Effect of textile mill effluent on growth of *Vigna unguiculata* and *Pisum sativum* seedlings

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Abstract

The aim of the presented research work was to determine the effects and suitability of textile mill effluent at different concentrations (0, 20,40,60,80 & 100%) for irrigation purposes. Effluent sample collected from Solapur industrial area and physico-chemical parameters of these samples were analyzed. The seed varieties of *Vigna unguiculata* (Cowpea) and *Pisum sativum* (Pea) were selected to grow in this effluent. These varieties grow abundantly in study area and are very demanding species for food purposes. The textile mill effluent did not show any inhibitory effect on seed germination at lower concentration. With the increase in effluent concentration, growth of seedlings was found more affected. Effect of textile mill effluent on various parameters of seedlings such as seed germination, mean root length of germinated seedlings, plumule germination, mean plumule length of germinated seedlings, disease (fungus) causes in germinated seedlings and other morphological characters are studied.

Keywords: Seed germination, textile mill effluent, growth, seedlings.

Introduction

Environmental pollution constitutes a great health hazard to human, animals and plants with local, regional and global implications (Irshad *et al.,* 1997). Pollution has adverse effects on land, water and its biotic and abiotic components. Effluents from industries are normally considered as the main industrial pollutants containing organic and inorganic compounds, acid, alkalis, suspended solids (Behera & Misra, 1982) and other wide variety of mineral elements including heavy metals such as Hg, Cu, As, Fe, Cr, Pb, Zn and Cd (Varma *et al.,* 1976; Clark, 1995). Some of those elements are essential for plant growth and metabolism but a few of such elements, such as Fe, Zn, Cu and Al depress growth at high concentrations (Wong and Bradshaw, 1982; Berti and Jacobs, 1996). Increasing population and consequent increase in food demand had necessitated intensive year round food production. Hence, irrigation of arable land and crops from water bodies is indispensable to ensuring food sufficiency (Qgunwenmo *et al.,* 2010). Phytotoxicity results from intoxication of living tissues by substances accumulated from the growth medium (Chang *et al.,* 1992). The toxic substance may be further bio-accumulated and magnified in the food chain with dire consequences for human. Therefore, it is imperative to evaluate the toxic effects of wastewater and their suitability for irrigation of crop plants. The transition between dormancy and germination represents a critical stage in the life cycle of crop plants which controls population dynamics and productivity (Radosevich *et al.,* 1997: Keller & Kollmann, 1999) constituting an important ecological and commercial trait (Holdsworth *et al.,* 2008).

The increasing agricultural reuse of treated effluent serves goals such as promoting sustainable agriculture, preserving scare water resources, and maintaining environmental quality. Moreover, irrigating with wastewater may reduce purification levels and fertilization costs, because soil and crops serve as bio-filters, while wastewater contains nutrients (Haruvy, 1997). Bioassays can be used to measure putative environmental risks (Gopalan, 1999). They are reliable, cost effective, quick and simple (Gustavson *et al.,* 2000). The use of plants offers an advantage over other organisms because they can be more sensitive to environmental stresses (Dutka, 1989). They are also easy to manipulate and store and furthermore, they offer a low-cost and good correlation (Fiskesjo, 1993; Valerio *et al.,* 2007). Textile industries have been placed in the category of most polluting industries by the Ministry of Environment and Forests, Government of India. India has a large network of textile industries of varying capacity that are distributed throughout the country. Their effluents constitute a major part of the total industrial effluents in India. The improper and indiscriminate disposal of textile effluents in natural waters and land is posing serious problems (Kaushik *et al.,* 2004). Solapur is one of the major cities in the State of Maharashtra, India. Being one of the important industrial cities, Solapur is a leading center for cotton mills and power-looms. Various textile products like bed-sheets, terry-towels and chaddars etc are exported to different countries in different parts of the world which have earned international fame and reputation due to their novel designs, attractive colours and durability. In solapur region water shortage is more; hence for irrigational purposes farmers are using wastewater in the agricultural practices.

The present research work, focused on the investigation of the use in irrigation of an effluent from Textile industry. This effluent was previously analysed. The efficiency of the treatment on the seed germination, Mean Root Length of germinated seedlings, plumule germination, mean plumule length of germinated seedlings, disease (fungus) causes in germinated seedlings and other morphological characters.

Materials and methods

The effluent sample was collected from the textile mill of solapur in polythene bottles and stored in dark place. The sample was analysed for various physico-chemical characteristics as per the standard methods described by APHA (1971). The effluents were stored at 4°C during storage period to avoid changes in its characteristics. The effluent colour was bluish and had pungent smell. The other properties are described in table 1. The seeds of *Vigna unguiculata* (Cowpea) and *Pisum sativum* (Pea) were collected from the local area. Only healthy and uniformly similar seeds were selected for exposure to different concentrations of textile mill effluent (Viz. 20, 40, 60, 80 & 100%) and distilled water as a control. The experiment was laid out in the Petri-plates (covered with filter paper) with 10 seeds in each treatment of effluent concentrations and control (n=3). The results were expressed as mean. Seeds were allowed to germinate at 25 ± 2°C on Petri dishes of 9 cm diameter containing a double layer Whatman No. 1 filter paper and irrigated with respective concentrations of effluents (Abdul-Baki and Anderson, 1971). The observations of seeds and growth parameters were measured after every 24 h interval of 7 days.

Results and discussion

The characteristics of textile mill effluent of the Solapur industrial area are shown in the table no 1. On the contrary, the untreated effluent had a negative effect by inhibition of the growth of all the species (Mbarka Gouider *et al*., 2010). The pH of the effluent sample was 6.74, i.e. slightly acidic in nature. We can also conclude that no pH neutralization was needed since this factor minimally affects phytotoxicity (Komilis *et al*., 2005). The electric conductivity (EC) of effluent was 151.6 mS/cm. The EC was higher than the permissible limit. It can also be attributed to the relatively high salinity of the effluent. Ramana *et al*. (2002) reported that crop species such as tomato, chilli, bottlegourd, cucumber, and onion showed a decrease in germination percentage with increase in concentration of effluent salinity. The TDS was 97024 mg/l of effluent. The total Alkalinity was 1170 mg/l of the effluent. The DO was 1.2 mg/l of the effluent. Acidity was 355 mg/l of the effluent. Total hardness (TH) concentration was 542 mg/l of the effluent. The effluent is very hard. The calcium (Ca) content was 132.264 mg/l of the effluent. Magnesium ion (Mg) concentration was 51.66 mg/l of the effluent. The Chloride (Cl_2) concentration was 1904.22 mg/l of the effluent. The Chloride content is very higher than the permissible limit. The sodium (Na) concentration was 1252.56 mg/l of the effluent, which was higher than the permissible limit. The Potassium (K) concentration was 162.76 mg/l of the effluent. The Sulphate (SO_4) concentration was 79.6 mg/l of the effluent. The use of treated wastewater in irrigation experiment, confirmed its beneficial effect on plant growth. This finding corroborated those reported by Seastedt and Suding (2007) who showed that, after fertilization experiment, P additions significantly increased primary productivity for a number of plant species.

The various concentration of effluent was studied in order to find out the effect and suitable concentration of effluent water for agricultural seeds. The results of the present study are presented in Table 2 to 11. It is revealed that the effect of different concentrations of textile industrial effluent on germination of seeds was highly significant. The observation shows that effect of effluent has remarkable, which were highly bad affect in comparison to control. Under the environmental stress conditions, the energy forming molecules may be disturbed and subsequently carbohydrate and protein metabolites of the membrane are altered (Kannan and Upreti, 2008). Sufficient water absorption is essential for proper seed germination, without which seedling growth and development is severely affected (Kelly *et al.,* 1992 and Debeaujan *et al.,* 2000).

From Table 2 it is seen that in control for the initial day the growth of *Vigna unguiculata* seed germination was faster than the other effluent concentration and after the 5^{th} day the growth of seed germination in 20% effluent concentration was very higher than the other concentration and control. The 60%, 80% and 100% effluent concentration growth of *Vigna unguiculata* seed germination was constant than the other effluent concentration (Fig.1). From the Table 3 it is seen that in control and 40% effluent concentration the initial growth of *Pisum sativum* seed germination was more than the other effluent concentration but in 20% effluent concentration the growth was more after 6^{th} day. The 80% and 100% effluent concentration growth of *Pisum sativum* seed germination was constant than the other effluent concentration. In 60% effluent concentration the growth of seed germination was very slow (Fig.2). Speedy germination results due to soaking of seeds for large interval (Visser and Tillekeratne, 1958). According to Hetherington and Woodward, (2003) differences in environmental conditions may be the cause for variable plasticity in responses within species, especially in relatively short-termed studies.

During normal germination in legumes, carbohydrates are formed in excess amount to produce energy for various metabolic activities and for the process of intensive differentiation and growth under relatively steady state conditions (Easwari and Lalitha, 1995). Under the environmental stress conditions, the energy forming molecules may be disturbed and subsequently carbohydrate and protein metabolites of the membrane are altered. Sufficient water absorption is essential for proper seed germination, without which seedling growth and development is severely affected (Kelly *et al.,* 1992; Debeaujan *et al.,* 2000). The absorbed water in the seed is used for activation of hydrolytic enzymes, which in turn break the seed reserves in to the simple molecules needed for various metabolic activities including cell

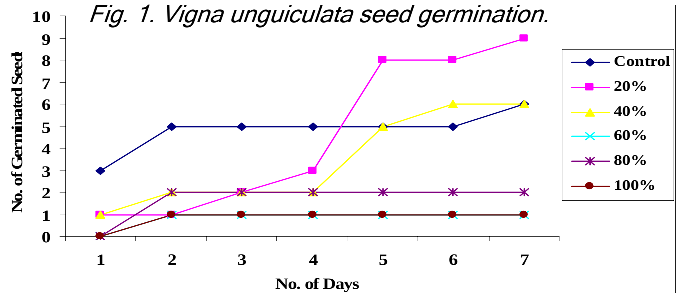

Fig. 1. Vigna unguiculata seed germination.

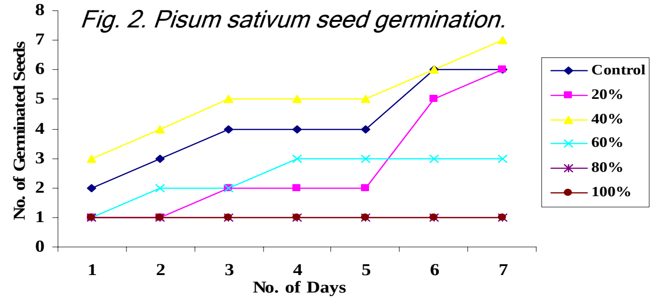

Fig. 2. Pisum sativum seed germination.

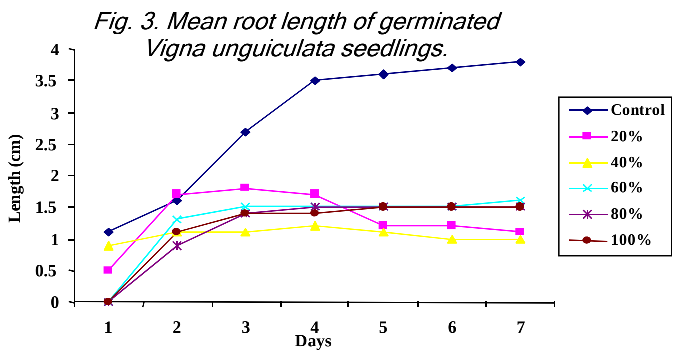

Fig. 3. Mean root length of germinated Vigna unguiculata seedlings.

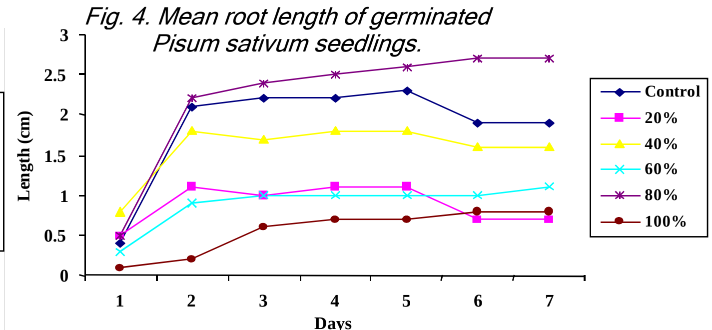

Fig. 4. Mean root length of germinated Pisum sativum seedlings.

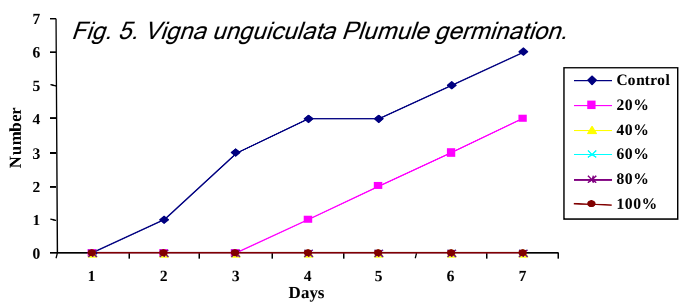

Fig. 5. Vigna unguiculata Plumule germination.

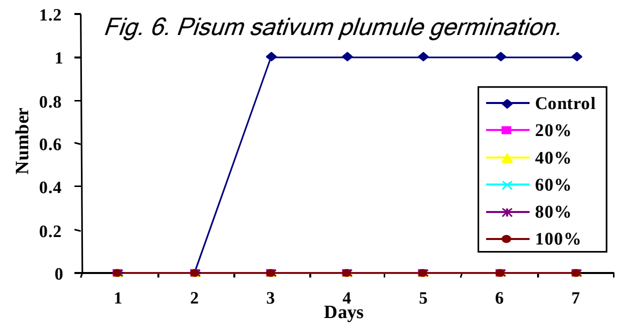

Fig. 6. Pisum sativum plumule germination.

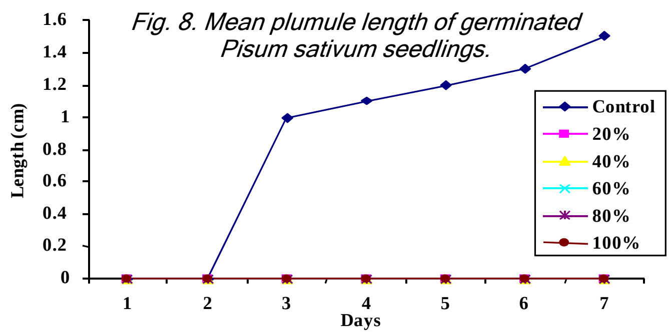

Fig. 8. Mean plumule length of germinated Pisum sativum seedlings.

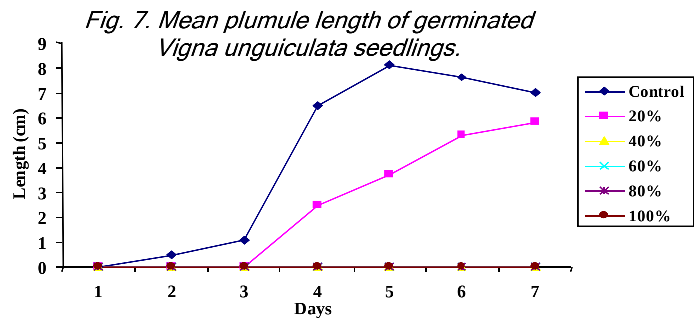

Fig. 7. Mean plumule length of germinated Vigna unguiculata seedlings.

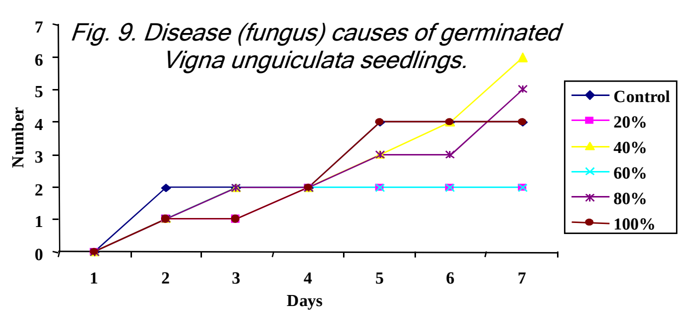

Fig. 9. Disease (fungus) causes of germinated Vigna unguiculata seedlings.

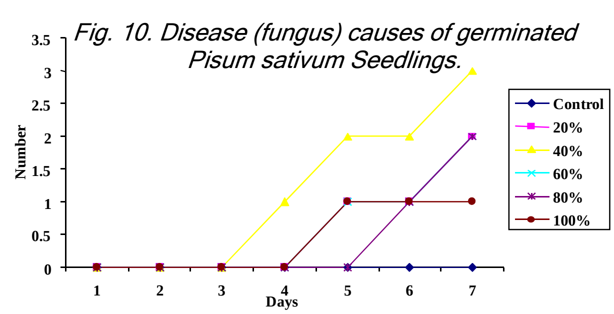

Fig. 10. Disease (fungus) causes of germinated Pisum sativum Seedlings.

Table 1. Characteristics of effluent in the Solapur industrial area.

Parameters		Results
Colour		Bluish
pH		6.74
EC	$mScm^{-1}$	151.6
TDS	MgL^{-1}	97024
Alkalinity		1170
Acidity		355
DO		1.2
Hardness		542
Calcium		132.26
Magnesium		51.66
Chloride		1904.22
Sodium		1252.56
Potassium		162.76
Sulphate		79.6

Table 2. Vigna unguiculata seed germination (n=3).

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	3	1	1	0	0	0
II	5	1	2	1	2	1
III	5	2	2	1	2	1
IV	5	3	2	1	2	1
V	5	8	5	1	2	1
VI	5	8	6	1	2	1
VII	6	9	6	1	2	1

Table 3. Pisum sativum seed germination (n=3).

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	2	1	3	1	1	1
II	3	1	4	2	1	1
III	4	2	5	2	1	1
IV	4	2	5	3	1	1
V	4	2	5	3	1	1
VI	6	5	6	3	1	1
VII	6	6	7	3	1	1

Table 4. Mean root length of germinated vigna unguiculata seedlings.

Days	Effluent % in Distilled Water					
	Control	20%	40%	60%	80%	100%
I	1.1	0.5	0.9	0	0	0
II	1.6	1.7	1.1	1.3	0.9	1.1
III	2.7	1.8	1.1	1.5	1.4	1.4
IV	3.5	1.7	1.2	1.5	1.5	1.4
V	3.6	1.2	1.1	1.5	1.5	1.5
VI	3.7	1.2	1	1.5	1.5	1.5
VII	3.8	1.1	1	1.6	1.5	1.5

Table 5. Mean root length of germinated Pisum sativum seedlings.

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	0.4	0.5	0.8	0.3	0.5	0.1
II	2.1	1.1	1.8	0.9	2.2	0.2
III	2.2	1	1.7	1	2.4	0.6
IV	2.2	1.1	1.8	1	2.5	0.7
V	2.3	1.1	1.8	1	2.6	0.7
VI	1.9	0.7	1.6	1	2.7	0.8
VII	1.9	0.7	1.6	1.1	2.7	0.8

Table 6. Vigna unguiculata Plumule germination.

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	0	0	0	0	0	0
II	1	0	0	0	0	0
III	3	0	0	0	0	0
IV	4	1	0	0	0	0
V	4	2	0	0	0	0
VI	5	3	0	0	0	0
VII	6	4	0	0	0	0

Table 7. Pisum sativum Plumule Germination.

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	0	0	0	0	0	0
II	0	0	0	0	0	0
III	1	0	0	0	0	0
IV	1	0	0	0	0	0
V	1	0	0	0	0	0
VI	1	0	0	0	0	0
VII	1	0	0	0	0	0

Table 8. Mean plumule length of germinated Vigna unguiculata seedlings.

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	0	0	0	0	0	0
II	0.5	0	0	0	0	0
III	1.1	0	0	0	0	0
IV	6.5	2.5	0	0	0	0
V	8.1	3.7	0	0	0	0
VI	7.6	5.3	0	0	0	0
VII	7	5.8	0	0	0	0

Table 9. Mean Plumule length of germinated Pisum sativum seedlings.

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	0	0	0	0	0	0
II	0	0	0	0	0	0
III	1	0	0	0	0	0
IV	1.1	0	0	0	0	0
V	1.2	0	0	0	0	0
VI	1.3	0	0	0	0	0
VII	1.5	0	0	0	0	0

Table 10. Disease (fungus) causes of germinated Vigna unguiculata seedlings.

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	0	0	0	0	0	0
II	2	1	1	1	1	1
III	2	1	2	2	2	1
IV	2	2	2	2	2	2
V	4	2	3	2	3	4
VI	4	2	4	2	3	4
VII	4	2	6	2	5	4

division, differentiation and cell elongation (Groot and Karssen, 1992; Leubner-Metgzer *et al.,* 1995).

From the Table 4 it is seen that the growth of *Vigna Unguiculata* mean root length of germinated seedlings was faster than the all effluent concentrations.
The all effluent concentrations growth of mean root length of germinated seedlings was slowly (figure 3). From the Table 5 it is seen that the growth

Table 11. Disease (fungus) causes of germinated Pisum sativum seedlings.

Days	Effluent % in distilled water					
	Control	20%	40%	60%	80%	100%
I	0	0	0	0	0	0
II	0	0	0	0	0	0
III	0	0	0	0	0	0
IV	0	0	1	0	0	0
V	0	1	2	1	0	1
VI	0	1	2	1	1	1
VII	0	2	3	2	2	1

of *Pisum sativum* mean root length of germinated seedling was faster than all effluent concentrations. From figure 4 it is seen that the 80% effluent concentration growth of root was more because only one seed is germinated. From the table 6 it is seen that in all the 20%, 40%, 60%, 80%, 100% effluent concentration and control for the initial one day there was no *Vigna Unguiculata* plumule germination but on 2nd day germination started in control and on 4th day germination started in 20% effluent concentration. In 40%, 60%, 80%, 100% effluent concentrations it was observed that not a single plumule is germinated (Fig.5). From the Table 7 it is seen that in all 20%, 40%, 60%, 80%, 100% effluent concentration and control for the initial two days there was no *Pisum sativum* plumule germination but on 3rd day germination started in control. In 20%, 40%, 60%, 80%, 100% effluent concentrations it was observed that not a single plumule is germinated (Fig.6). From the table 8 it is seen that in all the 20%, 40%, 60%, 80%, 100% effluent concentration and control for the initial one day there was no mean plumule length of germinated *Vigna Unguiculata* seedlings but on 2nd day plumule got germinated in control and on 4th day plumule got germinated in only 20% effluent concentration. In 40%, 60%, 80%, 100% effluent concentrations it was observed that not a single plumule is germinated (Fig.7). From the table 9 it is seen that in all 20%, 40%, 60%, 80%, 100% effluent concentration and control for the initial two days there was no mean plumule length of germinated *Pisum sativum* seedlings but on 3rd day plumule got germinated in control. In 20%, 40%, 60%, 80%, 100% effluent concentrations it was observed that not a single plumule is germinated (Fig.8). From the Table 10 it is seen that in all 20%, 40%, 60%, 80%, 100% effluent concentration and control for the initial one day there was no *Vigna Unguiculata* seeds infected to the disease (fungus) but on 2nd day germination started in all concentrations and control. In all concentrations and control it was observed that the *Vigna Unguiculata* seeds are susceptible for the disease (fungus) (Fig. 9). From the Table 11 it is seen that in all 20%, 40%, 60%, 80%, 100% effluent concentration and control for the initial three days there was no *Pisum sativum* seeds infected to the disease (fungus) but on 4th day infection started in 40% effluent concentration, on 5th day infection started in 20%, 60%, and100% effluent concentration and on 6th day infection started in 80% effluent concentration. In control no anyone seed was infected. From Fig.10 it was observed that no any pretreatment is required in *Pisum sativum* seeds for control of disease (fungus).

Conclusion

The physico-chemical characteristics of Textile Mill effluent sample are analyzed. The pH of the effluent sample was 6.74, i.e. slightly acidic in nature. In this effluent EC, TDS, Total Hardness, Chloride and Sodium content was higher than the permissible limit and the Calcium, Magnesium, Potassium and Sulphate content was less than the permissible limit. It can also be attributed to the relatively high salinity of the effluent, which is affected to the growth of the plant species. Due to degradation of water quality it became a concern when population growth and industrial development produces a concentration of society's wastes that imperiled public health (Anonymous, 1971). The collected effluent sample contains anion which can be beneficial for plant growth but its excessive level could be toxic retard the growth of the plants. Industrial effluents, which wastewater from manufacturing or chemical processes contribute to water pollution, which significantly affect the entire food chain (Agarwal, *et al.,* 1996). Certain physical, chemical and biological properties of water up to an adequate level are good for health but became toxic at excessive level (Sofia Nawaz, *et al.,* 2006). The textile mill effluent can be successfully utilized as irrigation for the germination and growth of *Vigna Unguiculata* and *Pisum sativum* seeds after appropriate dilution.

The findings of present study may be proved useful in agriculture for large scale irrigation of diluted effluent. The results of the present findings showed that sent percent germination and best seedling growth occurred in 20% effluent concentration and therefore a progressive decline is germination, root and plumule length of germination was observed. The 60%, 80% and 100% effluent concentration growth of *Vigna unguiculata* seed germination and in 80% and 100% effluent concentration growth of *Pisum sativum* seed germination was constant than the other effluent concentration. In 40%, 60%, 80%, 100% effluent concentrations in *Vigna Unguiculata* seed and in 20%, 40%, 60%, 80%, 100% effluent concentrations *Pisum sativum* seed, it was observed that not a single plumule is germinated. In control of *Pisum sativum* not a single seed was infected. In all concentrations and control of *Vigna Unguiculata* seeds are less infected as compare to *Pisum sativum* seeds. These studies showed that effects 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 (Kaushik *et al.,* 2004).

The textile mill effluent used for irrigation for the germination of seeds with increase in effluent concentration (20-100%) the germination value was adversely affected. Consequently, it was proved that although pure textile mill effluent could not be used for the germination of *Vigna Unguiculata* and *Pisum sativum* seeds but the little dilution (20%) of effluent concentration may be used. The better growth of all the seeds at 20% effluent concentration may be due to the growth promoting effect of nitrogen and other mineral elements present in the effluent (Sahai *et al.,* 1979 and Sahai *et al.,* 1983). Vegetables when treated continuously with textile factory effluent showed that different effluents exceed their recommended level that results in potential health risks (Itanna, 1998). The benefits of wastewater use in irrigation are numerous but precautions should be taken to avoid short and long-term environmental risks.

References

1. Abdul-Baki AA and Anderson JD (1971) Viability and leaching of sugars from germinating seeds by textile, leather and distillery industries. *Ind. J. Environ. Protec.* 11, 592-594.
2. Abu Shakra S and Aqil BA (1970) Observation of germination of tea seed as influenced by soaking, shell removal and shell cracking. *Infl. Seed Test Assoc*. 35, 631.
3. Agarwal SK, Swarnlata T and Dubey PS (1996) Sources of water pollution in: Biodiversity and Environment. *APH. Publishing Corporation*, New Delhi, PP: 180-182.
4. Anonymous (1971) International Standards for Drinking Water. 3rd Edn. WHO, Geneva.
5. Behra BK and Misra BN (1982) Analysis of the effect of industrial effluent on growth and development of rice seedlings. Environ. Res. 28, 10-20.
6. Berti WR and Jacobs LW (1996) Chemistry and phytotoxicity of soil trace elements from repeated sewage sludge application. J. Environ. Qual. 25, 1025-1032.
7. Chang AC, Granato TC and Page AL (1992) A methodology for establishing phyto-toxicity criteria for Cr, Cu, Ni and Zn in agricultural land application of municipal sewage sludges. J. Environ. Qual. 21, 521-536.
8. Clark RB (1995) Marine pollution. 3rd Edn. Oxford University Press, pp: 169
9. Daniele Quaratino, Alessandro D'Annibale, Federico Federici, Carlo Fausto Cereti, Francesco Rossini and Massimiliano Fenice (2007) Enzyme and fungal treatments and a combination thereof reduce olive mill wastewater phytotoxicity on *Zea mays* L. seeds. *Chemosphere.* 66(9), 1627-1633.
10. Debeaujan I, Karen M and Koorneef LM (2000) Influence of the testa on seed dormancy, germination and longivity in Arabidopsis. *Plant Physiol*. 122, 403-413.
11. Debeaujan I, Karen M and Koorneef LM (2000) Influence of the testa on seed dormancy, germination and longivity in *Arabidopsis. Plant Physiol.* 122, 403-413
12. Dunlop SG, Twedt RM & Wang W (1961) Studies on the use of sewage effluent for the irrigation of truck crop. *J. Milk & Food Technol.* 24, 44-50.
13. Easwari K and Lalitha K (1995) Sub-cellular distribution of selenium during uptake and influence on mitochondrial oxidation in *Vigna radiata* L., *Biol. Trace Elem. Res.* 48, 141-160.
14. Fazal Akbar, Fazal Hadi, Zakir Ullah and Muhammad Amir Zia (2007) Effect of Marble Industry Effluent on Seed Germination, Post Germinative Growth and Productivity of *Zea mays* L. *Pakistan Journal of Biological Sciences.* 10(22), 4148-4151.
15. Garg VK and Kaushik P (2008) Influence of Textile Mill Wastewater Irrigation on the Growth of Sorghum Cultivars. *Applied Ecology and Environmental Research.* 6(2), 1-12.
16. Groot SPC and Karssen CM (1992) Dormancy and germination of abscisic acid and deficient tomato seeds, *Plant Physiol.* 99, 952-958
17. Hetherington AM and Woodward IF (2003) The role of stomata in sensing and driving environmental change. *Nature.* 424, 901-908.
18. Holdsworth MJ, Bentsink L and Soppe WJJ (2008) Molecular networks regulating Arabidopsis seed maturation, after ripening, dormancy and germination. New Phytol. 179, 33-54.
19. Itanna F (1998) Metal concentration of some vegetables irrigated with industrial liquid waste at Akaki, Ethiopia. *Sinet. Ethiopian Sci. J.* 21, 133-144.
20. Kannan A and Upreti Raj K (2008) Influence of distillery effluent on germination and growth of mung bean (*Vigna radiata*) seeds. *Journal of Hazardous Materials*. 153(1-2), 609-615.
21. Keller M and Kollmann J (1999) Effects of seed provenance on germination of herbs for agricultural compensation sites. Agric. Ecosyst. Environ. 72, 87-99.

22. Kelly KM, J Van Staden and Bell WE (1992) Seed coat structure and dormancy. *Plant Growth Reg.* 11, 201-209.
23. Kelly KM, J Van Staden and Bell WE (1992) Seed coat structure and dormancy. *Plant Growth Reg.* 11, 201-209
24. Komilis DP, Karatzas E and Halvadakis CP (2005) The effect of olive mill wastewater on seed germination after various pretreatment techniques. *J. Environ. Manage.* 74, 339-348.
25. Leubner-Metgzer G, Fruindt C, Vogeli-Lange R and Meins J (1995) β-1,3-Glucanase in the endosperm of tobacco during germination. *Plant Physiol.* 109, 751-759
26. Mbarka Gouider, Mongi Feki and Sami Sayadi (2010) Bioassay and use in irrigation of untreated and treated wastewaters from phosphate fertilizer industry. *Ecotoxicology and Environmental Safety*. Article in press. Corrected proof. Domain site: http://www.sciencedirect.com.scopeesprx.elsevier.com.
27. Mohammad Ajmal and Ahsan Ullah Khan (1983) Effects of Sugar Factory Ettluent on Soil and Crop Plants. *Environmental Pollution (Series A).* 30, 135-141.
28. Ogunwenmo KO, Oyelana OA, Ibidunmoye O, Anyasor G and Ogunnowo AA (2010) Effects of Brewery, Textile and Paint Effluent on Seed Germination of Leafy Vegetables-Amaranthus hybrids and Celosia argentea (Amaranthaceae). *J. of Biological Sciences.* 10(2), 151-156.
29. Priya Kaushik, Garg VK and Bhupinder Singh (2005) Effect of textile effluents on growth performance of wheat cultivars. *Bioresource Technology*. 96(10), 1189-1193.
30. Radosevich S, Holt J and Ghersa C (1997) Weed ecology: Implications for management. 2nd Edn., John Wiley and Sons, New York, ISBN: 978-0-471-11606-6.
31. Ramana S, Biswas AK, Kundu S, Saha JK and Yadava RBR (2002) Effect of distillery effluent on seed germination in some vegetable crops. *Bioresource Technology.* 82, 273-275.
32. Rodger JBB, Williams GG and Davis A (1957) A rapid method for determining winter hardness of alfalfa. *Agronomy Journal.* 49, 88-92.
33. Sahai R, Agrawal N and Khosla N (1979) Effect of fertilizer factory effluent on seed germination, seedling growth and chlorophyll content of *Phaseolus radiatus* Linn. *Tropical Ecology.* 22, 156-162.
34. Sahai R, Shukla N, Jabeen S and Saxena PK (1983) Pollution effect of distillery waste on the growth behaviour of *Phaseolus radiatus* L. *Environmental Pollution (Series A).* 37, 245-253.
35. Seastedt GP and Suding KN (2007) Biotic constraints on the invasion of diffuse knapweed (*Centaurea diffusa*) in a Colorado grassland. *Oecologia.* 151, 626-636.
36. Sofia Nawaz, Syeda Maria Ali and Arza Yasmin (2006) Effect of Industrial Effluents on Seed Germination and early Growth of *Cicer arientum*. *J. of Biological Sciences.* 6(1), 49-54.
37. Thabaraj GJ, Bose SM and Nayudamma Y (1964) Utilisation of tannery effluent for agricultural purposes. *Ind. J. environ. Hlth.,* 6, 18-36.
38. Umebese CE and Onasanya OM (2007) effect of Minta Effluent on the Phenology, Growth and Tield of *Vigna unguiculata* (L) Walp Var. Ife Brown. *J. of Biological Sciences.* 10(1), 160-162.
39. Ungar IA (1987) Halophyte seed germination. *Botanical Review*. 44, 233-264.
40. Vahram Elagoz, Susan S Han and William J Manning (2006) Acquired changes in stomatal characteristics in response to ozone during plant growth and leaf development of bush beans (*Phaseolus vulgaris* L.) indicate phenotypic plasticity. *Environmental Pollution*. 140(3), 395-405.
41. Varma MM, Sedanely SG and Katz HM (1976) Physiological effects of trace elements and chemicals in water. J. Environ. Health. 39, 9-100.
42. Visser T and Tillekeratne LM (1958) Tea quality. *J. Sci. Ind. Res*. 29, 30.
43. Wong MH and Bradshaw AD (1982) A comparison of the toxicity of heavy metals using root elongation of Rye grass, *Lolium perenne*. New Phytol. 91, 255-261.
44. Zahoor Ahmad Bazai and Abdul Kabir Khan Achakzai (2006) Effect of Wastewater from Quetta City on the Germination and Seedling Growth of Lettuce (*Lactuca sativa* L.). *Journal of Applied Sciences.* 6(2), 380-382.

