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Research Article – Environmental Sciences

Use of tannery effluent for irrigation: an evaluative study on the response of *Sorghum* plants its growth and biochemical characteristics

V. Sangeetha[1], P.S. Sharavanan[2]*
[1]*PG Department of Botany, Govt. Thirumagal Mills College, Gudiyatham-632 602, Tamil Nadu, India*
[2]*Department of Botany, Annamalai University, Annamalai Nagar- 608 002, Tamil Nadu, India*

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***Corresponding author**

Abstract

The present study deals with the impact of various dilutions of tannery effluents on *Sorghum bicolor* seed germination with its growth and biochemical characteristics grown for a period of 11 days. *Sorghum* plant grown with different effluent concentrations i.e, 0%, 20%, 40%, 60% and 80% shows effects on plant growth parameters and biochemical parameters such as; germination percentage, shoot and root length, and chlorophyll. The result clearly shows that the concentrations of effluents straight influence on the growth and biochemical constituents. The heavy metal accretion found at higher level in root when compared with control. Accumulation of heavy metals creates chronic health problems to human and cattle through food chain in long run.

Keywords: *Sorghum*, tannery effluent, seed germination, cadmium, chromium

Introduction

The removal of sewage water is a main predicament of huge cities worldwide. Numerous toxic elements accrue in soils as a consequence of industrial and urban activities and because of the use of untreated sewage sludge (Mehdi *et al.*, 2003). But untreated waste water irrigation on urban and suburban lands has long been practiced in several parts of the world due to its high contents of plant nutrients and due to lack of infrastructure and facilities for safe disposal. The sewage effluents are not only a rich source of organic matter but also contain heavy metals like Fe, Mn, Cu, Zn, Pb, Cr and Ni. Continuous use of such effluents for crop production can result in accumulation of these metals in the soil as well as in plants, in concentrations that may become phytotoxic (Kirkhan, 1983). Accumulation of heavy metals over prolonged time becomes harmful to animals and human health after entering in their body systems through food chain. Heavy metal pollution of agricultural soils is one of the most severe ecological problems faced worldwide (Shukry, 2001). The environment is under increasing pressure from solid and liquid waste emanating from the leather industry. The byproducts of the leather mechanized process cause major pollution unless treated in some way prior to liberation (Karunya *et al*., 1994). Tanning industrial wastes are a serious threat when they pollute streams, fresh water bodies and land (Javaid, 2000).

Cadmium is a biologically non-essential metal it is poisonous both plants and human beings (Shukla *et al.,* 2007). It cause itai – itai disease, anemia, mainly in women over forty and induce homosis in plant (Calabrese and Baldwin, 1999). Cadmium toxicity is a vital growth restraining factor for plants (Akinola and Ekiyoyo, 2006). Cr is carcinogenic to humans and also causes cirrhoses and DNA damage (Kamavisdar, 2010). Due to this toxicity to plants human health and environment cr toxicity has become an increasing objective of studies much human diet depends directly on plant products like fruits and vegetables or indirectly as fodder given to livestock‘s. Chromium exists in two oxidation states, trivalent (Cr^{III}) and hexavalent (Cr^{VI}) chromium. Both the forms are toxic to the plants and hamper germination, decrease growth, produce oxidative stress, decrease protein content, inhibit photosynthesis and modify enzyme activities in the exposed plants (Panda and Choudhury, 2005). Waste water irrigation results in significant mixing of heavy metal content of agricultural land (Mapanda *et al.*, 2005). The principal cause is the waterways through which heavy metals are leached out of the soil and taken by the vegetation thus long term wastewater irrigation leads to build up of heavy metals in soils and food crops (Khan *et al.*, 2008). International and national regulation of food quality have lowered the greatest allowable levels of toxic metals in food items due to an increased awareness of the risk these metals pose to food chain contamination (Radwan and Salama, 2006). The present study was aimed at investigating the impact of tannery effluent on seed germination and biochemical characteristics of *Sorghum*.

Materials and Methods

Physicochemical parameters of the effluent

The physicochemical parameters such as pH, temperature, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), lead, chromium, cadmium were estimated by APHA. For the present study tannery industry effluent was collected from tannery effluent from Ambur, Tamil Nadu. After collection the effluent was instantly transported to the laborites for analysis samples were analyzed for various physicochemical properties following the methods given by APHA (2012) using AAS (atomic absorption spectrophotometer) used to determined heavy metals such as pb, cr, cd and other parameters pH was determined by the pH meter, EC by EC meter, TDS by gravimetric, COD by open reflex method.

Pot culture studies

Pot culture studies were conducted in the Botanical garden of Government Thirumagal Mills College, Gudiyattam. Pots were filled with equal amount of garden soil, sand and cow dung in the ratio of 1:2:1. The present study was conducted with *Sorghum bicolor* seeds. The seeds were obtained from seed importers by keeping the high purity and quality of germination. Dilutions of the effluents at T1 (20%), T2 (40%), T3 (60%), T4 (80%), Equal number a seeds were sown in each pot and irrigated with undiluted as well as diluted water for every alternate day to enough the soil moistened plants were allowed to grow till maturity. The total number of germinated seeds was counted at 24 hours interval starting from the third day of sowing up to 11 days and germination % was obtained.

Plant growth

Five seeds were planted in each pot. Slightly pressed and allow germinating. The effluent was irrigated periodically at every 24 hours interval. The shoot length of the plant was recorded at every 72 hours for 11 days. The plants were uprooted and washed thoroughly with distilled water and length of the roots was measured.

Root and shoot length

Five seedlings were taken from each treatment and their shoot and root lengths in cm were measured by using a measuring ruler and the values were recorded. The data was the average of three replicates and was represented in table.

The chlorophyll

The chlorophyll content was estimated by extracting fresh leaves with 80% acetone and after centrifugation at 8000 rpm for 20 minutes measuring the color intensity of the extract at (645 and 663) nm wave lengths by spectrophotometer. Chlorophyll concentration was determined by the method of Arnon (1999).

Determination of heavy metals

Samples were digested for heavy metal analysis using the method of Grath and Cunliffe (1985). 5gm of the sample was weighed into a teflon beaker a volume of 10 ml of analytical grade concentrated hno3 was added the solution was evaporated to dryness in order to remove the organic matter the residue was dissolved in 10 ml of 6n hno3, boiled gently for 5 minutes, cooled, filtered and made up to a volume of 25 ml with de-ionized water for heavy metal analysis by a perkin elmer model 372 atomic absorption spectrophotometer extracts were filtered, diluted to marks with de-ionized water and analyzed for Cr and Cd.

Data analysis

The experiment was set up as a completely randomized design. Statistically significance was assessed at the $P < 0.05$ level using one way ANOVA and means were separated by Duncan's multible range test ($P < 0.05$) with the help of SPSS 16.0 software package. Means and standard deviation were calculation from three replications.

Table 1: physiochemical characteristics of tannery effluent

Parameters	Concentration
Temp. (ºC)	27.4
pH	9.1
Bod (mg/l)	154.64
COD (mg/l)	956.21
TDS (mg/l)	2375
Lead pb (mg/l)	2.4
Chromium (mg/l)	6.412
Cadmium (mg/l)	3.95

Table 2: Some growth parameters of *Sorghum bicolor* seeds as affected by different concentrations

Concentration %	Germination %	Plant height (cm)	Plumule length (cm)	Radical length (cm)
T0	94.9 ± 3.37	11.52 ± 0.029	9.74 ± 0.295	5.42 ± 0.637
T1	79.6 ± 5.06	10.23 ± 0.214	8.01 ± 0.208	4.78 ± 0.232
T2	65.7 ± 3.34	8.78 ± 0.598	6.28 ± 0.261	4.04 ± 0.212
T3	53.1 ± 1.98	7.19 ± 0.395	5.43 ± 0.321	3.55 ± 0.192
T4	42.5 ± 5.09	5.93 ± 0.303	4.18 ± 0.255	2.79 ± 0.183

From the above analyzed data, shows the value of growth parameters were found to be higher in T1 treated at lowest effluent concentration however growth parameters were lowest in T4 germination at highest effluent concentration. Higher quantity of tannery industry effluent concentration (T4) inhibited the seed germination.

Table 3: Accumulation of heavy metal in effluent treated plant (Chromium mg/kg)

Concentration	Shoot (mg/kg)	Root (mg/kg)
T0	0.05 ± 0.03	0.09 ± 0.03
T1	1.67 ± 0.5	1.88 ± 0.6
T2	1.83 ± 0.4	2.3 ± 0.4
T3	2.05 ± 0.7	2.9 ± 0.8
T4	2.57 ±0.9	4.4 ± 0.9

Accumulation of heavy metal from the above analyzed data shows that the mean concentration of chromium (cr) in root and shoot values is also increased with increasing effluent concentration. The root accumulates chromium content higher than that of shoot.

Table 4: Accumulation of heavy metal in effluent treated plant (Cadmium mg/kg)

Concentration	Shoot (mg/kg)	Root (mg/kg)
T0	0.005 ± 0.003	0.13 ± 0.006
T1	0.74 ± 0.05	1.18 ± 0.6
T2	1.15 ± 0.08	1.45 ± 0.04
T3	1.34 ± 0.7	1.68 ± 0.08
T4	1.55 ± 0.9	1.88 ± 0.10

Accumulation of heavy metal from the above analyzed data shows that the mean concentration of cadmium (cd) in root and shoot values is also increased with increasing effluent concentration. The root accumulates cadmium content higher than that of shoot.

Table 5: Effect of different concentrations of tannery effluent on chlorophyll (mg/gm) contents of *S. bicolor*

Concentration	Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll
T0	5.07 ± 0.45	3.25 ± 0.18	8.43 ± 0.54
T1	4.12 ± 0.20	2.73 ± 0.14	6.82 ± 0.35
T2	4.3 ± 0.17	1.93 ± 0.12	5.96 ± 0.26
T3	3.5 ± 0.13	1.81 ± 0.09	4.85 ± 0.19
T4	2.18 ± 0.10	1.65 ± 0.6	3.73 ± 0.13

From the above analyzed data shows effect of various concentration of tannery effluent on chlorophyll content of *Sorghum* plant are presented in table 5. The chlorophyll a,b and total chlorophyll content were higher in T0 and lower in T4.

Discussion

The industrial effluents are released directly or indirectly into natural water resources, mostly without proper treatment, thus posing a serious threat to the environment in not only developing but also underdeveloped countries (Altug and Balkis, 2009). Now a day's the environmental pollution is an extremely important issue, affecting all of us in one way or the other. Due to rapid increase in human population and industrialization, the demand for natural raw materials and source of energy are increasing day by day (Abhay and Rajput, 2009). Many rivers of the world receive flux of sewage, domestic waste, industrial effluents and agricultural waste which contain substances varying from simple nutrients to highly toxic chemicals (Benazir *et al.,* 2010).

Tannery industry contributes significantly towards exports, employment generation and occupies an important role in Indian economy. Heavy metals released from tanneries are kept under environment pollutant category due to their toxic effects on plants, animals and human beings. They interfere with physiological activities of plants such as photosynthesis, gaseous exchange and nutrient absorption and cause reduction in plant growth (Sharma and Agrawal, 2005). Heavy metal pollution of soil and waste water is a significant environmental problem and has a negative impact on human health and agriculture (Michalak, 2006). The reuse of waste waters and industrial effluents for irrigation to crop plants after proper dilution is an useful technique (Rehman *et al.,* 2007). Tannery effluent can be diluted and reused for agriculture purpose which can also act as a good fertilizer (Mariappan and Rajan, 2002).

Due to high level of dissolved solids, which contain the salinity and conductivity of the absorbed solute by inhibition of seed germination (Gowtham and Bishoni, 1992). The salt content outside the seed is act as restrictive factor and causes less absorption of water by osmosis and inhibit the germination of seeds (Malla and Mohanty, 2005). Salt stress either alters metabolic process or does not permit the synthesis of enzymes required for seed germination (Ashraf *et al.,* 2002).

The decrease in root length of seedling treated with T3 and T4 effluent concentration over the control was attributed due to increase in concentration of various chemicals present in the effluent. These observations are in conformity with previous report of effect of tannery effluent on groundnut (Selvi *et al.,* 2012). A gradual decrease in shoot length of seedling treated with T3 and T4 may be due to excess amount of salts which affected plant growth. These findings are similar to result of Nath *et al.* (2008) who have reported that different concentration of tannery effluent inhibited seedling growth and pigments of *Phaseolus mungo* Roxb. with increase in concentration.

Under higher effluent concentration, the germinated seeds get low oxygen, which restrict the energy supply, and thus retard the growth and development of seedling (Rao and Kumar, 1983). Kannan and Upreti (2008) have reported that the root which continuously remains in direct contact with the effluent hence the higher concentrations of the effluent could affect cell multiplication or the growth.

Chromium accumulation in plants affect their metabolic process in several ways including reduction in growth, photosynthesis, chlorophyll content, inhibition of certain enzyme activities and degradation of chloroplast and mitochondria (Guilizzoni, 1991). The chlorophyll content decreased significantly higher doses of chromium and both the dilutions of treated effluent. It has been described that these effects are related to higher levels of free radicals generated during senescence, particularly under stressful conditions (Wise and Naylor, 1987).

Declare of interest statement

We declare that we have no conflict of interest.

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