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PHYSICO CHEMICAL ANALYSIS OF COFFEE EFFLUENT BEFORE AND AFTER TREATMENT WITH *TRIDAX PROCUMBENS* AND ITS IMPACT ON THE GROWTH OF TOMATO PLANT *SOLANUM LYCOPERSICUM*

NIRMALA T.,[1] K. JENCY PRIYA[2] AND M.R. DELPHINE ROSE[3]

[1,3]PG and Research Centre of Zoology,
[2]PG and Research Centre of Mathematics,
DST-Lab, Jeyaraj Annapackiam College for Women (A), Periyakulam, Theni District, Tamil Nadu, India

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ABSTRACT

The coffee effluent was collected from the dumping site of coffee effluent from the coffee industry to analyze the physico-chemical parameters of effluent using standard methods. The effluent from coffee industry had high value of the physical parameters such as total hardness, turbidity and electrical conductivity. The chemical parameters such as calcium, potassium, nitrate, dissolved oxygen were higher in effluent before and lowered after the treatment. The effluent from the coffee industry was the major source of pollution which will affect the flora and fauna existing in that dumping environment. Tomato plant growth signifies the dilution of effluent promotes the growth of the stem. Hence, a special care is needed for complete treatment of coffee effluent before they are discharged into the environment.

KEY WORDS : Coffee industry, Coffee effluent, *T. procumbens, S. lycopersicum*, Physico-chemical parameters

INTRODUCTION

All living organisms on the earth need water for their survival and growth. Water is one of the most important and abundant compounds of the ecosystem. Earth is the only planet having about 70 % of water. It is also necessary for domestic, irrigation, industrialization, agricultural and fishery production. Consequently, for each necessity, physicochemical analysis of water is relatively necessary, as contaminated or polluted water could not be used for any purpose (Rehman *et al.,* 2015). Technological improvement leads to major problems in the ecosystem. Even though development of industries has resulted in an improving lifestyle and increasing the standard of people, it leads to an indiscriminate exploitation to the environment (Pathode and Parwate, 2015). The increasing discharge of waste waters from various industries and urban population results in biosphere pollution (Naaz and Pandey, 2010).

A few research works were focused on persistent organic contaminants, which could be accumulated in soil and transferred through food chains and consequently cause adverse health effects on human beings or biological effects on soil fauna and flora after long term application (Blakely *et al.,* 2002; Tang *et al.,* 2002; Wang, 2003; Migaszewski *et al.,* 2002). Large amount of effluent was released due to the increasing use of metals and chemicals in the industrial process, toxic metals were accumulated due to their non-degradable and persistence nature (Ahluwalia and Goyal, 2007). The existing effluent disposal methods, facilities and attitudes are essential in order to make a positive impact on the environmental hygiene. The industries are not following the proper disposal methods. The treated waste water also contains heavy metal ions and

([1]Former Principal and Associate Prof., [2]Asstt. Prof., [3]Associate Prof.)

pollutes the land and ground water. Because of the accumulation of heavy metals, it will affect liver, kidney and leads to bone damage, nervousness occurs and it also blocks functional group of vital enzyme (Ramalingam *et al.,* 2013). Absorption of heavy metal ions into activated carbon has been applied widely as a unit operation in the treatment of industrial waste water (Amuda, 2007).

In the recent past, a number of approaches have been investigated for safe and economical treatment. Absorption has emerged out to be better alternative treatment methods. It is said to be effective and economical because of its relatively low cost. Authors have claimed adsorption to be the easiest, safest and most cost effective methods for the treatment of waste effluents (Shah *et al.,* 2009; Rahmani *et al.,* 2009). Biosorption processes are particularly suitable for the treatment of wastewater containing low concentration of heavy metals and other parameters (Feng, 2004). The phytoremediation potentials of plant species have been considered in many previous researches (Sharifi *et al*., 2007; Singh *et al*., 2007 and Zhang *et al*., 2009). A country's economy depends heavily on the weather, with a semi-arid climate and a well developed irrigation system; it is difficult to assure enough irrigation, at the same time, with population expanding at a high rate, the need for increased food production is apparent (Ouihman *et al.,* 2012). For that reason, planners are forced to consider the sources of water which might be used economically and effectively to promote further development (Hirich *et al.,* 2011).

Coffee is one of the most widely traded agricultural commodities in the world. It is grown in 80 countries and exported by over 50 countries. The 25 million coffee farmers in the developing countries are mostly small-scale producers. More than 100 million people are engaged in producing and processing coffee. The present study was carried out to analyse the physico chemical properties in Coffee effluent before and after the treatment with *T. procumbens*.

MATERIALS AND METHOD

Study area

Coffee Industry is located at Jayamangalam in Periyakulam taluk, Theni District. Theni lies at the foot of Western Ghats. Periyakulam is located at 10.07´N 77.33'E in Theni District. Tata Coffee's Instant Coffee Division is India's first export-oriented soluble coffee manufacturer. Coffee effluent is drained into the fertile land of nearby area (Plate 1).

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 (Hussain, 1989).

Physico chemical analysis of coffee effluent

The samples were subjected to various physico-chemical analysis such as pH, Total Dissolved Solids, Total Alkalinity, Total Hardness, Calcium, Magnesium, Sodium, Chloride, Fluoride, Sulphate and Phosphate using APHA (1998) method.

Preparation of absorbent

Tridax 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 °C for 6 hours followed by washing with distilled water until free of excess acid, and then dried at 150±5 °C.

Introducing absorbent in effluent

100 g of absorbent was introduced in each concentrated effluent. The effluent was soaked till the experimental work get over.

Irrigated to the Tomato seed

Tomato (*Solanum lycopersicum*) seeds were irrigated

Plate 1. Outlet of coffee effluent from industry

with treated wastewater of different concentrations such as control or 100%, 75%, 50% and 25%. Plastic bags were arranged in completely randomized design with three replicas per treatment for the experimental work, each bag contains 5 seeds. The plants were irrigated for 3 weeks. All precautions were taken to secure that all conditions were controlled and that the bags were watered during this period everyday in the morning.

Measured parameters

After a period of three weeks, tomato plants were selected from each treatment then tested by measuring their shoot length.

RESULTS AND DISCUSSION

Physico-chemical parameters of coffee effluent collected near the outlet of the effluent from TATA Coffee Industry and growth of tomato plant *S. lycopersicum* was estimated and analyzed.

Physical parameters of effluent from coffee industry

Colour and Odour

The collected effluent sample was dark brown in colour with an objectionable odour. Colour is a very important factor for aquatic life for making food from sun rays. The photosynthetic activity is found to be reduced due to dark coloration. Dark color will affect other parameters like temperature, dissolved oxygen and biochemical oxygen demand. During fermentation and acidification of sugars in the waste water, pectin oligosaccharides get out of solution and float on the surface of the waste water. The remaining highly resistant materials left in the effluent water are acids and flavanoid color compounds from coffee cherries. The same result was reported by Siddiqui and Waseem (2012) at around pH 7 and over where flavanoids turn waste water from dark green to black color.

Similar result was obtained by Sharma, (2000), and Padmapriya *et al.* (2015). Odour of water is caused like chemical agents such as hydrogen sulphide, free chlorine, ammonia, phenols, alcohols, esters, hydrocarbons and biological agents such as algae, fungi and other microorganisms. Ideal water must not possess any odour. The objectionable odour is directly related to the temperature and considered to be due to the presence of substances with high vapour pressure, which stimulates the human sensory organs of smell as reported by Pirzada *et al.,* (2013).

Turbidity

Turbidity of the coffee effluent was 76.5 NTU and was less after the treatment (Table 1). Ajao *et al.* (2011) reported that the colloidal and suspended impurities cause turbidity in the receiving streams and reduce the light penetration into water and ultimately decrease the photosynthesis. In general, it causes high turbulence and mixing of water leading to an increase of concentration of suspended particulate matter. Frada (2001) also pointed out that the surface water rich in turbidity suspends impurities of decaying organic matter, clay, microorganism like bacteria and small amount of mineral salts.

Electrical Conductivity

The electrical conductivity of coffee effluent was 7505 S/m before treatment and decreased after treatment (Table 1). Electrical conductivity in natural water is the normalized measure of the water's ability to conduct electrical current as reported by Kumar *et al.,* (2001). It's mainly of salinity which greatly affects the taste and thus has significant impact on its use. This is mostly influenced by dissolved solids such as sodium chloride and potassium chloride. The common unit for electrical conductivity is Siemens per meter (S/m). Khan (1997) suggested that the EC of water < 2 mS/cm is excellent for irrigation and crop production. Saranraj and Stella (2012) reported that the Electrical conductivity is a measure of the ability of aqueous solution to convey an electrical current. This ability depends upon the presence of ions, their total concentration, mobility, valence and temperature.

Total Dissolved Solids (TDS)

The total dissolved solid of untreated effluent was high at 4.126 ppm before treatment and decreased after treatment (Table 1). Wilcox (1955) suggested that the TDS content in water is a measure for salinity. A high content of dissolved solid elements affects the density of water, influences osmoregulation of fresh water in organisms and reduces solubility of gases and utility, of water for drinking, irrigation and industrial purposes. Waters can be classified based on the concentration of TDS as, desirable for drinking and permissible for drinking. This study report showed high TDS which is higher before treatment than after treatment.

Chemical examination of effluent from coffee industry

pH Value

The hydrogen ion concentration of the coffee effluent was alkaline 8.5 before treatment and decreased after treatment (Table 2). pH is most important in determining the corrosive nature of water (Gupta *et al.,* 2009). Lower, the pH value higher is the corrosive nature of water. P^H was positively correlated with electrical conductance and total alkalinity. The reduced rate of photosynthetic activity, the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH. Bulushu (1987) and WHO (1984) suggested that the variation in pH is an important parameter in water body since most of the aquatic organisms are adapted to average pH and do not stand with abrupt changes. Natural water with P^H value 6.5-8.5 can be considered as neutral water and majority of potable water falls within this category. Karanth, (1987) reported that the low oxygen values coincided with high temperature during the summer month. Various factors bring about changes the pH of water. The higher pH values observed suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physico-chemical condition. pH is typically for assessment of aquatic ecosystem health, recreational waters, irrigation sources and discharges, livestock, drinking water sources industrial discharge intake and storm water runoff.

Total Alkalinity

The value of total alkalinity was found to be 23 mg/l before treatment and decreased after treatment (Table 2). Total alkalinity is composed primarily of carbonate (CO_3^{2-}) and bicarbonate (HCO^{3-}), alkalinity acts as a stabilizer for pH. Alkalinity, P^H and hardness affect the toxicity of many substances in water as reported by Patil *et al.* (2012). Goel *et al.* (1984) reported that the high alkalinity may be attributed to increase the rate of organic decomposition during which CO_2 is liberated and it reacts with water from nitric oxide (HNO_3) thereby increasing the total alkalinity. Total alkalinity is due to the biological oxidation of organic matter. The alkalinity might be due to high pH. The high pH may be due to the hydroxide carbonates and bicarbonates. High alkalinity may be due to the addition of waste water from organic matter.

Total Hardness

Total hardness in the effluent of coffee industry was 1490 mg/l before treatment and decreased after treatment (Table 2). Garg *et al*. (2007) reported that the Hardness is defined as the concentration of multivalent metallic cations in solution. In general surface water is softer than groundwater. The hardness of water reflects the nature of geological formation with which it has been in contract. Total alkalinity is due to the biological oxidation of organic matter.

Calcium (Ca)

Higher concentration of calcium was observed in effluent from coffee industry 1251.8 mg/L before treatment and decreased after treatment (Table 2). Jayaprakash *et al.* (2005) reported that the Calcium is responsible for hardness of water. Calcium is an important element associated with different cations like carbonates, bicarbonates and fluorides. BIS, (1992) and WHO, (1994) reported that the Calcium is responsible for hardness of water and the addition of calcium in the fresh water system indicates that no removal has taken place. The maximum allowable concentration and permissible concentration of calcium in drinking water will be 75 ppm and 200 ppm respectively. Khan (1986) studied that the hardness varied from reservoir to reservoir due to this geological phenomenon. Ca^{2+} is directly related to hardness; higher Ca^{2+} contents increase hardness in water and make it unsuitable for domestic as well as agriculture purpose as reported by Pirzada *et al.* (2013).

Potassium (K)

Potassium concentration of coffee effluent was 200 mg/L before treatment and highly decreased after treatment (Table 2). The total potassium amount in

Table 1. Physical parameters of Coffee Effluent before and after treatment

Physical parameters of Coffee Effluent	Before treatment	After treatment
Turbidity (NTU)	76.5	20.6
Electrical conductivity (S/m)	7505	3289
Total Dissolved Solids (ppm)	4.126	1.736

the human body lies somewhere between 110 and 140 g and mainly depends upon muscle mass. Vital functions of potassium include its role in nerve stimulus, muscle contraction, blood pressure regulation and protein dissolution. It protects the heart and arteries and may even prevent cardiovascular disease. Skin contact with potassium metals results in caustic potash corrosion. This is more hazardous than acid corrosion, because it continues unlimitedly. Caustic potash drops are very damaging to the eyes. The intake of a number of potassium compounds may be particularly harmful. At high doses potassium chloride interferes with nerve impulses, which interrupts with virtually all bodily functions and mainly affects heart functioning.

A review of the fate of potassium in the soil–plant system after land application of wastewaters was studied by Arienzoa *et al.* (2009). The concentration of potassium affected the concentration of readily extractable (slime) proteins in the floc and the proteins in the surrounding solution. An increase in effluent total organic carbon and effluent turbidity was observed at higher concentrations of this ion. Conversely, an increase in concentration of potassium ion improved the settling properties of sludge with low equivalent monovalent to divalent cation ratio (Murthy and Novak, 1998). Moreover, Oxidized effluent had a higher stimulating effect than inorganic salts, showing the influence of other salts accompanying K, signifying the effect of alleviating the salt stress on microbial activity (Chandra *et al*., 2002).

Nitrate (NO_3) (Electrode Method)

The nitrate concentration in the effluent was 69.7 mg/l before treatment and decreased after treatment (Table 2). Nitrate is an essential nutrient but also a good indicator of contamination from natural and human activities. Sources include manures, inorganic fertilizer and onsite sewage disposal systems Chaudhary, (2005) level above 5 mg/l are considered harmful to aquatic organisms. Natural sources of nitrate are igneous rock, plant and animal debris. Nitrate esters are resistant to biodegradation and characterized by a slow decay rate, they tend to accumulate in the environment. Nitrate esters are capable of migrating over great distances (i.e. through groundwater); therefore they pose a threat not only in the primary contamination area but also to all ecological niches in the direct vicinity studied by Rifler and Medina, (2006). Nitrate ion (NO_3) is a common form of nitrogen in natural waters. Nitrite (NO_2) will oxidize into nitrate after entering an aerobic regime similarly, plants and microorganisms will reduce nitrate into nitrite but nitrite ion will quickly oxidize back into nitrate once it reenters the water. Nitrate reduction has attracted considerable attention from wastewater in wastewater management because total nitrogen (TN), in which nitrate is dominant in the effluent of most wastewater treatment plants, cannot meet the requirement of Chinese wastewater discharge standard (Yun *et al*., 2016).

Dissolved Oxygen

The effluent exhibits high values of dissolved oxygen at 15.5 mg/L before treatment and decreased after treatment (Table 2). Dissolved oxygen is used in biological treatment as the relative measure of oxygen dissolved in wastewater available to sustain life, including living bacteria. Premlata Vikal (2009) reported that the dissolved oxygen is one of the most important parameters. Its correlation with water body gives direct and indirect information about the bacterial activity, photosynthesis, availability of nutrients, stratification etc. Dissolved oxygen is very important for all physical and biological process going on in water. The dissolved oxygen levels in waters depend on physical, chemical and biological activities of the water body. The analysis of dissolved oxygen is very

Table 2. Chemical parameters of coffee effluent before and after treatment

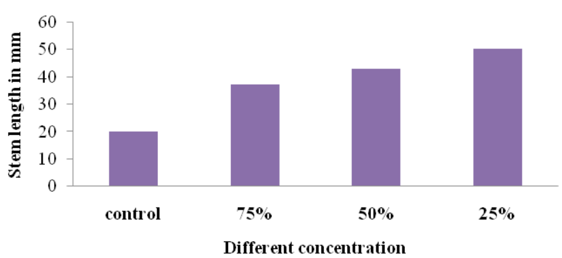
Chemical parameters of coffee effluent	Before treatment	After treatment
pH value	8.5	7.1
Total alkalinity (mg/L)	23	17
Total hardness (mg/L)	1490	478
Calcium (mg/L)	1251.8	605
potassium(mg/L)	200.1	52
Nitrate (mg/L)	69.7	42
Dissolved oxygen (mg/L)	15.5	9.3

important in water pollution and waste water analysis as suggested by Anoop and Renu (2014). Dissolved oxygen concentration is difficult to measure but optimum control is contingent on continuous measurements. Dissolved oxygen concentrations are water treatment factors for carbonations and plant-nutrient chemicals and an important factor in waste-solid bacterial uptake.

Irrigated to tomato plant

After a period of three weeks, tomato plant was irrigated with treated effluent; the concentration such as 25%. 50%, 75% and 100% were 50 mm, 43 mm, 37 mm and 20 mm respectively. Germination of seed was observed in five days and found that the lowest concentration makes the tomato plant to grow faster than the highest concentration of coffee effluent (Figure 2). The same result was obtained by Srivastava (1991) who has evaluated the paper mill and chloralkali plant effluent on seed germination of healthy seeds of radish and onion in different dilution of effluent. Ramana *et al.* (2002) also explained the effect of different concentrations of distillery effluent on seed germination. Dixit (2003) experimented with bioassay studies to evaluate the toxicity of raw and diluted distillery effluent on seed germination. Sharma *et al.* (2002) studied the effect of fertilizer factory effluents on seed germination of tomato cultivars. Behera and Misra (1982) studied the impact of distillery effluent on growth and advance of rice seedlings and reported that the germination percent, number of roots, shoot and root length, fresh and dry weight of the seedlings showed opposite relationship with effluent concentration.

Figure 2. Growth of stem lengths of tomato plant using treated effluent in different concentrations



In Control, there is no significance with average stem lengths where as the concentration of coffee effluent and growth of the tomato plant stem showed highly positive significance at 95% between 75%, 50%, 25% and average stem lengths (Table 3).

Mussarat *et al*. (2007) placed a record of ingestion of vegetables irrigated with waste water and grown in soils contaminated with heavy metals poses a possible risk to human health and wildlife. Jamalkhan *et al.* (2011) reported that pH was slightly alkaline and the low EC indicating no salinity problem in the study of effect of purified industrial wastewater on the growth of tomato plant (*Lycopersicon esculentum*). DAIFI *et al*. (2015) studied the effect of purified industrial wastewater discharged from CMCP of Kenitra city on the growth of tomato plant (*Lycopersicon esculentum*). After testing it was observed that the plants irrigated with drinking water had high fresh weight and those irrigated with unpurified wastewater have shown the lowest fresh weight.

CONCLUSION

The industrial waste water from the outlet of the coffee industry was collected from the dumping site of coffee effluent, to analyse the physico chemical parameters in Jayamangalam. The effluent from coffee industry had high value of the following physical parameters such as total hardness, Turbidity, TDS and Electrical conductivity which denotes that more concentration and temperature is prevalent in it. The chemical parameters such as calcium, potassium, nitrate, dissolved oxygen were higher in effluent before treatment and decreased after treatment. pH was alkaline before treatment and became neutral after treatment. K was reduced to one fourth of the concentration after treatment. High K level is recorded in this study may give high corrosion effect. High NO_3 is as they migrate over greater distances may be harmful to the living organisms including micro organisms. It has high salinity which may reduce the solubility of gases and density of water.

This effluent from the industry was directly discharged into the nearby land without proper treatment. Therefore the land remains barren

Table 3. Stem lengths of tomato plant in various concentrations

Different concentrations of Coffee Effluent	Significant (P)
Control / 100%	0
75%	0.026*
50%	0.026*
25%	0.026*

without any plant growth. In due course it may affect the fertility of the soil. The treated effluent was used to irrigate the tomato plant with different concentrations showed good impact on the growth of the plant. Germination of tomato plant was observed for five days. Maximum stem length of tomato plant was observed in 25% concentration than the control. Less usage of effluent water makes the plant to grow well than higher concentrations of effluent shows significant growth of stem. The lowest concentration of effluent can be used for irrigation of plants after treatment with *Tridax procumbens*.

Purification of the wastewater became an obligatory process to purify the water for removing some or all of the contaminants and making it fit for reuse or discharge back into the environment.

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