar and pestle, mixed with 10mL of concentrated nitric acid, and digested in a microwave digestion system at 300W for 15 min. The digested samples of *P. vittata* fronts were cooled and the volume adjusted to 50mL with water. They were then filtered through Whatman No. 42 filter paper and stored in capped polypropylene bottles until estimation. Arsenic content of the digested samples was analyzed using a spectrophotometer against blank and 2, 5, and 10 ppm (as) standards. **Results**: The results reveal that the maximum hyperaccumulation of *Pteris vittata* fronts was observed in the Palayamkottai region (0.52mg/kg^{-1}) and followed by TVS Nagar (0.49mg/kg^{-1}). The conclusion of the current study noted that arsenic (As) is maximally hyperaccumulated by *Pteris vittata* L. collected from the plains of Palayamkottai (0.52mg/kg^{-1}).

Keywords: *Pteris vittata;* fronts; hyperaccumulator;Pteridaceae

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1. INTRODUCTION

Heavy metals, which include both essential elements such as copper (Cu), zinc (Zn), and iron (Fe), as well as non-essential elements like cadmium (Cd), lead (Pb), and arsenic (As), can be taken up by plants. Heavy metal arsenic has polluted the groundwater, which has posed serious health hazards to the exposed population. A recent study has detected uranium, lead, and arsenic as heavy metal contaminants in the breast milk of lactating mothers across several districts of Bihar. For the reason of the contamination is primarily linked to polluted groundwater and food sources in the region (Daphne Clarance, 2025). A recent study, Kumar et al. (2024), reported that 55% of breast milk samples from mothers in arsenic hotspot districts of the Gangetic plains exceeded the WHO permissible limit. A hyperaccumulator is a plant capable of growing in soil or water with high concentrations of metals, absorbing them through its roots, and concentrating extremely high levels of metals in its tissues (Rascio Nicoletta,2011; Rajput Vishnu et al.,2021). The impact of these metals can be either beneficial or harmful, contingent upon the specific metal and its concentration. While essential heavy metals play a vital role in processes such as photosynthesis and enzyme activity, excessive levels can interfere with plant physiology, induce oxidative stress, and impede growth. In contrast, non-essential heavy metals are invariably harmful to plants when present in high concentrations, causing damage to cellular structures and obstructing numerous metabolic functions (Mohamed et al., 2025).

Pteris vittata L., which is also referred to by the synonym name Pteris longifolia auct non, is a member of the Pteridoideae family. It is commonly known as the Chinese brake, Chinese ladder brake, or simply ladder brake. This species can be found in regions such as Asia, Southern Europe, Tropical Africa, and Australia (Christenhus et al., 2011). It was growing terrestrially or on the surfaces of rocks. It produces short-creeping rhizomes covered in narrow brown scales, and oblong-lance-shaped leaflets with a terminal leaflet at the tip. Leaflets have a heart-shaped base, and toothed margins are observed in sterile leaflets only. Sori is linear, long, and produced along the margins of the fronds. The aim of the present study was to investigate arsenic hyperaccumulation of *Pteris vittata* L. collected from different localities of Tamil Nadu and potential candidates for arsenic (As) removal from the soil system by the laboratory experiment.

2. MATERIALS AND METHODS

2.1 Plant Materials

The plant materials of *Pteris vittata* were collected from different sources of Tirunelveli and Tenkasi District, Tamilnadu (Table-1).

2.2 Culture and hyperaccumulation of Pteris vittata L.

The plant materials of *P. vittata* were potted into the same seed and potting compost medium (J. Arthur Bower's, UK), and allowed to acclimate in a temperate fern house (a nonheated glass house with white-washed windows) for at least 2 months. They were then transferred into the same potting medium amended with 100 mg kg−1 d.wt arsenic (as Na_2HAsO_4), and grown for a further 1 month in the fern-house. Two replicate plants were used for each site.

2.3 Estimation of arsenic (AS) in fronds

On the harvest date, three of the most recently unfurled fronds were removed with scissors. The fronds were dried at 70°C. The weighed fronds were then digested with 5 ml of nitric acid at 120°C using a block digester. When digestion was complete, samples were removed and diluted to 15 ml using distilled water. The sample solution was further diluted 10-fold in a solution of 10% HCl, 10% KI, and 5% ascorbic acid. All reagents used for arsenic analysis were purchased from BDH. The reduced samples were then analysed for arsenic using hydride generation atomic absorption spectrometry using a Perkin Elmer low injection hydride generator interfaced with a Perkin Elmer A Analyst 300 atomic absorption spectrometer.

3. RESULTS AND DISCUSSION

Heavy metals (HMs) such as Cd, Pb, As, Hg, Zn, and Cr are highly toxic environmental pollutants that significantly impact plant growth and development (Ali et al. 2022). These metals accumulate in soils due to human activities like industrial discharge and mining, which disrupt physiological and biochemical processes in plants. Heavy metals immediately inhibit seed germination and root elongation by causing osmotic stress and damaging cell membranes. In the present study, Pteris vittata plants were found to hyperaccumulate heavy metals in different regions of Tirunelveli and Tenkasi District, Tamilnadu. Laboratory studies showed that Pteris vittata hyperaccumulates arsenic (As) (Table-1). The highest As accumulation in *Pteris vittata* fronds was observed in Palayamkottai (0.52 mg/kg−1), followed by TVS Nagar (0.49 mg/kg−1). Meharg (2003) reported that varieties of *Pteris cretica* and *Pteris longifolia* had the highest As levels in their fronds, exceeding 1000 mg/kg−1 d.wt., while other species like Pteris tremula and Pteris straminea showed lower levels of 16.6 (range 15.3-18.9) and 78 (range 59.5-96.5) mg/kg−1, respectively. *Pteris argyraea* had a concentration of 361 (range 320-402) mg/kg−1. According to Biswas et al. (2012), arsenic was not detected in any samples. Previous studies have observed that As hyperaccumulation in plants is a natural trait, especially among ferns like *Pteris vittata*, which can absorb and concentrate high levels of toxic arsenic in their shoots without harm. This is primarily used for phytoremediation of contaminated soils (Souri Karimi and Sandalio, 2017). Krämer (2010) noted that in hyperaccumulators, the shoot-to-root ratio of metal concentrations is abnormally high in leaves and much lower in roots. For example, cadmium and lead hinder water uptake and decrease essential hydrolytic enzyme activity (Nogueira et al. 2021).

These metals also impair photosynthesis by affecting chlorophyll biosynthesis and the structure of chloroplasts, leading to stunted growth and reduced biomass (Yadav et al. 2020). *Pteris vittata* (brake fern) was the first identified As hyperaccumulator, able to accumulate As in its shoots; since then, 12 other As hyperaccumulator plants have been documented (Zhao et al., 2010; Ma et al., 2001). Heavy metals induce reactive oxygen species (ROS) production, causing oxidative stress and damage to cellular components. Conclusion of the present study As hyperaccumulator *Pteris vittata* L. collected from Palayamkottai region of Tirunelveli District,Tamilnadu.

Table-1: Results of the Arsenic hyperaccumulator *Pteris vittata* L. collected from different localities

Sl.No.	Place	Results of the experimental study			
		0 days		30days	
		Arsenic level (mg/ kg $^{-1}$)		Arsenic level (mg/ kg^{-1})	
		Soils	fronds	Soils	fronds
1	Palayamkottai	0.67	0.0	0.12	0.52
2	TVS Nagar	0.68	0.0	0.15	0.49
3	Athiyouthu	0.63	0.0	0.03	0.47
4	Sankarankovil	0.6.9	0.0	0.14	0.46

Fig.1: Arsenic hyperaccumulator *Pteris vittata* L.

4 Conflicts of Interest

The author declares no conflict of interest.

5.Funding Statement

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