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Physico - chemical and heavy metal analysis of contaminated soil near coffee industry in Jayamangalam, Theni district, T.N., India

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ABSTRACT

The coffee industry is located in Jayamangalam near Periyakulam, Theni District. The soil was collected from dumping site of coffee effluent, to analyse the physico chemical parameters during January-May, 2017. It was analyzed using standard methods. The pH of the sample was alkaline in nature. The value of electrical conductivity was higher than the permissible limit. The amount of available nitrogen, phosphorous and potassium concentration was also high. Heavy metals such as Zn, Fe, Cr, Cu, Mg, Pb and Mn were also analyzed. This soil contains high amount of heavy metals where Cu followed by Magnesium was the highest among them and exceed permissible limits. The effluent from the coffee industry was the major source of pollution which will affect the flora and fauna existing in such soil environment. Thus, there is need for treatment of coffee industry effluent before they are discharged into the soil environment.

Key words*: Physico-chemical analysis, Coffee industry, Contaminated soil, Heavy metal.*

Introduction

India's environment has become fragile and environmental pollution is one of the undesirable effects of industrialization, urbanization, population growth and unconscious attitude towards the environment. Though industrialization and development in agriculture are necessary to meet the basic requirements of people, it is necessary to preserve the environment. With the rapid industrialization in the country, environment pollution by industrial waste has increased tremendously (Tiwari, 1994; Muthuswamy and Jayabalan, 2001; Noorjahan, 2011). The discharge of waste w ater from industries such as tanneries, pulp and paper, textile, petroleum, chemical industries etc. pollute water bodies and soil.

In human life, one of the major concerns is heavy metal accumulation in the environment, which leads to toxicity and threat (Singanan, 2011). Heavy metal can be accumulating in the tissue through food. Increasing heavy metals cause poisoning, cancer and brain damage (Al-Garni, 2005). Water bodies are the major cause of inclusion of heavy metals due to the rapid industrialization. The aim of sustainable heavy metal management in agro-systems, in fact, is to ensure long-term protection of soil fertility along with the quality of agricultural produce (Moolennaar *et al.,* 1997).

The contamination of soil by atmospheric depo-

sition of toxic metals affects soil properties and further increase plant metal levels through root uptake. Lands under peri-urban agriculture are worst affected by this problem (Kaur and Rani, 2006). Soil is a dynamic natural body developed as a result of pedogenic processes through weathering of rocks, consisting of mineral and organic constituents, possessing definite chemical, physical, mineralogical and biological properties, having a variable depth over the surface of the earth, and providing a medium for plant growth (Thakre *et al.,* 2012). Raskin *et al.* (1997) suggested that soil and water contaminated with metals pose a major environmental and human health problem; that is still in need of an effective and affordable technological solution. Most metals do not undergo microbial or chemical degradation and are toxic and their total concentration in soil persists for a long time after their introduction (Kirpichtchikova *et al.,* 2006).

Soil formation is a constructive as well as destructive process. Soil is not only important for agriculture but also have more useful for living organism. The differences in soil characteristics associated with landscape position are usually attributed to differences in the runoff, erosion and deposition processes that affect soil genesis (Dengðz, 2010). Coffee which belongs to the genus Coffea of Rubiacea family is one of the most popular beverages consumed throughout the world. The average annual production is 0.291 million tons from an area of 0.354 million hectares of land. 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. The present study was carried out to analyse the physico-chemical properties and heavy metals in Coffee effluent contaminated soil.

Materials and Method

Study area

Theni lies at the foot of Western Ghats. Periyakulam which is located at 10.07´N 77.33´E in Theni District, is a Taluk for Jayamangalam. Tata Coffee's Instant Coffee Division is India's first export-oriented soluble coffee manufacturer. Coffee Industry is placed at Jayamangalam near Periyakulam, Theni District.

Collection of contaminated Soil

The soil samples were collected from 0-30 cm deep locations immediate to the dumping site of Effluent. The soil sample was collected in clean plastic bags washed with distilled water and dried.

Physico chemical analysis of Contaminated Soil

The soil sample was subjected to various Physico-chemical analysis such as pH, Available nitrogen, Phosphorous, Potassium and Electrical Conductivity using APHA (1998) method.

Analysis of heavy metal by Atomic Absorption Spectrophotometer

The calibration plot method described in the British pharmacopoeia (2005) was adopted for the preparation of metal ion and Atomic Absorption Spectroscopy analysis. A stock standard solution, 1000ppm, of the metal ion was prepared by dividing the molar mass of the compound containing the element by the molar mass of the element. The weight obtained was equivalent to 1.0g of the metal ion. This weight (which is equivalent to 1.0 g of the metal) was dissolved in 1000 ml to give 1000 ppm. A working solution of 100 ppm was prepared from the stock solution and serial dilutions were made from the working solution. The absorbance of these solutions was obtained using Atomic Absorption Spectroscopy for Chromium, Zinc, Manganese, Iron, Magnesium, Lead, and Copper. The calibration graph was plotted and the regression equation was used to determine the heavy metal concentration deionized water was used as control.

Sample Preparation for Atomic Absorption Spectroscopy Analysis

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

Preparation of Soil sample for heavy metal analysis

The soil sample was sieved through the plastic sieve to remove the large particles. Soil sample was placed overnight on an oven at 150^{o}C till it is dried. Sample was weighed 5 g in flask for the digestion. Then sample was digested by Hydrochloric acid and Nitric acid in 1:3 ratios. The sample was digested for 2 hours at 100^{o}C with reflex condenser. The soil was allowed to cool. It was filtered with Whatmann filter paper into 100 ml standard flask

and it was used for heavy metal analysis.

Results and Discussion

Physico-chemical analysis of coffee effluent contaminated soil

Physico chemical parameters of coffee effluent contaminated soil collected near the outlet of the effluent from TATA Coffee Industry was analyzed.

pH

In the present study pH of the soil sample was 7.99. The same result was obtained by Jaishree and Khan, (2014) in contaminated soil from different areas of textile industry and Pirzada *et al.* (2013) reported in agricultural soil. Janeshwar *et al.* (2013) reported the same in locked soil of Sadli Reservoir. The soil pH is usually increased when total alkalinity increases, but the balance of the added cations also had a marked effect on the soil pH, increasing the amount of sodium in an alkaline soil will tend to induce dissolution of calcium carbonate, which will increase the pH.

Available Nitrogen

In the present study, the value of nitrogen concentration in the soil sample was 2.81 ppm (Table 1). Nitrogen is available to plants as either ammonium or nitrate. Animal manures and other organic wastes can be important sources of nitrogen for plant growth. The amount of nitrogen supplied by manure will vary with the type of livestock, handling, rate applied and method of application. Nitrate, (NO_3-) is a negatively charged ion (anion). Very little nitrate can be stored in the soil and negatively charged soil colloids (such as clay and humus) largely repel it. Therefore when water drains through the soil, nitrate leaches out (Franklin, 1957). Nitrogen greatly contributes in agriculture and lower quality of crops throughout the world is due to improper and non judicious use of nitrogen (Shah Jahan *et al*., 2016).

Phosphorous

Phosphorus concentration was higher than the permissible limit (Table 1). Phosphorus is an essential element for plant and animal growth, but too much of it can accelerate the natural aging of lakes and streams. Phosphorus build up is caused by excessive use of inorganic fertilizer or the use of composts and manures high in phosphorus. High soil phosphorus levels also can threaten streams, rivers, lakes and oceans. Animal wastes often contain elevated levels of phosphorus because of high levels of phosphorus in animal feeds (Franklin E. Allison, 1957). Manure is commonly over-applied with respect to the phosphorus needs of crops, especially when it is used as the main source of nitrogen for crops, or when it is applied merely for convenience on fields closes in most soils, the amount of phosphorus available to plants from the soil solution at any one time is very low, seldom exceeding about 0.01% of the total phosphorus in the soil. The bulk of the soil phosphorus exists in three general groups of compounds namely, organic phosphorus, calcium-bound inorganic phosphorus, and iron- or aluminum-bound inorganic phosphorus (Weil, and Brady, 2017).

Potassium

In the present investigation, potassium concentration of the soil sample is 314 ppm (Table 1). Plants require potassium ions (K^+) for protein synthesis and for the opening and closing of stomata, which is regulated by proton pumps to make surrounding guard cells either turgid or flaccid. A deficiency of potassium ions can impair a plant's ability to maintain these processes. Potassium also functions in other physiological processes such as photosynthesis, protein synthesis, activation of some enzymes, phloem solute transport of photo assimilates into

Table 1. Physico chemical characteristics of contaminated soil

Physico chemical parameters of contaminated soil	Permissible value of Physico chemical parameters in soil	Values
pH	7	7.99
Available nitrogen (ppm)	0.43	2.81
Phosporous (ppm)	10.2	16.6
Potassium (ppm)	165	314
Electrical Conductivity (S/m)	0	0.21

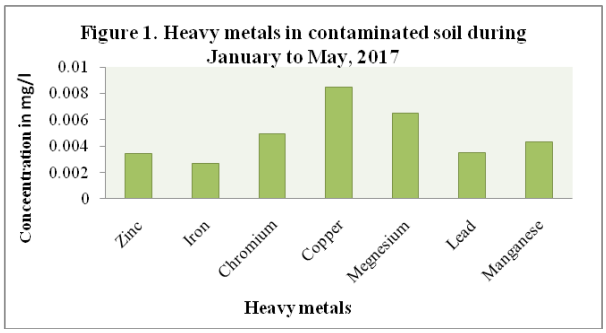
source organs and maintenance of cation: anion balance in the cytosol and vacuole (Hopkins, 2010).

Electrical Conductivity

Electrical conductivity of soil sample was 0.21S/m (Table 1). Electrical conductivity is a measurement of the dissolved material in an aqueous solution, which relates to the ability of the material to conduct electrical current through it. The electrical conductivity of a soil sample might be considered relatively high. No indication from the electrical conductivity test was available to determine if this condition was from irrigation with salty water or if the field had been recently fertilized and the elevated electrical conductivity was from the soluble fertilizer salts (Hanlon, 2015).

Heavy metal analysis of contaminated soil

Coffee effluent loaded soil sample report showed the presence of various toxic heavy metals (Figure 1) and the sample contained zinc, iron, chromium, copper, magnesium, lead and manganese where Cu followed by Mg as the highest and Fe as the lowest concentration (Figure 1). This result was on a par with Nazir *et al.* (2015) in the accumulation of heavy metals in the soil. The same result was obtained in bioremediation of heavy metals by employing resistant microbial isolates for agriculture soil in the study of Kumar *et al.* (2015).



Conclusion

The coffee effluent contaminated soil was collected from the dumping site of coffee effluent and analysed the physico-chemical parameters and heavy metals in Jayamangalam. The contaminated soil from coffee industry had high value of pH, available Nitrogen, Phosphorous, Potassium and Electrical conductivity. The presence of heavy metal such as Zinc, Iron, Chromium, Copper, Magnesium, Lead and Manganese were present in contaminated soil with Cu followed by Mg in high and Fe in low concentration. This effluent from the industry was directly discharged into the nearby land without analyzing its impact and proper treatment. It may be a threat to the coffee effluent contaminated land because in due course it may affect the fertility of the soil.

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