Research Paper

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Impact of Tannery Effluent on Germination, Seedling Growth and Pigment Content of Brassica Napus L

Environmental Science

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Smiley Sharma — Department of Environmental Science, University of Jammu, Jammu-180006 (J&K) INDIA

Piyush Malaviya — Department of Environmental Science, University of Jammu, Jammu-180006 (J&K) INDIA *Corresponding Author

ABSTRACT

The present study assessed the impact of different concentrations of tannery effluent on seed germination, growth and pigment content of Brassica napus L. var. Punjabi Special. Germination and growth parameters exhibited concentration dependent reduction with minimum germination (5%), root length (0.4 cm), shoot length (1.5 cm) and moisture content (79.60%) at 100% tannery effluent concentration. Likewise, total chlorophyll and carotenoids have also exhibited minimum values at 100% tannery effluent concentration.

Introduction

Production of leather from raw hides has been one of the most important industrial processes since ancient times. Chronologically, the birth of leather in India dates back to 3,000 years B.C. Today, Indian Leather Industry is 6th largest in the World, and is among the top ten foreign exchange earners for the country (www.leatherindia.org).

On the environmental front, tanneries are considered as worst polluters of water and land. The water pollution from tannery discharges is assessed by the fact that processing one metric ton of raw hide generates 50,000 kg of wastewater (containing 5 kg of chromium) (Huffer and Taeger, 2004). The final effluent contains high Biochemical oxygen demand (BOD), chemical oxygen demand (COD), Total Dissolved Solids (TDS), chromium and residual dyes (Sharma and Malaviya, 2014). The release of these effluents into land and water spoils surface and ground water quality, soil, vegetation and productivity of crops which deteriorates human health (Khurana and Pritpal, 2012).

In the present study, an attempt has been made to assess the toxic effects of different concentrations of tannery effluent on germination, growth and pigment content of Brassica napus, as a direct quantitative measure of actual environmental toxicity of tannery effluent.

Materials and methods

2.1 Sample collection and effluent analysis

The effluent used in the study was collected in acid-rinsed polyethylene containers from a tannery located in Central Leather Research Institute (CLRI) complex, Kapurthala Road, Jalandhar, India. The collected samples were brought to the laboratory and stored in a refrigerator at 4°C till their use. For physicochemical analysis, the methodology of APHA was followed (Greenberg et al., 1995).

2.2 Germination experiment

For germination experiment, seeds of Brassica napus were procured from Directorate of Agriculture, Talab Tillo (J&K). Twenty seeds were surface sterilized and placed in a petriplate lined with filter discs. The different concentrations of tannery effluent viz., E_{25}, E_{50}, E_{75} and E_{100} were made by adding tap water to the effluent. The petriplate poured with tap water was considered as control (E_0). Three replicates of each set were maintained and kept in a BOD incubator at a room temperature of 28±2°C. The number of seeds germinated on each day was noted until it became constant. Various germination indices adopted from Czabator (1962), Rao et al. (1979) and Zucconi et al. (1981) were used to record the germination parameters and seedling growth. For the estimation of pigment content, the leaves were extracted in 80% acetone and the absorbance of pigment extract was measured spectrophotometrically at wavelength 663 and 645 nm for chlorophyll content (Arnon, 1949) and 480 and 510 nm for carotenoid content (Duxbury and Yentsch, 1956).

Results and Discussion

The tannery effluent used in the study was dark grey in color with offensive smell. Values of various parameters for different concentrations of the effluent are given in Table 1, which shows an increasing trend of COD, electrical conductivity, Na^+, Cl^-, NO_3^- and Ca^{2+} with increasing concentrations of the effluent. The various positive germination parameters i.e., speed of germination, germination index, germination value etc., were highest for 25% effluent concentration and then decreased gradually with increase in the concentration of the effluent (Table 2). Similarly, for negative germination parameters (delay index and percentage inhibition) the values were minimum at 25% effluent. Earlier studies have also shown a specific correlation between effluent concentration and germination parameters. The reason for reduction in germination parameters at higher concentration could be attributed to the excessive qualities of inorganic salts and consequently its higher EC. The increased EC of the effluent made imbibition more difficult and retarded germination (Malaviya and Sharma, 2011).

Data regarding the effect of tannery effluent on seedling growth and pigment content of Brassica napus have been shown in Table 3 and 4. There has been a significant decrease in root length, shoot length, fresh weight and pigment content in the seedlings irrigated with tannery effluent. The reduction of seedling growth in the tannery wastewater was due to the toxic effect of various ions and unbalanced nutrient uptake by seedlings. These deleterious effects may result in a decrease in photosynthesis and increase in respiration rate leading to a shortage of assimilates to the developing organs, thus slowing down growth.

The irrigation of plants with tannery effluent has shown an overall gradual decrease in the foliar content of chlorophyll 'a' (chl-a), chlorophyll 'b' (chl-b), total chlorophyll and carotenoids. The depletion in chlorophyll content in the plants exposed to different concentrations of tannery effluent might be attributed to both altered chlorophyll biosynthesis due to the disruption of chloroplast phosphorylation and replacement of Mg ions by Cr ions (Chandra and Kulshreshtha, 2004). ä-aminolevulinic acid dehydratase (ALAD) is a metalloenzyme and its activity in plants is dependent on availability of Mg (Chen and Nelands, 1973). It has been reported that Cr causes toxicity to ALAD (an enzyme involved in chlorophyll biosynthesis) by impairing ä- aminolevulinic acid (ALA) utilization. Further, it has also been reported that Cr inhibits chlorophyll biosynthesis by causing Fe deficiency and creating nutrient imbalances.

Moreover, fresh weight, dry weight and moisture content (biomass production in seedling) were also decreased which might be ascribed to the lowered photosynthesis and chlorophyll 'a' production in the seedlings. Decrease in the fresh weight of the plants with increasing effluent concentration could be attributed to increase in the percentage of moisture loss due to increase in the values of osmotic potential owing to the presence of excess salts.

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Table 1: Physico-chemical characteristics of different concentrations of tannery effluent used for irrigating Brassica napus.

Treatment	pH	COD (mg L^{-1})	EC (mS cm^{-1})w	Na^+ (mg L^{-1})	Cl^- (mg L^{-1})	NO_3^- (mg L^{-1})	Ca^{2+} (mg L^{-1})	Total Cr (mg L^{-1})	Total Pb (mg L^{-1})
E_0	7.26±0.5	20.4±1.0	0.16±0.2	nd	8±1.6	12±2.0	32±1.8	nd	nd
E_{25}	9.68±1.1	1589±18.4	10.2±0.5	896±18.0	1189±20.0	185±12.0	69.3±8.4	3.89±0.0	0.348±0.0
E_{50}	9.46±0.9	2986±16.9	16.8±0.7	1760±12.8	2396±16.6	368±14.6	138±14.8	7.56±0.1	0.612±0.0
E_{75}	9.24±1.3	3872±20.0	26.8±1.5	2492±35.8	3595±12.0	498±7.3	179±11.6	10.82±1.2	0.826±0.1
E_{100}	9.16±0.2	5776±30.1	35.3±0.3	3080±35.6	4700±40.1	600±5.0	258±12.0	12.26±0.6	1.126±0.0

Mean±SD of three replicates
nd: non-detectable
E_0: Tap water
E_{25}, E_{50}, E_{75}, E_{100}: 25, 50, 75 and 100% tannery effluent, respectively

Table 2: Effect of tannery effluent on germination parameters in Brassica napus.

Treatments	Seed germination (%)	Germination index	Speed of germination	Delay index	Peak value	Percent inhibition	Seedling Vigour Index (SVI)
E_0	80±2.0	-	16±1.8	-	8.00±3.4	-	864±18.4
E_{25}	35±4.0	25.40±6.1	1.75±0.8	0.7±0.9	5.00±2.8	65±4.0	248.5±16.5
E_{50}	20±6.0	10.48±3.5	1.00±0.5	0.9±0.5	3.33±3.3	80±3.0	98±12.6
E_{75}	10±3.0	4.05±4.3	0.50±0.6	1.25±0.8	1.11±2.0	90±2.6	38±15.7
E_{100}	5±2.0	0.80±1.8	0.25±0.3	1.78±0.4	0.60±1.9	95±1.8	9.5±12.4

Mean±SD of three replicates
E_0: Tap water
E_{25}, E_{50}, E_{75}, E_{100}: 25, 50, 75 and 100% tannery effluent, respectively

Table 3: Effect of tannery effluent on growth of Brassica napus.

Treatments	Root length (cm)	Shoot length (cm)	Root/Shoot ratio	Fresh weight(g)	Dry weight (g)	Moisture (%)
E_0	3.3±0.90	7.5±1.10	0.44±0.006	0.200±0.08	0.028±0.02	86.00±0.02
E_{25}	2.0±0.81	5.1±1.00	0.39±0.004	0.135±0.06	0.019±0.04	85.92±0.02
E_{50}	1.3±0.88	3.6±0.95	0.36±0.002	0.129±0.03	0.012±0.02	82.51±0.05
E_{75}	1.0±0.85	2.8±0.83	0.35±0.004	0.096±0.05	0.007±0.02	81.14±0.02
E_{100}	0.4±0.82	1.5±0.80	0.26±0.005	0.065±0.08	0.002±0.01	79.60±0.06

Mean±SD of three replicates
E_0: Tap water
E_{25}, E_{50}, E_{75}, E_{100}: 25, 50, 75 and 100% tannery effluent, respectively

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Table 4: Effect of tannery effluent on pigments of Brassica napus.

Treatments	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Carotenoid
E_0	0.3296±0.0910	0.1537±0.0120	0.4833±0.092	0.7650±0.0180
E_{25}	0.2486±0.0820	0.1132±0.0130	0.3618±0.088	0.5562±0.0172
E_{50}	0.2198±0.0878	0.1076±0.0124	0.3274±0.086	0.4510±0.0178
E_{75}	0.1782±0.0800	0.0829±0.0118	0.2611±0.094	0.3062±0.0188
E_{100}	0.1402±0.0830	0.0742±0.0129	0.2144±0.081	0.2512±0.0175

Mean±SD of three replicates
E_0: Tap water
E_{25}, E_{50}, E_{75}, E_{100}: 25, 50, 75 and 100% tannery effluent, respectively

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