Research Article

Phytoremediation Behaviour of Some Mosses in Polluted Sites Around Chandigarh (U.T.)

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ABSTRACT

Six moss taxa, namely *Anoectangium clarum, Gymnostomum calcareum, Hyophila involuta, H.spathulata, Hydrogonium arcuatum var. gangeticum* and *Hydrogonium consanguineum* are found in sites polluted by dark effluents discharged from the industries. The pH value of the substrata supporting these taxa is found to be in a very range (6.66- 7.81). The concentration of the micro elements, As+, Pb++, Ni++, Cr+++, Cd+++., Mn++, Cu++, Zn++, Co+++ and Fe++ found in the plant material and substratum has brought out at the extent of toleration capacity of these taxa which enabled these mosses to out compete in such sites.

Keywords: Moss taxa, pollution, pH, microelements, substratum, phytoremediation.

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INTRODUCTION

Bryophytes form important constituents of both natural as well as manmade ecosystem of the world. They are autotrophic cryptogams which include several species which are pioneers on new grounds forming bulk of biomass responsible for most of primary production1. A perusal of the available literature has revealed tremendous ecological importance of bryophytes, particularly mosses and their role in pollution monitoring[2-6].

Their distinctive features i.e small size, simple structural organization, lack of cuticle, ability to survive under long or short photoperiod including prolonged darkness, extreme environmental conditions (long drought, high and low temperature), high regeneration potential, low mineral nutritional requirement, short life cycle coupled with their ability to absorb mineral nutrients through their conducting elements (hydroids) and also over their general surface, the capacity to bind these elements to their cell walls (enabling accumulation of even heavy metals) make them unique among other plant groups to merit as a favorable material for pollution studies and can play a role in phytoremediation[7-12]. The present study is under taken to estimate to the elemental concentration (key components in heavy metals pollution studies) of As+, Pb++, Ni++, Cr+++, Cd+++., Mn++, Cu++, Zn++, Co+++ and Fe++ in six moss taxa and their supporting substrata collected from 17 polluted sites (shown in map).

MATERIALS AND METHODS

Six moss taxa along with their substratum were collected from 17 sites (listed in Table-1) with industries emitting gases and discharging dark effluents to cause varied degree of pollution in the area. The plant material, after separation from the substratum, was washed several times with tap water and then checked under binoculars to avoid contamination with any other plant material. The purified plant material was then cleaned in water with pressurized air to remove any adhering soil particles. It was finally washed with double distilled water and then dried at room temperature between folds of blotting sheet. Each plant sample and its supporting substratum were then finely powdered in pestle and mortar separately after drying in an oven at 50°-60°C and then analyzed separately to determine their elemental content by Emission Spectroscopy. The pH of the substratum was determined using Beckman's pH meter.

Detection Processes

Estimation of micro-elements

Ten micro-elements namely, As+, Pb++, Ni++, Cr+++, Cd+++., Mn++, Cu++, Zn++, Co+++ and Fe++ were determined by Emission Spectroscopy using JY7OPLUS 1CP (Inductively Coupled Plasma) Spectrometer.

Principle involved

Inductively Coupled Plasma (ICP) analysis involves introducing the elements to be analyzed into an argon plasma induced by a high frequency, where temperature is in the order of 8000°K. The sample in the form aerosol is introduced into the plasma via a "torch", where it is exited. Each excited element furnishes a characteristic spectrum whose light intensity is directly proportional to the quantity of the element present in the sample.

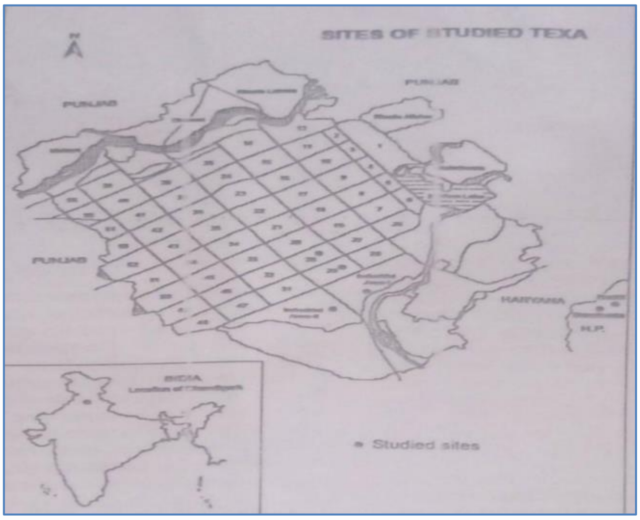

Figure 1: Showing the sites of studied area

Sample preparation

200mg of separated, cleaned, dried and powdered plant material was taken in 100ml conical flask. To the flask 10 ml of digestion mixture HNO_3: $HClO_4$-3:1 was added. The flask was shaken gently and then heated on sand bath till a white to orange- brown residue was obtained. 10mM Nitric acid was added to the residue. This solution was used as the stock solution for determination of various trace elements in plant material by Emission Spectroscopy.

To analyze soil samples, the soil was sieved and 500mg of it was used to detect various trace elements by Emission Spectroscopy. The rest of the procedure was the same as followed for the plant samples.

OBSERVATION AND RESULTS

The collection data along with the pH value of the supporting substratum of the six studied taxa is given in Table 1. The pH range of the supporting substrata (Table-1) in 17 sites was found to vary between 6.66-7.81. This narrow range of pH of the supporting substrata is indicative of little modification of the habitat in respect of acidity/ alkalinity in 17 different sites. Uptake of heavy metal Arsenic and *Hydrogonium consanguineum*

Table 1: Showing the list of sites, studied taxa, substratum and its pH

Site No	Site	Name of taxon	Substratum	pH
I	Vijay Remedies Industry, Barotiwala (Himachal Pradesh)	*Anoectangium clarum* Mitt.	On boundry wall (upper part)	7.68
II	Vijay Remedies Industry, Barotiwala (Himachal Pradesh)	*Gymnostomum calcareum* Nees and Hornsch	On boundry wall (lower part)	7.47
III	Shivalik Steel Alloy Industry, Barotiwala (Himachal Pradesh)	------do--------	On wall	7.47
IV	Chander Laxmi Glass Factory, Barotiwala (Himachal Pradesh)	*Hyophila involuta* (Hook.)Jaeg.	On wall	7.57
V	Transport Depot-1 Industrial area Chandigarh	Hyophila spathulata (Harv.) Jaeg	On brick wall	7.12
VI	Transport Depot-1I Industrial area Chandigarh	------do--------	On brick wall	6.89
VII	Modern Bread Factory, Industrial area Chandigarh	------do--------	On cemented wall	7.01
VIII	Sanson Pharmaceutical Industry, Baddi (Himachal Pradesh)	------do--------	On wall	7.56
IX	Chhabra Steel strips Limited, Baddi (Himachal Pradesh)	Hydrogonium arcuatum var. gangeticum (Griff.) Wijk and Marg.	On back wall	7.47
X	LML Agency, Industrial area, Chandigarh	Hydrogonium consanguineum 9 Thw. and Mitt.) Hilp.	On back wall	7.23
XI	Sector-29, Road side, Chandigarh	------do--------	On moist soil	6.93
XII	Sector-30, Road side, Chandigarh	------do--------	On wall	7.06
XIII	Pfizer Industry, Industrial area. Chgandigarh	------do--------	On wall (Outer wall)	6.66
XIV	Pawa Chain Industry, Industrial area, Chandigarh	------do--------	On wall	7.10
XV	Thread factory, Baddi (Himachal Pradesh)	------do--------	On boundry wall	7.81
XVI	Rama Steel Industry, Barotiwala (Himachal Pradesh)	------do--------	On wall	7.14
XVII	Rama Steel Industry, Barotiwala (Himachal Pradesh)	On wall (Inner side) ------do--------	7.43	

Collected from sites V, VI, X, XI, XIV and XV which are exposed to high automobile exhaust, contained high of concentration of Lead which also get deposited on aerial parts of the plant especially on leaves along with the dust. A positive correlation between Pb++deposition on plants and traffic volume was earlier observed by [13, 14]. Though lead is considered to be the most toxic element for plant life, its accumulation in the moss samples without affecting their natural growth, is indicative of its extracellular uptake.

Of the six studied taxa, *Gymnostomum calcareum* overtook others in Ni++ accumulation (3.95pprn) at site II (pH 7. 45), Interestingly, *Hyophila spathulata* showed highest concentration of Cr+++ (1.53ppm) in disregard of its substratum which contained only 0.33ppm of this element. Likewise, Cr +++content in *Hyophila spathulata* (site V, VI) and *Hydrogonium consanguineum* (site X, ,XI , XIV and XV) was also more than that found in their respective substrata. *Hyophila spathulata* also showed maximum accumulation of Cd+++. (0.30ppm) at site V, where the substratum (pH 7.12) contained only 0.08ppm of Cd+++. Mn++ content was highest (10.02ppm) in *Gymnostomum calcareum* (site II), whereas its substratum (pH 7.47) contained only 17.94 ppm of Mn++. Likewise, Cd++ content in *Hydrogonium consanguineum* at site XVII (pH 7.43) was also less (1.67ppm) as compared with that found in its supporting substarta (20. 81ppm). *Hyophila spathulata* growing on site V showed more Cu++ content (4.01ppm) than that found (1.14ppm) in its supporting substrata (pH 7.12). The same taxon (collected from site Vlll (pH 7.56) was found to contain only 2.25 ppm Cu++ inspite of its relatively Cu++ rich substratum (23. 39ppm) Highest Zn++ concentration 56.70 ppm) was observed in *Hydroionium consaguineum* at site XII, whereas in its substratum (pH 7.06) it was 94.45ppm. The Zn++ in content in the substrata at sites II,V and XIV was much lesser; but the moss growing on these substrata were found to be accumulate concentration of Zn++ much higher than that of the substratum Co+++ concentration was highest (0.13 ppm) in *Hydroionium consaguineum* growing at site XVII while its highest content in the substratum was observed to be 0.19 ppm at two sites (site II and Site XVII). The data showed that the affinity of the plants for this metal ion and its accumulation in the substratum was least in almost all the sites studied. Microelement Fe++ was highest (347.00 ppm) in *Hyophila spathulata* growing at site V, whereas its content in the supporting substratum (pH 7.12) was 82.04 ppm *Hyophila spathulata* at site VI (158.00ppm) and *Hydroonium consanguineum* at sites X (49.26ppm) and XII (43.03ppm) accumulated Fe++ from air and precipitation since their respective substrata lacked any iron content.

The differences in the elemental content of different taxa may be due to their genetic differences, which govern the variation is in their potential to uptake the heavy metals from the substratum (endohydrically) and/or through surface absorption (ectohydrically) by the aerial parts of the plant from the atmosphere. Occurrence of mainly six taxa i.e.. *Anoectangium clarum*, *Gymnostomum calcareum*, *Hyophila invotula*, *H. spathulata*, *Hydrogonium arcuatum* var. *gangeticum* and *Hydrogonium consanguineum* in the studied polluted sites is indicative of their tolerance capacity and superior adaptability in polluted sites as compared with several other moss taxa found luxuriantly growing on not far removed sites/ substrata. The ability of bryophyets to colonize heavy metal enriched sites perhaps suggest their higher degree of adaptation resulting from the evolution of metal tolerant ecotypes which is further aided by reduced competition in such sites as suggested by [15].

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