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Effect of *Tridax procumbens* in treating coffee effluent for heavy metals in jayamangalam, Theni district

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Abstract
The coffee industry is located in Jayamangalam near Periyakulam, Theni District. The industrial waste water was collected from outlet of the coffee industry in the dumping site of coffee effluent. The effluent was diluted with distilled water and prepared in various concentrations like control T1, 75% T2, 50% T3 and 25% T4, the absorbent was kept soaked from January to May, 2017. The heavy metals concentration of effluent was analyzed using Atomic Absorption Spectrophotometer. A novel medicinal plant, *Tridax procumbens* was introduced in 4 different concentrations of effluent during the period of January to May, 2017. Initially the coffee effluent showed the presence of higher concentration of heavy metals such as Zn, Fe, Cr, Cu, Mg, Pb and Mn and after treatment it was lowered. Thus from the present investigation it was evident that *T. procumbens* was effective to absorb the heavy metals present in the effluent.

Keywords: coffee effluent, phytoremediation, heavy metal, *t.procumbens*

Introduction

Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. Earth is the only planet having about 70 % of water. But due to increased human population, industrialization, use of fertilizers in the agriculture and manmade activity the water resources are highly polluted with different harmful contaminants. With the rapid industrialization in the country, environment pollution by industrial waste has increased tremendously [1, 2, 3]. In human life one of the major concerns is heavy metal accumulation in the environment, which leads to toxicity and threat [4]. Heavy metal toxicity even at low concentration, leads to a serious threat to aquatic system. The increasing discharge of waste waters from various industries and urban population results in biosphere pollution [5]. Tripathi and Ranjan[6] explained that the conventional methods for heavy metal removal from wastewater includes chemical precipitation, chemical oxidation, ion exchange, membrane separation, reverse osmosis, electro dialysis etc. Due to inappropriate legislation, industrial waste, that contains mainly toxic heavy metals, are discharged without treatment into the environment thereby contaminating soils, underground water and surface water [7].

The after mount effects include: Destruction of eco system, contamination of surface and underground water, disturbances of soil function, reduction of plant productivity and chance of survival etc. Phytoremediation methods are comparatively cheap and ecologically advantageous and several species of plants known for their phytoremediative abilities [8, 9] and potentials [10]. Phytoremediation technique was used for the removal of metalloids and heavy metals from contaminated soils, water or sediments [11]. Water Hyacinth (*Eichornia crassipes*) is effective in cleaning up contaminants (heavy metals) in water and determines the highest concentration of heavy metal absorption [12].

Coffee is one of the most widely traded agricultural commodities in the world. The production of coffee has a significant impact on the economic development of the producing areas and their environment. Coffee is processed either by wet or dry method. Wet method of coffee processing results in a coffee of superior quality compared to the dry method. Presently in India, around 75-80% of Arabica and 15-20% of Robusta are processed by the wet method. Activated carbon has been reported to have high and fast absorption capacities due to its well developed porous structure and tremendous surface area [13]. Adsorption has emerged out to be better alternative treatment methods. It is said to be effective and economical because of its relatively low cost and efficient method. Phytoremediation is now being used. The present study was carried out using phytoremediation of heavy metals from coffee effluent using *T.procumbens.*

2. Materials and methods

2.1 Study area

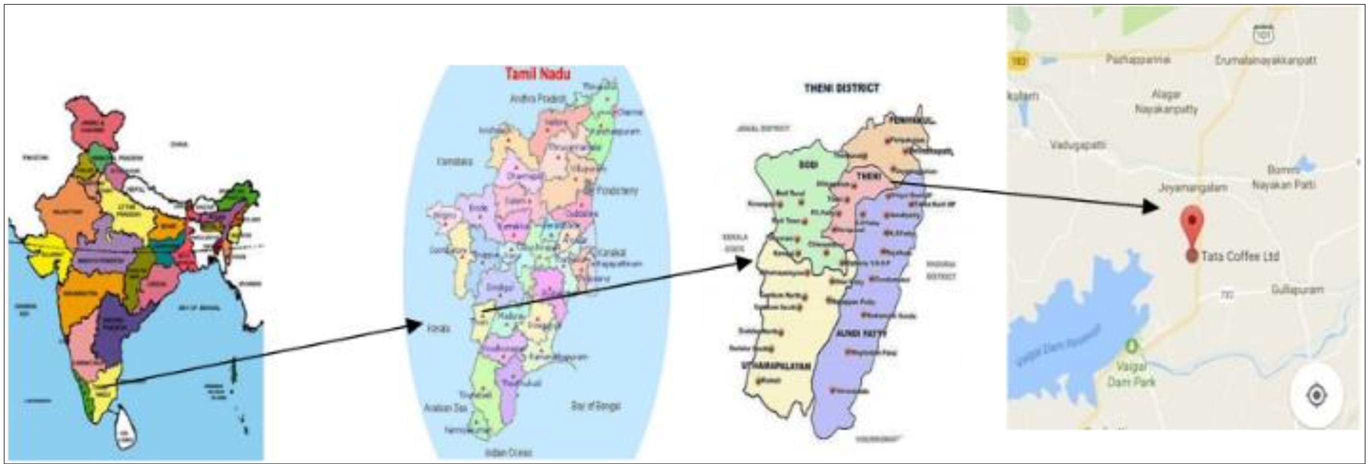

Fig 1: Map showing study area

Theni lies at the foot of Western Ghats. Periyakulam which is located at 10.07 'N 77.33'E in Theni District. It has an average elevation of 282 meters (925 feet). It is located at the foot hills of the Western Ghats bordering the neighboring State of Kerala. Jayamangalam is situated in Periyakulam Taluk (Figure 1). It contains both dry land and wetland. Agriculture is the primary occupation for the population here. It is a fertile area that has an annual supply of surplus rainfall. The climate is dry and hot. Northeast monsoon receives rain during October and December, and high temperature during summer reaches the maximum of 40^{o}c and the minimum of 26.3^{o}c. Winter temperature ranges between 29.6^{o}C and 18^{o}C; the average rainfall is about 135cm. Paddy is cultivated twice a year. Soil is a medium for plant growth which provides nutrients, water and anchorage to the growing plants. Maintenance of proper physical chemical and biological conditions of the soil is necessary for realizing higher growth, yield and quality of paddy. Theni District has around 5267 industries producing chemicals, pharmaceuticals, paints, pesticides, cotton, textile, food industry, sugar, chemicals, beverages, paper products, steel and different types of metallic products for the last twenty years. Many of these industries discharge their treated and untreated effluent to the open land. Tata Coffee's Instant Coffee Division is India's first export-oriented soluble coffee manufacturer. The company has three 100% Export Oriented Units (EDU). Instant Coffee manufacturing units have two locations, one at Toopran near Hyderabad and another at Jayamangalam near Periyakulam, Theni District, with an installed capacity of 8500 tons per annum, producing spray dried and agglomerated and freeze dried instant coffee. In Theni Tata Coffee acquired a 4000 TPA instant coffee plant in the year 2004.

2.2 Collection of Effluent

The effluent was collected from TATA Coffee industry located in Jayamangalam near Periyakulam in January, 2017. Samples were collected in a wide mouth plastic bottle. The cans were properly washed with detergent and distilled water prior to water collection and were carefully rinsed with sample effluent, filled up to the brim and tightly closed to ensure bubble-free sample storage [14].

2.3 Analysis of heavy metal by Atomic Absorption Spectrophotometer

The calibration plot method described in the British pharmacopoeia [15] was adopted for the preparation of metal ion and Atomic Absorption Spectroscopy analysis. The absorbance of these solutions was obtained using Atomic Absorption Spectroscopy for Chromium, Zinc, Manganese, Iron, Magnesium and Copper. The coffee effluent was filtered in a micro filter and it was used for analyzing the heavy metals by Atomic Absorption Spectroscopy. The analytical technique used to determine heavy metal level in all sample was thermo element Sys-813 Atomic Absorption Spectroscopy (International Equipment trading Ltd, USA).

2.4 Sample Preparation for Atomic Absorption Spectroscopy Analysis

The coffee effluent was filtered in a micro filter and it was used for analyzing the heavy metals by Atomic Absorption Spectroscopy.

2.5 Preparation of water sample for absorption

The effluent was diluted with distilled water. Each concentration contains 100%, 75%, 50%, 25% of coffee effluent. 100% effluent is considered as control or T1, 75% effluent + 25% distilled water as T2, 50% effluent + 25% distilled water as T3, 25% effluent + 75% distilled water as T4.

2.6 Preparation of absorbent

Tridax procumbens commonly known as coat buttons or Tridax is a species of flowering plant belong to the daisy family. It is known as a wide spread weed and pest plant. Tridax procumbens has been in use in India for wound healing and as an anticoagulant, antifungal and insect repellent. *T.procumbens* plants were collected and air dried for 48 hours. The dried leaves were grounded. Activated biocarbon of the *T. procumbens* was prepared by treating the leaves powder with concentrated sulphuric acid in a weight ratio of 1:1.8. The resulting black product was kept in an air-free oven maintained at 160±5^{0}C for 6 hours followed by washing with distilled water until free of excess acid, and then dried at 150±5^{0}C.

2.7 Introducing absorbent in effluent

100gms of absorbent was introduced in each concentrated effluent. The effluent was soaked till the experimental work finished.

3. Results

3.1 Heavy metal analysis of coffee effluent in different concentrations

The concentration of Zinc, Iron, Chromium, Copper, Magnesium, Lead and Manganese in 4 different samples was analyzed before treatment, and after treatment with Tridax procumbens in all the months and the results are tabulated and figured as follows.

3.1.1 Absorption of various heavy metals in Control/100% effluent by *Tridax procumbens*

The concentration of Zinc in the control sample before treatment with *Tridax procumbens* was 0.0034 mg/l. After introduction of *T. procumbens*, it showed a gradual reduction of Zinc from 0.0034 to 0.0026 mg/l during February to May, 2017. The initial reading of Iron in the T1 sample of coffee effluent was higher (0.0081 mg/l), but it was slowly reduced to 0.0075 mg/l in May after treating it with *T. procumbens*. Presence of Chromium in the coffee effluent was observed in the T1 sample. Higher concentration (0.0066 mg/l) of Chromium was observed in February and it was lowered in May (0.0057 mg/l). This is because of the biosorption of *T. procumbens*. In the control sample, the concentration of Copper was higher (0.0069 mg/l) before treatment. After treatment the concentration of Copper has been reduced to 0.0059 mg/l. The concentration of Magnesium in the control sample was 0.0051mg/l and this is before treatment with *T. procumbens.* After introduction of *T. procumbens*, it showed a gradual reduction (0.0045 mg/l). The initial reading of Lead in the T1 sample of coffee effluent was higher (0.0069mg/l), but it was slowly reduced to 0.0063mg/l in May after treating it with *T. procumbens.* Presence of Manganese in the coffee effluent was observed in the T1 sample. Higher concentration of Manganese (0.0019 mg/l) was observed in February and it was lowered (0.0013 mg/l) in May (Figure 2). This is because of the biosorption of *T. procumbens*. After treatment with *T. procumbens* the heavy metals were reduced from the February to May.

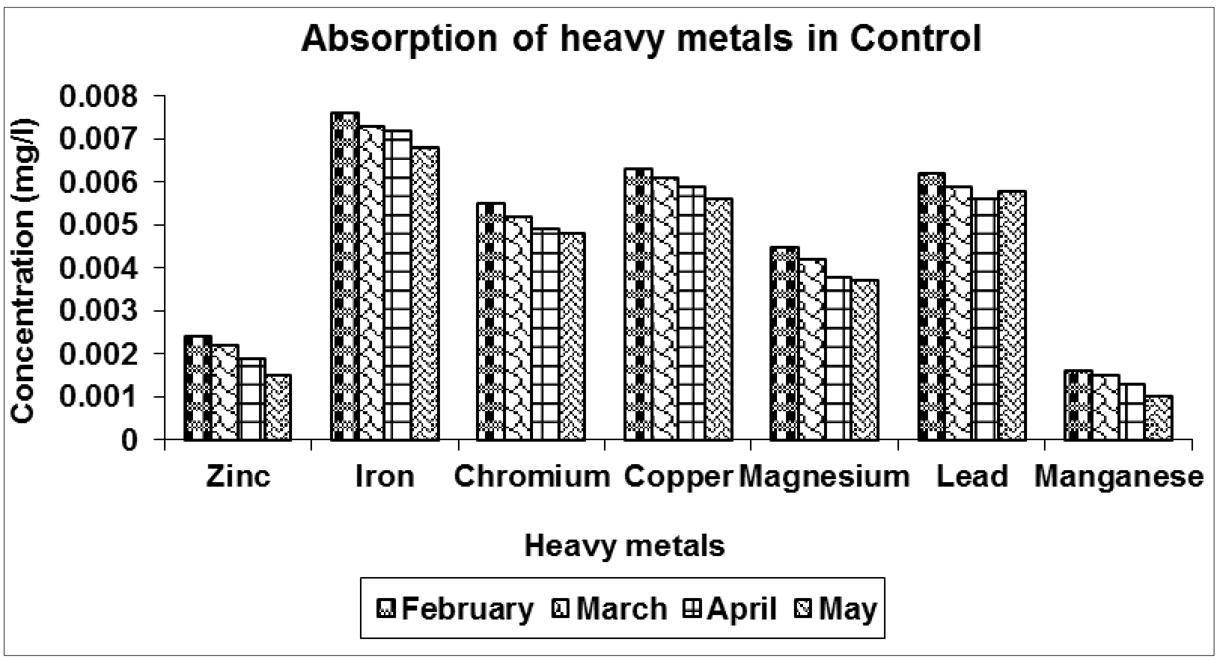

Fig 2: Absorption of heavy metals in Control by *Tridax procumbens*

3.1.2 Absorption of various heavy metals in 75% concentrated effluent by Tridax *procumbens*

The concentration of Zinc in the 75% concentrated sample was 0.0031 mg/l and this is before treatment with *T. procumbens.* After treatment it showed a gradual reduction of Zinc from 0.0031 to 0.0021 mg/l during February to May, 2017. The initial reading of Iron in the T1 sample of coffee effluent was higher (0.0080 mg/l), but it was slowly reduced to 0.0073 mg/l in May after treating it with *T. procumbens*. Presence of Chromium in the coffee effluent was observed in the T1 sample. Higher concentration (0.0060 mg/l) of Chromium was observed in February and it was low in May (0.0055 mg/l). This is because of the biosorption of *T. procumbens*. In the control sample,
the concentration of Copper was higher (0.0069 mg/l) before treatment (Figure 3). After treatment the concentration of Copper has been reduced (0.0057 mg/l). The concentration of Magnesium was 0.0049mg/l. After introduction with *T. procumbens*, it was reduced to 0.0040 mg/l. The initial reading of Lead in the T1 sample of coffee effluent was higher (0.0067 mg/l), but it was slowly reduced to 0.0061 mg/l in May after treating it with *T. procumbens.* Presence of Manganese in the coffee effluent was observed in the T1 sample. Higher

concentration of Manganese (0.0019 mg/l) was observed in February and it was lowered (0.0012 mg/l) in May. This is because of the biosorption of *T. procumbens*.

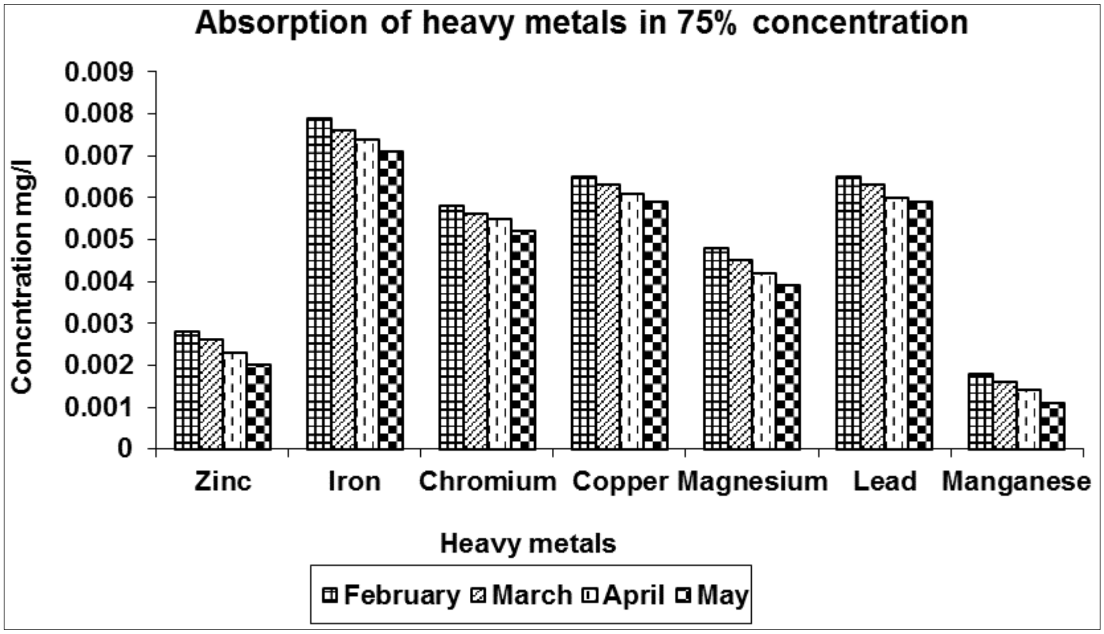

Fig 3: Absorption of heavy metals in 75% concentrated effluent by Tridax procumbens

3.1.3 Absorption of various heavy metals in 50% concentrated effluent by *Tridax procumbens*

The concentration of Zinc in the 50% concentrated sample was 0.0028 mg/l and this is before treatment with *Tridax procumbens*. After introduction of *T. procumbens*, it showed a gradual reduction of Zinc from 0.0028 to 0.0020 mg/l during February to May, 2017. The initial reading of Iron in the T1 sample of coffee effluent was higher (0.0079 mg/l), but it was slowly reduced to 0.0071 mg/l in May after treating it with *T. procumbens*. Presence of Chromium in the coffee effluent was observed in the T1 sample. Higher concentration (0.0058 mg/l) of Chromium was observed in February and it was lowered in May 0.0052 mg/l. In the control sample, the concentration of Copper was higher (0.0065 mg/l) before treatment (Figure 4). After treatment the concentration of Copper has been reduced to 0.0054 mg/l. The concentration of Magnesium in the control sample was 0.0048 mg/l and this is before treatment with *T. procumbens*. After introduction of *T. procumbens*, it showed a gradual reduction (0.0039 mg/l). The initial reading of Lead in the T1 sample of coffee effluent was higher (0.0065 mg/l), but it was slowly reduced to 0.0059 mg/l in May after treating it with *T. procumbens*. Presence of Manganese in the coffee effluent was observed in the T1 sample. Higher concentration of Manganese (0.0018 mg/l) was observed in February and it was lowered (0.0011 mg/l) in May.

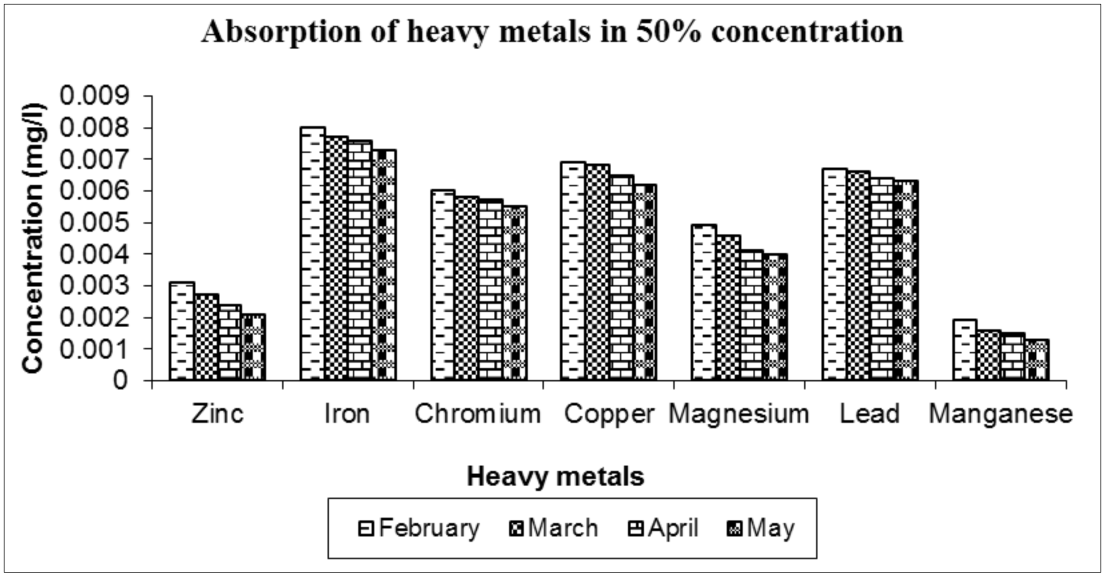

Fig 4: Absorption of heavy metals in 50% concentrated effluent by Tridax procumbens

3.1.4 Absorption of various heavy metals in 25% concentrated effluent by *Tridax procumbens*

The concentration of Zinc in the 25% concentrated sample was 0.0024 mg/l and this is before treatment with *Tridax procumbens*. After introduction of *T. procumbens*, it showed a gradual reduction of Zinc from 0.0024 to 0.0017 mg/l during February to May, 2017. The initial reading of Iron in the T1 sample of coffee effluent was higher (0.0076 mg/l), but it was slowly reduced to 0.0068 mg/l in May after treating it with *T. procumbens*. Presence of Chromium in the coffee effluent was observed in the T1 sample. Higher concentration (0.0055 mg/l) of Chromium was observed in February and it was lowered in May (0.0048 mg/l). This is because of the biosorption of *T. procumbens*. In the control sample, the concentration of Copper was higher (0.0063 mg/l) before treatment. After treatment the concentration of Copper has been reduced to 0.0051 mg/l. The concentration of Magnesium in the control sample was 0.0045 mg/l and this is before treatment with *T. procumbens*. After introduction of *T. procumbens*, it showed a gradual reduction (0.0037 mg/l). The initial reading of Lead in the T1 sample of coffee effluent was higher (0.0062 mg/l), but it was slowly reduced to 0.0058 mg/l in May after treating it with *T. procumbens*. Presence of Manganese in the coffee effluent was observed in the T1 sample. Higher concentration of Manganese (0.0016 mg/l) was observed in February and it was lowered (0.0010 mg/l) in May. This is because of the biosorption of *T. procumbens* (Figure 5). All the metals showed highly significant biosorption at different concentrations except control or 100% concentrations (Table 1).

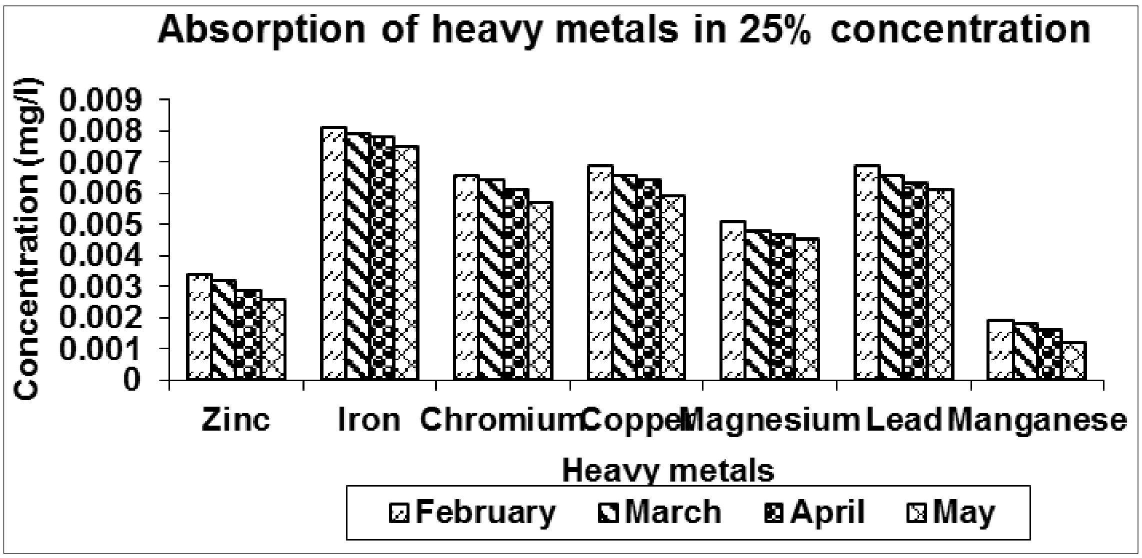

Fig 5: Absorption of heavy metals in 25% concentrated effluent by Tridax procumbens

Table 1: Absorption of different heavy metals in various concentrations by *Tridax procumbens*

Heavy metals	Concentrations of Coffee Effluent	Months				Significant (P)
		February	March	April	May	
Zinc	Control or 100 %	0.0034	0.0032	0.0029	0.0026	0
	75 %	0.0031	0.0027	0.0024	0.0021	0.028*
	50 %	0.0028	0.0026	0.0023	0.0020	0.028*
	25 %	0.0024	0.0022	0.0019	0.0017	0.041*
Iron	Control or 100 %	0.0081	0.0079	0.0078	0.0075	0
	75 %	0.0080	0.0077	0.0076	0.0073	0.012*
	50 %	0.0079	0.0076	0.0074	0.0071	0.044*
	25 %	0.0076	0.0073	0.0072	0.0068	0.018*
Chromium	Control or 100 %	0.0066	0.0064	0.0061	0.0057	0
	75 %	0.0060	0.0058	0.0057	0.0055	0.003*
	50 %	0.0058	0.0056	0.0055	0.0052	0.046*
	25 %	0.0055	0.0052	0.0049	0.0048	0.047*
Copper	Control or 100 %	0.0069	0.0066	0.0064	0.0059	0
	75 %	0.0069	0.0065	0.0062	0.0057	0.023*
	50 %	0.0065	0.0063	0.0061	0.0054	0.025*
	25 %	0.0063	0.0061	0.0059	0.0051	0.016*
Magnesium	Control or 100 %	0.0051	0.0048	0.0047	0.0045	0
	75 %	0.0049	0.0046	0.0045	0.0040	.001**
	50 %	0.0048	0.0045	0.0042	0.0039	0.013*
	25 %	0.0045	0.0042	0.0038	0.0037	0.014*
Lead	Control or 100 %	0.0069	0.0066	0.0064	0.0063	0
	75 %	0.0067	0.0064	0.0063	0.0061	0.014*

	50 %	0.0065	0.0063	0.0060	0.0059	0.014*
	25 %	0.0062	0.0059	0.0056	0.0058	0.031*
Manganese	Control or 100 %	0.0019	0.0018	0.0016	0.0013	0
	75 %	0.0019	0.0016	0.0015	0.0012	0.014*
	50 %	0.0018	0.0016	0.0014	0.0011	0.013*
	25 %	0.0016	0.0015	0.0013	0.0010	0.001**

*. Correlation is significant at 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Table 2: Showing the difference in the concentration of heavy metals before and after treatment with *T. procumbens*

S. No.	Heavy metals	Before treatment with *T. procumbens*	After treatment with *T. Procumbens* (in 100%)
1	Zinc	0.0035	0.0026
2	Iron	0.0082	0.0075
3	Chromium	0.0068	0.0057
4	Copper	0.007	0.0059
5	Megnesium	0.0052	0.0045
6	Lead	0.007	0.0061
7	Manganese	0.002	0.0012

All the 7 metals showed drastic changes positively by the absorbent (Table 2) and are positively correlated as depicted in Table 1.

4. Discussion

4.1 Zinc

It is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms. Nevertheless, higher concentration of zinc can be toxic to the organism. It plays an important role in protein synthesis; it is a metal which shows fairly low concentration in surface water due to its restricted mobility from the place of rock weathering or from the natural sources. The same result was obtained in *Typha domingensis L.* It has the potential to be used in phytoremediation purposes to remove zinc from contaminated wastewaters [16]. Several absorbents have been used for absorption of zinc from waste water. Some of the highest adsorption capacities reported for Zn^{2+} are powdered waste sludge, dried marine green macroalgae, lignin, cassava waste and bentonite. The roots of Indian mustard are found to be effective in the removal of Zn, from hydroponic solutions [17, 18, 19]. Ingole and Bhole [20] conducted hydroponic studies to investigate the uptake of zinc by water hyacinth from the aqueous solution. *Typha domingensis* was capable of accumulating the zinc preferentially from wastewater than from sediments. *Typha domingensis* could be effective to the decrease of zinc from municipal wastewater [21]. The experimental studies showed that *Xanthium Pensylvanicum* could be used as an alternative, inexpensive and effective material to remove high amounts of zinc from wastewater [22].

4.2 Iron

in drinking water is present as Fe^{2+} or Fe^{3+} in suspended form. It causes staining in clothes and imparts a bitter taste. It comes into water from natural geological sources, industrial wastes, domestic discharge and also from by products. Excess amount of iron (more than 10 mg/kg) causes rapid increase in pulse rate and coagulation of blood in blood vessels, hypertension and drowsiness. The result was on a par with the effect of coffee husk absorbent dosage on the absorption of iron; it showed that the percentage of removal increased with the increase in absorbent dosage due to increased adsorption surface area [23]. Absorbent prepared from *Xanthium pensylvanicum* is suitable for removing Fe^{+} heavy metal ion [22]. *Typha domingensis* could be effective to decrease the Fe^{+} heavy metal from municipal waste [21]. *Typha domingensis* has the potential to be used in phytoremediation purpose to removal Fe^{+} pollutants from contaminated wastewaters [16].

4.3 Chromium

The permissible limit of Chromium for plants is 1.30mg/kg recommended by WHO. The maximum permissible limit for Cr in water is 0.1 mg/l. The same result was obtained in various low cast absorbents derived from agricultural waste or natural products; the researchers have extensively investigated for chromium heavy metal removal from contaminated waste water [6]. The agricultural by products like Bengal gram husk, tur dal husk and tamarind husk have been used as an effective absorbent for the treatment of waste water containing chromium metal [23]. The potential duck weed was investigated by Zayed *et al.* [24] for the removal of chromium from nutrient added solution. The concentration of chromium before and after treatment was analysed using Atomic Absorption Spectrophotometer. *Salvina molesta* has been accumulated by the chromium heavy metal from industrial effluent [25]. The removal of chromium in synthetic waste water and tannery waste water would be undertaken by using *Tridax procumbens* [4].

4.4 Copper

The permissible limit of copper for plants is 10 mg/kg recommended by WHO [26]. Copper particles are released into the atmosphere by windblown dust; volcanic eruptions; and anthropogenic sources, primarily copper smelters and ore processing facilities. The same result was obtained in *Salvina molesta* that has been accumulating in the copper heavy metal from industrial effluent [25]. Various low cast absorbents derived from agricultural waste or natural products have been extensively investigated for copper heavy metal removal from contaminated waste water [6]. Dried leaves of *Tridax procumbens* can remove 91% copper from synthetic metal solution [27]. Bioconcentration factor showed that the investigated plant *Eichornia crassipes* hyper accumulated copper heavy metal. The experimental studies showed that *Xanthium Pensylvanicum* could be used as an alternative, inexpensive and effective material to remove high amount of copper from wastewater [22].

4.5 Magnesium
It also follows the same trend as that of calcium. In the untreated water sample high level of magnesium was observed as where the values lowered gradually by the uptake of water hyacinth and reached the permissible limit. However magnesium content was less than that of calcium in natural bodies, but due to the entry of sewage and other waste in the water, these elements increased the hardness of water [28] and very high concentration of magnesium, causes an unpleasant taste to the potable water [29]. The same result was obtained by Kaplan [30] who had reported high value of magnesium that indicates, the groundwater is polluted because of industrial effluents.

4.6 Lead
The permissible limit of lead in plants recommended by WHO is 2 mg/kg. It accumulates with age in bones aorta, and kidney, liver and spleen**.** It can enter the human body through uptake of food (65%), water (20%) and air (15%). The same result was obtained by Singh *et al.* [31] the duck weed showed a better lead removal than others from polluted water. The absorption behavior of lead onto *Calotropis procera* roots from industrial waste water [33]. The removal of lead in synthetic waste water by using *Tridax procumbens* activated carbon is very effective [34]. Bioabsorption of lead is studied on fish bone, grape and spinach from contaminated water [35]. Bioconcentration factor showed that the investigated plant *Eichornia crassipes* hold hyper accumulated lead heavy metal. The experimental studies showed *Xanthium Pensylvanicum* could be used as an alternative, inexpensive and effective material to remove high amounts of lead from wastewater [22]. Bioaccumulation of lead was found in the roots of water hyacinth from industrial waste water [7]. Santos and Lenzi, [36] tested the effect of aquatic macrophyte, *Eiochhornia crasipes* in the elimination of Pb from industrial effluent in a green house study and found it useful for Pb removal. The removal of Pb in industrial waste water by using *Tridax procumbens* is very effective [4]. *Typha domingensis* has the potential to be used in Phytoremediation purpose for the removal of Pb pollutants from contaminated wastewater [16]. *Salvina molesta* have been accumulating lead from industrial effluents [25].

4.7 Manganes
The same result was obtained in *Typha domingensis* could be effective to decrease manganese from municipal waste [21].

5. Conclusion
The industrial waste water from the outlet of the coffee industry and contaminated soil were collected from the dumping site of coffee effluent, for analysis in Jayamangalam. The effluent was diluted in various concentrations like 100 %, 75 %, 50 % and 25 %. The absorbent *Tridax procumbens* was kept soaked from January to May in 2017 to test its biosorption capacity. The presence of heavy metal such as Zinc, Iron, Chromium, Copper, Magnesium, Lead and Manganese were observed higher in control or 100% effluent. After treatment with *T. procumbens*, the heavy metals were reduced highly in 25% concentrated effluent. The study revealed that heavy metal of coffee effluent was relatively high before treatment and reduced after treatment. This effluent from the industry was directly discharged into the nearby land without proper treatment. Therefore the land remains barren without any plant growth. In due course it may affect the fertility of the soil. The *T. procumbens* was proved to be effective for treating the coffee effluent. This study concluded that *T. procumbens* directly reduce the heavy metal pollution in coffee effluent. This effluent is a biological renewable, eco friendly, nontoxic, cost effective and can be used for agriculture and treating this soil.

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