International Journal of Botany Studies
ISSN: 2455-541X; Impact Factor: RJIF 5.12
Received: 25-11-2019; Accepted: 26-12-2019
www.botanyjournals.com
Volume 5; Issue 1; January 2020; Page No. 137-140

Phytoremediation of soil nickel concentration as a function of growth of different plant species in the soil polluted with textile industry waste water in Yavatmal region

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Abstract
Typical polluted soils contain large quantity of nickel. The chief area is arsenides and sulphides. Nickel is used as a component in some alloys and for metal plating for catalysts, for batteries and in certain fungicides. Many nickel salts are soluble in water. Contamination in water is due to the industrial discharge to river of effluent containing nickel compounds. The information pertaining to the soil Ni concentration recorded as function of growth of different plant species on the textile industry wastewater amended soil and which are grown under experimental conditions. control set where *Bacopa monnieri* were planted the soil Ni concentration was 91±4.9mg/Kg, *Alternanthera sessilis* plantation the soil Ni concentration was 92±4.1mg/Kg, *Alternanthera sessilis* grown in soil amended with microorganisms (*Azotobacter* and *Rhizobium*) it was 74±5.2mg/Kg and *Typha angustata* the soil Ni concentration was 85±4.8mg/Kg after 3 months of experimental period. The above predominant plants in contaminated soil shows plants shows Ni uptake more or less similar with all the combinations i.e. only farm yard manure or combination of microorganisms (*Azotobacter* and *Rhizobium*).

Keywords: textile effluents, nickel, *Bacopa monnieri*, *Alternanthera sessilis* and *Typha angustata*

Introduction
There are several ways in which plants are used to clean up, or remediate, contaminated sites. To remove pollutants from soil, sediment and/or water, plants can break down or degrade organic pollutants or contain and stabilise metal contaminants by acting as filters or traps. The uptake of contaminants in plants occurs primarily through the root system, in which the principal mechanisms for preventing contaminant toxicity are found. The root system provides an enormous surface area that absorbs and accumulates the water and nutrients essential for growth, as well as other non-essential contaminants. Several reports suggest that the use of trees (rather than smaller plants) is effective in treating deeper contamination because tree roots penetrate more deeply into the ground. Plant roots also cause changes at the soil-root interface as they release inorganic and organic compounds (root exudates) in the rhizosphere. These root exudates affect the number and activity of the microorganisms, the aggregation and stability of the soil particles around the root, and the availability of the contaminants. Root exudates, by themselves can increase (mobilise) or decrease (immobilise) directly or indirectly the availability of the contaminants in the root zone (rhizosphere) of the plant through changes in soil characteristics, release of organic substances, changes in chemical composition, and/or increase in plant-assisted microbial activity. Phytoremediation is an alternative or complimentary technology that can be used along with or, in some cases in place of mechanical conventional clean-up technologies. Since, it is an *In Situ* remediation technology and also an ecofriendly, solar-energy driven clean-up technology; it was adopted for the wastewater contaminated soil treatment.

The challenge of textile wastewater treatment
Furthermore, the dye bath wastewater generated by textile mills is often rated as the most polluting among all industrial sectors. The pollution load is characterized by high color content, suspended solids, salts, nutrients and toxic substances such as heavy metals and chlorinated organic compounds. Many textile mills in the state currently discharge their wastewater to local wastewater treatment plants with minimum treatment such as pH neutralization. This process removes much of the residual dye colour. Larger mills can discharge more than 2 million gallons of wastewater of this kind per day

Nickel of textile wastewater
Typical polluted soils contain large quantity of nickel. The chief area is arsenides and sulphides. Nickel is used as a component in some alloys and for metal plating for catalysts, for batteries and in certain fungicides. Many nickel salts are soluble in water. Contamination in water is due to the industrial discharge to river of effluent containing nickel compounds.
Levels are much lower and nearly 1 mg/l have been reported in surface waters. Nickel is removed by conventional water treatment and levels in treated water are generally lower than in untreated water.

Material and Methods
Principle
Nickel is separated from the other ions by extraction of the nickel heptoxime complex with $CHCl_3$; re-extracted into the aqueous phase with HCl and determined calorimetrically in the acidic solution with heptoxime in the presence of an oxidant. Dimethyl glyoxime may be used instead of

heptoxime to develop colour with nickel. The conditions of colour formation are identical.

Apparatus

1. Spectrophotometer for use at 445 nm, with 1 cm cell or filter photometer with violet filter.
2. Separating funnels.

Reagents

1. Standard nickel sulfate solution: Dissolve 447.9 mg $NiSO_4$ $6H_2O$ in 1000 ml distilled water 1.00 ml = 100 µg Ni.
2. Hydrochloric acid : HCl (1N)
3. Bromine water: Saturate distilled water with bromine.
4. Ammonium hydroxide: conc.NH_4OH.
5. Heptoxime reagent: Dissolve 0.1 gm 1.2 cycloheptanedionedioxime (heptoxime) in 100 mL 95% ethyl alcohol.
6. Ethyl alcohol: 95%.
7. Sodium tartrate solution: Dissolve 10 gm $Na_2C_4H_4O_62H_2O$ in 90 ml distilled water.
8. Methyl orange indicator solution: As directed in alkalinity.
9. Sodium hydroxide: NaOH (6N) as directed in phosphate.
10. Acetic acid: Glacial A.R. grade.
11. Cupferron solution: Dissolve 1 gm cupferron in 100 ml distilled water. Store in refrigerator or prepare fresh for each series of determinations.
12. Chloroform: $CHCl_3$ A.R. grade.
13. Hydroxylamine-hydrochloride solution: Dissolve 10 gm NH_2OH-HCl in 90 ml distilled water. Prepare fresh daily.

Procedures

A) Treatment of Sample : (Separation of Cu and Fe)

1. Take a portion of digested (HNO_3-H_2SO_4) sample containing 50 to 200 µg Ni place in a separating funnel and add 10 ml sodium tartrate solution 2 drops methyl orange indicator and enough 6N NaOH to make the solution basic.
2. Add 1 ml acetic acid and cool funnel under tap water.
3. Add 4 ml cupferron reagent, add 10 ml $CHCl_3$ and shake.
4. Let layers separate and if necessary add more cupferron until a white precipitate forms.
5. Shake mixture again, let separate and discard $CHCl_3$ layer.
6. Add 1 ml fresh NH_2OH solution: Mix and let stand for 10 min.

B) Separation of Nickel

1. Add 10 ml heptoxime reagent and extract nickel-complex with atleast three 10 ml portions of $CHCl_3$.
2. Continue until final $CHCl_3$ layer is colourless.
3. Collect $CHCl_3$ layers in a separating funnel and extract with 10 ml 1 N HCl. Re-extract $CHCl_3$ with 10 ml 1 N HCl by taking it in another separating funnel.
4. Combine HCl layers and determine absorbance as directed in the procedure from 12 to 14. Plot absorbance against micrograms Ni in 20 ml final volume.
5. Pipette $NiSO_4$ solution 50 to 250 µg Ni if 1 cm cells are used in to 100 ml volumetric flasks.
6. Add 25 ml 1 N HCl and 5 ml bromine water.
7. Cool with cold running tap water and add 10 ml conc. NH_4OH. Immediately add 20 ml heptoxime reagent and 20 ml ethyl alcohol. Dilute to mark with distilled water and mix.
8. Measure the absorbance at 445 nm; 20 min after adding the reagent; using a reagent blank as reference.
9. Calculate as follows :

$$\text{Mg Ni/1} = \frac{\text{µg ni (2ml Final volume)}}{\text{ml of samples}} \times \frac{100}{\text{ml. portion}}$$

Note

1. Dimethylglyoxime may be used instead of heptoxime but prepare separate calibration curve.
2. Make reading exactly after 10 min. after adding regent.
3. In both systems make measurements at 445 nm.
4. Heptoxime system is more stable.
5. In the extraction procedure dimethylglyxime cannot be used.

Result and Discussion

Nickel (Ni) uptake by different plant species (N=3)

Table 4.9: Soil Ni concentration as a function of growth of different plant species in the soil polluted with textile industry waste water

Plant species	Treatment	Initial Ni Conc. (mg/Kg of soil)	After 3 months
Bacopa monnieri	Control	100	91±4.9
	Soil amended with microorganisms (*Azotobacter* + *Rhizobium*)	100	78±3.4
	Farm Yard Manure	100	69±4.4
Alternanthera sessilis	Control	100	92±4.1
	Soil amended with microorganisms (*Azotobacter* + *Rhizobium*)	100	74±5.2
	Farm Yard Manure	100	77±4.7
Typha angustata	Control	100	85±4.8
	Soil amended with microorganisms (*Azotobacter* + *Rhizobium*)	100	73±5.9
	Farm Yard Manure	100	68±3.7
Kyllinga tenuifolia	Control	100	86±6.8
	Soil amended with microorganisms (*Azotobacter* + *Rhizobium*)	100	71±4.3
	Farm Yard Manure	100	67±5.7

The information pertaining to the soil Ni concentration recorded as function of growth of different plant species on the textile industry wastewater amended soil and which are grown under experimental conditions. It was evident from the study results that for the control set where *Bacopa monnieri* were planted the soil Ni concentration was

91±4.9mg/Kg after 3 months, however, for the *Bacopa monnieri* grown in soil amended with microorganisms (*Azotobacter* and *Rhizobium*) it was 78±3.4mg/Kg after 3 months, whereas for the *Bacopa monnieri* grown in farmyard manure the soil Ni concentration was 69±4.4mg/Kg after 3 months experimental period.

Moreover, it was observed that for the control *Alternanthera sessilis* plantation the soil Ni concentration was 92±4.1mg/Kg after 3 months, whereas for the *Alternanthera sessilis* grown in soil amended with microorganisms (*Azotobacter* and *Rhizobium*) it was 74±5.2mg/Kg after 3 months, however, for the *Alternanthera sessilis* grown in farmyard manure it was 77±4.7mg/Kg after 3 months.

Furthermore, it was evident from the study results that for the control set planted with the *Typha angustata* the soil Ni concentration was 85±4.8mg/Kg after 3 months of experimental period, however, for the *Typha angustata* grown in soil amended with microorganisms (*Azotobacter* and *Rhizobium*) the soil Ni concentration was 73±5.9mg/Kg after 3 months, whereas for the *Typha angustata* grown in farmyard manure it was 68±3.7mg/Kg after 3 months.

In addition to this, it was apparent from the study results that for the control set with *Cyprus sps* plantation the soil Ni concentration was 86±6.8mg/Kg after 3 months, however, *Cyprus sps* grown in soil amended with miNioorganisms (*Azotobacter* and *Rhizobium*) indicated the soil Ni concentration to be 71±4.3mg/Kg after 3 months, whereas for the *Cyprus sps* grown in farmyard manure the soil Ni concentration was 67±5.7mg/Kg after 3 months (Table 4.9).

The field experimental data indicated that highest heavy metal uptake rate was observed with the plants, such as *Bacopa monnieri* (Brahmi), *Alternanthera sessilis*, *Typha angustata* (Lesser Indian Reed Mace)**,** *Kyllinga tenuifolia* (Cyprus grass)**.**

Bacopa monnieri (Brahmi)

Bacopa monnieri showed highest Cu uptake when grown with the amendment of microorganisms (*Azotobacter* and *Rhizobium),* whereas, the Cr uptake was high in presence of farm yard manure. In addition to this, the Ni uptake was more or less similar with all the combinations i.e. only farm yard manure or combination of microorganisms (*Azotobacter* and *Rhizobium*).

Alternanthera sessilis

Alternanthera sessilis showed highest Cu uptake when grown with the amendment of microorganisms (*Azotobacter* and *Rhizobium),* whereas, the Cr and Ni uptake was more or less similar with all the combinations i.e. only farm yard manure or combination of microorganisms (*Azotobacter* and *Rhizobium*).

Typha angustata

Typha angustata showed highest Cu uptake when grown with the amendment of microorganisms (*Azotobacter* and *Rhizobium*) as well as farm yard manure, whereas, the Cr uptake was high in presence of only farm yard manure. In addition to this, the Ni uptake was more or less similar with all the combinations i.e. only farm yard manure or combination of microorganisms (*Azotobacter* and *Rhizobium*).

Kyllinga tenuifolia

Kyllinga tenuifolia showed highest Cu uptake when grown with the amendment of microorganisms (*Azotobacter* and *Rhizobium*) as well as farm yard manure, whereas, the Cr uptake was high in presence of microorganisms only. In addition to this, the Ni uptake was more or less similar with all the combinations i.e. only farm yard manure or combination of microorganisms (*Azotobacter* and *Rhizobium*).

Conclusion

Bacopa monnieri (Brahmi): *Bacopa monnieri*, *Alternanthera sessilis*: *Alternanthera sessilis*, *Typha angustata and Kyllinga tenuifolia* plants shows Ni uptake more or less similar with all the combinations i.e. only farm yard manure or combination of microorganisms (*Azotobacter* and *Rhizobium*).

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