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Research Article

EFFECT OF TANNERY EFFLUENT AND DOMESTIC WASTE WATER ON FLOWER CROPS

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Abstract- The ever increasing population imposes continuous pressure on limited water resources. Treated wastewater appears to be a visible and viable option as other sources are windling. In the present study treated tannery effluent mixed with domestic wastewater was used as irrigation source as it provides valuable nutrients. Germination studies and pot culture studies were conducted to assess the impact of treated tannery effluent, mixed with domestic wastewater on the growth of flower crops *viz., Calendula offcinalis, Cosmos bipinnatus, Dahlia apiculata, Belli perennis, Dianthus alpines, Hibbertia humifusa, Gomphrena globosa and Tagetes erecta. Highest* germination percentage (96%) as well as vigour index (1872) was observed with 25 % treated tannery effluent mixed with 75% domestic wastewater irrigation when compared to other mixing ratios.

Keywords- Tannery effluent, Domestic Wastewater, Flower Crops, Vigour index

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Introduction

Industrial processes generate significant profit and contribute to economic development of any country like India. Tanning industry came about 100 years ago in India, which now has taken a predominant place in the country's economy. Though these industries plays an important role in the country's development, they also produce significant levels of wastes, which increased steadily due to large scale usage of chemicals [1] as well as increased number of industries [2]. In many tannery industries, wastes produced are disposed of by an improper way, which leads to accumulation of potentially toxic materials in the environment. The effluent has high amount of sodium chloride, sulphates, bicarbonates, calcium, magnesium and high amount of chromium salts [3, 4]. In order to address these issues, there is an active research on new ways to dispose and recover wastes. In recent years, tanneries are ready to adopt cleaner practices, can be evident through the construction and operation of high number of dedicated CETPs [5].

Agricultural production is responsible for vast majority of fresh water use up to 85% and is going to be doubled by 2050 [6]. With all the river basins having deficit volume of water for irrigation, the effluent from industries can reduce the pressure on water scarcity [7]. This waste water contains not only high salt content; it also contains lot of nutrients. Recycling waste water in agriculture is not only helpful for conserving water for irrigation also the plant nutrients. Various studies have shown the benefits of application of tannery sludge and wastewater in different Agricultural crops [8-12].

Discharge of untreated sewage in water course is the most important polluting source in India. A quantity of 38000 million liter of sewage is generated per day [13]. Concurrently, there are great demands for the use of sewage wastewater in Agriculture because it adds nutrients, thereby improves the yields [14-16]. Long-term utilization of domestic wastewater adds large amounts of major and micronutrients to the soil [17]. There are great demands for the use of domestic sewage, as a valuable source of reusable water, fertilizer, soil conditioner and energy [18]. Despite the evidences that both tannery and domestic wastewater can be useful to Agriculture, there is a resistance among farmers related to food and nutritional quality which in turn grown from soil enriched with potentially contaminated waste water. So it is essential that the implications of the use of effluents in crop field and their effect should be assessed before using it for irrigation [19]. Well documented studies are there for agricultural crops, but only limited studies had been conducted with non food crops. With this background a study was planned to use treated tannery effluent of CETP, Dindigul, Tamil Nadu along with domestic wastewater for growing nonfood crops like flower crops.

MaterialsandMethods

The treated tannery effluent sample was collected from CETP, Dindigul and Domestic wastewater was collected from Dindigul sewage treatment plant. Physico chemical and Biological properties of the collected samples were determined as per the standard procedures [20]. The wastewater from tannery industry and Domestic wastewater as irrigation source was studied for its influence on seed germination and vigour index of flower crops. Pot culture experiment comprising six treatments were carried out with irrigation sources *viz.,* T_1- Control, T_2 - Domestic wastewater (DWW) alone, T_3- 25 per cent Treated Tannery Effluent (TTE) + 75 per cent DWW, T_4 - 50 per cent TTE + 50 per cent DWW , T_5 - 75 per cent TTE + 25 per cent DWW, T_6 – TTE alone and the flower crops selected for the study includes *Calendula offcinalis , Cosmos bipinnatus, Dahlia apiculata, Belli perennis, Dianthus alpines, Hibbertia humifusa, Gomphrena globosa and Tagetes erecta.* The experiment was conducted in CRD and replicated four times. The germination test was carried out in a paper medium (Roll towel) using 4 x 100 seeds [21] in a germination room maintained at 25 ± 1°C temperature. The incubation period of seven days for Dianthus, eight days for Cosmos, ten days for Guinea, Calendula, twelve days for Marigold, fourteen days for Vadamalli, Dahlia were maintained for emergence of seedlings and the seedlings were evaluated for their response to different treatments and expressed in percentage. Root length; shoot length and Vigour index (VI) was calculated by using the standard methods [19].

Results

Characterization of the treated tannery effluent and domestic wastewater

The physico chemical and biological properties of the effluent samples as irrigation are given in the table [Table-1]. The treated tannery effluent had objectionable colour and odour. The effluent was dark in colour and odour. All the samples used as irrigation source had neutral pH and it ranged from 7.10 to 7.6. Tannery wastewater had high EC (9.2dSm-1) compared to domestic wastewater (1.2 dSm^{-1}) with objectionable TDS. Considerable amount of essential nutrients *viz*., Ca, Mg, N, P, K were observed in TTE and DWW. Na, Cl^- and SO_4^{2-} were estimated to be higher as 48, 60, and 15.1 ($meql^{-1}$) for Treated tannery effluent. The heavy metal concentration appears to be very low in all the samples [Fig-1].

Table-1 *Characterization of treated tannery effluent and domestic wastewater*

Parameters	Treated Tannery Effluent	Domestic Wastewater	Bore well water
pH	7.6	7.4	7.10
EC (dS m^{-1})	9.2	1.2	0.43
TSS (mg L^{-1})	760	230	225
TDS (mg L-1)	5900	770	80
Total solids (mg L^{-1})	6660	1000	305
Carbonates (mg L^{-1})	BDL	2.0	0.9
Bicarbonates (mg L^{-1})	17.2	8.8	0.04
DO (mg L^{-1})	2.1	3.8	5.6
BOD (mg L^{-1})	27	28.5	6.10
COD (mg L^{-1})	210	160	42.0
Organic matter (%)	2.5	2.6	BDL
Calcium (meq L^{-1})	5.0	3.4	0.8
Magnesium (meq L^{-1})	6.2	8.2	0.12
Sodium (meq L^{-1})	48	9.8	0.14
Potassium (meq L^{-1})	4.75	7.5	BDL
Chloride (meq L^{-1})	60	11.2	0.05
Sulphate (meq L^{-1})	15.1	8.7	0.04
SAR	6.9	3.7	0.16
ESP (%)	7.80	3.9	1
Total nitrogen (meq L^{-1})	18.8	48	BDL
Total phosphorus (meqL^{-1})	3.6	19	BDL
Total potassium(mgL^{-1})	4.8	36.7	BDL
NO3-N (mg L^{-1})	0.07	0.42	BDL
Bacteria x 10^6	10	18	7
Fungi x 10^4	7	11	3
Actinomycetes x 10^3	BDL	BDL	BDL
Total coli form count MPN 100 mL^{-1}	6	8	BDL

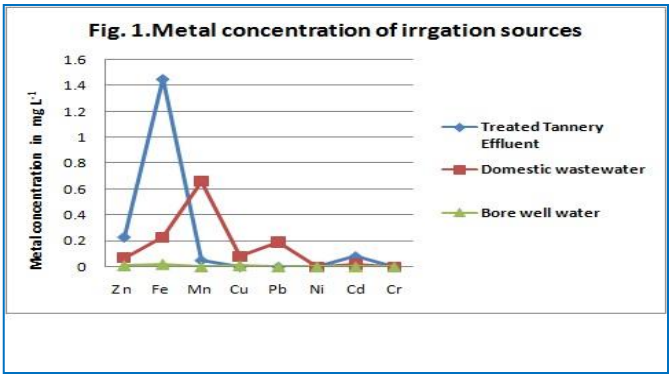

Fig-1 Metal concentration of irrigation sources

Germination percentage

The germination study conducted with flower crops at different concentrations (0, 25, 50, 75 and 100 %) revealed that the plant performed well under 25 and 50 per cent tannery effluent concentrations along with domestic wastewater. The germination percentage was reduced at higher concentrations *i.e.* 75 and 100 per cent effluent. The highest germination percentage was recorded by *Comphrena globosa* (96%), followed by *Calendula officinalis* (94%), *Cosmos bipinnatus* (94%) and other crops in the treatment T_3 (25% TTE +75% DWW) [Table-2a and 2b].

Root Length

Irrigation treatments had significant influence on root growth [Table-2a & 2b]. While comparing the flower crops, the highest root length is recorded in *Hibbertia humifusa* (12 cm) and *Tagetes erecta* (12 cm), followed by *Dahlia apiculata* (10 cm), *Cosmos bipinnatus* (6.5 cm) and other crops in the treatment T_3 (25% TTE +75% DWW). The lowest root length was recorded by *Comphrena globosa (0.1*cm) in the treatment T_6 (100% TTE), which is significantly lesser than all other treatments.

Shoot length

As far as shoot length is concerned, significant differences were observed between the irrigation sources. The highest shoot length was recorded in *Cosmos bipinnatus* (10 cm) followed by *Hibbertia humifusa* (7.5 cm), *Tagetes erecta* (7.5 cm), *Dahlia apiculata* (4.9 cm), *Calendula officinalis* (4.7 cm), *Belli perennis* (3.4 cm), and *Dianthus alpines* (2.4 cm) in the treatment T_3 (Combination of 25% TTE +75% DWW). *Dianthus alpines* and *Comphrena globosa* showed significantly lower shoot length as compared all other treatments [Table-2a & 2b].

Table-2a *Effect of mixed treated tannery effluent with domestic wastewater irrigation on germination per cent and vigour index of flower crops*

Treatments	*Calendula offcinalis*				*Cosmos bipinnatus*				*Dahlia apiculata*				*Gomphrena globosa*			
	G.P	R.L	S.L	V.I	*G.P*	*R.L*	*S.L*	*V.I*	*G.P*	*R.L*	*S.L*	*V.I*	*G.P*	R.L	S.L	V.I
T1 (Control)	68.0	2.1	3.2	360.0	68.0	5.6	6.5	822.8	71.0	7.1	3.0	717.1	86.0	0.6	1.2	154.8
T2 (100% DWW)	92.0	3.0	4.5	690.0	92.0	6.0	10	1472.0	91.0	10	4.7	1337.7	88.0	1.2	2.2	299.2
T3 (25% TTE+75%DWW)	94.0	3.2	4.7	743.0	94.0	6.5	10	1551.0	93.0	10	4.9	1385.7	96.0	1.5	2.4	374.4
T4(50% TTE+50% DWW)	88.0	2.8	3.5	554.0	86.0	5.2	7.5	1092.2	88.0	9.8	3.8	1196.8	84.0	0.9	1.8	226.8
T5(75%TTE+ 25% DWW)	54.0	1.2	3.0	173.0	56.0	3.0	6.1	509.6	58.0	4.2	2.8	406.0	42.0	0.2	1.0	50.4
T6 (100% TTE effluent)	30.0	1.0	2.6	108.2	34.0	2.0	1.8	129.2	42.0	3.0	2.6	235.2	24.0	0.1	0.3	16.8
Mean	71.0	2.2	3.6	355.3	71.7	5.2	7.2	1204.9	73.8	7.4	3.6	879.9	70.0	0.7	1.5	185.5
SEd	11.4	0.3	0.5	31.1	11.4	0.8	1.1	7.43	11.6	1.2	0.5	110	11.1	0.1	0.2	19.8
CD (0.05)	3.9	0.7	1.1	65.3	24.0	1.8	2.5	195	24.4	2.5	1.2	231.7	24.1	0.2	0.5	41.6

Table-2b *Effect of mixed treated tannery effluent with domestic wastewater irrigation on germination per cent and vigour index of flower crops*

Treatmets	*Belli perennis*				*Dianthus alpinus*				*Hibbertia humifusa*				*Tagetes erecta*			
	G.P	R.L	S.L	V.I	G.P	R.L	S.L	V.I	G.P	R.L	S.L	V.I	G.P	R.L	S.L	V.I
T_1 (Control)	48.0	0.7	2.0	129.6	66.0	0.7	0.7	92.4	74.0	5.6	4.2	725.2	84.0	5.6	4.2	823.2
T_2 (100% DWW)	71.0	1.8	3.1	347.9	86.0	1.8	1.8	309.6	82.0	11	7.2	1492.4	92.0	11	7.2	1674.4
T_3 (25% TTE+75%DWW)	75.0	2.0	3.4	405.0	88.0	2.0	2.4	387.2	84.0	12	7.5	1638.0	96.0	12	7.5	1872.0
T_4 (50% TTE + 50% DWW)	70.0	1.1	2.8	273.0	74.0	1.1	1.1	162.8	74.0	10	6.8	1243.2	84.0	10	6.8	1411.2
T_5 (75% TTE + 25% DWW)	32.0	0.4	1.6	64.0	52.0	0.4	0.4	41.6	52.0	3.2	3.5	348.4	62.0	3.2	3.5	415.4
T_6 (100% TTE effluent)	18.0	0.2	0.5	12.6	30.0	0.2	0.2	12.0	30.0	2.5	2.0	135.0	56.0	2.5	2.0	252.0
Mean	52.3	1.0	2.2	205.4	66.0	1.0	1.0	167.6	66.0	7.4	5.2	930.4	79.0	7.4	5.2	930.6
Sed	8.60	0.1	0.3	13.6	10.5	0.1	0.1	12.7	10.5	1.2	0.8	111	12.3	1.2	0.8	71.9
CD (0.05)	18.1	0.3	0.7	28.7	22.1	0.3	0.3	26.7	22.1	2.6	1.7	233	25.8	2.6	1.7	151

Vigour index

The influence of irrigation sources in root length, shoot length and germination of seedlings could be seen from vigour index. The highest vigour index was observed in treatment T_3 (25% TTE + 75% DWW) *Tagetes erecta (1872),* followed by Hibbertia *humifusa* (1638), *Cosmos bipinnatus* (1551) and other crops. The treatment T_3 was on par with T_2 and significantly different from all the other treatments in most of the flower crops studied. In case of *Calendula officinalis and Dahlia apiculate,* treatment T_4 was also on par with T_2 in addition to T_3.

Discussion

Characteristics of the irrigation Sources

The treated tannery effluent had objectionable colour and odour. The effluent was dark in colour and the use of high molecular weight organic and inorganinic compounds during the processing might be the reason. The unpleasant odour of the effluent may be due to degradation of organic wastes produced during the processing of skin and hides, excess polyphenols which making them unfit for consumption [22, 23]. Black colored untreated effluent may be due to large number of pollutants, which affects the receiving water bodies making it unfit for consumption [24, 25]. Eighty per cent of the tanneries are using vegetable tanning process, which uses tan barks, powdered plant or aqueous extracts of those parts, which comprised of polyphenols [26]. The sample analysis revealed that the pH was neutral [27,28] with high EC which may be due to excessive dissolved salts which indicated the discharge of chemicals as cations and anions were higher in the waste water. The composition of the solids present in tannery effluent depends upon the process adopted for production of different qualities of skins and hides [29-31].

Treated tannery effluent and domestic waste water under the present study had BOD and COD, total and ammonical Nitrogen level well within the standard limits [32]. The high level of ammonia-N is toxic to aquatic organisms and nitrogen may cause eutrophication [32]. Considerable amount of essential nutrients *viz*., Ca, Mg, N, P, K were observed in TTE and DWW, similar to the report of earlier workers [25, 28]. Chloride is an indicator of pollution when present in higher concentrations [33]. Sodium chloride is used as a dehydrating and antiseptic agent, which may be the source of chloride in treated tannery effluent. The presence of very high amounts of chloride and sulphate is responsible for high hardness and further it increases the degree of eutrophication [34, 35].

The disposal of aqueous effluent from tanneries with high chromium concentration compared to the recommended permissible discharge limits of 2 mg/L is the major problem, which requires strict discharge regulations. Based on the tanning process adopted, the physicochemical properties and heavy metals concentration of the effluent varies [36, 37]. In the present study, the heavy metal concentration was considerably low. In addition, the wastewater was diluted before using it for irrigation. When this mixture was used for growing non food crops certainly the above issues may not arise. Prolonged exposure to high levels of copper results in adverse health problem [38]. In the present study, Copper content in tannery and domestic waste water samples used for irrigation was well within the limit.

Impact on Flower Crops

The tannery effluent along with domestic wastewater used for crop production process has been an attractive method for disposal of industrial wastewaters, because of its versatility and environmental compatibility. Sumangala Rao [39] observed that treated tannery effluent may be utilized for irrigation purpose through proper dilution. Effluent concentration at 75 and 100 per cent killed the plants and only 25 per cent was found to be suitable [40]. Nath [41] also had the same opinion who reported that as the concentration of tannery effluents and Cr6+ increased there was a reduction in seedling performance. In the present study also dilution of treated tannery effluent with domestic wastewater was done, which may helps in reducing the concentration of the pollutant present in the treated tannery effluent**.** When treated tannery effluent is mixed with domestic wastewater that favoured the dilution of higher amount of dissolved salts and the mixed irrigation contain low amount of TDS.

The seed germination and seedling growth was inhibited upon using effluents with high concentration of dissolved solids, chlorides, sulphates, chromium, high BOD and COD [42]. The chelating characteristics of water bodies are altered by high electrical higher conductivity, which may be due to high concentration of acid base and salt in the effluent [24, 43]. The reduction in germination of the flower crops with high concentration of effluent could be due to the inhibitory effect of the effluent [44]. Presence of salts like sodium and chloride in the effluent leads to an increase in the osmotic pressure of water thereby the seeds might have suffered water stress. This might have an inhibitory effect and hence seed germination was very less in higher concentrations. Restricted growth of plants happened due to reduced availability of water to the plant when irrigated with tannery effluent, which enhances osmotic pressure of the root medium due to its high soluble salts. So, high concentrations of effluent (80 - 100%), proved to be deleterious to plant growth, both at vegetative and reproductive stages. Jagathjothi [40, 42] reported irrigation of 25% TTE with 75% DWW with gypsum application through enhanced yield.

Conclusion

The concept of dilution chemistry was explored in the present study to understand the effect of mixed irrigation on soil properties and non - food crop growth. This preliminary study offers evidence that with proper dilution ratio of treated tannery effluent and domestic waste water could be used as an irrigation source for growing non food crops. However, this study is not exhaustive and further research is needed to assess the long-term impact.

Abbreviations: TTE-Treated Tannery Effluent; DWW-Domestic Waste Water

Author Contributions: PD- Assisted in manuscript preparation and statistical analysis; GB-Execution of the Project; MK- Lab analysis

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Conflict of Interest: None declared

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