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Effects on some crops growth under the tannery effluent

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The tannery industry, one of the oldest and most important industries, uses an enormous amount of freshwater for leather processing and releases a huge amount of toxic effluent every day. The rapid growth of industries in par with the threatening population lasted to the high discharge of industrial wastewater spoiling groundwater quality, soil and vegetation in that area. The effective management of tannery effluent is the need of the hour. In this study, tannery effluent was collected at Shobhapur village, Meerut city and physico-chemical properties analyzed. The effluent was treated with 0% (control), 25%, 50%, and 100% concentration of effluent. The main crops species in the area of study are *Pennisetum typhoidis* (Millet), *Hordeum vulgare* (Barley), *Vigna mungo* (Urad), *Cicer arietinum* (Black gram) and *Trigonella foenum-graecum* (Methi) are grown in control or with effluent in triplicates. Full strength effluent concentration caused a reduction in biomass accumulation and reproductive growth. The accumulation of metal from wastewater to crops after ten days did not follow any particular pattern and had very little or no concentration on it. The treatment designated W4 (25% effluent + 75% tap water) showed a good rate of germination, growth of seedlings and can use for the cultivation of selected crop species.

Keywords: Tannery effluents, seed germination, seed growth, moisture content, adverse effect.

Introduction

Industrial effluents is one of the major problems throughout the world. It was increasing at an alarming rate due to urbanization and industrialization. Tanning is one of the oldest industries in the world. During ancient times, tanning activities organized to meet the local demands of leather footwear, drums and musical instruments. With the growth of population, the increasing requirement of leather and its products led to the establishment of large commercial tanneries. Two methods have adopted for tanning of rawhide/skin viz. vegetable tanning and chrome tanning. The production processes in a tannery can split into four main categories: (1) hide and skin storage and beam house operations, (2) tanyard operations, (3) post-tanning operations and (4) finishing operations[1,2]. Water used in these industries creates huge quantity of effluent that has potential to hazard environmental because of the toxic chemical and heavy metals in their effluent[3,4]. The effluent from the tannery industry considered as a severe environmental threat throughout the world[5]. Significant problems of tannery effluent are toxic heavy metals like chromium, chloride, lime with high dissolved and suspended solids and other pollutants[6]. The continuous input of wastes containing poisonous metals on the agricultural land causes an imbalance in the ecosystem. The crops growing under such habitats accumulate high amount of toxic metals, which in turn are being assimilated and transferred within food chain by the process of biomagnifications[7] and becomes a risk factor for human beings[8]. At higher pollution levels, the root system almost lost and, at maturity, plants yield are much reduced[9–11]. Wastewater from industries also destroys our productive land by adding chemical compounds to these soils. Delayed germination and earlier leaf senescence are the two most important parameters which correspond to the final yield loss at the end of the season[12,13]. The phytoremediation can be applied for municipal wastewater treatment[14–16].

In the present study, an attempt has made to investigate the effect of Shobhapur (Meerut) tannery effluent in various dilution on seed germination and seed growth of important cultivated crops species. Also, the investigation is carried out for the accumulation of metals in the above crops species when germinated with tannery effluent. The essential crops species cultivated in Meerut city are *Pennisetum typhoidis* (Millet), *Hordeum vulgare* (Barley), *Vigna mungo* (Urad), *Cicer arietinum* (Black gram) and *Trigonella foenum-graecum* (Methi) have taken for the study.

Materials and methods

The Meerut city, located in the northern part of Uttar Pradesh, 60 km from Capital of India, Delhi. The leather work is going on, in the number of villages and all parts of the Meerut city. The Shobhapur village is in Meerut city and is famous for the leather work. All the villagers are involved in leather work for their livelihood. The liquid waste released after the leather preparation comes into the small dugs outside the houses. The effluent of leather from these dugs collected into a large pond outside the village, as shown in Fig. 1.

Fig. 1. Sampling site for leather waste polluted water.

Analysis of tannery effluent:

The samples of tannery effluent were collected from the main ponds in the village. The collected tannery samples were analyzed for physic-chemical properties i.e. EC, hardness, TSS, TDS, BOD, Ca, Mg, Cr, Zn, Fe and Cd. The "Standard Methods" APHA (2012)[17] used for determined the parameters.

Seed germination:

The four types of dilutions of tannery effluent were used for seed germination, as shown in Table 1. Taking, 25 number of seeds of selected crop species in petri-plates after sterilization in 0.2% mercuric chloride. The germination of seeds was carried out in sterilized petri-dishes. For each species and a given treatment 12 petri-dishes were used. i.e. 4 numbers of (Control + 3 treatments with varying concentration) x 3 numbers replicates. The petri-dishes were incubated at 25±2°C for 10 days in seed germinator and the number of seeds germinated was recorded every day. Germination percentage was calculated using eq. (1)

Table 1. Control and dilutions of waste water for treatment of selected seeds

Treatment	Type of dilution
W1	Control (Tap water)
W2	100% effluent (WW)
W3	50% effluent (50% WW: 50% tap water)
W4	25% effluent (25% WW: 75% tap water)

$$\text{Germination \%} = \frac{\text{Number of germinated seeds} \times 100}{\text{Total number of seeds}} \quad (1)$$

Seeding growth:

After completion seed germination, seeding was taken out from the petri-dishes and the excess of moisture was removed by drying them gently between the tissue papers. The length of plumule and radicals of each seeding was measured in mm with the help of the graph sheet. For the fresh weight, ten seedlings were dried by using tissue paper from each replicate and then weighed. For the dry weight, the same seedlings were dried in the oven at 77°C for 24 h[18]. After 24 h of drying, the seedlings of selected crops species were weighed again for moisture content of each species.

Estimation of chlorophyll content:

In the present investigation, the chlorophyll content has estimated by Arnon method[19]. The leaf tissue 100 mg was suspended in 10 mL of 80% acetone, crushed, mixed well and kept at 4°C overnight in the dark. The supernatant was withdrawn after centrifugation at 5000 rpm/24°C for 5 min. The absorbance of the supernatant recorded at 663 and 645 nm in spectrophotometer.

Estimation of protein content:

Bradford protein assay used for the determination of protein content in leaves[20]. In Bradford protein assay method, a standard curve prepared with the sample of known concentration of protein and by comparing their absorbance with that of the unknown, the unknown quantity can be estimated.

Statistical analysis of data:

The data obtained from seed germination, seedling growth, chlorophyll and protein content subjected to statistical analysis. The fundamental mathematical concepts to the present study include a measure of central tendency, standard deviation and standard deviation error.

Results and discussion

Quality of tannery effluent:

The results of the physic-chemical analysis of wastewater effluent of a tannery presented in Table 2. It found that the pH value of full-strength (100%) effluent water was highly basic and had a high TSS, TDS, total hardness, BOD, COD, Ca, Mg, and Fe than the permissible limits. The concentration of toxic heavy metal i.e. chromium, zinc and cadmium, was found to be very high.

Table 2. Characteristics of the tannery effluent

Sr. No.	Parameter	Characteristic/ constituent
1.	pH	8.86
2.	Colour	Light grey
3.	Electrical conductivity (EC)	1490 m Siem/cm
4.	Total hardness	5500 mg/L as $CaCO_3$
5.	Total suspended solid	1280 mg/L
6.	Total dissolved solid	23400 mg/L
7.	Total solid	24680 mg/L
8.	Chloride	11182 mg/L
9.	Chemical oxygen demand (COD)	310 mg/L
10.	Biochemical oxygen demand (BOD)	32 mg/L
11.	Magnesium (Mg)	1800 mg/L
12.	Iron (Fe)	4.62 mg/L
13.	Zinc (Zn)	99 mg/L
14.	Chromium (Cr)	200 mg/L
15.	Cadmium (Cd)	4.5 mg/L
16.	Calcium (Ca)	295 mg/L

Seed germination:

Fig. 2 shows the seedlings of germination after ten days. Percentage germination initially delayed with increasing levels of effluent water but it became relatively faster after four days. Figs. 3 to 7 show that the percentage of seed germination concerning time in all five crop species. The result revealed that the germination of five cultivated crop species was affected by the tannery effluent. All crop species show germination by treating with W3 and W4 treatment but no germination by W2 treatment in *Pennisetum typhoidis, Hordeum vulgare, Trigonella foenum-graecum* and *Vigna mungo*.

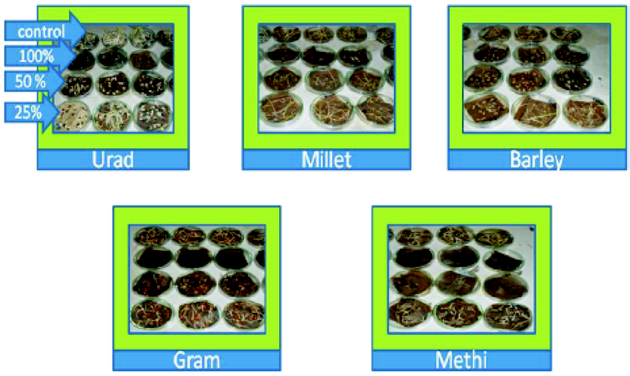

Fig. 2. Figure of seedlings after ten days.

The rate of seed germination was much faster in *Cicer arietinum* (W1, W2 and W4 treatment) in ten days.

Seeding growth:

Significant differences observed among the various treatments about plumule and radical length and moisture contents of seeding in either of the species (Table 3). The plumule length was found maximum in *Pennisetum typhoidis* treated with W3 and W4 treatment and no growth of plumule in *Trigonella foenum-graecum* with different types of treatment. *Hordeum vulgare* also do not shows any growth treated with W3 treatments. The radical length was found maximum in *Pennisetum typhoidis* treated with W3 and W4 treatments comparison to control and retarded in *Hordeum vulgare* (W3 treatment).

Chlorophyll content:

The chlorophyll content of the three crop species *Vigna mungo, Pennisetum typhoidis* and *Hordeum vulgare* shown in Table 4. The chlorophyll contents observed in *Pennisetum typhoidis, Hordeum vulgare* and *Vigna mungo*. Amount of total chlorophyll was maximum in *Vigna mungo*, than *Pennisetum typhoidis* and *Hordeum vulgare* after being treated with 25% tannery effluent. In 50% tannery effluent treated seeds total chlorophyll was 56.57% and 31.56% in *Pennisetum typhoidis* and *Vigna mungo* respectively.

Protein content:

The protein contents of three crop species observed in *Pennisetum typhoidis, Hordeum vulgare* and *Vigna mungo*. Bradford protein assay used for the determination of protein content in leaves[20]. Amount of total protein was found maxi-

Table 3. Growth measurements per seedling of different crop grown in different treatments

Sr. No.	Crop	Treatment	Plumule[a] length (mm)	Radicle[a] length (mm)	Fresh[a] weight (g)	Dry[a] weight (g)
1	*Pennisetum typhoidis*	W1	33.07±1.69	26.83±1.40	0.05±0.005	0.005±0.0003
		W2	–	–	–	–
		W3	21.41±1.85	51.99±4.13	0.038±0.002	0.009±0.002
		W4	59.24±4.63	40.20±2.30	0.05±0.002	0.009±0.0003
2	*Vigna mungo*	W1	84.56±4.54	50.22±2.75	0.26±0.026	0.027±0.001
		W2	–	–	–	–
		W3	4.61±2.67	10.9±0.99	0.45±0.04	0.04±0.001
		W4	12.45±1-34	45.17±2.68	0.18±0.007	0.033±0.001
3	*Hordeum vulgare*	W1	31.60±6.45	6.75±2.76	0.135±0.008	0.03±0.012
		W2	–	–	–	–
		W3	–	–	–	–
		W4	16.74±5.38	38.56±4.01	0.134±0.002	0.05±0.003
4	*Cicer arietinum*	W1	5.37±0.28	71.08±2.74	0.578±0.006	0.38±0.007
		W2	–	–	–	–
		W3	1.90±0.21	14.68±0.92	0.56±0.01	0.34±0.01
		W4	5.69±0.45	43.10±1.78	0.64±0.013	0.39±0.45
5	*Trigonella foenum-graecum*	W1	–	80.08±3.09	0.08±0.006	0.01±0.0004
		W2	–	–	–	–
		W3	–	21.21±1.58	0.05±0.002	0.008±0.001
		W4	–	46.72±3.39	0.32±0.49	0.07±0.004

[a]Mean ±SE.

Table 4. Chlorophyll contents of three crop species

Sr. No.	Crop	Treatment	Chlorophyll A (chl. A) (mg chl./g)	Chlorophyll B (chl. B) (mg chl./g)	Total chlorophyll (mg chl./g)
1	*Vigna mungo*	W1	3.56×10^{-4}	1.23×10^{-4}	4.79×10^{-4}
		W2	–	–	–
		W3	2.59×10^{-4}	1.15×10^{-5}	2.71×10^{-4}
		W4	2.90×10^{-4}	9.23×10^{-5}	3.83×10^{-4}
2	*Pennisetum typhoidis*	W1	2.95×10^{-4}	1.38×10^{-4}	4.34×10^{-4}
		W2	–	–	–
		W3	1.30×10^{-4}	6.71×10^{-5}	1.37×10^{-4}
		W4	1.93×10^{-4}	3.64×10^{-4}	2.28×10^{-4}
3	*Hordeum vulgare*	W1	2.51×10^{-4}	1.44×10^{-4}	3.95×10^{-4}
		W2	–	–	–
		W3	–	–	–
		W4	1.38×10^{-4}	7.61×10^{-4}	2.26×10^{-4}

mum and was 87.43% in *Pennisetum typhoidis*, than *Vigna mungo* and *Hordeum vulgare* after being treated with 25% tannery effluent. In 50% of tannery effluent treated seeds, total chlorophyll found to be 45.18% and 32.86% in *Pennisetum typhoidis* and *Vigna mungo* respectively, as shown in Table 5.

Metals content on crop species:

The accumulation of metals after ten days in the three crops species *Pennisetum typhoidis, Hordeum vulgare* and *Vigna mungo* observed. The accumulation of metal from tan-

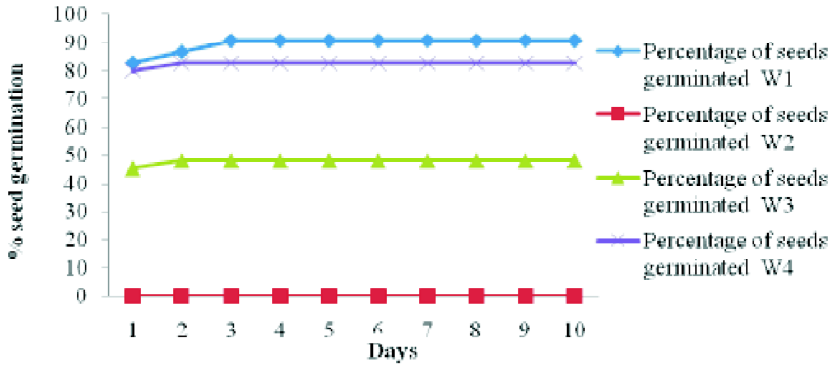

Fig. 3. Percentage of seeds germination in *Pennisetum typhoidis.*

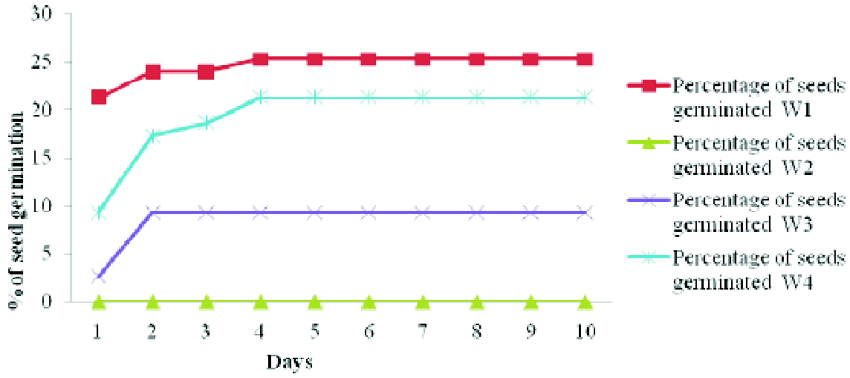

Fig. 4. Percentage of seeds germination in *Hordeum vulgare.*

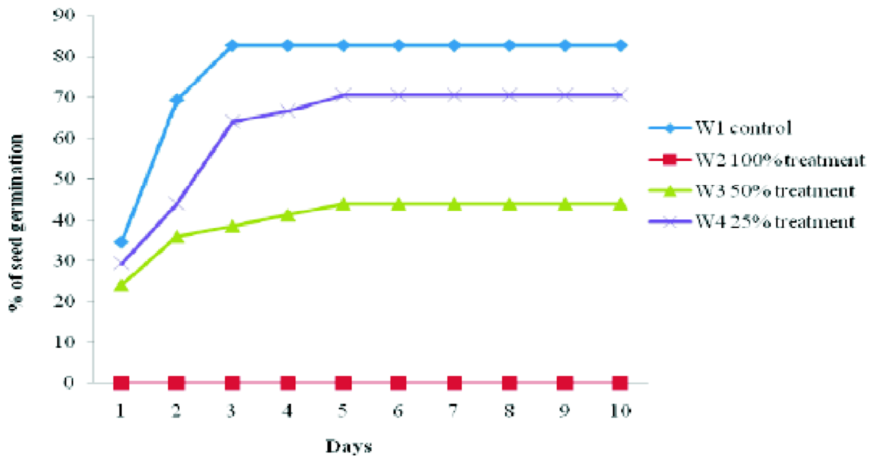

Fig. 5. Percentage of seeds germination in *Vigna mungo.*

nery effluent to crop species did not follow any particular pattern and varied concerning metal and species type, as shown in Table 6.

The results of the study revealed that the tannery effluent of Shobhapur has a toxic chemical, as shown in Table 1. The possibility of toxic effects, which might determine the

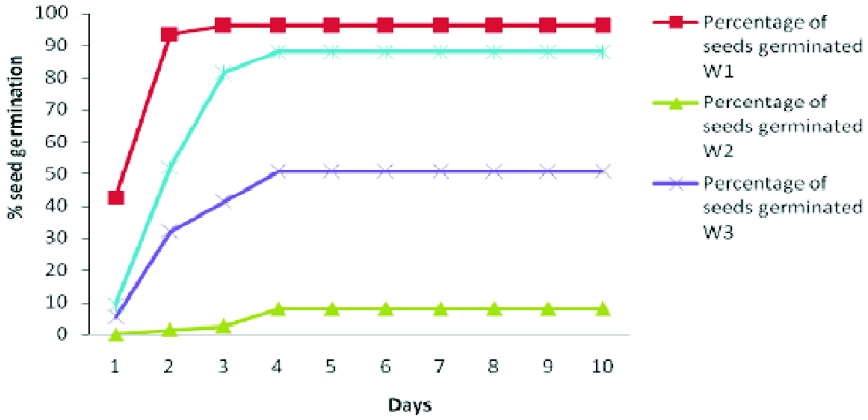

Fig. 6. Percentage of seeds germination in *Cicer arietinum.*

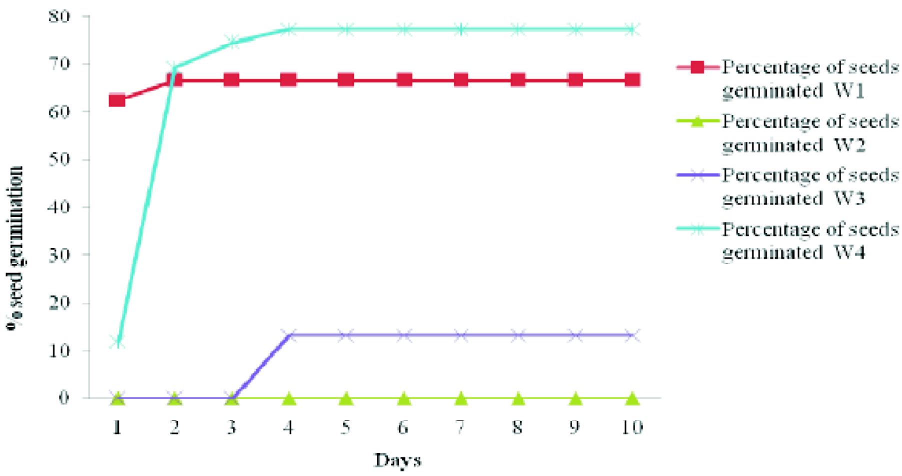

Fig. 7 Percentage of seeds germination in *Trigonella foenum-graecum.*

Table 5. Protein content of three crops

		Concentration (mg/ml)		
		Pennisetum typhoidi	*Hordeum vulgare*	*Vigna mungo*
Treatment	W1	12.56	0.027	1.093
	W2	0	0	0
	W3	5.3	0	0.027
	W4	10.89	0.027	4.3

choice of crop, should be attributed to the presence of a greater amount of chloride in tannery effluent. Since higher chloride contents are dangerous for the growth of the crops, the effluent of the tannery is not directly useful for irrigation. The growth of cultivated crops species increases, as com-

Table 6. Chromium and zinc levels three crop species

Sr. No.	Crop	Treatment	Chromium (mg/g)	Zinc (mg/g)
1.	*Vigna mungo*	W1	0	0
		W2	–	–
		W3	0.03	0.01
		W4	0	0
2.	*Pennisetum typhoidis*	W1	0	0
		W2	–	–
		W3	0.01	0.01
		W4	0.01	0
3.	*Hordeum vulgare*	W1	0	0
		W2	–	–
		W3	–	–
		W4	0.01	0

pared to that in the effluent as such, when the wastewater was diluted with the tap water. The high conductivity value in tannery effluent indicated the presence of positive ions and negative ions, which may be another factor for the inhibition of the crop growth. Heavy metals found to be toxic for the seed growth because the accumulation of metal from effluent to crops did not follow any particular pattern and varied concerning metal, species and crop parts and had very little or no concentration on it. The diluted effluent can be used for the cultivation of selected crop species and may be used as a liquid fertilizer. Similarly, *Brassica* species also accumulate metals well and often used in the context of phytoremediation[21,22].

Conclusion

Tannery industry uses an enormous amount of fresh water for processing of leather and other purposes and releases a huge amount of toxic effluent every day. The physico-chemical analysis of effluent reveals that the concentration of total hardness, total solids, Mg, Fe, Cr and Zn were very high, so the dilutions of tannery effluent can be used for the cultivation of selected crops species. The tannery effluent at lower doses of diluted samples showed better results in terms of seed germination, seedling growth, fresh weight, dry weight, chlorophyll content and protein content of *Pennisetum typhoidis* (Millet), *Hordeum vulgare* (Barley), *Vigna mungo* (Urad), *Cicer arietinum* (Gram) and *Trigonella foenum-graecum* (Methi). Full strength effluent concentration caused reduction in biomass accumulation and reproductive growth. The accumulation of metal from effluent to crop after 10 days did not follow any particular pattern and had very little or no concentration on it. The treatment W4 (25% effluent + 75% Tap water) showed a reasonable rate of germination, growth of seedlings and can be used for the cultivation of selected crop species.

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