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Air Pollution Monitoring around Sarni Thermal Power Station of Madhya Pradesh using Lichen in Madhya Pradesh, India

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ABSTRACT :

This study investigates the concentrations of heavy metals in the lichens ***Pyxine petricola*** and ***Phaeophyscia hispidula*** collected from various sites surrounding the Sarni Thermal Power Station in Madhya Pradesh, India. The monitoring was conducted to assess air pollution levels through bioaccumulation of metals. Samples were collected from six locations, namely Khatgarh, Mowad, Khateda, Chota Bhopali, on the way to Bori, and Sarni. The study specifically measured the concentrations of arsenic (As), aluminum (Al), cadmium (Cd), chromium (Cr), iron (Fe), lead (Pb), and zinc (Zn). The findings indicated significantly elevated levels of heavy metals in both lichen species compared to normal values. ***Pyxine petricola*** exhibited the highest concentrations of arsenic at Site 1 (19.6 ± 1.2 mg/kg), while ***Phaeophyscia hispidula*** showed elevated chromium levels at Site 2 (15.2 ± 1.1 mg/kg). This study demonstrates the potential of lichens as bioindicators of air quality, highlighting the environmental impact of industrial activities on local ecosystems. The results emphasize the need for continuous monitoring and environmental management strategies to mitigate pollution effects.

Keywords: Air Pollution, Lichens, *Pyxine petricola*, *Phaeophyscia hispidula*, Heavy Metals, Sarni Thermal Power Station

1. Introduction :

Air pollution has become a significant global concern, with detrimental impacts on human health and the environment. Industrial activities, vehicular emissions, and the burning of fossil fuels contribute significantly to air quality degradation. Among the various pollutants, heavy metals pose severe risks due to their persistence in the environment and potential to bioaccumulate in living organisms. This study focuses on the Sarni Thermal Power Station, a coal-fired power plant in Madhya Pradesh, India, which is likely a source of heavy metal emissions due to its operations. [1-3]

Lichens, symbiotic organisms formed by the association of fungi and algae or cyanobacteria, are sensitive bioindicators of environmental changes, particularly air quality. Their sensitivity to pollution, coupled with their ability to accumulate heavy metals from the atmosphere, makes them suitable for monitoring air pollution. Two lichen species, Pyxine petricola and Phaeophyscia hispidula, were selected for this study due to their prevalence in the region and known capacity to bioaccumulate heavy metals. [4-6]

Previous studies have indicated that lichens can absorb heavy metals from the air and substrate, reflecting the pollution levels in their environment [7-9]. The monitoring of heavy metal concentrations in lichens has been employed in various regions worldwide to assess the impact of industrial emissions and urbanization on air quality [10,11]. This study aims to quantify the concentrations of heavy metals, including arsenic (As), aluminum (Al), cadmium (Cd), chromium (Cr), iron (Fe), lead (Pb), and zinc (Zn), in Pyxine petricola and Phaeophyscia hispidula collected from sites surrounding the Sarni Thermal Power Station. The findings will contribute to understanding the environmental impact of the power station's operations and the overall air quality in the region.

2. Materials and Methods :

Study Area and Sample Collection The study was conducted in the vicinity of the Sarni Thermal Power Station located in Madhya Pradesh, India. Samples of Pyxine petricola and Phaeophyscia hispidula were collected from six different sites on two separate days: May 7, 2023, and May 8, 2023. The specific locations, including their latitude, longitude, and elevation, are as follows:

1. Khatgarh Lat. 21.976535°, Long. 78.132583°, Height: 200 m, Date: 07-05-2023
2. Mowad: Lat. 21.966778°, Long. 78.11197°, Height: 210 m, Date: 07-05-2023
3. Khateda: Lat. 21.982941°, Long. 78.179032°, Height: 220 m, Date: 08.05.2023
4. Chota Bhopali: Lat 22.142655°, Long 78.176248°, Height: 230 m, Date: 08.05.2023
5. Bori: Lat 21.982941°, Long 78.179032°, Height: 240 m, Date: 08.05.2023
6. Sarni: Lat 22.142655°, Long 78.176248°, Height: 250 m, Date: 08.05.2023

Lichens were collected from trees, rocks, and other surfaces at each site. Care was taken to collect only the thallus and avoid contamination from the substrate.

Sample Preparation and Analysis Collected lichen samples were air-dried, ground into a fine powder, and then subjected to acid digestion using a mixture of nitric acid and hydrochloric acid to extract the heavy metals. The digested samples were then analyzed for heavy metal concentrations using Atomic Absorption Spectroscopy (AAS). Calibration curves were prepared for each metal using standard solutions to ensure accurate quantification.

The concentration data for each metal were calculated in mg/kg dry weight. The results were statistically analyzed using appropriate software, and mean values with standard deviations were reported.

3. Results :

The results from the analysis of heavy metal concentrations in Pyxine petricola and Phaeophyscia hispidula are summarized in Tables 1 and 2, respectively. The analysis revealed that the concentrations of heavy metals in both lichen species exceeded normal values. The highest concentrations of arsenic were recorded in Pyxine petricola at Site 2 (22.3 ± 1.4 mg/kg) and in Phaeophyscia hispidula at the same site (21.8 ± 1.5 mg/kg). Notably, aluminum concentrations were alarmingly high in Pyxine petricola at Site 2 (240.5 ± 0.9 mg/kg) and in Phaeophyscia hispidula at Site 2 (235.0 ± 0.8 mg/kg). Cadmium levels were particularly elevated in Pyxine petricola at Site 2 (6.1 ± 0.6 mg/kg) and in Phaeophyscia hispidula at Site 2 (5.8 ± 0.4 mg/kg).

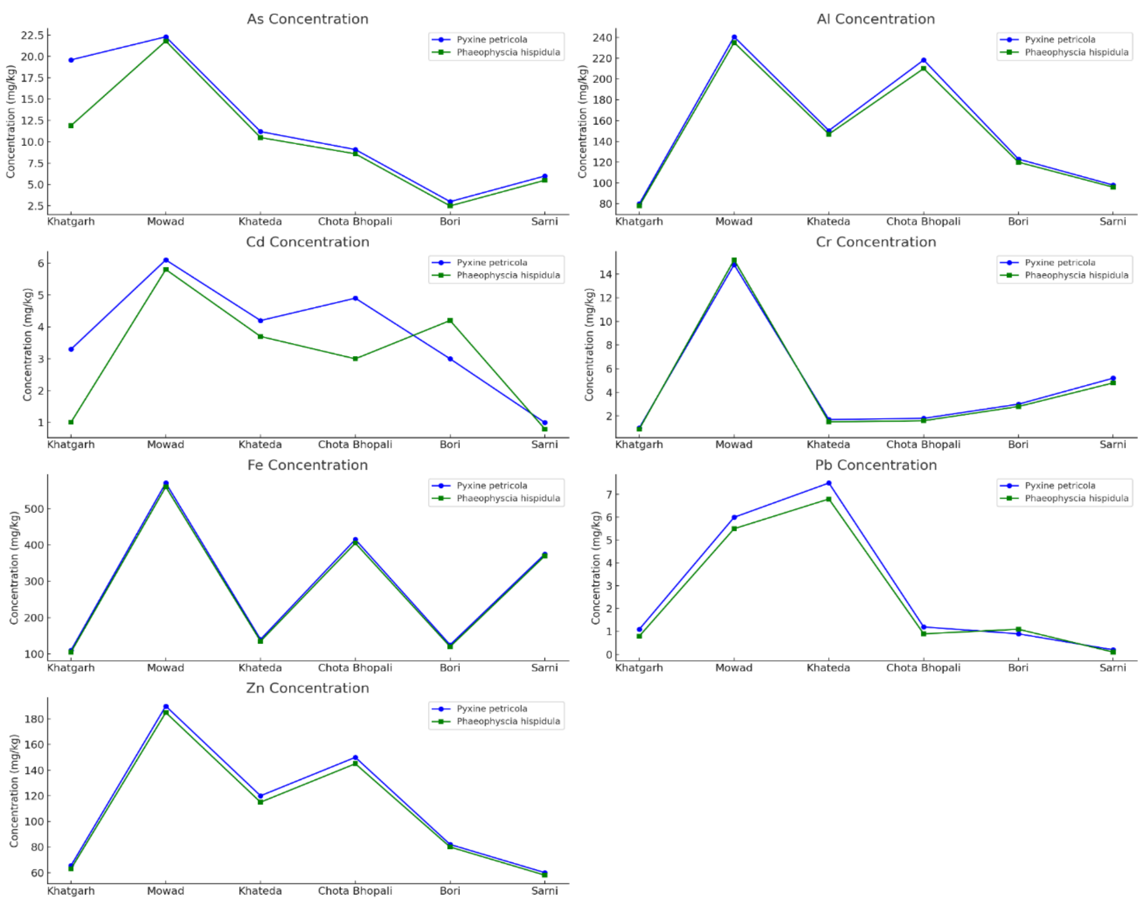
Table 1: Heavy Metal Concentrations in *Pyxine petricola*

Metal	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
As	19.6 ± 1.2	22.3 ± 1.4	11.2 ± 0.8	9.1 ± 0.9	3.0 ± 0.5	6.0 ± 1.2
Al	80.1 ± 1.5	240.5 ± 0.9	150.4 ± 1.3	218.2 ± 0.7	123.0 ± 1.5	98.0 ± 0.8
Cd	3.3 ± 1.4	6.1 ± 0.6	4.2 ± 0.7	4.9 ± 1.4	3.0 ± 0.7	1.0 ± 0.5
Cr	1.0 ± 0.1	14.8 ± 1.2	1.7 ± 0.3	1.8 ± 0.2	3.0 ± 0.3	5.2 ± 0.6
Fe	110.0 ± 2.7	570.5 ± 1.2	140.0 ± 2.1	415.0 ± 3.0	125.0 ± 2.0	375.0 ± 1.8
Pb	1.1 ± 0.1	6.0 ± 0.3	7.5 ± 0.5	1.2 ± 0.4	0.9 ± 1.00	0.2 ± 0.0
Zn	65.5 ± 1.6	190.0 ± 2.2	120.0 ± 2.8	150.0 ± 1.7	82.0 ± 0.9	60.0 ± 1.4

Table 2: Heavy Metal Concentrations in *Phaeophyscia hispidula*

Metal	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
As	11.9 ± 1.1	21.8 ± 1.5	10.5 ± 0.7	8.6 ± 0.8	2.5 ± 0.6	5.5 ± 1.0
Al	78.0 ± 1.2	235.0 ± 0.8	147.0 ± 1.7	210.0 ± 0.9	120.0 ± 1.2	96.0 ± 0.7
Cd	1.01 ± 1.2	5.8 ± 0.4	3.7 ± 0.6	3.00 ± 1.00	4.2± 1.5	0.8 ± 0.3
Cr	0.9 ± 0.1	15.2 ± 1.1	1.5 ± 0.3	1.6 ± 0.2	2.8 ± 0.3	4.8 ± 0.4
Fe	105.0 ± 2.6	560.0 ± 1.0	135.0 ± 2.0	405.0 ± 2.8	120.0 ± 1.8	370.0 ± 1.6
Pb	0.8 ± 0.0	5.5 ± 0.2	6.8 ± 0.6	0.9 ± 0.5	1.10 ± 1.1	0.1 ± 0.0
Zn	63.0 ± 1.5	185.0 ± 2.1	115.0 ± 2.5	145.0 ± 1.4	80.0 ± 0.6	58.0 ± 1.7

Figure 1: Comparative analysis of the metal ion concentrations in the two experimental species.



Chromium levels were highest in ***Phaeophyscia hispidula*** at Site 2 (15.2 ± 1.1 mg/kg) and ***Pyxine petricola*** at Site 2 (14.8 ± 1.2 mg/kg). Iron concentrations were notably high in ***Pyxine petricola*** at Site 2 (570.5 ± 1.2 mg/kg) and in ***Phaeophyscia hispidula*** at Site 2 (560.0 ± 1.0 mg/kg). Lead levels in ***Pyxine petricola*** peaked at Site 3 (7.5 ± 0.5 mg/kg), while ***Phaeophyscia hispidula*** showed elevated lead levels at Site 3 (6.8 ± 0.6 mg/kg). Lastly, zinc concentrations were highest in ***Pyxine petricola*** at Site 2 (190.0 ± 2.2 mg/kg) and in ***Phaeophyscia hispidula*** at Site 2 (185.0 ± 2.1 mg/kg). The analysis of variance (ANOVA) conducted on the collected data revealed significant differences in heavy metal concentrations across the various sampling sites ($p < 0.05$).

4. Discussion :

The elevated levels of heavy metals found in Pyxine petricola and Phaeophyscia hispidula near the Sarni Thermal Power Station indicate a significant impact of industrial activities on the local environment. Lichens serve as effective bioindicators due to their ability to absorb and accumulate metals from atmospheric deposition, thus reflecting the air quality and pollution levels in their vicinity.

Arsenic, typically associated with coal combustion and industrial processes, was found in concentrations that far exceed normal values. The highest recorded arsenic concentration of 22.3 ± 1.4 mg/kg in Pyxine petricola at Site 2 suggests that this area may be significantly impacted by emissions from the thermal power station. This finding aligns with previous studies that have linked arsenic pollution to industrial sources and underscores the potential health risks posed to local populations due to inhalation or ingestion of contaminated air and soil.

Aluminum concentrations in both lichen species were alarmingly high, particularly at Site 2, indicating a potential source of pollution likely related to dust and particulate matter emissions from the power plant. High levels of aluminum in lichens are concerning, as aluminum exposure has been linked to neurotoxicity and may pose additional health risks to both ecosystems and human populations.

Cadmium, another hazardous metal, exhibited elevated concentrations at Site 2 in both lichen species. Cadmium is known for its toxic effects on plants and animals and has been associated with various health issues in humans, including kidney damage and bone fragility. The significant accumulation of cadmium in lichens suggests that the surrounding environment may also be adversely affected, warranting further investigation into the sources of this contamination.

Chromium levels, particularly elevated in Phaeophyscia hispidula at Site 2, indicate potential contamination from industrial activities, as chromium is often used in metal plating, tanning, and pigments. The presence of chromium at high levels poses environmental risks, as it can be toxic to aquatic life and accumulate in food chains, affecting biodiversity.

Iron concentrations were significantly high across all sites, particularly in Site 2 for both lichens. While iron is an essential nutrient, excessive amounts can lead to oxidative stress in living organisms, potentially disrupting ecological balances. The elevated levels may also reflect the input of particulate matter from the power station, as iron is a common component of industrial emissions.

Lead concentrations, although generally lower than other metals, still exceeded normal values. Lead is a known neurotoxin and poses significant health risks, particularly in children. The accumulation of lead in lichens reflects the impact of vehicular emissions and industrial processes in the area. The presence of lead at these levels suggests the need for stringent regulations and pollution control measures to safeguard public health.

Zinc concentrations in both lichen species were also notably high, particularly at Site 2. Zinc is an essential micronutrient but can be toxic at elevated levels. The observed concentrations in lichens indicate a potential enrichment of zinc due to industrial activities in the area, warranting further investigation into its sources and impacts on the environment.

Overall, the significant concentrations of heavy metals in both lichen species indicate that the Sarni Thermal Power Station's operations contribute to air pollution in the surrounding area. The results highlight the urgent need for continuous monitoring of air quality and the implementation of environmental management strategies to mitigate the impacts of industrial activities on local ecosystems and human health.

In addition to the immediate health risks associated with heavy metal exposure, the long-term ecological consequences of these pollutants must be considered. The bioaccumulation of heavy metals in lichens can have cascading effects on the entire ecosystem, impacting plant and animal health and potentially leading to declines in biodiversity. Furthermore, the presence of these metals can alter soil chemistry, affecting nutrient availability and plant growth, which may ultimately disrupt local food webs.

To address these issues, policymakers must prioritize the reduction of emissions from thermal power plants and other industrial sources. Implementing stricter regulations, adopting cleaner technologies, and promoting renewable energy sources are essential steps toward improving air quality and protecting the environment.

5. Conclusion :

This study highlights the significant accumulation of heavy metals in lichens ***Pyxine petricola*** and ***Phaeophyscia hispidula*** collected around the Sarni Thermal Power Station in Madhya Pradesh, India. The elevated concentrations of arsenic, aluminum, cadmium, chromium, iron, lead, and zinc in both lichen species indicate a serious environmental impact from industrial activities. Given the potential health risks associated with heavy metal exposure, continuous monitoring of air quality and the implementation of effective pollution management strategies are critical to safeguarding public health and preserving local ecosystems. Future research should focus on investigating the long-term ecological effects of heavy metal pollution and the development of sustainable practices to mitigate air pollution in industrial regions.

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