INFLUENCE OF TEXTILE MILL WASTEWATER IRRIGATION ON THE GROWTH OF SORGHUM CULTIVARS

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Abstract. The aim of the presented study was to evaluate the suitability of textile mill wastewater (treated and untreated) at different concentrations (0, 6.25, 12.5, 25, 50, 75, and 100%) for irrigation purposes. Effect of textile mill wastewater on germination, delay index, physiological growth parameters and plant pigments of two cultivars of sorghum was studied. The textile effluent did not show any inhibitory effect on seed germination at lower concentration (6.25%). The other reported plant parameters also followed the similar trend. Seeds germinated in 100% effluents but did not survive for longer period. It has also been concluded that effect of the textile effluent is cultivar specific and due care should be taken before using the textile mill wastewater for irrigation purpose.
Keywords: *Textile mill wastewater, sorghum cultivars, germination (%), delay index, plant biomass.*

Introduction

India has a large network of textile industries of varying capacity. Textile industries have been placed in the category of most polluting industries by the Ministry of Environment and Forests, Government of India. Textile industries in India were initially centred around big cities like Ahmedabad, Mumbai, Chennai, Coimbatore, Bangalore and Kanpur. Now the industries are well developed and a large number of small textile processing units are scattered all over the country. Wet processes like bleaching, dyeing and screen printing are being carried out by these industries. Textile processes requires large volumes of fresh water after the cloth processing operations. The wastewater volume varies from mill to mill. The combined wastewater volume from Indian textile mills lies in the range of 86 to 247 litres with an average 172 litre per kg of cloth produced. Their effluents constitute a major part of the total industrial effluents in India. On an industrial scale the effluents resulting from the dyeing and printing operations of textile mills are managed through primary or secondary wastewater treatment.

A huge amount of effluent from textile mills is being discharged on land or into water courses. This effluent is characterized by high biological oxygen demand (BOD), chemical oxygen demand (COD), sodium and other dissolved solids as well as micro-nutrients and heavy metals. Whatever the pollution source may be, soils can act as a sink of heavy metals [13] but three main kinds of ecological risks [19] are associated to this fact:

- the loss of productivity in the soil compartment,
- the pollution of ground-water due to metal leaching, and
- the accumulation of pollutants in the food-chain, with effects on vegetation and animals, including humans

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In India, the abundance of soils with low organic matter content, favours the use of industrial wastewaters containing organic matter as an organic amendment and nutrient supply to soil. Although the benefits of wastewater use in irrigation are numerous but precautions should be taken to avoid short and long-term environmental risks related. Earlier studies have shown that the effect of an industrial effluent vary from crop to crop [10]. So it is essential to study the effect of industrial effluents on individual crops before their use in agricultural fields. Sorghum is a kharif crop which was sown in 9.49 million hectors in 2004 in India, but different cultivars are used in different regions depending upon soil type, local climate and irrigation facilities. Sorghum (*Sorghum vulgare* Pers.) is indigenous to Africa, and many of today's varieties originated on that continent. Sorghum was also grown in India before recorded history and in Assyria as early as 700 BC. Sorghum is a common name for corn-like grasses. It is a dry-land Indian crop most frequently grown as staples in central and western India. Sorghum is mainly grown where rainfall distribution ranges from 10-20 mm per month at least for 3 to 4 months of the south-westerly monsoon or is still more abundant. Farmers grow this crop as fodder for animals in Haryana state of India. A field survey showed that farmers use industrial waste waters for the irrigation of sorghum crop with the intention that the grain of sorghum are not used by human so even industrial wastewaters can be used for its irrigation. Forage sorghum grows 2 to 3 m tall, produces more dry matter tonnage than grain sorghum, is coarse stemmed and used for silage for livestock. Sorghums are best suited to warm, fertile soils; cool, wet soils limit their growth. In the present investigation the impact of textile industry effluent in various concentrations (0, 6.25, 12.5, 25, 50, 75, 100%) on seed germination (%), delay index, shoot length, root length, dry weight and chlorophyll content of two varieties of sorghum viz. *Pioneer jowar* and *Desi jowar* has been explored.

Review of literature

The volume of wastewater generated from pulp and paper mill varies from 227-455 litres per kg of paper produced. The value of spent wash generated during the process of alcohol production varied from 15-20 litre per litre of alcohol produced, on the other hand, the wastewater generated by a dairy industries being 2-8 litres per litres of milk processed. It was noticed that land application of sewage wastewater has become a common practice in many countries. The reuse of wastewater for irrigation in agriculture is one of the oldest forms of water reclamation. Awareness of this resource is not apparent in the Middle East and North African countries [16]. Due to diversity in industrial growth there is a considerable variation in the quantity and quality of wastewater generated from industry to industry. Management of such effluents to avoid damage to the environment warrants urgent attention. The various approaches [12] relevant to wastewater management under Indian conditions could be

(1) Conservation of various resources, viz., energy, raw materials and water.
(2) Adoption of more efficient processes of manufacturing for better resource utilization.
(3) Water use minimization strategies
(4) Reduction in quantity and quality of wastewater requiring treatment

Laboratory scale experiments were conducted [10] to study the effect of different concentrations (0, 6.25, 12.5, 25, 50, 75, and 100%) of textile effluents (untreated and treated) on seed germination(%), delay index, plant shoot length and root length, plant biomass, chlorophyll content and carotenoid of three different cultivars of wheat. The textile effluent did not show any inhibitory effect on seed germination at low concentration (6.25%). Seeds germinated in 100% effluents but did not survive for longer period. Differential responses of wheat cultivars to effluent treatment were noted. PBW-373 was most sensitive followed by WH-147 and PBW-343. The delay index showed variation for wheat cultivars as well as for effluent concentration. The better growth of all the cultivars at 6.25% effluent concentration may be due to the growth promoting effect of nitrogen and other mineral elements present in the effluent [20, 21].

The germination of kidney bean (*Phaseolus aureus*) and lady's finger (*Abelmoschus esculentus*) seeds were affected adversely when 75 and 100% concentrations of the textile effluent were used as compared to control (water). But there was no effect up to 50% effluent concentration [14]. Where as, Bengal gram (*Cicer arietinum*) seeds' germination was adversely affected even as low as 5% textile effluent concentration [6]. But unlike above said crops, 50% diluted textile effluent increased the seed germination, total sugars, starch, reducing sugars, and chlorophyll than control (distilled water) of groundnut seedlings. These studies showed that the effect of an industrial effluent vary from crop to crop. So it is essential to study the effect of industrial effluents on individual crops before their disposal in agricultural fields.

Saomashekar et al. [22] reported the effect of paper, automobile, textile and food industry wastewaters on soil and seedling growth. The wastewaters of all mills were alkaline in nature with variable concentrations of different chemical species. Application of untreated effluents altered the physicochemical properties of the soil and rate of seed germination was also lower than control. However, the application of diluted effluents was favourable to the seed germination and seedling growth.

The distillery effluents contain various organic and inorganic nutrients and may have a beneficial effect on the crop yield [15, 18]. Ramana et al. [17] reported the effect of different concentrations (0, 5, 10, 15, 25, 50, 75% and undiluted) of distillery effluent (raw spend wash) on seed germination (%), speed of germination, peak value and germination value of some vegetable crops, viz., tomato, chilli, bottle gourd, cucumber and onion. It was concluded that the effect of the distillery effluent is crop-specific and due care should be taken before using the effluent for pre-sowing irrigation purposes. The distillery effluent did not showed any inhibitory effect on seed germination of low concentration expect in tomato. Irrespective of the crop species, at highest concentration (75% and undiluted) complete failure was observed for germination. Based on the tolerance the crops were arranged in order: cucumber > capsicum > onion > bottle gourd > tomato.

Srivastava and Sahai [23] studied the impact of distillery effluents in various concentrations (1, 2.5, 5, 10, 25, 50, 75 and 100%) on the seed germination, speed of germination index, growth, leaf area, biomass, net primary productivity, pigment content, reproduction capacity, seed output, seed weight, seed densities and seed protein content of C*icer arietinum*. It was concluded that very high BOD load and the presence of excessive concentration of soluble salt could be responsible for the toxicity of the effluents. The effluent at up to 5% concentration was, however, beneficial for the overall growth parameter and its use as a liquid fertilizer has been suggested.

Kulkarni et al. [11] classified spent wash as a dilute liquid organic fertilizer, with high potassium content with nitrogen mostly in colloidal forms, which behaves as a "slow release fertilizer" better than most of the inorganic nitrogen sources.

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Dongale and Savant [7] found a significantly higher yield of sugarcane and increase in available N content of soil (300 kg N per ha) through applied spent wash and also thought that spent wash was a good source of potassium for sorghum.

Addition of tannery effluent caused deflocculation of soil particles and increase in the N, P and K levels of soil. Similarly, deleterious effects, such as increase in pH, sodicity and EC in soils due to use of textile effluent have been reviewed by Chhonkar et al. [5]. But the adverse effects of these could be reduced by diluting the effluent. Salinization and alkalization of groundwater due to application of these effluents are also reported.

Ahmad et al [1] studied the response of sugarcane to treated wastewater of oil refinery. The sugarcane growth was better when irrigated with treated wastewater of oil refinery than control (groundwater). The soil receiving wastewater did not show any changes in physicochemical characteristics. The soil accumulated all the heavy metals but the sugarcane accumulated Ni, Pb and Zn only whose values were much lesser then the permissible limits.

Bhati and Singh [4] studied the growth and mineral accumulation in *Eucalyptus camaldulensis* seedlings irrigated with mixed industrial effluent. Addition of textile/municipal effluent increased the survival time for 2 to 3 months. Mixing of effluent was useful in tree irrigation to increase biomass productivity.

Gulfraz et al [8] evaluated the suitability of different industrial effluents (textile mill, oil refinery, soap and detergent mill, hydrogenated oil mill, and rubber industry) for irrigation purposes in wheat crop. The germination of wheat seeds was most affected by textile mill wastewater followed by soap and detergent, oil refinery, hydrogenated oil and rubber industry wastewater. It was concluded that wastewaters should not be discharged in agricultural crops, water stream etc. It was also recommended that industries should install wastewater treatment plants to protect the crops.

Materials and methods

The effect of textile effluents was studied on two varieties of sorghum (*Sorghum vulgare* Pers.) namely *Pioneer jowar* and *Desi jowar*. Both the cultivars have genetic purity of 95%. The seeds were procured from the certified local seed supplier. The textile effluents (untreated and treated) used in the present study were collected in pre-cleaned containers from a textile mill located near Hisar (Haryana), India. Various physicochemical characteristics of both the effluents were analyzed using standard methods [2]. The effluents were stored at $4^{o}C$ during storage period to avoid any change in its characteristics.

Experimental design

For germination tests, 10 seeds of each sorghum cultivar were placed in sterilized glass Petri dishes of uniform size lined with two filter paper discs. These filter discs were then moistened with 5 ml of distilled water for control and with the same quantity of various concentrations of the textile effluent (6.25, 12.5, 25.0, 50.0, 75.0 and 100%) in distilled water. The Petri dishes were incubated at $30 \pm 1^{o}C$ in an incubator. Germination was recorded daily at a fixed hour, and the emergence of the radicle was

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taken as a criterion of germination. All the experiments were carried out in triplicate and the results were averaged.

Germination time, defined as the time taken for 60% germination was worked out for studied sorghum cultivars under different effluent concentrations.

Delay index (DI), a normalized parameter, was calculated to compare the performance of different sorghum cultivars under different effluent concentrations as given below.

$$DI = \frac{X}{Y} \qquad \text{(Eq.1)}$$

Where
DI = Delay Index
X= delay in germination time over control (no effluent) and
Y= germination time for control.

For observing seedling growth, five 7 days old seedlings were picked from each of the sets, and the length of the root and shoot were recorded. Plants at the termination of experiment were collected, and their roots and stems along with leaves were separated and dried at 65^{O}C in a hot- air oven for 24h. Their dry weights were recorded.

Table 1. *Physicochemical characteristics of textile effluents*

Parameter	Untreated effluent	Treated effluent
Colour	Brownish black	Muddy grey
pH	9.9	8.2
EC (mmho cm^{-1})	8.13	7.34
Specific gravity	1.01	0.99
Suspended solids (mgL^{-1})	210	128
Total Solids (mgL^{-1})	7333	6786
Total alkalinity (as $CaCO_3$, mgL^{-1})	946	792
Dissolved oxygen (mgL^{-1})	nil	nil
BOD (mgL^{-1})	1626	496
COD (mgL^{-1})	2190	960
Total nitrogen (as N) (mgL^{-1})	246	238
Sodium (mgL^{-1})	186	142
Potassium (mgL^{-1})	9	7
Calcium (mgL^{-1})	318	267
Chloride (mgL^{-1})	860	692
Sulphate (mgL^{-1})	381	326
Fluoride (mgL^{-1})	nil	nil
Phosphate-P (mgL^{-1})	18	14

Pot culture experiment

Pots of 15 cm (diameter) x 14 cm (height) size were filled with equal amounts of sandy loam soil of medium fertility and 10 seeds Pioneer cultivar of sorghum were sown in each pot. The pots were irrigated with selected concentrations (6.25, 12.5, 25, 50, 75 and 100%) of the textile effluents. For each treatment, 100ml of each of these was applied to the respective pot at 5-day interval, throughout the study period. Each treatment had three replications. A control set, irrigated with distilled water was also maintained for comparison. After germination seeds were thinned to five seedlings per pot in all the pots.

The chlorophyll and carotenoid content of the plants were measured. The chlorophyll content was estimated by extracting fresh leaves with 80% acetone and after centrifugation at 8000 rpm for 20min, measuring the colour intensity of the extract at 445, 645 and 663 nm. The formulae of Arnon [3] were used to calculate the *chlorophyll a* and *chlorophyll b* contents and that of Ikan [9] for the carotenoid content.

The data in this study were analyzed using the SPSS package, and all the values are presented as the mean± SE. Student *t*-tests were used to compare the nutritional quality of vermicomposts and fecundity data between the control (cow dung) and other feed wastes. The probability levels used for statistical significance were $P < 0.05$ for the tests.

Results and discussion

The physicochemical characteristics of untreated and treated forms of the effluent are shown in Table 1. Untreated effluent was brownish black in colour, deficit in dissolved oxygen, rich in total solids, total alkalinity, BOD and COD with considerable amounts of total nitrogen, phosphate, chlorides, sulphates, sodium and calcium. The potassium content was negligible.

Treated effluent was muddy grey in colour. The magnitude of analyzed parameters was lower for treated effluent than untreated effluent (Table 1). The data further showed that suspended solids and BOD content of the studied effluents exceeded the prescribed Indian disposal standards (100 mg L^{-1} and 150 mg L^{-1} respectively).

At lower concentration, the textile effluent (untreated and treated) did not inhibit seed germination in both the varieties. In *Pioneer jowar* 100% seed germination was observed at 6.25% effluent concentration after 120h in both the effluents. Whereas *Desi jowar* seed germination was 100% in untreated effluent and 96.7±5.8% in treated effluent at 6.25% effluent concentration. The germination was inhibited in both the varieties when effluent concentrations exceeded 12.5% in irrigation water. Minimum seed germination was 76.7±5.8% and 83.3±5.8% in *Pioneer jowar* with untreated and treated effluent, and 63.3±5.8 and 80±0.00 in *Desi jowar.* It is evident from the Table 2 that in case of treated effluent the inhibitory effect in *Pioneer jowar* started at 50% effluent concentration onward. Whereas in *Desi jowar* inhibitory effect appeared at lower concentration (6.25%) Table 2. It is observed that germination of *Pioneer jowar* was least affected by both the effluent and showed 100% germination in treated effluent at 6.25%, 12.5% and 25% concentrations. Seed germination (%) of *Desi jowar* was

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inhibited even at 6.25% effluent concentration. So it appears seed germination of *Desi jowar* is more sensitive to effluent irrigation among both the tested varieties.

There was no effect of increasing effluent concentration on delay index in both the varieties up to 50% effluent concentration. The *Pioneer jowar* had a greater value of delay index in both the effluent (UTF and TF) at >50% concentration (Table 3). Whereas in *Desi jowar* the identical delay index value was at 75% concentration (UTF) and at 100% concentration in (TF). The order of delay index among the two verities of sorghum followed this trend: Pioneer (UTF) = Pioneer (TF) < Desi (UTF) < Desi (TF).

Table 2. *Effect of textile effluents on germination (%) of different sorghum cultivars (after 120h) [n= 3, mean± SE]*

Effluent	**Untreated effluent**		**Treated effluent**	
Conc. (%)	**Pioneer jowar**	**Desi jowar**	**Pioneer jowar**	**Desi jowar**
0(DW)*	100± 0.00a	96.7± 5.8a	100± 0.00a	100± 0.00a
6.25	100± 0.00a	100± 0.00a	100± 0.00a	96.7± 5.8a
12.5	86.7± 5.8b	96.7± 5.8 a	100± 0.00a	96.7± 5.8a
25.0	83.3±5.8b	86.7± 5.8 b	100± 0.00a	93.3± 5.8a
50.0	76.7± 5.8c	83.3± 5.8 b	90± 10.0a	83.3± 5.8b
75.0	76.7± 5.8c	73.3± 5.8 c	86.7± 5.8b	80± 0.00b
100	76.7± 5.8c	63.3± 5.8d	83.3± 5.8b	80± 0.00b

Values followed by same letters in a column are not significantly different ($p \leq 0.05$)

Table 3. *Effect of textile effluent concentrations on delay index (DI) of different sorghum cultivars*

Effluent	**Pioneer Jowar**		**Desi jowar**	
Conc. (%)	**UTF***	**TF****	**UTF***	**TF****
6.25	0	0	0	0
12.50	0	0	0	0
25	0	0	0	0
50	0.50	0.50	0.25	0.25
75	0.50	0.50	0.50	0.25
100	0.50	0.50	0.50	0.50

UTF* = Untreated effluent; TF** = Treated effluent

The greatest effect on shoot and root lengths was observed in untreated effluent concentrations (Table 4). There was a decrease at 50, 75 and 100% effluent concentrations in shoot and root lengths of both the tested varieties in untreated as well as treated effluent at all the studied effluent concentrations. The effect was more pronounced for untreated effluent. Shoot length of *Pioneer jowar* in untreated effluent was only 1.3±0.31 cm in 100% concentration which is 9.2 times lower than control (11.9±0.49 cm) (Table 4). For Desi *jowar* shoots emerged in 100% untreated effluent but could not survive. The shoot length of Desi *jowar* in 75% untreated effluent concentration was 1.2±0.25 cm which is 7.4 times lower than control. The roots of both the varieties could not survive in 100% untreated effluent. The effect of untreated effluent was more on Desi *jowar* than Pioneer *jowar*. The deleterious effects were more pronounced at 50, 75 and 100% effluent concentrations.

In treated effluent, the effect on shoot and root length of Pioneer *jowar* was lesser. Shoot length of Pioneer *jowar* in 100% treated effluent was 6.1±0.95 cm which is 2 times lower than control (11.9±0.49 cm) (Table 4). The root length of Pioneer *jowar* in 100% treated effluent was 11.2±2.66 cm which is 1.78 times lower than control (19.9±1.68 cm). For Desi *jowar* shoot length was only 1.9±0.40 cm in 100% treated effluent which is 4.7 times lower than control (8.9±0.44 cm) (Table 4). Root length of Desi *jowar* was 2.2±0.25 cm which is 5.13 times lower than control (11.3±1.56 cm). The results also indicated that the treated effluent had lesser deleterious effects than untreated effluent on sorghum.

Table 4. *Effect of textile effluent on shoot and root length of sorghum cultivars (after 7 days) (in cm) [n= 3, mean± SE]*

Effluent	**Pioneer jowar**		**Desi jowar**	
Conc. (%)	**SL***	**RL****	**SL***	**RL****
Untreated effluent				
0 (DW) ***	11.9± 0.49a	19.9± 1.68a	8.9± 0.44a	11.3± 1.56a
6.25	10.4± 0.91a	14.0± 1.39b	6.9± 1.77b	11.3± 1.71a
12.5	9.0± 1.34ab	11.3± 2.31b	7.3± 0.97b	10.8± 2.08a
25.0	7.5± 1.10b	7.87± 0.65c	1.9± 0.81c	3.9± 1.17b
50.0	5.6± 0.79c	3.87± 1.56d	1.5± 0.50c	3.7± 1.56b
75.0	2.1± 0.45d	2.40± 0.70e	1.2± 0.25c	3.8± 0.64b
100	1.3± 0.31e	0.00± 0.00f	0.0± 0.00d	0.0± 0.00c
T*reated effluent*				
0 (DW) ***	11.9± 0.49a	19.9± 1.68a	8.9± 0.44a	11.3± 1.56a
6.25	11.5± 3.12a	13.9± 2.50b	9.0± 0.89a	17.6± 0.75b
12.5	9.1± 1.80a	13.6± 2.06b	8.3± 0.28a	15.5± 0.6bc
25.0	8.0± 1.30b	14.1± 3.49b	7.0± 1.72b	14.3± 1.20c
50.0	6.8± 2.08c	13.8± 0.58b	4.6± 0.65c	7.9± 1.40d
75.0	7.2± 2.00c	12.2± 0.90b	3.4± 0.20c	5.1± 0.66e
100	6.1± 0.95c	11.2± 2.66b	1.9± 0.40d	2.2± 0.25f

SL*= Shoot length, RL** = Root length, (DW) *** = Distilled water
Values followed by same letters in a column are not significantly different ($p \leq 0.05$)

The dry weight of shoots and roots of sorghum also exhibited the similar trend (Table 5). The dry weight of Pioneer *jowar* shoot in untreated effluent was 0.73±0.20 mg per plant at 100% effluent concentration which is 30.7 times lower than control plants (22.4±3.80 mg per plant).

Root biomass of Pioneer *jowar* was 1.1±0.15 mg per plant which is 9.4 times lower than control (10.3±0.20 mg per plant) (Table 5). Effect of untreated effluent was more pronounced at 75 and 100% concentrations for shoot dry weight, where as effect was more pronounced at 50, 75 and 100% concentrations for root dry weights. The shoots of *Desi jowar* could not survive in 100% untreated effluent. The dry weight of *Desi jowar* shoot at 75% untreated effluent concentration was 15±0.20 mg per plant which is 12.5 times lower than control (18.8±0.32 mg per plant). The root dry weight of *Desi jowar* in 75% untreated effluent concentration was 1.7± 0.36 mg per plant which is 4.6 times lower than control (7.9±0.41 mg per plant) (Table 5). The results indicated that dry weights of *Desi jowar* were lesser than *Pioneer Jowar*. The effect of treated effluent was comparatively lesser than untreated effluent. The shoot and root of *Desi Jowar* survived as well as grew in 100% treated effluent. The shoot dry weight of *Desi jowar* in 50% treated effluent was equal to 12.5% dose of untreated effluent (Table 5).

Table 5. *Effect of textile effluent on dry weight (after 7 days) of different sorghum cultivars (mg/plant) [n= 3, mean± SE]*

Effluent Conc. (%)	**Pioneer jowar**		**Desi jowar**	
	Shoot	**Root**	**Shoot**	**Root**
Untreated effluent				
0 (DW) ***	22.4± 3.80a	10.3± 0.20a	18.8± 0.32a	7.9± 0.41a
6.25	16.6± 0.65b	10.1± 1.0a	17.5± 0.86a	6.6± 0.80ab
12.5	15.8± 0.40b	11.0± 0.78a	10.1± 0.36b	6.1± 0.35b
25.0	14.6± 0.35b	7.1± 0.85b	6.6± 0.15c	2.7± 0.43c
50.0	14.2± 0.45b	4.9± 0.56c	2.8± 0.40d	1.8± 0.10d
75.0	8.6± 0.35c	3.4± 0.30d	1.5± 0.20e	1.7± 0.36e
100	0.73± 0.20d	1.1± 0.15e	0.0± 0.00f	0.0± 0.00f
Treated effluent				
0 (DW) ***	22.4± 3.80a	10.3± 0.20a	18.8± 0.32a	7.9± 0.41a
6.25	18.7± 0.62b	10.6± 0.31a	20.7± 2.10a	9.4± 0.35a
12.5	17.9± 0.20b	9.9± 0.35a	19.6± 1.38a	7.5± 0.20a
25.0	15.2± 0.40c	7.5± 0.55b	17.5± 0.90a	6.5± 0.25b
50.0	14.3± 0.20c	7.1± 0.76b	10.3± 0.30b	3.3± 0.26c
75.0	12.2± 0.31d	6.8± 0.40bc	9.8± 0.59b	3.0± 0.10d
100	10.3± 0.30d	6.1± 0.30c	9.0± 0.75b	2.1± 0.15e

Values followed by same letters in a column are not significantly different ($p \leq 0.05$)

The *chlorophyll a* and *chlorophyll b* contents were increased at 6.25% concentration and decreased significantly at higher concentrations by both the effluents. Similar observation has been reported by other co-workers [21] in *Phaselous radiatus* treated with distillery effluent. The inhibitory effect of untreated effluent was more on the pigments than treated effluent. The carotenoid content also increased up to 6.5% effluent concentration and decreased at higher concentrations (Table 6).

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Table 6. *Effect of textile effluent on plant pigments of Pioneer Jowar [after 30 days] (mg g^{-1} fresh weight) [n= 3, mean± SE]*

Effluent Conc. (%)	**Chl. a**	**Chl. b**	**Total Chl.**	**Carotenoid**
Untreated Effluent				
0(DW)*	0.618 ± 0.084a	0.274 ± 0.035a	0.931 ± 0.051a	1.62 ± 0.063a
6.25	0.636 ± 0.075a	0.271 ± 0.041a	0.946 ± 0.058a	1.73 ± 0.095a
12.5	0.603 ± 0.064a	0.235 ± 0.032a	0.859 ± 0.035a	1.58 ± 0.084a
25.0	0.578 ± 0.067a	0.217 ± 0.025ab	0.814 ± 0.037a	1.35 ± 0.067ab
50.0	0.413 ± 0.059b	0.178 ± 0.012b	0.612 ± 0.023b	1.24 ± 0.048b
75.0	0.245 ± 0.026c	0.153 ± 0.017b	0.362 ± 0.014c	0.67 ± 0.045c
100	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00d	0.00 ± 0.00d
Treated effluent				
0(DW)*	0.618 ± 0.084a	0.274 ± 0.035a	0.931 ± 0.051a	1.62 ± 0.063a
6.25	0.632 ± 0.068a	0.281 ± 0.032a	0.987 ± 0.053a	1.67 ± 0.035a
12.5	0.625 ± 0.047a	0.275 ± 0.031a	0.973 ± 0.043a	1.58 ± 0.037a
25.0	0.588 ± 0.051a	0.268 ± 0.027a	0.958 ± 0.036a	1.42 ± 0.021a
50.0	0.513 ± 0.071a	0.263 ± 0.024a	0.917 ± 0.051a	1.31 ± 0.025a
75.0	0.472 ± 0.032b	0.245 ± 0.018a	0.818 ± 0.026a	1.37 ± 0.034a
100	0.386 ± 0.035b	0.236 ± 0.037a	0.674 ± 0.038b	1.24 ± 0.051a

Values followed by same letters in a column are not significantly different ($p \leq 0.05$)

Conclusion

The physicochemical characteristics of the textile mill wastewater exceeded the prescribed Indian standards. So some more effective treatment is necessary to minimize the pollution effects before the textile industry effluent is discharged on the land. But disposal of these effluents after proper dilution may be a favourable approach. After dilution, the effluent characteristics come within the prescribed disposal limits and pollution load per unit effluent volume is decreased. The better growth of both the cultivars at 6.25% effluent concentration may be due to the growth promoting effect of nitrogen and other mineral elements present in the effluent Differential responses of sorghum cultivars to untreated and treated wastewater were noted. Pioneer Jowar was lesser affected than Desi Jowar by both the wastewaters. The use of wastewater for irrigation may serve as an additional source of water with fertilizing properties after appropriate dilution. Irrigation water quality not only affect the growth of crops, but also have long term effects on soil health, grain quality, fodder quality and health of consumers. So finally it is suggested that long term experiments should be conducted to explore the effect of textile mill wastewater on above suggested aspects before its use for irrigation.

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