

**IMPACT OF TEXTILE DYEING EFFLUENTS ON GERMINATION,  
GROWTH, YIELD AND NUTRITIONAL QUALITY OF  
TOMATO (*Solanum lycopersicum* L.)**

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**Abstract**

An experiment was conducted at the experimental field of the Soil Science Division, Bangladesh Agricultural Research Institute (BARI) during 2017-18 to find out the impact of textile dyeing effluents on germination and seedling stage for the production of Tomato. There were six treatments comprising five concentrations of textile dyeing effluents along with ground water as control treatment for irrigation purposes and tomato (var. BARI tomato-15) was used as plant material. In most of the cases 100% ground water irrigation (T<sub>6</sub> treatment) treated plant showed the best result regarding plant characteristics such as germination percentage (100%), fresh weight of fruit (70.00 g), yield/plant (1867g) which were statistically identical to waste water 20% + 80% of pure water treatment (T<sub>5</sub>). On the other, waste water 100% + pure water 0% (T<sub>1</sub> treatment) showed the lowest result were germination percentage (66.67%), fresh weight of fruit (59.21g) and yield/plant (553 g). T<sub>6</sub> treatment showed the highest amount of ascorbic acid (1.34 mg/100 g) and β-carotene (0.08 mg/100 g) and the lowest amount (0.65 mg/100 g and 0.02 mg/100 g, respectively). The accumulation of heavy metals such as Zn, Fe, Cu, Pb accumulated in fruits at the rate of 3.95-9.73, 3.34-9.42, 4.43-11.31 and 2.79-6.19 ppm, respectively. Among these T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> treated samples, those containing Zn, Fe, Cu and Pb exceed the WHO recommended permissible limit. So, it can be suggested that, selected wastewater of a dyeing factory should be applied as irrigation water for the purpose of crop production as well as tomato cultivation.

Keywords: Textile, effluents, tomato, germination, growth, nutritional quality.

**Introduction**

Bangladesh is an agricultural country, where industrialization is taking place in a gradually increasing phase. The important industries are textiles, leather tanning, fertilizer, sugar, chemical, pharmaceutical, oil refining etc. Among these, textile industry is rapidly expanding day by day. There are 2030 small and large knit dyeing industries in Bangladesh (BKMEA, 2015). These industries are major source of effluents due to the nature of their operations, which require a high volume of water that eventually results in high waste water generation. The most common textile wet processing set up consists of desizing, scouring, bleaching,

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mercerizing, dyeing as well as finishing processes. Among these dyeing is the process of adding color to the fibers, which normally requires a large volume of water and reported that to dye 1 kg of cotton materials with reactive dyes requires an average of 70-150 L water, 0.6 kg NaCl and 40 g reactive dyes, alkalis and others pretreatment and dyeing auxiliaries (Allegre *et al.*, 2006). After the completion of dyeing, the used water is discharged as wastewater or effluents.

The wastewater from textile processing contains huge residues of dyestuff, which are major sources of heavy metals, salt, organic halogens (AOX), acid, alkalis, carcinogenic aromatic amines and color (Reife, 2003 & Smith, 2006). Dyeing effluents are characterized by high bio-chemical oxygen demand (BOD), Chemical oxygen demand (COD), sodium and other dissolved solids as well as micro nutrients and heavy metals (Garg & Kaushik, 2007). Considering these facts, textile industries are considered harmful for our natural environment such as soil, plants, aquatic life and human being as well.

Industrial wastes are the major source of heavy metals in the surface water, ground water and soils (Correia, 1998). On the other hand, heavy metals such as Cadmium, Copper, Plumbum, Nickel and Mercury may be present in soil from the parent materials during soil formation. Soil is a supporting layer for all organisms in the world. The most important one is that soil acts as a medium for plant growth and can recycle the nutrient and resources needed by plant. Soil will absorb heavy metals from the polluted wastewater as well as ground water and these will cause side effects for vegetable growth. As root grows in the soil, it will absorb water and nutrients from the solution. Heavy metals that are attached to soil water and soil particles will be absorbed by plant roots and accumulate in vegetables (Ross, 2007).

Higher concentrations of heavy metals in human bodies may induce tumors and mutations and are capable of causing genetic damage to germ cells (Dianne *et al.*, 1999). It is seen that several research studies were done on the above mentioned issue in different parts of the world. Regarding the issue, only a few research studies have been done in Bangladesh with leafy vegetables. However, no research has been conducted with fruit crops, specifically tomato. This is very popular vegetable in Bangladesh and has good nutritional value and taste. This vegetable is possible to cultivate in the effluent discharge areas. The present study was undertaken to observe the toxic effect of textile dyeing effluents on growth and yield of tomato and to find out the suitable stages of textile effluents for safe reutilization as irrigation.

## **Material and Methods**

### **Collection of Textile Effluents**

A pot experiment was conducted at the experimental field of Soil Science Division, Bangladesh Agricultural Research Institute (BARI) during 2017-18. Different

concentrations of textile dyeing effluents were collected in pre cleaned plastic bottles from Tex Euro Bd. Ltd, a 20 tons dyeing capacity knit composite factory that is situated near Gazipur, Bangladesh. The effluents were stored at 25°C temperature to avoid changes in their physiochemical properties. Various physiochemical characteristics were analyzed at the laboratory of Soil Science Division, BARI, Joydebpur, Gazipur to assess the effects of textile dyeing effluents on germination, growth, yield and nutritional quality of tomato. A germination test of tomato seed under different concentrations of textile dyeing effluents was conducted in soil Physics lab. In case of field growth observation, three tomato plants were planted in each pot. After being planted, all plants were irrigated by textile dyeing effluents according to treatments. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. A treatment detail of the treatments is given below.

T<sub>1</sub> = Waste water 100% + pure water 0%

T<sub>2</sub> = Waste water 80% + pure water 20%

T<sub>3</sub> = Waste water 60% + pure water 40%

T<sub>4</sub> = Waste water 40% + pure water 60%

T<sub>5</sub> = Waste water 20% + 80% of pure water

T<sub>6</sub> = Waste water 0% + pure water 100% (control)

#### **Laboratory analysis of textile dyeing effluent**

The physico-chemical parameters such as pH, temperature, electrical conductivity, dissolved oxygen (DO), total suspended solids (TSS), total dissolved solids (TDS), and nitrate (NO<sub>3</sub><sup>-</sup>), phosphate (PO<sub>4</sub><sup>-3</sup>), sulphate (SO<sub>4</sub><sup>-2</sup>), chloride (Cl<sup>-</sup>) and some heavy metals were determined in the soil science laboratory at the BARI, Gazipur. The pH and temperature of waste water were determined using portable HACH pH meter. Determination of other parameters such as nitrate (NO<sub>3</sub><sup>-</sup>), sulphate (SO<sub>4</sub><sup>-2</sup>), phosphate (PO<sub>4</sub><sup>-3</sup>) was carried out in the laboratory using DR-2800™ portable Spectrophotometer. Electrical conductivity was determined by conductivity meter (EC150, HACH). Biochemical oxygen demand (BOD) was measured by dilution method (APHA, AWWA and WEF, 1998). Keeping samples 5 days in an incubator at 20°C after measuring initial DO of samples. Dissolved oxygen (DO) was measured by chemical method. Chemical oxygen demand (COD) was determined by dichromate digestion method. Chloride was determined by Mohr's silver-nitrate method. Suspended solids (SS) were measured gravimetrically while total solid was obtained by the sum of SS and TDS. Heavy metals (nickel, zinc, copper, chromium, lead, and cadmium) determination was carried out using Atomic Absorption Spectrophotometer (SPECTRA A.A-55B, VARIAN, and Australia) as per standard methods.

The experiment was laid out following the randomized complete block design (RCBD) with three replication. The values were subjected to one-way analysis of

variance (ANOVA) and DMRT for comparison of means to determine statistical significance by using open source R program.

## Results and Discussion

### Physiochemical properties of wastewater and groundwater

The pH of different wastewater treatments varied between 7.2 and 9.5 while T<sub>1</sub> and T<sub>2</sub> exceeded the recommended value (6.5 to 8.5) of DOE for irrigation water quality standard and the values were 9.5 and 9.1, respectively. The concentration of total dissolved solids (TDS) was found to be well above in sample T<sub>1</sub> (3320 mg L<sup>-1</sup>) than the irrigation standard (2100 mg L<sup>-1</sup>) suggested by DOE. The concentration of total suspended solids (TSS) in T<sub>1</sub> was 310 mg L<sup>-1</sup> which was much higher than the prescribed value (200 mg L<sup>-1</sup>) of DOE for irrigation. The value of electrical conductivity (EC) highest in T<sub>1</sub> wastewater samples was 3450  $\mu\text{s cm}^{-1}$  which exceeded the standard limit (1200  $\mu\text{s cm}^{-1}$ ). T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> treatments also exceeded the standard limit. Dissolved oxygen (DO) is very important for aquatic life. The DO of different studied samples was in this range except for T<sub>1</sub> T<sub>2</sub> & T<sub>3</sub> which contained the lowest DO (0.58, 2.85, 3.58 mg L<sup>-1</sup>, respectively). Moreover, other element contents such as sulphate, nitrate, phosphate, lead, copper, nickel, cobalt, chromium and zinc were within the standard limit for irrigation purposes (table 1).

**Table 1. Physio-chemical parameters of textile dyeing effluent**

Parameters	Irrigation standard (DOE)	Treatments					
		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>
pH	6.5-8.5	9.5	9.1	8.2	7.4	7.3	7.2
TDS (mg/l)	2100	3320	2790	2070	1380	690	300
TSS (mg/l)	200	310	260	195	142	78	30
EC ( $\mu\text{s cm}^{-1}$ )	1200	3450	2690	1950	1355	660	350
DO (mg/l)	4.5-8	0.58	2.85	3.58	4.8	5.77	6.5
Cl <sup>-</sup> (mg/l)	1000	2700	8	2500	64	42	31
NO <sub>3</sub> <sup>-</sup> (mg/l)	10	0.8	1.0	1.2	1.3	1.4	1.5
PO <sub>4</sub> <sup>-</sup> (mg/l)	15	0.19	0.23	0.32	0.38	0.48	0.52
SO <sub>4</sub> <sup>-2</sup> (mg/l)	1000	65	48	35	21	10	0
Copper (ppm)	3	0.1110	0.0890	0.0275	0.0050	0.0002	BDR
Zinc (Zn) ppm	10	0.9140	0.7940	0.5660	0.4154	0.3240	BDR
Iron (Fe) ppm	1.0	0.7306	0.3406	0.0870	0.0326	0.0078	BDR
Lead (Pb) ppm	0.1	0.0262	0.0050	BDR	BDR	BDR	BDR

Note: DOE= Department of Environment, Bangladesh, BDR= below the detectable range  
T<sub>1</sub> = waste water 100% + pure water 0%), T<sub>2</sub> = waste water 80% + pure water 20%), T<sub>3</sub> = waste water 60% + pure water 40%), T<sub>4</sub> = waste water 40% + pure water 60%), T<sub>5</sub> = waste water 20% + pure water 80%), T<sub>6</sub> = waste water 00% + pure water 100% (control).

### Germination percentage

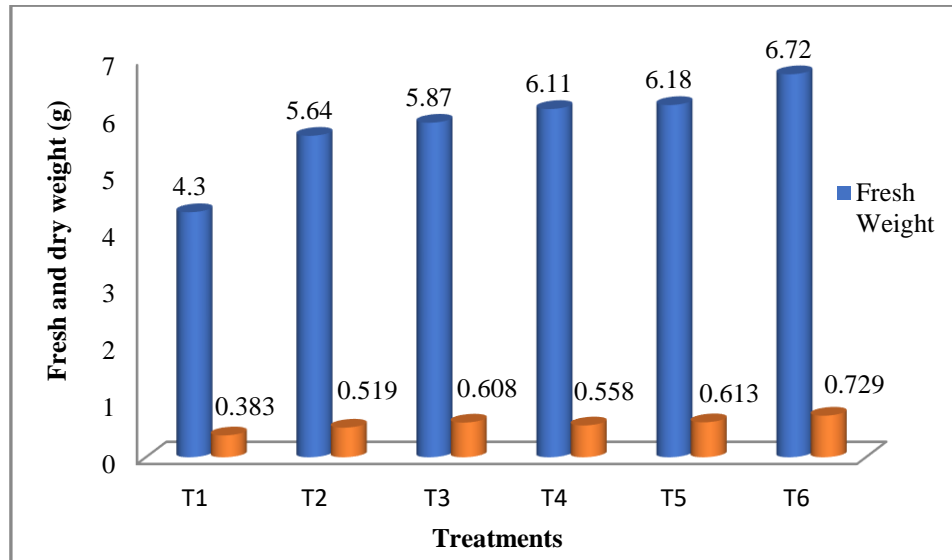
Germination percentage varied significantly among the treatments at 2 DAS and 5 DAS (Days After Seeding) but there was no significant variation among the treatments at 3 and 4 DAS. In case of 2 DAS the germination percentage ranged between 0 to 33.33% where the maximum germination percentage observed in treatment T<sub>6</sub> (33.33%) and the lowest in the T<sub>1</sub> (0.00%) which was statistically similar to T<sub>2</sub> (6.67%) and T<sub>3</sub> (6.67%). In case of 3 DAS and 4 DAS there was no significant variation among the treatments. In case of 5 DAS treatments T<sub>5</sub> and T<sub>6</sub> showed the highest result of (100%) germination. However, T<sub>1</sub> showed the lowest result of (0.00%) germination. The other treatments showed a moderate germination percentage which ranged from 33.33%-83.33%. From the above findings it is assumed that the germination rate is almost inhibited with increasing concentrations of effluents. It may also occur due to high pH and high temperature of the effluent. Ramana, *et al.*, (2002) showed the effect of different concentrations (0%, 5%, 10%, 15%, 20%, 25%, 50%, 75% and 100%) of distillery effluent (raw spent wash) on seed germination in some vegetable crops viz., tomato, chili, bottle gourd, cucumber and okra and stated that higher the concentration, the lower the germination percentage.

### Fresh and dry weight of plant at 3<sup>rd</sup> leaf stage

The fresh weight of plant at 3<sup>rd</sup> leaf stage was found to be the highest in T<sub>6</sub> treatment (6.72 g) and the lowest in T<sub>1</sub> treatment (4.30 g) (Figure 2). The other treatments varied from 5.64 g - 6.18 g. In case of dry weight of plant at 3<sup>rd</sup> leaf stage, the highest was found in T<sub>6</sub> treatment (0.729 g) and the lowest was in T<sub>1</sub> treatment (0.383 g). There was no significant difference among the other treatments. Khan *et al.*, (2009) showed that plant growth promoting factors largely depend on the irrigation water, which determines the external and internal characteristics of plant. The application of textile dyeing wastewater into soil for irrigation purposes raises the soil pH, EC and SAR values which reduce nutrient uptake by vegetative growth of plant. Since among the different stages of textile effluents used in the present study T<sub>1</sub> treated samples contained several constituents that had a negative impact on plant growth habit and provided the lowest fresh and dry weight as well.

**Table 2. Effect of textile dyeing effluent on fresh and dry weight of plant**

Treatments	Fresh Weight (g)	Dry Weight (g)
T <sub>1</sub> =Waste water 100% + pure water 0%	4.30	0.383
T <sub>2</sub> =Waste water 80% + pure water 20%	5.64	0.519
T <sub>3</sub> =Waste water 60% + pure water 40%	5.87	0.608
T <sub>4</sub> =Waste water 40%+ pure water 60%	6.11	0.558
T <sub>5</sub> =Waste water 20% + 80% of pure water	6.18	0.613
T <sub>6</sub> =Waste water 0% + pure water 100% (control)	6.72	0.729
CV (%)	7.91	8.49



**Fig. 2. Effect of textile dyeing effluent on fresh and dry weight of plant.**

T<sub>1</sub> = waste water 100% + pure water 0%), T<sub>2</sub> = waste water 80% + pure water 20%), T<sub>3</sub> = waste water 60% + pure water 40%), T<sub>4</sub> = waste water 40% + pure water 60%), T<sub>5</sub> = waste water 20% + pure water 80%), T<sub>6</sub> = waste water 00% + pure water 100% (control)

**Table 3. Effect of textile dyeing effluent on fruit characteristics and yield**

Treatment	Plant height (cm)	No of fruit/plant	fruit Length (cm)	fruits diameter (cm)	Fresh weight/fruit (g)	Yield/ plant (g)
T <sub>1</sub>	54.56	9.33	3.87	3.52	59.21	553
T <sub>2</sub>	59.31	14.00	3.91	3.56	62.32	873
T <sub>3</sub>	62.89	18.33	3.93	3.59	63.47	1164
T <sub>4</sub>	67.39	19.67	3.96	3.61	65.35	1286
T <sub>5</sub>	68.32	23.33	4.09	3.64	67.50	1575
T <sub>6</sub>	71.13	26.67	4.33	3.67	70.00	1867
CV (%)	8.88	9.79	3.90	1.37	5.42	15.38
LSD (0.05)	2.81	3.34	0.24	0.03	2.50	292

T<sub>1</sub> = waste water 100% + pure water 0%), T<sub>2</sub> = waste water 80% + pure water 20%), T<sub>3</sub> = waste water 60% + pure water 40%), T<sub>4</sub> = waste water 40% + pure water 60%), T<sub>5</sub> = waste water 20% + pure water 80%), T<sub>6</sub> = waste water 00% + pure water 100% (control)

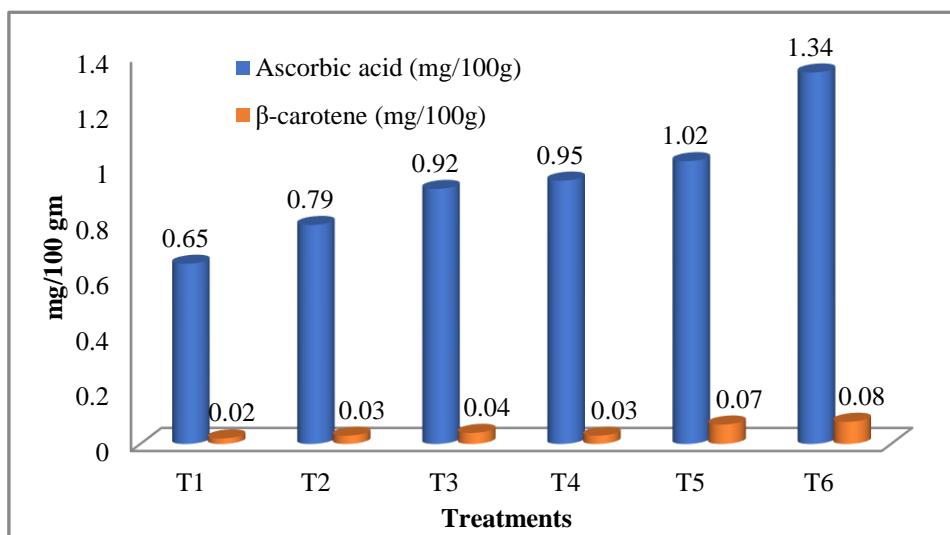
### Fruit characteristics and yield

The highest plant height was observed in T<sub>6</sub> treatment (71.13 cm), while the shortest plant in T<sub>1</sub> treatment (54.56 cm) (Table 3). The highest number of fruits was counted in T<sub>6</sub> treatment (26.67), while the lowest in T<sub>1</sub> treatment (9.33) (Table 3). The other treatments provided 14.00-23.33 fruits. Fruit length was the highest

in T<sub>6</sub> treatment (4.33 cm) and the lowest in T<sub>1</sub> treatment (3.87 cm). Other treatments varied from 3.91-4.09 cm. In case of fruit diameter the highest was found at 3.67 cm in T<sub>6</sub> treatment, and the lowest in T<sub>1</sub> treatment (3.52 cm). The highest fresh weight of fruit was found in T<sub>6</sub> treatment (70.00 g), while the lowest in T<sub>1</sub> treatment (59.21 g). Yield /plant was found to be the highest in T<sub>6</sub> treatment (1867 g) and the lowest in T<sub>1</sub> treatment (553 g). The result showed a great variation in case of yield/ plant. Ahmed *et al.*, (2011) also reported that higher concentrations of heavy metals in waste water creating adverse effects on growth and yield of crops.

### Concentration of ascorbic acid and $\beta$ -carotene

The highest amount of ascorbic acid was found in T<sub>6</sub> treatment (1.34 mg/ 100 g) and the lowest was found in T<sub>1</sub> treatment (0.65 mg/ 100 g). Other treatments ranged from 0.79 -1.02mg/ 100 g (Fig. 2). In case of  $\beta$ -carotene T<sub>6</sub> treatment gave the highest amount (0.08 mg/100 g), while T<sub>1</sub> treatment gave the lowest amount of  $\beta$ -carotene (0.02 mg/100 g). Other treatments ranged between 0.03-0.07 mg/ 100 g. Hussain *et al.*, (2010) stated that textile effluents with heavy metals caused a reduction in parameters like chlorophyll content, protein, carbohydrate, ascorbic acid and  $\beta$ -carotene. Hence, plants treated with mixed effluent from equalization tank (T<sub>1</sub> treatment) showed lower levels of ascorbic acid and  $\beta$ -carotene than those treated with groundwater and other effluents.



**Fig. 2. Effect of textile dyeing effluent on ascorbic acid and  $\beta$ -carotene of tomato**

T<sub>1</sub> = waste water 100% + pure water 0%), T<sub>2</sub> = waste water 80% + pure water 20%), T<sub>3</sub> = waste water 60% + pure water 40%), T<sub>4</sub> = waste water 40% + pure water 60%), T<sub>5</sub> = waste water 20% + pure water 80%), T<sub>6</sub> = waste water 00% + pure water 100% (control

### Heavy metals accumulation in edible part after harvest

Zinc concentration was found to be the highest in T<sub>1</sub> treated tomato (9.73 ppm) and the lowest in T<sub>6</sub> treatment (3.95 ppm) (Table 4). According to WHO/FAO (2007) critical level of zinc ions in edible portion of different vegetables is 5.00 ppm. Fruits of T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> treatments exceed this level, so these may cause harm to the health if intake these fruits. Fe was found to be the highest in fruit for T<sub>1</sub> treatment (9.42 ppm) and the lowest in T<sub>6</sub> treatment (3.34 ppm). Cu was found to be the highest in fruit of T<sub>1</sub> treatment (11.31 ppm) and the lowest in T<sub>6</sub> treatment (4.43 ppm). According to WHO/FAO (2007) critical level of Cu ions in edible portion of different vegetables is 8.00 ppm. Fruits of T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> treatments exceed this level, so these may cause harm to the health if intake them. Lead concentration was found to be the highest in okra of T<sub>1</sub> treatment 6.19 ppm and T<sub>6</sub> gave the lowest of 2.79 ppm. According to WHO/FAO (2007) critical level of Pb ions in edible portion of different vegetables is 4.00 ppm. In the present research work it was observed that fruits of T<sub>5</sub> and T<sub>6</sub> treatments didn't exceed this level. Fruits from other treatments exceed this level, so these may cause harm to the health if intake them.

**Table 4. Accumulation of heavy metal (ppm) in fruit of tomato**

Treatment	Zinc (Zn) ppm	Iron (Fe) ppm	Copper (Cu) ppm	Lead (Pb) ppm
T <sub>1</sub>	9.73 a	9.42 a	11.31 a	6.19 b
T <sub>2</sub>	7.85 ab	9.61 a	10.33 ab	8.72 a
T <sub>3</sub>	7.52 ab	5.03 c	8.67 bc	8.23 a
T <sub>4</sub>	6.57 bc	7.66 b	8.39 bc	4.20 c
T <sub>5</sub>	4.11 d	3.40 d	5.51 d	3.73 c
T <sub>6</sub>	3.95 d	3.34 d	4.43 d	2.79 d
CV (%)	12.55	6.92	13.11	13.87

### Conclusion

It is concluded that Textile dye industrial untreated effluent significantly influence growth parameters of tomato crop due to toxic effects of chemicals and heavy metals. Growth and yield performance of tomato was the best in 100% groundwater. Furthermore, accounting for the effect of textile dyeing effluents revealed that waste water 20% + 80% pure water (T<sub>5</sub>) performed better than the others in terms of tomato growth and yield. Nutritional qualities of tomato varied remarkably, and observed that the maximum amount of ascorbic acid and  $\beta$ -carotene were found in 100% groundwater (T<sub>6</sub>) treated sample which was statistically identical to waste water 20% + 80% of pure water (T<sub>5</sub>). So, it can said that 20% mixed textile dyeing effluents in irrigation water should be tolerated in agricultural crop production to ensure the accumulation of heavy metals in different plant parts within the safe limit set by WHO standard. Mixture of less

polluted dyeing wastewater can be used in vegetables cultivation to observe the growth, yield, food value and heavy metals accumulation to provide cost effective wastewater neutralization technique. As uptake of heavy metals by plant depend on many factors therefore, further research is needed to precisely identify the suitable steps of dyeing wastewater discharge for the betterment of human, agriculture as well as textile industry owners.

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