Abstract

Title: “Biogeochemical exploration of rare earths elements mainly Yttrium, Cerium and Thorium in the Siri River areas India”

Objective of the thesis:

Earlier, rare earths were finding application mainly in metallurgy, petroleum cracking catalysts ceramic and glass industries. Some of the World’s most exotic and innovative technologies which play a significant role in our day-to-day life own their success to rare earths.

In view of the wide potential of the rare earths elements in diverse fields the research work entitled “Biogeochemical exploration of rare earths elements mainly Yttrium, Cerium and Thorium in the Siri River areas India” is taken up. The basic objectives of the work is biogeochemical studies of REE in the Siri River areas, Jashpur district, Chhattisgarh, India to facilitates the bio geo exploration of REE with special reference to cerium (light REE) and yttrium (heavy REE) and thorium by -

1. Analysing soil, sand, stream sediments etc. and ashes of different parts of the plant samples such as root, steam and leaf including grass, bush, and shrubs from the area under consideratión. The analysis has been taken up in view of their potentiality to hold the placer deposits even during heavy rains/flood which serve as source of REE.

2. Studying the co-relation between-
   a) REE, and U, Fe, Mn and trace elements.
   b) Thoruim and U, Fe, Mn and trace elements to decipher suitable path finder for REE and thorium. The analysis had helped in determining adsorption index of REE and by the plants.

As concentration of rare earths in soil in the area was observed, it was thought of interact to examine their up take by plants in the surrounding areas.
In this contest fifty plants and their bed sand samples were examined for their uptake of rare earth in their various parts.

Besides, tulsi plant, Holy basil a commonly found household plant was considered to be worth while for the uptake of heavy elements.

To understand the mechanism of absorption by the plant, rate of transmission, absorption of \( \text{H}_2\text{O} \) and photosynthesis was thought of interact as rare earth present as oxide in soil may be taken up along with absorption of \( \text{CO}_2 \) and water in form of carbonates.

The finding is so interesting that the detailed study about tulsi plant was enclosed exclusively in a Chapter - VIII.

**Chapter II**

**Experiments, Materials, Methods and Results:**

The survey was carried out in two separate areas Up and Down stream of Siri River at an interval of about 5 km distance.

The river is in dense reserved forest Jashpur Nagar Sub-Division and the common trees in forest are *Diospyros melacoxylon* (Tendu), *Bussia lactifolia* (Mahua), *Acacia leucophlea* (Hiwar), *Aegle marmelas* (Bel), *Ziziphus jujuba* (Ber), *Ficus religose* (Palas). *Plerocarpus marsupium* (Timber wood- Sal and Bija etc).

Fifty plant species of approximately height of 20-80 cm and forty seven sand samples were collected for comparative study. The samples collected include the roots, stem, leaves, tender leaves, bark, fruit, fern and grass.

The common species identified are *cypercus cria* (Gangurla), *Polygonum species*. (Ambachani), *Glycanea species*. (Fern), *Cynodon decylion* (Grass- I), *Eugenia heynexa* (Chotta jamun), *Ixora parviflora* (Chirda jamun), *Allum cepa* (kandrai) and *Eragrostric species* (Grass- II).

**Area wise data:**

Area wise data of the plant species collected from up and down stream and their elemental analysis are as follows.

1). Up Stream: Twenty-five each plant and sand samples were collected from different placer deposits. High concentration of \( Y (485 \text{ ppm}) \), \( \text{Ce} (1887 \text{ ppm}) \),
Th (619 ppm) and U (51 ppm) were analysed in *calamus scandent* (Sir khajura) plant. The copper, zinc and strontium obtained are 65, 279, and 379 ppm respectively.

1.27% (average) of total iron was also analysed in the plants species.

2). Down Stream: Twenty-five plant species and twenty-two sand samples were collected from different placers deposits. High concentration of Y (455 ppm), Ce (1859 ppm), Th (459 ppm) and U (52 ppm) were analysed in *Ixora porriflora* (Chirda jamun- Lokhandi). The copper, zinc and strontium concentration obtained are 64, 222, 613 ppm respectively.

About 1% (average) of total iron also analysed in the plant species.

Forty seven sand samples were also collected near the plant for knowing the absorption index and comparative study of plant ash with their sand samples.

Chapter III

Yttrium:

The comparisons of plant with their bed soils/sand variation were carried out and the results are encouraging and the plants shown their adsorption capacity.

1. In the plants, Gangurla - *Cypercus Cria* and Ambachani - *Polygonum Species*, the adsorption index of Yttrium is predominately positive in relation. It shows that these plants are good accumulator of Yttrium both in up and down stream of the Siri River.

2. High Yttrium of 485 ppm is analysed in Sir khajura - *Calamus Scandent*. The plant has developed longer, fibrous root system, penetrate deeply in the stream sediment and analysed high yttrium as compared to the other plants.

3. The Gangurla - *Cypercus Cria* develops dense fibrous root system, cover the stream sediments bars, tightly hold it and not allowing to wash out during the heavy flood of river.

4. The Ambachani - *Polygonum Species*, also grows with tiny fibrous roots covers the bars, and helped to hold the stream sediment deposit along with the other plants.
Chapter IV

**Cerium:**

The comparisons of plant with their bed soils/sand variation were carried out and observed that the concentration of Cerium is higher than Yttrium.

1. In four plant species *Cypercus cria* (Gangurla), *Polygonum sp.* (Ambachani), *Glycanea Sp.* (Fern) and *Cynodon dactylon* (Grass-I), both from up and down stream of Siri River.

2. In the plants, Gangurla - *Cypercus Cria* and Ambachani - *Polygonum Species*, the Adsorption Index of Cerium is very high, these plants are good accumulator of Cerium both in up and down stream of the Siri River.

3. High Cerium of 1253 ppm is analysed in *Cypercus Cria* (Gangurla). The plant has long green stem, fibrous root system, penetrate deeply in the stream sediment and adsorb and concentrate Cerium more as compared to the other plants.

4. The Ambachani - *Polygonum Species* also analysed high Cerium up to 178 ppm and helped to hold the stream sediment deposit along with the other plants.

5. The absorption index suggested that there Cerium concentration is remarkably very high in both Gangurla and Ambachani plants.

Chapter V

**Thorium:**

1. The concentration of Thorium is low as compared to Yttrium and Cerium. The analytical values suggested that the concentration of Thorium is lower than its bed sand sample.

2. In the four plant species *Cypercus cria* (Gangurla), *Polygonum sp.* (Ambachani), *Glycanea sp.* (Fern) and Chota Jamun *Eugenia hyeneaxa*, both from up and down stream, the concentration of Thorium is low than its bed sand sample.
Chapter VI

Comparative study of Yttrium, Cerium and Thorium

The plants give geo-chemical pattern that reflects the bed sand variations and are closely related to mineralization. These plants are well grown and cover over the bars of stream sediment deposits.

1. Due to the adventitious, tuberous and thick hairy net like root system, these plants hold the deposits safely and not allow to washout from the heavy flood during rainy season. Such types of placer deposits are safe guarded by these plants.

Thus, the riverine placers of Siri River surveyed and identified during 1971-73 had been mined and treated after 1986.

2. The variation of rare earth elements in the plant species and sand samples can be explained in terms of their relative abundance.

3. In Cypercus cria (Gangurla) Cerium is more concentrated than Yttrium both in up and down stream. It indicates that the rare elements are concentrated by the plants rather than adsorption.

4. The concentration of thorium is more than yttrium in up stream while the concentration of yttrium is more than thorium in down stream in Gangurla plant.

5. No perceptible morphological/ mutational color changes were observed in the area surveyed.
Chapter VII

Absorption study of Yttrium, Cerium and Thorium

The results are encouraging and indicated that the Fe-Mn oxide (transfer factor) is varying from 0.04 to 0.09 and Mn plays an important role in oxidation with Fe.

1. In both the plants, Cypercus cria (Gangurla) and Polygonum species (Ambachani), it has been confirmed that Cerium is more concentrated than yttrium and thorium. It indicates that the rare earth elements are concentrated by the plants.

2. The concentrations of yttrium and thorium are low. It depends on the plant species, their growing conditions and rare earth contents in the substrate of sand or rocks on which they have grown.

3. The dose dependent accumulation of individual rare earth elements in different plants is important and helpful for the safety assessment of plantation.

4. Plants grow in normal condition; some changes in color were seen initially but no any morphological, mutation changes were observed later on.

Chapter VIII

Tulsi plant, a gift of nature for Human being

Tulsi – the Indian Basil plant often grown in the courtyards of Hindu families is a revered symbol of worship in the Hindu religious tradition.

The name 'Tulsi' connotes "the incomparable one". Traditional Hindus worship this holy plant every morning and evening as a diurnal ritual.

Studies had been carried out on this sacred plant and it has been compared with other herbal plants. Tulsi adsorbs heavy elements like iron and manganese from soil. Manganese is synergistic with iron and they need each other, work together during biological process. Oxidation potential of Fe is lower then Mn.
1. Ash and soil samples of tulsi plant were analysed both by XRF and Chemical technique for iron, manganese, calcium and other trace element. The ratios of MnO/FeO vary from 0.03 to 0.06; higher ratio suggests the fast oxidation process during the photosynthesis.

2. Experiments of measuring the respiratory rate and photosynthesis process of plants suggest that Rama tulsi absorb more CO$_2$ and release equal amount of O$_2$ as compared other plants.

3. The photosynthetic rate of Rama tulsi is also higher (7.42 $\mu$ mol m$^{-2}$ s$^{-1}$) and CO$_2$ absorption is 6.77% abs gives off oxygen and thus improve air quality.

4. The photosynthetic rate of Neem tree (*Azadirachta indica*) is (45.54 $\mu$ mol m$^{-2}$ s$^{-1}$) and CO$_2$ absorption is 6.266 % abs, comparatively higher than the other plants and useful for both as a medical and air purifier plant.

5. The other parameters such as H$_2$O absorption, CO$_2$ sub-stomatal concentration, Stomatal conductance, Stomatal resistance & molar flow per unit leaf area are very important for photosynthetic process and play an important role for preparing the food of plants. They are differing and varying plant to plant.

6. To know the growth of plant, half of the portion of the tulsi plants was cut in the month of June before the rainy season start.

It is observed that tulsi grows fast and remain healthy more than two years. Periodically the flowering part has to be cut to maintain the normal vegetation of tulsi plant.

Hence, tulsi venerated in India as mother plant and always honored for its remarkable healing properties.

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