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Effect of textile waste water on tomato plant, *Lycopersicon esculentum*

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Abstract

In this study Sanganer town, Jaipur was selected as study area. The plants of *Lycopersicon esculentum* var. K 21(Tomato) treated with 20 and 30% textile wastewater were analyzed for metal accumulation, growth and biochemical parameters at per, peak and post flowering stages. Findings of the study revealed that chlorophyll content was most severely affected with the increase in metal concentration. Total chlorophyll content showed a reduction of 72.44% while carbohydrate, protein and nitrogen content showed a reduction of 46.83, 71.65 and 71.65% respectively. With the increase in waste water treatment the root and shoot length, root and shoot dry weight and total dry weight were reduced to 50.55, 52.06, 69.93, 72.42, 72.10% respectively. After crop harvesting, the fruit samples of the plants treated with highest concentration of textile waste water contained 2.570 mg g^{-1}d.wt. of Zn, 0.800 mg g^{-1}d.wt. Cu, 1.520 mg g^{-1}d.wt. Cr and 2.010 mg g^{-1}d.wt. Pb.

Key words

Textile waste water, Dye industry, Heavy metals, *Lycopersicon esculentum*, Sanganer town.

Introduction

Textile industry is considered to be one of the world worst polluters. Water pollution due to textile industry is a topic of major concern as they discharge large quantity of effluent into near by water bodies. Central pollution control board has listed the dye industry as one of the heavily polluting industries (CPCB, 1990) The dye effluent is highly toxic in nature as it contains high suspended solid, COD, dye and chemicals along with high concentration of heavy metals like Cu, Cd, Zn, Ni and Pb. The dye effluent contaminates the surface and ground water, therby, making it unfit for irrigation and drinking (Mathur *et al.* 2007). The dye effluent contains certain chemicals that could be toxic, carcinogenic or mutagenic to living organisms (Suzuki *et al*., 2001) Crops and vegetables grown in the agricultural fields irrigated by textile effluent are adversely affected both qualitatively and quantitatively. Impact of textile waste water on agricultural crops has been studied earlier by several workers (Gupta and Nathawat, 1991; Khan and Jain, 1995; Jain and Khan, 1996; Sharma and Rao, 1996; Prasad *et al*., 1997; Angadi and Mathad, 1998; Shrivastava and Purnima, 1999; Tomar *et al*., 2000). Antonious *et al.* (2011) reported heavy metal accumulation in different parts of sweet potato grown in soil amended with municipal sewage sludge. The accumulation and mobility of heavy metals such as Cd, Co, Cu, Fe, Ni, Pb and Zn from soil to leaves through roots and stems in vegetable crop has been reported by Kumar *et al.* (2009). Houshmandfar and Moraghebi (2011) reported the effect of Cd, Cu, Ni and Zn on seed germination and seedling growth of safflower under controlled light and temperature conditions. The heavy metal mixture treatment showed toxic effects on seed germination and seedling growth of safflower.

In view of the above, the present study aimed to investigate the effect of textile waste water on the growth parameter of tomato plant.

Materials and Methods

Study area: Sanganer town in Jaipur was selected as study area. It is famous for many thriving cottage industries like dyeing and printing, waste paper recycling, and blue potteries. These industries cover about 12.9 sq.km. urban area of Sanganer. A large number of small, medium and large scale textile industrial units are located in Sanganer. The untreated waste water which contains chemicals like anelin, caustic soda, acids, bleaching powder and heavy metals are used for irrigating agricultural fields for growing vegetables and other crop plants.

Experimental setup: For the experimental study *Lycopersicon esculentum* var. K 21 was selected as test plant. *Lycopersicon esculentum* (Tomato) belongs to family Solanaceae. It is a commonly used fruit vegetable. The plants were grown in the earthern pots and the population of five plants per pot was maintained for experiment. The plants were treated with 20 and 30% effluent concentration. The plants treated with distiled water served as control.

Growth parameters: The plants were harvested at pre-flowering, peak-flowering and post-flowering stages for studying different growth parameters (root and shoot length, dry weight of root and shoot and total dry weight). For dry weight determination roots and shoots were separated and dried in hot air oven at 80ºC for 72 hr.

Biochemical analysis: Chlorophyll *a, b* and total chlorophyll content in fresh leaves of treated and control plant was estimated following the method suggested by Arnon (1949). Carbohydrate content was estimated following the Anthrone method (Hedge and Hofreiter,1962). Protein content was determined by following the method of Lowry *et al.* (1951) while nitrogen content was estimated by microkjeldhal's method (Allen, 1931). Heavy metals in the soil and crop plant samples were estimated using Atomic Absorption Spectrophotometer (AAS Model GBC 932 place).

Soil analysis: After harvesting at pre-, peak- and post-flowering stages of *Lycopersicon esculentum,* soil samples were collected, oven-dried, crushed and passed through 2mm sieve and stored in polythene bags for physico-chemical analysis following the standard method suggested by Maiti (2003).

Results and Discussion

The plants of *L.esculentum* treated with 30% effluent showed a maximum reduction in root length (50.55%), root (69.93%) and shoot (72.42%) dry weight , total dry weight (72.10%) and total Chl (72.44%) content at post-flowering stage (Table 1 a, b, c). While a maximum reduction in carbohydrate (46.83%), nitrogen (71.65%) and protein (71.65%) content was found at peak-flowering stage at 30% effluent treatment (Table 1d).

The result of heavy metal analyzed in different plant parts and composite samples of *Lycopersicon esculentum* at pre-flowering, peak-flowering and post-flowering stages are given in Table 2. The concentration of Zn incresed with increase in waste water treatment. At 30% treatment, the plants accumulated 1.293, 1.041 and 1.490 mg gm^{-1} d.wt. Zn in leaf; 0.887, 0.783 and 1.309 mg gm^{-1} d.wt. Zn in stem and 1.299 , 1.154 and 1.840 mg gm^{-1} d.wt. Zn at pre, peak and post-flowering stages, respectively. In composite plant samples, Zn concentration was 1.261, 0.971 and 1.297 mg gm^{-1} d.wt. at pre, peak and post-flowering stages respectively. Whereas in fruit samples Zn concentration was 2.570mg gm^{-1} d.wt. (Table 2). Whereas in leaf samples, Cu concentration was 0.276, 0.469 and 0.215 mg gm^{-1} d. wt. in leaves; 0.138, 0.207and 0.109 mg gm^{-1} d. wt. in stem; 0.246, 1.036 and 0.299 mg gm^{-1} d. wt. in roots at pre, peak and post-flowering stages, respectively. In composite plant samples, Cu concentration was 0.207, 0.328 and 0.196 mg gm^{-1} d. wt. at pre, peak and post flowering stages, respectively. In fruit samples, Cu concentration was 0.800 mg gm^{-1} d. wt. at post flowering stage. (Table 2). Cr concentration in leaf samples was 0.725, 0.355 and 0.283 mg gm^{-1} d. wt.; 0.583, 0.473 and 0.524 mg gm^{-1} d. wt. in stem; 0.979, 0.707 and 0.949 mg gm^{-1} d. wt. in roots at pre, peak and post-flowering stages, respectively. In composite plant samples, Cr concentration was 0.860, 0.618 and 0.842 mg gm^{-1} d. wt. at pre, peak and post flowering stages, respectively. In fruit samples, Cr concentration was 1.520 mg gm^{-1} d. wt. at post flowering stage. (Table 2). At 30% effluent treatment the plant accumulated 1.126, 1.134 and 0.694 mg gm^{-1} d. wt. in leaves; 1.214, 1.346 and 0.838

Table- 1a: Effect of textile waste water on root length and shoot length of *L. esculentum*

Treatment	Root length (cm)			Shoot length (cm)		
	Pre-flowering	Peak-flowering	Post-flowering	Pre-flowering	Peak-flowering	Post-flowering
Control	19.46 ± 1.397	26.28 ± 1.666	32.32 ± 1.785	45.02 ± 2.209	52.88 ± 1.986	68.10 ± 2.559
20%	13.36 ± 1.519	19.30 ± 0.977	20.10 ± 2.906	30.86 ± 0.698	41.50 ± 2.423	52.82 ± 1.289
	(31.34)	(26.56)	(37.80)	(31.45)	(21.52)	(22.43)
30%	11.56 ± 1.659	15.62 ± 1.867	15.98 ± 1.492	21.58 ± 1.565	32.92 ± 0.875	40.22 ± 1.947
	(40.59)	(40.56)	(50.55)	(52.06)	(37.74)	(40.93)

Values are mean of replicates of ± S.D.

Table - 1b: Effect of textile waste water on root dry weight, shoot dry weight, and total dry weight of *L. esculentum*

Treatment	Root dry wt. (gm)			Shoot dry wt. (gm)			Total dry wt. (gm)		
	Pre-flowering	Peak-flowering	Post-flowering	Pre-flowering	Peak-flowering	Post-flowering	Pre-flowering	Peak-flowering	Post-flowering
Control	0.534 ± 0.082	0.766 ± 0.091	1.284 ± 0.187	4.078 ± 0.509	4.586 ± 0.464	8.726 ± 0.353	4.612 ± 0.534	5.352 ± 0.543	10.010 ± 0.491
20%	0.284 ± 0.082	0.450 ± 0.063	0.538 ± 0.140	2.716 ± 0.757	2.958 ± 0.281	4.140 ± 0.300	3.000 ± 0.821	3.408 ± 0.302	4.678 ± 0.318
	(46.81)	(41.25)	(58.09)	(33.39)	(35.49)	(52.55)	(34.95)	(36.32)	(53.26)
30%	0.196 ± 0.086	0.268 ± 0.080	0.386 ± 0.076	1.878 ± 0.520	2.030 ± 0.215	2.406 ± 0.555	2.074 ± 0.605	2.298 ± 0.289	2.792 ± 0.629
	(63.29)	(65.01)	(69.93)	(53.94)	(55.73)	(72.42)	(55.03)	(57.06)	(72.10)

Values are mean of replicates of ± S.D.

Table - 1c: Effect of textile waste water on Chl *a* , Chl *b* and Total Chl of *L. esculentum*

Treatment	Chl *a* (mg gm^{-1})			Chl *b* (mg gm^{-1})			Total Chl (mg gm^{-1})		
	Pre-flowering	Peak-flowering	Post-flowering	Pre-flowering	Peak-flowering	Post-flowering	Pre-flowering	Peak-flowering	Post-flowering
Control	1.176 ± 0.129	1.567 ± 0.177	2.814 ± 0.116	0.473 ± 0.048	0.557 ± 0.027	0.965 ± 0.055	1.649 ± 0.131	2.124 ± 0.158	3.779 ± 0.085
20%	0.912 ± 0.122	0.964 ± 0.179	1.081 ± 0.152	0.342 ± 0.061	0.376 ± 0.051	0.390 ± 0.064	1.254 ± 0.164	1.340 ± 0.211	1.471 ± 0.127
	(22.45)	(38.48)	(61.57)	(27.56)	(32.44)	(59.58)	(23.91)	(36.90)	(61.06)
30%	0.690 ± 0.055	0.789 ± 0.061	0.830 ± 0.178	0.161 ± 0.055	0.208 ± 0.065	0.210 ± 0.033	0.852 ± 0.104	0.997 ± 0.049	1.041 ± 0.162
	(41.29)	(49.63)	(70.49)	(65.83)	(62.57)	(78.14)	(48.33)	(53.02)	(72.44)

Values are mean of replicates of ± S.D.

Table - 1d: Effect of textile waste water on carbohydrate content, nitrogen content and protein content of *L. esculentum*

Treatment	Carbohydrate (mg gm^{-1})			Nitrogen(%)			Protein(%)		
	Pre-flowering	Peak- flowering	Post- flowering	Pre-flowering	Peak- flowering	Post- flowering	Pre-flowering	Peak- flowering	Post flowering
Control	571.00 ± 1.581	761.00 ± 1.581	591.40 ± 2.073	1.351 ± 0.006	1.208 ± 0.006	0.628 ± 0.004	8.448 ± 0.041	7.556 ± 0.040	3.930 ± 0.027
20%	432.80 ± 2.588	620.00 ± 1.581	486.60 ± 1.341	0.866 ± 0.005	0.595 ± 0.004	0.307 ± 0.002	5.414± 0.032	3.720 ± 0.025	1.924 ± 0.018
	(24.20)	(18.52)	(17.72)	(35.91)	(50.76)	(51.04)	(35.91)	(50.76)	(51.04)
30%	395.40 ± 2.073	404.60 ± 1.816	400.60 ± 3.209	0.629 ± 0.005	0.342 ± 0.005	0.229 ± 0.004	3.932 ± 0.031	2.142 ± 0.034	1.432 ± 0.030
	(30.75)	(46.83)	(32.26)	(53.45)	(71.65)	(63.56)	(53.45)	(71.65)	(63.56)

Values are mean of replicates of ± S.D.

Table - 2: Concentration of heavy metals (mg gm^{-1} d.wt.) in different plant parts of *L. esculentum*

Heavy metals	Plant parts	Pre-flowering stage			Peak-flowering stage			Post-flowering stage		
		Control	20%	30%	Control	20%	30%	Control	20%	30%
Zinc	Leaves	0.455	0.900	1.293	0.301	0.687	1.041	0.476	0.920	1.490
	Stem	0.421	0.706	0.887	0.250	0.547	0.783	0.574	0.828	1.309
	Root	0.257	0.966	1.299	0.399	0.799	1.154	0.605	0.976	1.840
	Composite plant samples	0.398	0.956	1.261	0.261	0.678	0.971	0.436	1.106	1.297
	Fruit samples	-	-	-	-	-	-	0.446	2.300	2.570
Copper	Leaves	0.097	0.259	0.276	0.053	0.136	0.469	0.068	0.137	0.215
	Stem	0.043	0.085	0.138	0.044	0.098	0.207	0.057	0.098	0.109
	Root	0.047	0.179	0.246	0.073	0.179	1.036	0.115	0.179	0.299
	Composite plant samples	0.063	0.170	0.207	0.039	0.099	0.328	0.047	0.168	0.196
	Fruit samples	-	-	-	-	-	-	0.106	0.570	0.800
Chromium	Leaves	0.125	0.427	0.725	0.191	0.348	0.355	0.007	0.256	0.283
	Stem	0.071	0.343	0.583	0.199	0.417	0.473	0.090	0.347	0.524
	Root	0.137	0.428	0.979	0.267	0.525	0.707	0.151	0.596	0.949
	Composite plant samples	0.119	0.348	0.860	0.152	0.415	0.618	0.061	0.449	0.842
	Fruit samples	-	-	-	-	-	-	0.112	1.163	1.520
Lead	Leaves	0.184	0.923	1.126	0.104	0.826	1.134	0.086	0.479	0.694
	Stem	0.346	1.023	1.214	0.219	1.010	1.346	0.183	0.601	0.838
	Root	0.646	1.123	1.719	0.546	0.910	1.124	0.287	0.641	0.863
	Composite plant samples	0.540	0.999	1.110	0.449	0.479	0.694	0.107	0.419	0.694
	Fruit samples	-	-	-	-	-	-	0.190	1.218	2.010

mg gm^{-1} d. wt. in stem; 1.719, 1.124 and 0.863 mg gm^{-1} d. wt. in roots at pre, peak and post-flowering stages, respectively. In composite plant samples, Pb concentration was 1.110, 0.694 and 0.694 mg gm^{-1} d. wt. at pre, peak and post-flowering stages, respectively. While in fruit samples, Pb concentration was 2.010 mg gm^{-1} d. wt. (Table 2).

At 30% effluent treatment, the soil contained 3.510, 3.920,4.000 mg gm^{-1} d. wt. Zn ; 0.710, 1.030 and 1.470 mg gm^{-1} d. wt. Cu ; 5.190, 5.470 and 5.860 mg gm^{-1} d. wt. Cr ; 1.910, 2.400 and 3.940 mg gm^{-1} d. wt. Pb at pre-, peak- and post-flowering stage, respectively (Table 3).

The result of physico-chemical analysis of soil samples is given in Table 4. The pH of the soil samples collected from the pot experiment of *Lycopersicon esculentum* ranged from 7.08 to 7.53 at pre flowering stage, 7.10 to 7.59 at peak flowering stage and 7.13 to 7.62 at post flowering stage. Electrical conductivity varied from 0.304 to 0.477 mmho cm^{-1} at pre flowering stage, 0.340 to 0.520 mmho cm^{-1} at peak flowering stage and 0.350 to 0.526 mmho cm^{-1} at post flowering stage. Chloride concentration varied from 0.300 to 0.700 mg $100gm^{-1}$ at pre flowering stage, 0.300 to 1.151 mg $100gm^{-1}$ at peak flowering stage and 0.300 to 2.460 mg $100gm^{-1}$ at post flowering stage. Organic matter content varied from 5.761 to 6.990% at pre-flowering stage, 6.119 to 7.323 % at peak-flowering stage and 6.222 to 6.887 % at post-flowering stage (Table 4) Earlier studies by Khan and Marwari (2002, 2003) and Khan *et al*. (2003 a, b) reported high concentration of heavy metal in vegetables grown in agricultural fields receiving textile waste water. Metal accumulation in vegetables may pose a direct threat to human health (Türkdogan *et al*., 2003; Damek-Poprawa and Sawicka-Kapusta, 2003). Heavy metals may enter the human body through inhalation of dust, direct ingestion of soil, and consumption of food plants grown in metal-contaminated soil (Cambra *et al*., 1999; Dudka and Miller, 1999; Hawley, 1985). Crop plants growing on heavy metal contaminated medium can accumulate high concentrations of trace elements to cause serious health risk to consumers. Long *et al*., (2003) studied the effects of excess zinc on plant growth of three selected vegetables i.e. Chinese cabbage, celery and pakchoi. They found that excess Zn in growth media caused toxicity to all three vegetable crops and showed symptoms like chlorosis in young leaves, browning of coralloid roots, and serious inhibition on plant growth.

Table - 3: Metal content (mg gm^{-1} d. wt.) in pot soil of *L. esculentum* after harvesting at pre, peak and post-flowering stages

Treatment	Pre-flowering				Peak-flowering				Post-flowering			
	Zn	Cu	Cr	Pb	Zn	Cu	Cr	Pb	Zn	Cu	Cr	Pb
Control	0.760	0.150	0.170	0.130	0.790	0.190	0.195	0.135	0.810	0.210	0.209	0.142
20%	2.700	0.550	2.600	0.790	2.999	0.730	3.650	1.290	3.210	1.250	4.430	1.570
30%	3.510	0.710	5.190	1.910	3.920	1.030	5.470	2.400	4.000	1.470	5.860	3.940

Table - 4: Physico-chemical analysis of pot soil of *L. esculentum* after harvesting at pre, peak and post-flowering stages

Treatment	Pre-flowering				Peak-flowering				Post-flowering			
	pH	EC (mmhos cm^{-1})	Chloride (mg $100gm^{-1}$)	Organic matter (%)	pH	EC (mmhos cm^{-1})	Chloride (mg $100gm^{-1}$)	Organic matter (%)	pH	EC (mmhos cm^{-1})	Chloride (mg $100gm^{-1}$)	Organic matter (%)
Control	7.08	0.304	0.300	5.761	7.10	0.340	0.300	6.119	7.13	0.350	0.300	6.222
20%	7.46	0.404	0.600	6.247	7.50	0.415	0.710	6.540	7.56	0.518	0.900	6.503
30%	7.53	0.477	0.700	6.990	7.59	0.520	1.151	7.323	7.62	0.526	2.460	6.887

Yang *et al.* (2002) assessed copper thresholds for phytotoxicity and potential dietary toxicity in selected vegetables crops. Lokeshwari and Chandrappa (2006) reported that Zn and Cd content in food crops increased with the degree of contamination of the soil. Different vegetable species accumulate different metals depending on environmental conditions, metal species and plant available forms of heavy metals. Singh and Agarwal (2006) reported that cowpea, okra raddish, spinach, chickpea, pea and wheat grown in heavy metals contaminated soils affected biomass, yield and metal distribution in different parts of crop plants. Among the heavy metals, Zn showed highest tissue concentration followed by Cu, Pb and Cd. The concentration of metals was higher in edible parts of leafy vegetables such as spinach and radish than in the edible parts of fruit type of vegetables and field crops. Among the crops, wheat showed maximum uptake of Cu and Zn, while spinach and okra manifested maximum uptake of Pb and Cd respectively. Although maximum proportion of heavy metals absorbed by the crops accumulated in their vegetative shoots (leaves, stem and root), but substantial proportion of metals transported to seeds and fruits as well. Athar and Ahmad (2002) conducted a pot study to investigate the toxic effects of certain heavy metals on the plant growth and grain yield of wheat (*Triticum aestivum L.*). The results revealed that heavy metals brought about significant reductions in both parameters, Cd being the most toxic metal followed by Cu,Ni, Zn, Pb and Cr. Moreover, the presence of Cd in the soil resulted in the maximum inhibition (84.9%) in the number of freeliving *Azotobacter chroococcum* cells over the control. The phytotoxicity was apparently due to the susceptibility of the free living *Azotobacter chroococcum* cells to the toxic doses of heavy metals. Protein content decreased from 19.0–71.4% in metal exposed plants at metal concentrations equivalent to those found in polluted soil. Metal uptake by grains was directly related to the applied heavy metal with greater concentrations of metals found in cases where metals were added separately rather than in combinations. The toxic effects on the plant growth, nitrogen content in plant parts, and protein content in grains, exerted by two metals in combination were not additive, but rather only as severe as for the most toxic metal alone.

Klumpp *et al.* (2003) reported that high sulphur and copper deposition significantly reduce microbial biomass and altered functional diversity of soil microorganisms. Brun *et al.* (2003) quanitifed survival growth and and reproduction in *Poa annua* throughout one flowering season and found that high concentration of copper in the soil resulted in low survival, low total plant biomass, delayed in flowering and fruiting and low seed set. Gagnon and Isabelle (2003) studied the distribution and fate of metals in the municipal effluents. While Zwetien *et al*. (2004) reported that no earthworm was found in orchard soil containing 270 mg kg^{-1} Cu. Thus, the practice of growing vegetables using sewage and textile waste water should be checked in order to reduce biomagnification of metals *via* food chain.

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