

Impact of Textile Dying Wastewater Irrigation on Yield, Growth and Food Value of Tomato

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Abstract: *In Bangladesh, textile dyeing industries are the main culprit for terrific water pollution during the last two decades. Besides, huge water consumption for industrial activities causes a tremendous pressure on groundwater resources. For example, on an average 200-300 liters of fresh water is used for each kg of hosiery and nearly 75 to 95 percent of which is discharged as effluents. Hence, reuse of wastewater in irrigation or other reasonable purposes can solve these problems. This study was conducted to evaluate the suitability of seven different types of textile dyeing wastewater (untreated) for irrigation of fruit vegetable like Tomato. An experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications. Tomato plants were irrigated by groundwater (control) and seven different types of textile dyeing wastewater (untreated) to study the effects on yield, growth and food value of tomato. Wastewaters were analyzed and compared with irrigation water quality standards. Although, two type of wastewater, i.e. wastewater generated from the second wash after dyeing and raw effluent of ETP did not meet the irrigation water quality standards, they did not render remarkable effect on plant's growth and yield of tomato. Vitamin C of tomato which was irrigated with wastewater did not vary substantially in comparison with groundwater. However, beta carotene, chlorophyll a, and chlorophyll b of wastewater irrigated plants varied significantly with that of groundwater irrigated tomato. The study suggests that this type of wastewater can be reused in irrigation purposes as they do not have significant effect on plant's growth and yield. However, further studies could be carried out to examine the variation of nutritional qualities.*

Keywords: *irrigation, nutritional qualities, physicochemical properties, textile wastewater, yield and growth.*

1. Introduction

The textile and dyeing industries have occupied a major position in the industrial sector of Bangladesh with the increasing demand of ready-made garments for local consumption as well as export business. With the industrial development in Bangladesh, the waste management systems did not develop accordingly [1]. Almost all industries are seen to discharge their wastes into water and on land without any treatment or after partial treatment. The toxicity of the river water is increasing day by day due to untreated wastewater discharge from industries. Textile and dye industries consume large volume of water and chemicals for wet processing of textiles. On an average 200-300 liters of fresh water is used for each kg of hosiery and nearly 75 to 95 percent of which is discharged as effluent [2]. Effluents from industries are normally considered as the main industrial pollutants containing organic and inorganic compounds, acids, alkalis, suspended solids

and other materials. When untreated effluents are discharged in to the environment, they disrupt the ecological niches of living organisms.

Though the industrial effluent is a great burden for environment, it has some useful aspects which may be reutilized for beneficial purposes. Instead of disposal of wastewater into the environment, there has been it is widely used in both developed and developing countries including India and Pakistan for agricultural irrigation and other purposes after its treatment [3][4]. This type of practice in Bangladesh has not yet started. Since the generation of industrial effluent is a continuous process; it can be used to meet the substantial irrigation requirements in Bangladesh.

The industrial effluent as an alternative means of irrigation can offer a number of advantages. It contains various trace elements which can satisfy the need of micronutrients of crop plants. The environment can be saved from its hazardous effects and utilizing the effluent the dependency on groundwater can be reduced to a great extent.

In this experimental research, different qualities wastewater; generated from textile dyeing industries were used in irrigation of tomato. Several physicochemical properties were investigated and plants growth and yield were measured along with nutritional qualities.

2. Methodology

2.1. Sample Collection

Less contaminated wastewater samples were collected from Le-Nouveautex (Pvt.) Ltd, a dyeing and readymade garment industry; situated in the vicinity of DUET, Gazipur using 120 litter plastic drum for irrigation of vegetables. The wastewater samples were collected from dyeing process (D2, D3, D3, D4, D5, D6, and D7). Mixed effluent sample (D8) was taken from equalization tank of ETP and groundwater sample (D1) was collected as control treatment from a tube-well near experimental site. Two litter plastic bottles were used for collecting wastewater samples from plastic drums for analysis purposes. Bottles were thoroughly washed with 1 (M) HCl and rinsed several times with de-ionized water before sample collection. Sampling was carried out using the grab method except mixed effluent [5].

2.2. Laboratory Analysis of Wastewater

The pH, temperature and electrical conductivity were measured during collection of wastewater before acidified according to the standard procedures[6]. Colour, nitrate (NO_3^-), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}) were carried out in the laboratory using DR-2800™ Spectrophotometer. Electrical conductivity (EC) was determined by conductivity meter (EC150, HACH). Biochemical oxygen demand (BOD5) was measured following dilution method (APHA, 1998). Dissolved oxygen (DO) was measured by chemical method and chemical oxygen demand (COD) was determined by dichromate digestion process. Chloride was determined by Mohr's method. Total solids (SS) was measured gravimetrically while suspended solids (SS) was obtained by subtracting the TDS from TS. The determinations of heavy metals (nickel, zinc, copper and chromium) were carried out using Atomic Absorption Spectrophotometer (SPECTRA A.A-55B, VARIAN, Australia) as per standard method.

2.3. Cultivation of Tomato

Pot experiment of Tomato was conducted at the nursery of Horticulture Department at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh on January, 2014- May, 2014. 24 pots were arranged according to the randomized complete block design (RCBD) with three replications for eight wastewater samples including one groundwater irrigated plants. After rising of plants, thinning and wedding were done properly and each pot was irrigated with equal amount (500 ml) of wastewater from respective drum at one alternate day to keep soil moisture. Harvesting was done 120 days after seed sowing because maximum

yield and growth of Tomato was obtained in this period. Plants and fruits were taken randomly from each replication of treatments to analysis the growth and yield of Tomato.

2.4. Nutritional Analysis

Fresh tomato was sampled manually for estimations of chlorophyll and β carotene. Chlorophyll and β carotene pigments were extracted in 80% acetone and estimated according to the methods of Maclachlan and Zalik [7] and Duxbury and Yentsch [8], respectively. Ascorbic acid was determined by the methods described by Keller and Schwager [9].

3. Results and Discussions

3.1. Physicochemical Properties of Wastewater and Groundwater

Physicochemical properties of different textile dyeing wastewater and groundwater were compared with irrigation water quality standard, suggested by DOE (Department of Environment, Bangladesh) to understand the suitability for using in irrigation purpose. A range of parameters such as pH, colour, turbidity, BOD, COD, DO, TDS and SS were measured of the collected samples and analytical results are shown in Table 1.

TABLE I: Physicochemical Properties of groundwater and wastewater

Source of Sample	Sample ID	pH	Color (Pt. Co Unit)	Turbidity (N.T.U)	Dissolved Oxygen (DO) (mg/L)	EC (Micro S/cm)	BOD (mg/L)	COD (mg/L)	Dissolved Solid (mg/L)	Suspended Solid (mg/L)
Irrigation std. Of DOE		6.0-9.0	NA	NA	4.5-8.0	1200	100	400	2100	200
Groundwater	D1	7.35	32	8.83	2.33	379	2	ND	180	ND
2 nd wash after scouring and bleaching	D2	9.18	270	10.80	5.17	920	90	260	750	20
Enzyme treated wastewater	D3	4.95	121	6.64	3.52	1586	600	1340	1920	140
2 nd wash after dyeing	D4	8.15	800	13.20	4.35	5730	12	56	1790	130
Neutralized wastewater	D5	7.54	670	12.30	3.85	1627	65	135	1080	130
2 nd wash after soaping	D6	7.81	500	83.00	4.52	593	20	77	320	110
Fixing Wastewater	D7	7.25	269	26.30	4.43	666	10	93	380	10
Mixed Effluent	D8	9.26	1550	98.40	0.14	3100	340	638	3280	300

[NA= Not available]

pH is one of the important parameters for irrigation water because nutrients uptake by plants depends on soil pH. pH in different wastewater varied and enzyme treated, second wash after scouring and bleaching and mixed wastewater exceeded the recommended range (6.0-9.0) of pH which might be using of acid and alkali in fabric treatment process. Considering dissolved oxygen, mixed wastewater is the poorest quality wastewater

The BOD and COD levels of wastewater varied from 10 -600 mgL⁻¹ and 56 –1340 mgL⁻¹ respectively. It has shown that BOD and COD levels of enzyme treated wastewater and mixed effluent surpassed the irrigation levels. Both amounts reflect the dangerous impact of using this wastewater for irrigation. Moreover, dissolved solids and suspended solids in mixed effluent were 3280 mgL⁻¹ and 300 mgL⁻¹ and these values exceeded the irrigation standard.

3.2. Heavy Metals in Wastewater

Residual metal complex dyes in wastewater are the main source of heavy metals. Except D8, less contaminated wastewater were collected as sample for further reusing in irrigation without treatment.

TABLE II: Concentration of Heavy Metals in wastewater

Sample source	Sample ID	Trace Heavy Metals (mg/L)				
		Cr	Pb	Ni	Cu	Zn
Irrigation Standard (mg/kg)		1.0	NA	1.0	3.0	10.0
Ground Water	D1	0.129	0.316	ND	ND	3.421
2nd wash after scouring and bleaching	D2	0.209	0.055	ND	ND	ND
Enzyme treated wash water	D3	0.174	0.047	ND	ND	0.219
2nd wash after dyeing	D4	0.164	0.119	ND	ND	ND
Neutralized wash water	D5	0.244	0.134	ND	ND	ND
2nd wash after soaping	D6	0.214	0.150	ND	ND	ND
Fixing wastewater	D7	0.194	0.095	ND	ND	0.145
Mixed Effluent	D8	0.184	0.184	ND	0.066	ND

ND: not detectable (The minimum detectable limit of Atomic absorption Spectrophotometer for Cu, Zn, Cr, Pb and Ni were 0.002)

NA: Not Available

Heavy metals particularly chromium (Cr), copper (Cu) and zinc (Zn) are widely used for the production of color pigments of textile dyes [10]. The detected amounts of heavy metals in wastewater samples were found to be well below of their respective acceptable limits of irrigation standard [11]. Ni was the below detectable range of Atomic Absorption Spectrophotometer (AAS) in all wastewater samples where Cu was detected only in D8 (Table 2). Therefore, heavy metals are not taken under consideration for further investigation in plants and fruits.

3.3. Growth Performance of Tomato Plants

The number of leaves of a plant is an important character of plant's growth. The highest numbers of leaves were found in D4 while the number of leaves in D5 was the lowest. The figures were 47.66 and 29.66 respectively. D1, D2, D3 and D7 treatments produced almost equal number of leaves (44.66 to 46.33). However, there is no significant variation was found for the total number of leaves in different wastewater treated plants.

Similarly, leaf length of different treatments did not varied remarkably. Leaf length varied from 25 cm to 27 cm. On the other hand, leaf widths of all treatments were statistically similar and varied from 15.66 cm to 19.33 cm.

TABLE III: Growth of tomato plant

Treatments	Leaf Number	Leaf length	Leaf width	Plant height	Shot fresh weight	Root length
D1	46.00a	25.00a	16.33a	168.00a	79.21a	34.00a
D2	46.33a	26.00a	19.33a	152.67a	70.27a	35.66a
D3	46.00a	26.00a	15.66a	146.00a	54.75a	19.00a
D4	47.66a	26.33a	18.33a	159.67a	72.50a	38.00a
D5	29.66a	27.00a	16.66a	154.00a	63.11a	36.00a
D6	37.00a	26.66a	16.33a	194.33a	81.88a	35.33a
D7	44.66a	25.33a	17.00a	180.33a	82.94a	42.66a
D8	32.00a	25.66a	18.00a	160.67a	67.04a	29.66a
CV%	41.83	10.63	21.04	11.52	22.10	35.54

NB: In a column, means followed by common letters are not significantly different from each other at 5% level of probability by DMRT.

Statistically no significant difference was observed in the plant height of tomato. Maximum plant height was recorded from D6 (194.33 cm) while it was minimum in D3 (146.00 cm). The plant height of other treatments varied from 152.67 cm to 180.33 cm.

The highest shot fresh weight was in D7 (82.94 cm) whereas the lowermost weight was in D5 (63.11 cm). Maximum root length was seen in D7 and the minimum root length was found in D3.

3.4. Yield of Tomato

The yield of tomato generally asses by the fruit size, number of fruits per plants and fruit weight etc. Results shown in Table 4 reveal that although the fruit size and individual fruit weight varied significantly, the number of fruits and yield per plant were statistically similar. Individual fruit fresh weight varied from 13.78 g to 21.98 g . The highest yield was observed in D5 (600.71 g) while the lowest yield was found in D2 (248.92 g). The yield of all treatments can be arranged in decreasing order as follows: D5> D1> D8> D6> D3> D7> D4> D2.The number of fruits varied from 14 to 27.33 where D2 treatment produced the lowest number of fruits. Siddique et al. [12] shown that the production of tomato (number/plant) cultivated with different organic manure varied from 13 to 30 per plants. As the most of the dyeing wastewater were less polluted, therefore, it may have not significant impact on yield of tomato.

TABLE IV: Yield of Tomato

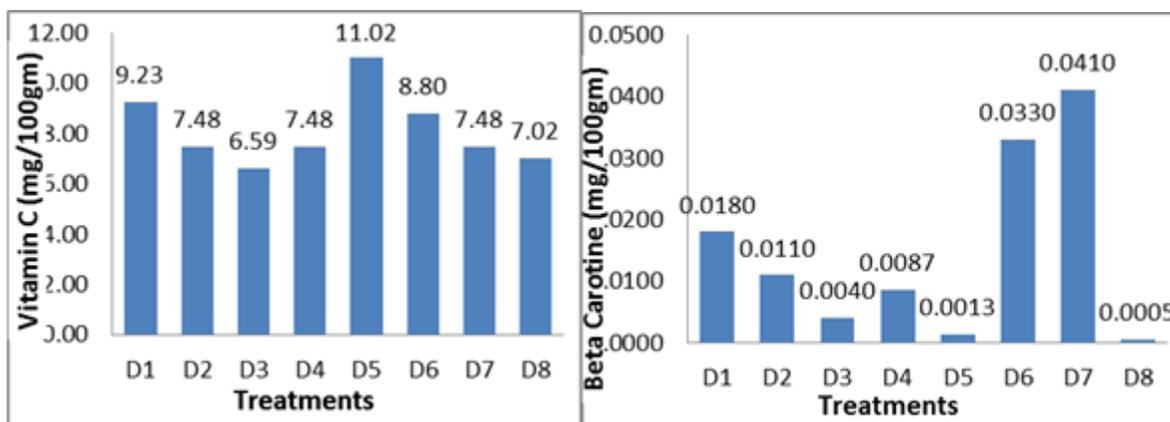
Treatments	Individual Fresh Weight(g)	Fruit Length (mm)	Fruit Width (mm)	Fruit Fresh weight (g)	Fruit Dry weight(g)	Fruit number/Plant	Yield /plant (g/plant)
D1	19.61a	32.18a	32.28ab	19.19abc	2.886a	24.00a	470.64a
D2	17.78a	32.32a	34.32a	21.39a	2.413a	14.00a	248.92a
D3	15.55a	27.64ab	29.57ab	13.31bc	2.540a	22.00a	342.10a
D4	13.93a	27.33b	28.42b	12.04c	2.333a	19.00a	264.67a
D5	15.54a	27.86ab	28.76b	12.64bc	2.256a	27.33a	600.71a
D6	21.98a	32.09a	33.09ab	19.38ab	2.873a	22.33a	347.01a
D7	13.78a	31.39ab	31.03ab	15.81abc	2.673a	21.33a	293.93a
D8	17.60a	30.92ab	33.07ab	19.21abc	3.566a	22.66a	398.82a
CV%	18.60	5.41	5.34	14.99	31.32	19.57	18.38

NB: In a column, means followed by common letters are not significantly different from each other at 5% level of probability by DMRT

3.5. Nutritional Qualities of Tomato

• Vitamin C and Beta Carotene

There was significant variation observed in Vitamin C of Tomato among the treatments irrigated with wastewater compared with groundwater. Vitamin C was varied from 6.59 to 11.02 mg/100 g whereas groundwater treated plant contained 9.23 mg mg/100 g (Figure 1a). The amount of β carotene in Tomato varied from 0.0005 to 0.0410 mg/100 g. The β carotene in D2, D4, D6 and D8 irrigated plants were also significantly varied with D1 irrigated plant which is 0.0180 mg/100 g (Figure 1b).



(a) Vitamin C

(b) Beta Carotene

Figure 1: (a) Vitamin C and (b) Beta Carotene

- **Chlorophyll A and Chlorophyll B**

In Tomato, the amount of Chlorophyll A and Chlorophyll B of different wastewater treated plants were significantly varied from the groundwater irrigated plant. The highest amount of both Chlorophyll A and Chlorophyll B were seen in D7 treated plant 0.85 mg/g and 0.38 mg/g respectively. The concentration of Chlorophyll A and chlorophyll B ranged from 0.14 to 0.85 mg/g and 0.07 to 0.38 mg/g in Tomato (Figure 1a & b).

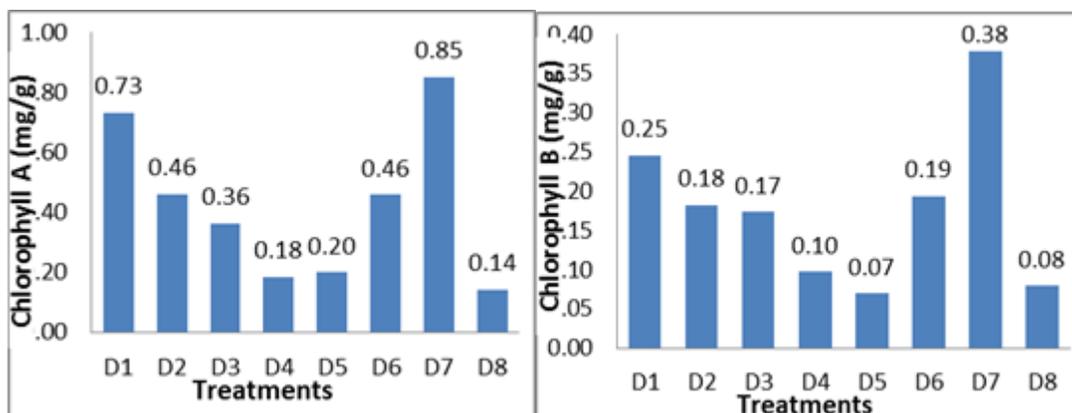


Figure 2: (a) Chlorophyll A and (b) Chlorophyll B

Vitamin C in Tomato was 6.59- 11.02 mg per 100. These figures are varied significantly with ground water irrigated Tomato (9.23 mg/100g). In Tomato, beta carotene in wastewater irrigated plant (ranges 0.0005-0.0410 mg per 100 gm) was different from groundwater treated plant (0.0180 mg/100g). In Tomato, the amount of chlorophyll a and chlorophyll b were significantly varied in wastewater treated plats than ground water treated plant.

4. Conclusions

This study was conducted to assess the the suitability of different type of effluents from textile dyeing process in cultivation of fruit vegetables. Different physicochemical properties were analyzed along with the different yield and growth parameters of tomato plants. Moreover, nutritional qualities also determined of tomato, cultivated with different type of wastewater and compared with that of the ground water. Although, heavy metals in different wastewater were not quite a threat for short term irrigation however, wastewater generated from the second wash after dyeing and raw effluent of ETP were not fulfill the all requirements of irrigation standard. But, no significant impact of these wastewater were not found in plant's growth and yield. On the other hand, vitamin C in different wastewater irrigated tomato was not remarkable varied with the ground

water irrigated tomato whereas, beta carotene, chlorophyll a and chlorophyll b varied remarkably in different wastewater irrigated tomato.

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