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RESEARCH ARTICLE

Effect of treated tannery effluent and domestic waste water irrigation on *Tagetes erecta*

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ABSTRACT : Tanning industry is generating enormous quantities of effluent every day. The scientific ways and means of utilizing this liquid waste is of utmost important in reducing pollution load to the environment. Present study has been carried out to apply treated tannery effluent (TTE) diluted with domestic waste water (DWW) as irrigation sources at different concentration of 25 per cent, 50 per cent, 75 per cent and 100 per cent on a non food crop *Tagetes erecta.* Results reveal that application of diluted mixture of TTE along with DWW can be used efficiently for crop production. Germination percentage of 73.13 per cent was recorded with 25 per cent of TTE and 75 per cent of DWW dilution as compared with 71.17 per cent in control. Different growth parameters showed variation with different level of diluted tannery waste water application. Highest root and shoot length was observed in control (11.08 cm and 10.70 cm) followed by 25 per cent effluent irrigation (11.22 cm and 10.47 cm). Different concentrations of tannery effluent were found to influence the vigour index significantly. The highest vigour index was observed at control (1601.1) followed by 25 per cent effluent concentration (1585.59). The lowest vigour index was observed in case of treatment receiving 100 per cent effluent concentration (173.48). Red soil with different concentration of treated tannery effluent with domestic waste water recorded good results as compared to the black cotton soil.

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Key Words :
Tannery effluent, Domestic waste water, Growth , Yield of marigold

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The Indian leather industry plays a major role on economic development at global level. Among the source of global raw material used for tannery industry, India has 10 per cent. The Indian leather industry employs nearly 2.5 to 3 million people, of which 30 per cent are women (Gupta *et al.,* 2014, Suganya and Selvaseelan, 2009). One of the unique characteristics of Indian leather industry is occurring in clusters. The three states *viz*.Tamil Nadu, West Bengal and Uttar Pradesh together accounts for 88 per cent of the country's tannery units (Vijayanand and Hemapriya, 2014). Among the 113 clusters in India, 15 clusters are located in Tamil Nadu. About 1120 tanneries are located in Vellore, Ranipet, Trichy, Dindigul, Erode and Pallavaram in Chennai (Noorjahan, 2014).

Nearly 30 m^3 of wastewater is generated for every ton of skin/ hide processing and the wastewater discharged is highly polluted in terms of Biological oxygen demand, Chemical oxygen demand, sulphates, bicarbonates etc (Mondal *et al.,* 2005 and Jagathjothi and Amanullah, 2015). Common treatment facilities are established to treat the wastewater, which is aided by cluster nature

of the tannery industries. The wastewater after treatment is discharged in to rivers and land. The discharged effluent not only loaded with high concentration of pollutants like sodium, chloride, sulphate, bicarbonate, calcium and magnesium, it also contained large concentration of valuable plant nutrients such as nitrogen, phosphorus and potassium. Recycling of treated tannery effluent for crop production is an effective method of disposal and pollution may also be minimised (Nava, 1997 and Vasudevan *et al*., 2010)

On the other hand, the domestic wastewater generation in Dindigul city is nearly five times greater than the tannery wastewater. Utilization of domestic wastewater for irrigation is a long time practice, which helps in reducing the fertilizer cost as well as reduces the burden on the scarce water resource. Opportunities are there to utilise sewage effluents from municipal origin, containing rich organic matter and also with appreciable amounts of major plant nutrients. Thereby upon irrigation, nutrient levels of soils are expected to improve considerably with continuous irrigation with sewage (Brar *et al*., 2000). Though the effect of tannery effluent on agricultural crops has been studied widely (Rajendra *et al.,* 2010; Mythili and Karthikeyan, 2011 and Kumar and Ghosh, 2013), the effect on non-food crops like flower crops are in limited numbers only.

Application of treated tannery effluent (TTE) along with domestic waste water (DWW) as a source of irrigation would offer a safe disposal of waste water and also reduce the pressure on depleting natural resources. Research on recycling of treated tannery effluent and sewage wastewater for agriculture purpose is gaining importance in this momentum as they are the important sources of nutrients (Zalawadia *et. al.,* 1996) that could be used similar to fertigation on proper dilution to various agricultural crops. If properly treated and diluted effluents are used for crop cultivation, the problem of disposal of effluents and also irrigation water needs will be solved (Sumangala Rao *et al.,* 2014). But it requires adequate studies on the ratio of mixing treated tannery effluent and domestic wastewater and its effects on crops. Hence the following study was planned to study the effect of irrigating treated tannery effluent with domestic wastewater on a non-food crop *Tagetes erecta.*

EXPERIMENTAL METHODOLOGY

The treated tannery effluent and domestic waste water was collected from CETP, Dindigul using standard procedures and was analysed for its characteristics (APHA, 2005). A pot culture experiment was conducted with treated tannery effluent and domestic wastewater as irrigation source to study its influence on seed germination and vigour index of marigold seedlings. Germination test was carried out in germination room maintained at a temperature of 25 ± 1.5^0 C, relative humidity 95 ± 2 per cent with diffused light during day. The observation of per cent of germination was recorded by counting the seeds germinated out of the total number of seeds sown at 10 DAS in each treatment and expressed as percentage. The shoot and root length was taken after 25 days to calculate the vigour index as given by Abdul-Baki and Anderson (1973).

The same study was conducted with two different soils black cotton soil and red soil to know the impact on growth and yield of marigold with treated tannery effluent and domestic wastewater as irrigation source. The experiment was laid out in Factorial Randomised Block Design with four replications. Five different combinations of TTE and DWW as listed below were used as treatments with bore well water as control.

T_1 : Control

T_2 : 100 per cent domestic wastewater (DWW)

T_3 : 25 per cent tannery effluent + 75 per cent domestic wastewater

T_4 : 50 per cent tannery effluent + 50 per cent domestic wastewater

T_5 : 75 per cent tannery effluent + 25 per cent domestic wastewater

T_6 : 100 per cent tannery effluent

S_1 : Black cotton soil; S_2 : Red soil

The recommended dose of fertilizers in the form of urea, single super phosphate and muriate of potash were applied to the crop based on the type and quantity of soil. As per the treatment, same quantity of irrigation was used throughout the study period. The data on various parameters were statistically analysed as suggested by Gomez and Gomez (2010). Wherever necessary critical difference probability level at 0.05 was worked out for comparison.

EXPERIMENTAL FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Characterisation of the waste water samples :

The treated tannery effluent and domestic wastewater was characterized and the results are furnished in Table 1. The effluent contained high amounts of total dissolved solids (5900 mg lit.$^{-1}$) and total suspended solids (760 mg lit.$^{-1}$). The sample had objectionable EC and TSS due to use of lime, sodium chloride and sodium sulphate in tanning process. The electrical conductivity was 9.2 dSm^{-1}. The analysis indicated that the pH was neutral with high EC in T_6 (TTE alone) followed by T_5 (75% TTE with 25% DWW), T_4 (50% TTE with 50% DWW) and T_3 (25% TTE with 75% DWW) which was in accordance with the report of Thambraj *et al.*, 1964; Chadha and Pandey, 1993; Dhulasi and Saradha, 1994 and Mariappan *et al.*, 2001. The treated tannery effluent had very high TDS, BOD, COD and Colour when compared to domestic wastewater which had low BOD, COD with objectionable TDS and Colour. This was in accordance with the report of Singaram (1996) who have reported higher levels of BOD in tannery effluent. The effluent contained considerable amounts of salts like sodium, chloride and sulphate. The other cations like calcium and magnesium were also observed in the effluent. The level of sodium and chloride are in accordance with the report given by Ramasamy and Naidu (1998) and also with the report of Singaram (1996). Although the effluent had high amount of undesirable salt load, it contained some favourable cations like Ca^{++}, Mg^{++} and K^{+}, which favours plant growth. The results on the heavy metal analysis of the irrigation sources were given in Fig.1. Heavy metal concentration was observed to be very low in the treated tannery effluent.

The domestic wastewater contained total solids, sodium, chloride and sulphate well within the limit. The carbonates, bicarbonates, BOD and COD values were high, but less than the level of these compounds in tannery effluent. The concentration of heavy metals like Cu, Pb, Ni, Cr, Cd were in traceable quantity. In case of microbial population the effluent was found to have bacteria (10 x 10^{-6} CFU ml^{-1}) and fungi (18 x 10^{-4} CFU ml^{-1}) with a total coliform count of 6 and 8 per 100 ml^{-1} of tannery wastewater and domestic waste water, respectively.

Effect of irrigation sources on germination :

The germination percentage of marigold was assessed with two irrigation sources and the results are given in Table 2. The concentration of 100 and 75 per

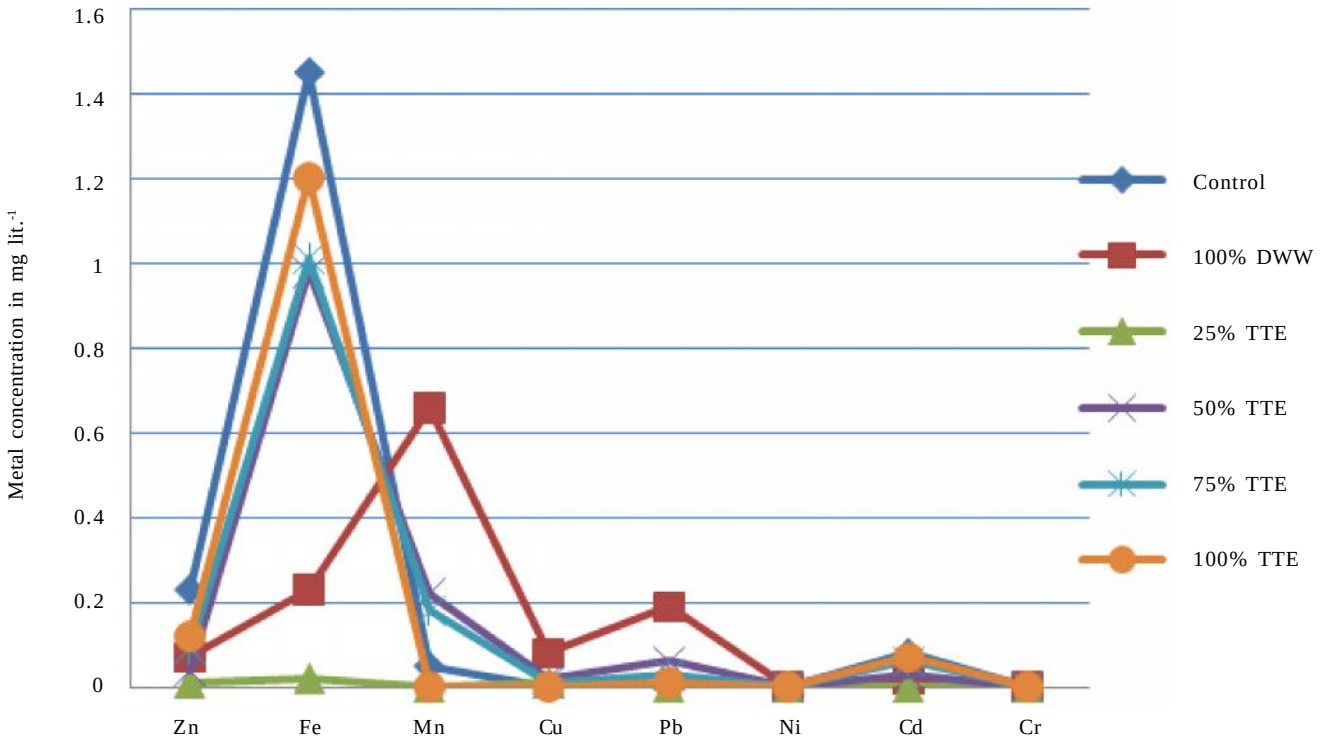

Fig. 1 : Heavy metal concentration in irrigation sources

cent inhibited the germination of marigold. Among all treatments, germination percentage was gradually decreased as the concentration increased from 25 per cent to 100 per cent. The different concentrations of tannery effluent significantly influenced the root length, shoot length and vigour index of marigold seedlings.

The germination percentage of marigold was significantly influenced by different proportions of tannery and domestic wastewater. Among all treatments germination percentage was gradually increased as per the concentration decreased from 100 per cent to 25 per cent. The effluent at 25 per cent concentration with red soil showed marked improvement in germination. Thangvel *et al.* (2003) and Mahmood *et al.* (2005) observed the similar results at different concentrations of tannery effluent. 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. Reduction in germination percentage, root length and shoot length in crops at increased concentration of tannery effluent was reported by Kamalam and Raj (1980); Teekaraman *et al.* (1982); Kumaravelu *et al.* (2000) and Sumithabharathi (2011).

Effect of irrigation sources on growth parameters of marigold:

The same study was conducted with two different soils black cotton soil and red soil to know the impact on growth and yield of marigold with the two irrigation sources. The highest root length was observed in control (T_1) (11.56 cm), followed by 25 per cent effluent (T_2) (Table 3). Notable variation in root length was observed

Table 1 : Characterisation of treated tannery effluent and domestic wastewater

Parameters	Treated tannery effluent (TTE)	Domestic wastewater (DWW)	Bore well water	25% TTE +75% DWW	50% TTE +50% DWW	75% TTE +25 % DWW
pH	7.6	7.4	7.10	7.46	7.5	7.54
EC (dS m^{-1})	9.2	1.2	0.43	3.2	5.3	6.4
TSS (mg lit^{-1})	760	230	225	356	510	632
TDS (mg $lit.^{-1}$)	5900	770	80	2060	3412	4116
Total solids (mg $lit.^{-1}$)	6660	1000	305	2416	3922	4748
Carbonates (mg $lit.^{-1}$)	BDL	2.0	0.9	1.6	0.8	0.4
Bicarbonates (mg $lit.^{-1}$)	17.2	8.8	0.04	8.4	12.7	14.8
DO (mg $lit.^{-1}$)	2.1	3.8	5.6	3.4	2.8	2.3
BOD (mg $lit.^{-1}$)	27	28.5	6.10	28.1	28.4	28.7
COD (mg $lit.^{-1}$)	210	160	42.0	176.2	185.4	198.8
Organic matter (%)	2.5	2.6	BDL	2.56	2.55	2.54
Calcium (meq $lit.^{-1}$)	5.0	3.4	0.8	4.2	4.8	4.9
Magnesium (meq $lit.^{-1}$)	6.2	8.2	0.12	4.8	5.4	5.8
Sodium (meq $lit.^{-1}$)	48	9.8	0.14	16.7	24.8	36.5
Potassium (meq $lit.^{-1}$)	4.75	7.5	BDL	6.9	5.7	4.3
Chloride (meq $lit.^{-1}$)	60	11.2	0.05	19.4	32.6	48.9
Sulphate (meq $lit.^{-1}$)	15.1	8.7	0.04	10.6	13.9	14.8
SAR	6.9	3.7	0.16	3.6	4.6	5.8
ESP (%)	7.80	3.9	1	3.8	5.1	6.64
Total nitrogen (mg $lit.^{-1}$)	18.8	48	BDL	42.3	36.8	22.7
Total phosphorus(mg $lit.^{1}$)	3.6	19	BDL	15.2	9.4	6.2
Total potassium(mg $lit.^{-1}$)	4.8	36.7	BDL	32.4	18.6	9.3
NO_3-N (mg $lit.^{-1}$)	0.07	0.42	BDL	0.32	0.26	0.10
Phosphate (mg $lit.^{-1}$)	8.2	26	0.16	21.5	19.6	17.4
Bacteria x 10^6 (Cfu m $lit.^{-1}$)	10	18	7	16	13	11
Fungi x 10^4 (Cfu m $lit.^{-1}$)	7	11	3	10	9	8
Total coli form count MPN 100 m $lit.^{-1}$	6	8	BDL	7	7	6

Table 2 : Effect of tannery wastewater and domestic wastewater on *Tagetes erecta*

Treatments	*Tagetes erecta*			
	G.P	Root length	Shoot length	V.I
T_1 (Control)	84.0	5.6	4.2	823.2
T_2 (100%DWW)	92.0	11	7.2	1674.4
T_3 (25% TTE + 75% DWW)	96.0	12	7.5	1872.0
T_4 (50% TTE + 50% DWW)	84.0	10	6.8	1411.2
T_5 (75% TTE + 25% DWW)	62.0	3.2	3.5	415.4
T_6 (100% TTE)	56.0	2.5	2.0	252.0
Mean	79.0	7.4	5.2	930.6
S.E.±	12.3	1.2	0.8	71.9
C.D. (P=0.05)	25.8	2.6	1.7	151

Table 3 : Effect of different proportions of tannery effluent and domestic wastewater on germination, root length shoot length and vigour index of *Tagetes erecta*

Treatments	Germination percentage (%)			Root length (cm)			Shoot length (cm)			Vigour index		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1 (Control)	69.42	70.11	69.76	9.32	10.12	9.72	9.45	11.14	10.23	1305.97	1490.54	1398.26
T_2 (100%DWW)	70.33	72.00	71.20	11.56	12.03	11.80	10.50	10.90	10.70	1551.48	1650.96	1601.22
T_3 (25% TTE+75% DWW)	71.53	74.73	73.13	11.10	11.33	11.22	10.50	10.43	10.47	1545.05	1626.13	1585.59
T_4(50% TTE+50% DWW)	61.86	62.10	61.98	8.66	8.93	8.80	8.10	8.20	8.15	1036.77	1063.77	1050.27
T_5(75% TTE+25% DWW)	40.20	41.40	40.80	5.43	6.53	5.98	4.33	5.66	4.99	392.35	504.67	448.51
T_6(100% TTE)	20.30	21.93	21.11	3.93	5.06	4.50	3.05	4.30	3.68	141.69	205.27	173.48
Mean	52.84	54.43		8.14	8.78	8.46	7.30	7.90	7.60	933.47	1010.16	971.82
	S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
T	1.76	3.68		0.36	0.75		0.34	0.71		16.60	34.63	
S	1.12	2.36		0.29	0.48		0.216	0.45		10.50	21.90	
TS	2.49	5.20		0.51	1.06		0.48	1.01		23.48	48.98	

T_1 :Control ; T_2 : 100 % domestic wastewater ; T_3 : 25% Tannery effluent + 75% Domestic wastewater;
T_4 : 50% Tannery effluent + 50% Domestic wastewater; T_5 : 75% Tannery effluent + 25% Domestic wastewater;
T_6 : 100% Tannery effluent; S_1: black cotton soil; S_2: red soil

Table 4 : Effect of different proportions of tannery effluent and domestic wastewater on plant height, collar diameter, volume index and flowers per plant of *Tagetes erecta*

Treatments	Plant height (cm)			Collar diameter (mm)			Volume index (cc)			Flowers per plant		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1 (Control)	34.24	35.21	34.73	12.12	16.23	14.18	7123.21	9245.13	8184.12	6.30	7.40	6.85
T_2 (100%DWW)	36.25	38.16	37.21	15.41	17.30	16.36	8608.21	11420.91	10014.56	8.30	10.70	9.50
T_3 (25% TTE+75% DWW)	30.12	36.51	33.32	14.30	15.10	14.70	6159.23	8324.64	7241.94	7.20	9.30	8.25
T_4(50% TTE+50% DWW)	33.16	33.87	33.52	13.39	14.70	14.05	5945.32	7318.96	6632.14	6.40	8.60	7.50
T_5(75% TTE+25% DWW)	7.06	16.66	11.86	9.12	11.60	10.36	587.21	2241.77	1414.49	0.67	1.50	1.09
T_6(100% TTE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean	21.32	25.04	23.18	10.44	11.74	11.09	299.55	380.52	340.04	4.51	6.02	5.27
	S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
T	1.2576	2.5685		0.5742	1.1726		0.5742	1.1726		0.3025	0.6179	
S	0.7954	1.6245		0.3631	0.7416		0.3631	0.7416		0.1913	0.3908	
TS	1.7786	3.6324		0.8120	1.6583		0.8120	1.6583		0.4279	0.8738	

T_1 :Control; T_2 : 100 % domestic wastewater T_3 : 25% Tannery effluent + 75% Domestic wastewater;
T_4 : 50% Tannery effluent + 50% Domestic wastewater; T_5 : 75% Tannery effluent + 25% Domestic wastewater;
T_6 : 100% Tannery effluent; S_1: black cotton soil; S_2: red soil

due to different effluent concentration compared to control. The lowest root length was observed in T_5 (receiving 100% effluent) (3.93 cm). In all concentrations, which tested for germination, the shoot length was increased at 25 per cent effluent (T_2). The other concentrations reduced the shoot length in both the soils. The shoot length was significantly reduced in T_5 (receiving 100% effluent). The different concentrations of tannery effluent were significantly influenced the vigour index of marigold seedlings. High concentration at 100 and 75 per cent significantly reduced the vigour index of crop. The highest vigour index was observed at control (T_1) (1601.22) followed by 25 per cent effluent concentration (T_2) (1585.59). The lowest vigour index was observed in T_5 (receiving 100% effluent concentration). In all treatments T_1 and T_2 were on par with each other. The effluent at 25 per cent concentration with red soil showed marked improvement in germination.

The details on effect of different proportions of tannery effluent and domestic wastewater on plant height, collar diameter, volume index and flowers per plant are furnished in Table 4. The different concentrations of tannery effluent were significantly influenced the height of marigold plant. Highest plant height was observed in 25 per cent effluent concentration (T_2) followed by 50 per cent effluent concentration (T_3). The lowest plant height was observed in T_4 (75 % effluent). Plants get collapsed in treatments (T_5) receiving 100 per cent effluent. Treatment T_1 was on par with T_3. Highest collar diameter was observed in 25 per cent effluent concentration (T_2) (16.36 mm) followed by control (T_1) (14.70 mm). The lowest plant height was observed in T_4 (75 % effluent concentration) (10.36 mm). In case of soil interaction effect, red soil shows better results as compared to black cotton soil. Highest volume index was observed in 25 per cent effluent concentration (T_2) followed by control (T_1). The lowest volume index was observed in T_4 (75 % effluent concentration) (1414.49). The different concentrations of tannery effluent were significantly influenced the flowers per plant of marigold. Highest number of flowers per plant was observed in 25 per cent effluent concentration (T_2) followed by control (T_1). The lowest number of flowers per plant was observed in T_4 (75 % effluent concentration) (1.09). In case of all growth parameters, 25 per cent effluent application showed the better results compared to higher concentrations in both the soils. Red soil treatments with different concentration recorded good results as compared to the black cotton soil. In treatments receiving 100 per cent effluent concentration plants were collapsed due to higher concentration of tannery effluent. Scientists reported that 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 (Kumaravelu *et al.*, 2000).

Germination, survival and growth characters were higher under domestic wastewater irrigation, which was comparable with 25 per cent treated tannery waste water irrigation. The 1:3 ration of TTE and DWW had performed better and could be used for growing non food crops compared to other mixing ratios of TTE and DWW. Economic reasons and environmental considerations necessitate the utilization of waste materials generated by industries and communities, which helps in reducing the pollution load on the environment and also brings out the usefulness of these wastes.

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