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Rhizofiltration of Textile Dye Sludge Using Sunflower Plant

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Abstract: *Textile wastewater generated from different stages of textile processing contains huge amount of pollutants that are very harmful to the environment if released without proper treatment. The present paper describes the application of rhizofiltration based wastewater and sludge technology with the primary objective of converting semisolid effluent into eco-friendly safe water. The research on the Helianthus annuu (L.) indicates the heavy metals uptake at different concentrations such as 25%, 50% and 75%. The growth parameter of sunflower like root and shoot length (10.3 ± 0.2 and 38.5 ± 0.1 L), fresh and dry weight (2.85 ± 0.2 and 0.90 ± 0.1 g) recorded was prominently greater in 50%. Initial and final metal analysis was done in all the concentration. It was concluded that the absorption of lead was found to be the maximum in 75% (0.76 ± 0.02 ppm) on comparison with the initial level (1.78 ± 0.01 ppm).*

Keywords: *Rhizofiltration, Heavy Metal, Helianthus annuus, Textile Dye Wastewater Sludge (TDWS).*

I. Introduction

Environmental pollution is the presence of chemicals at toxic levels in land, water and air. Pollution can be defined as an accidental or deliberate contamination of the environment with waste generated by human activities. Metals such as Cd, Cu, Cr, Ni, Zn and Pb are known to be serious environmental pollutants. Severe toxic effects of heavy metal intake includes reduced growth and development, cancer, organ and nervous system damage and in extreme cases, death. The danger of heavy metal pollutants in water lies in two aspects of their impact. Textile industries are one of the biggest users of water and complex chemicals during textile processing at various processing stages. Now-a-days, the demand of textile products have increased dramatically and the latter caused proportional increase in textile industry and its wastewaters in India. There are more than 800 dyeing, bleaching and textile processing industries in Tirupur that generate over 100000 m^3/day of textile effluent [1].

Rhizofiltration is a type of phytoremediation that makes use of plant roots to sorb, concentrate and precipitate heavy metals present in the irrigated wastewater through soil plant root system into the harvestable parts of the roots and above-ground shoots [2]. A plant should have rapidly growing roots to be able to remove toxic metals from water and soil for an extended period of time. Sunflower *(Helianthus annuus)* has been a popular ornamental plant. However, in recent years its importance as an environmental crop is being increasingly recognized. Agronomic experiments conducted on a farm research site in India using recycled organic manure from integrated farming system. Terrestrial plants are thought to be more suitable for rhizofiltration because they produce long, more substantial, often fibrous root systems with large surface area for metal sorption [3]. The objective of the present study was, to treat the sludge using plant to reduce the level of heavy metals and to compare the growth parameter of the sunflower plant in various treatments.

II. Materials and Methods

2.1. Study Area and Sample Collection

The experiments were carried out at PG and Research Department of Zoology, Periyar E.V.R. College (Autonomous), Tiruchirappalli. Glass bottles were arranged in a complete randomized design with triplicates for each treatment. The untreated textile dye wastewater sludge (TDWS) released into the river Noyyal by large scale dye industries in Tiruppur, Tamil Nadu, India were collected using sterile plastic bottles from a place where these textile effluents and sewage confluence with river Noyyal and transported to the laboratory in an ice-packed chest box within 4 h of collection. Sunflowers (*Helianthus annuus* L.) were used for the rhizofiltration experiments. Seeds were obtained from the Tamil Nadu Agricultural Institute, Tiruchirappalli. Seeds were sown and plantlets were used for the experiment in glass bottles. The entire cultivation process was conducted for 2-3 weeks in a growth chamber at 25^{o}C.

2.2. Experimental Design

Ten glass bottles of 500 ml capacity were taken and labeled as T_1, T_2, T_3 and C. Based upon the tolerance of plants; the concentrations selected for the experiment were 25%, 50%, 75% with a control (0%). Various concentrations were prepared by mixing the sludge with distilled water. At the end of the experimental

period (2-3 weeks), the plant samples were washed with distilled water and dried in an oven at 70^{o}C for 3 days, to determine the dry biomass and stored in brown paper bags for further analysis.

2.3. Metal Analysis

Heavy metal concentration in the soil was determined from 1g fine powder of each sample. The humidity was determined by drying them at 104^{o}C for 24 h. Cadmium (Cd), Copper (Cu), Nickel (Ni), Lead (Pb), and Zinc (Zn) was determined using Atomic Absorption Spectrophotometer (AAS) at Bharathidasan University, Triruchirappalli.

2.4. Statistical Analysis

The data entry and one-way Analysis of Variance (ANOVA) were analyzed using SPSS version - 16.0.

III. Results and Discussion

The results of biomass after 2-3 weeks of experiment indicate the mean plant biomass of sunflower (*H. annuus*). The growth parameters like root and shoot length (cm), fresh and dry weight (g) of sunflower were recorded for 21 days. There was an increase in all the growth parameters at 50% dilution. There was an increase in root and shoot length in all the treatments. However, the growth of sunflower was prominently greater in 50% (10.3 ± 0.2 and 38.5 ± 0.1 L). The dry weight also increased considerably. It was 2.85 ± 0.2 and 0.90 ± 0.1 g in 50% (Fig. 1 and 2).

Fig.1 - Root and Shoot Length of Sunflower

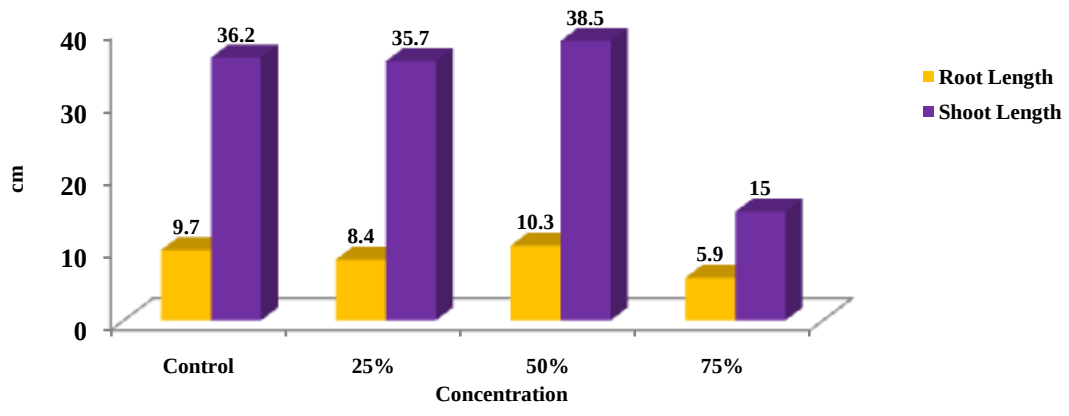
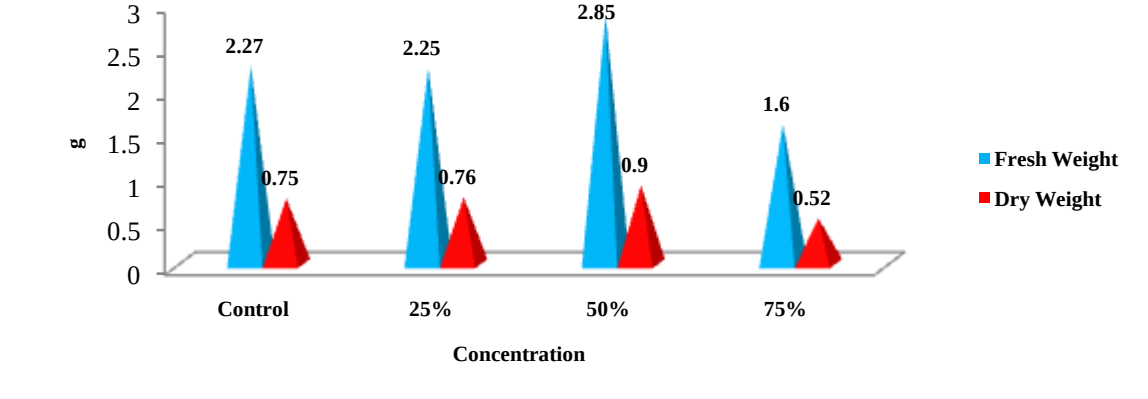


Fig. 2 - Fresh and Dry Weight of Sunflower



The growth parameter were analysed statistically and the significance was $p < 0.05$ level. In the present study the increase of growth parameters like root length and shoot length was noticed. Growth stimulation was more pronounced with control supplement loosen the contaminated sludge and make the soil texture suitable for the root penetration. The results showed that sunflower had better growth in soil though the heavy metals like Cu, Cd, Ni, Pb, and Zn were present. Similar study was carried out by Roongtanakiat and Chariroj [4] and they observed that the concentration of heavy metals in shoot increased as the amount of the applied heavy metals

increased. Increasing the amount of heavy metals applied to soils did not affect the growth and dry weight of the sunflower.

Table – 1 Initial and Final Level of Heavy Metal in TDWS

Metal (ppm)	Control		TDWS - 25 %		TDWS - 50 %		TDWS - 75 %	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Cu	0.21 ± 0.01	0.04 ± 0.02	0.74 ± 0.20	0.03 ± 0.01	0.77 ± 0.01	0.06 ± 0.02	0.80 ± 0.02	0.09 ± 0.01
Cd	0.20 ± 0.02	0.02 ± 0.01	0.35 ± 0.01	0.05 ± 0.02	0.40 ± 0.02	0.08 ± 0.01	0.34 ± 0.01	0.06 ± 0.02
Ni	0.25 ± 0.01	0.09 ± 0.02	0.52 ± 0.02	0.03 ± 0.01	0.67 ± 0.01	0.02 ± 0.02	0.68 ± 0.02	0.01 ± 0.02
Pb	0.32 ± 0.01	0.06 ± 0.02	1.70 ± 0.01	0.69 ± 0.02	1.76 ± 0.02	0.74 ± 0.01	1.78 ± 0.01	0.76 ± 0.02
Zn	0.42 ± 0.01	0.05 ± 0.02	1.10 ± 0.02	0.17 ± 0.01	1.12 ± 0.01	0.50 ± 0.01	1.15 ± 0.02	0.68 ± 0.01

Results are the mean value in replicates ± SD with significant difference at p < 0.05.

The effect of different concentrations of TDWS on the magnitude of heavy metal removal of sunflower (*H. annuus*) plant grown for 2-3 weeks was examined. Heavy metals like Cu, Cd, Ni, Pb and Zn were found to be reduced in all the treatments after 21 days (Table-1). In all the treatments the amount heavy metals were found to be reduced due to rhizofiltration technique. The amount of copper in 25%, 50% and 75% TDWS were 0.74 ± 02.0, 0.77 ± 0.01 and 0.80 ± 0.02 ppm in the initial stage and it was reduced to 0.03 ± 0.01, 0.06 ± 0.02 and 0.09 ± 0.01 ppm in the final stage. Tang *et al*., [5] reported the increase in uptake of copper by Indian mustard and sunflower plant. Nehnevajova *et al*., [6] investigated that the highest metal concentration was found in leaves (shoot) of commercial cultivars of sunflower plants grown on metal-contaminated soil. Among the cultivated crops rape and sunflower revealed higher Cd concentrations in their shoots than in the roots. Studies done in sunflower plant showed that the maximum concentration of Pb was found in root and leaf (shoot) was the major organ of Zn accumulation [7].

The initial and final level of Cd in 25% TDWS were 0.35 ± 0.01 and 0.05 ± 0.01 ppm, in 50% were 0.40 ± 0.02 and 0.08 ± 0.01 ppm and in 75% were 0.34 ± 0.01 and 0.06 ± 0.02 ppm respectively. The initial amount of nickel in 25%, 50% and 75% TDWS were 0.52 ± 0.02, 0.67 ± 0.01 and 0.68 ± 0.02 ppm respectively. This was found to be reduced as 0.03, 0.02 and 0.01 ppm in the final. The initial and final level of lead in 25% diluted TDWS was 1.70 ± 0.01 and 0.69 ± 0.02 ppm in 50% was 1.76 ± 0.02 and 0.74 ± 0.01 ppm and in 75% was 1.78 ± 0.01 and 1.76 ± 0.02 ppm In the same way the reduction was seen in zinc. The initial amount in 25% of TDWS was 1.10 ± 0.02 ppm, in 50% was 1.12 ± 0.01 ppm and in 75% was 1.15 ± 0.02 ppm respectively. This was reduced to 0.17 ± 0.01, 0.50 ± 0.01 and 0.68 ± 0.01 ppm in the final testing after 21 days.

The high accumulation of metals (Cu, Cd, Ni, Pb and Zn) particularly in the root tissues of *H. annuus* may be due to complexation of metals with the sulphydryl groups resulting into less translocation of metals to upper part of the plant, which vary from one metal to another. Similar study was also conducted by Glass, Kumar *et al*., Lee *et al*., [8], [9], [10] and found the effectiveness of sunflower in the removal of lead, uranium and plutonium. Certain varieties of sunflower were also identified as the most efficient plants for rhizofiltration [2], [11]. In the present study the wet and dry biomass of the shoot and roots were analysed. The result shows that there is more difference in high dose. This result coincides with the results of Kayser *et al*., [12] who demonstrated that *H. annuus* produced the largest biomass as compared to *B. juncea* and *S. viminalis* in Zn and Cd contaminated soil. Boonyapookana *et al.,* [13] have studied that the plant biomass of *H. annuus* in Pb contaminated nutrient media declined with increasing concentration. Higher doses of heavy metal can affect the physiology, reduced plant growth and dry biomass yield [14], [15].

IV. Conclusion

In the present study it was observed that the heavy metal condition of the textile dye wastewater sludge (TDWS) sample collected from Tiruppur textile dye wastewater contaminated site revealed a high load of pollution indicators. Rhizofiltration may provide efficient treatment of TDWS depending upon the characteristics of wastewater and sludge to be treated.

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