



## Study of Morphological Characteristics of Spinach Irrigated with Industrial waste water of Bhiwadi, Rajasthan, India

Saini Madhvi, Sharma K.C. and Sharma Manju\*  
Department of Botany, University of Rajasthan, Jaipur, INDIA

Available online at: [www.isca.in](http://www.isca.in), [www.isca.me](http://www.isca.me)

Received 19<sup>th</sup> February 2014, revised 25<sup>th</sup> February 2014, accepted 21<sup>st</sup> March 2014

### Abstract

*In the present investigation industrial area of Bhiwadi, (Alwar district) was selected as study area. The plants of spinach were treated with 3 types of water samples i. ground water ii. Treated water (CETP outlet) and iii. untreated water (CETP inlet) and analyzed for morphological characters. Results showed that waste water increased stem length, root length, fresh and dry weight, leaf length and leaf breadth and decreased seedling length, vigour index, and germination percentage of seeds. Waste water effects leaf colour and shape and seed colour, seed size and spermoderm patterns. Results revealed that waste water irrigation brought up negative changes in most of the important growth parameters of plants and hence this water is not found suitable for crop irrigation.*

**Keywords:** Industrial waste water, spinach, morphological characteristics, spermoderm patterns.

### Introduction

Industrialization is rapidly increasing to fulfill human needs. Waste water from industries is released in water bodies. The untreated and partially treated waste water contains fertilizers, pesticides, textiles, pharmaceuticals and various types of other chemicals which have been proven harmful to living beings particularly animals, plants and human beings<sup>1-4</sup>. Physio-chemical parameters of water are induced due to discharge of untreated or partially treated industrial waste and sewage waste into water bodies<sup>5-7</sup>. The untreated or partially treated waste water from industries are continuously used in irrigating the agricultural fields in developing countries including India<sup>8-10</sup>. Continuous use of this waste water for irrigation effects soil quality<sup>11,12</sup>.

The industrial effluents, in lower quantities provide macro and micro nutrient requirements of the plants. But higher quantity becomes harmful.

Leafy green vegetables like spinach, kale, chards and others are the most potent superfood. Leafy green vegetables are rich source of minerals like calcium, magnesium, iron and potassium, vitamin K and C. they are low in fat, high in protein, and high in dietary fiber and also contain a lot of water. Leafy vegetables like spinach are more sensitive to toxic pollutants than other vegetable crops because of higher amounts of accumulation of heavy metals in their leafy growth and long term intake of these leafy vegetables cause clinical problems both to animals and human beings.

The present study was aimed at analyzing quality of water from industrial area of Bhiwadi, and its effect on morphological characteristics of spinach.

### Material and Methods

**Study area:** Bhiwadi is called gateway of Rajasthan. It is located in Tijara tehsil of Alwar Distt.. It comes under Delhi NCR region. It is 55 km away from Indira Gandhi International airport, New delhi and 200 km from Jaipur. It is a industrial hub. It has 1500 small and large industries including MNC industrial units and steel, furnance, engineering, pharmaceuticals, textiles etc.

**Collection of water samples:** The study was conducted with effluents released from industries at Bhiwari, Alwar. There are industries like steel, electronics, textiles, drugs, chemicals food processing etc.

The waste water released from these industries were collected at the main outlet point where combined effluent from the industries is being disposed and inlet point of CETP (common effluent treatment plant)/untreated water and other water samples were collected from CETP outlet point (treated water) and third water sample is ground water.

**Experimental set up and raising of plants:** 3 plots of 6.5 × 4.5 m<sup>2</sup> size were prepared and genetically uniform seeds of spinach were sown in each plot. Uniform irrigation schedule was followed at all the sites to maintain similar moisture condition throughout the growth of plants. Names of the 3 plots were given as GW, inlet, outlet plots. When the plants were growing morphological characteristics (vegetative growth) like stem length, root length, petiole length, leaf colour, fresh and dry weight, seed germination percentage, seed colour, seed size, and seed surface patterns were recorded.

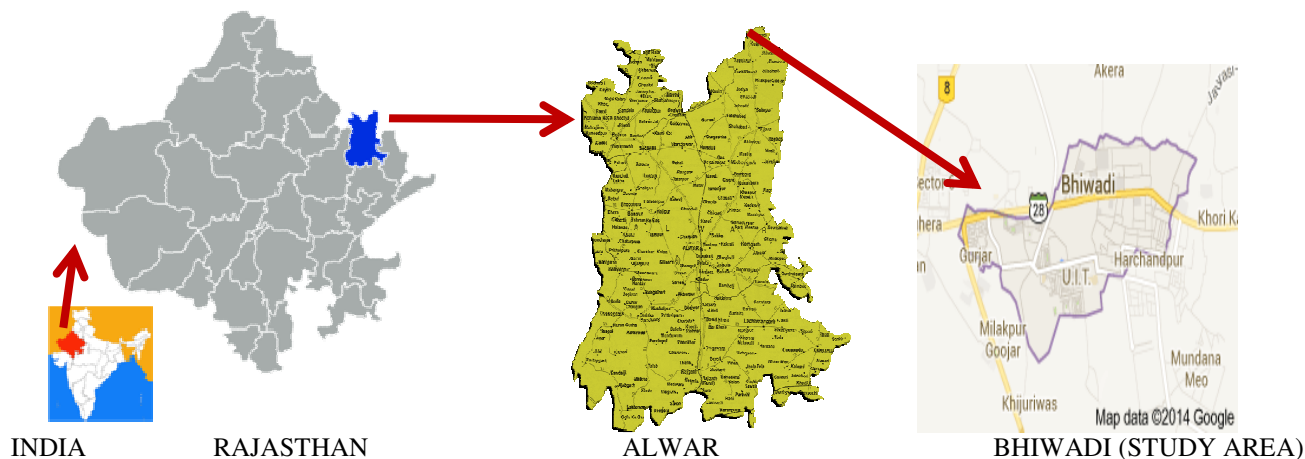


Figure-1  
Bhiwadi (study area) map

For plant sampling, five replicates from each sub plot were collected randomly from ground water, treated water and untreated water irrigated plots. Seed germination percentage, seedling length, root and shoot length, petiole length, leaf length and breadth and seed size were quantified. leaf shape, leaf colour, seed colour and were also observed.

Seed surface patterns were studied by SEM .For this seeds were affixed on aluminium stub with help of transparent adhesive. Seeds coated with gold and examined at a range of magnification in a EVO 18 Scanning Electron Microscope at USIC department, University of Rajasthan, Jaipur. For fresh weight estimation, plant samples were separately washed to remove the soil particles and weighed. For estimation of dry weight plant sample were dried in shade. Plant samples were weighed separately and biomass was expressed in gm. For germination percentage, 50 sterilized seeds of sorghum were placed in sterilized petri dishes containing filter paper. They were kept wet continuously by adding different water samples. The number of germinated seeds in each Petri dish was recorded daily up to 10 days and expressed as % seed germination. After 10 days vigor index (VI) was calculated<sup>13</sup>.

$$VI = \text{Germination\%} \times \text{Seedling Growth}$$

## Results and Discussion

Leaf length, leaf breadth and petiole length, leaf area are  $2.96 \pm 0.343$ ,  $2.27 \pm 0.194$ ,  $3.74 \pm 0.380$  cm respectively;  $1.54 \pm 0.194$ ,  $0.74 \pm 0.258$ ,  $1.81 \pm 0.293$  cm respectively and  $2.26 \pm 0.509$ ,  $1.73 \pm 0.245$ ,  $2.93 \pm 0.330$  cm respectively,  $126.3 \pm 13.05$ ,  $158.85 \pm 25.65$ ,  $202.2 \pm 32.8$  cm<sup>2</sup> as observed in plants grown in ground water, treated water and untreated water respectively (figure 2). Irrigation with sewage has increased in sorghum leaf width and also, increased the yield rate<sup>14</sup>.

Seedling length was  $6.52 \pm 0.852$ ,  $5.62 \pm 0.825$ ,  $5.7 \pm 2.05$  cm as observed in ground water, treated water and untreated water

respectively figure-3. Shoot and seedling length was reduced after metal treatments<sup>15-16</sup>. This could be because of reduction in meristematic cells present in the region and some cotyledonary and endosperm enzymes which became active and began to digest the stored food. This resulted in not proper supply of food to the radical and plumule.

The value for vigor index is 521.6, 359.68 and 319.2 cm respectively and germination percentage is 80%, 64%, and 56% was observed in plants grown in ground water, treated water and untreated water samples respectively. Figure-4, 7.

Growth characteristics such as plant health (i.e. radicle length and plumule lengths) and seed vigor index increased with 50% effluent irrigation and decreased with 100% (undiluted) effluent irrigation at all soil column heights<sup>17-18</sup>.

Fresh weight of leaves is  $0.3565 \pm 0.031$ ,  $0.383 \pm 0.018$  and  $0.6745 \pm 0.014$  gm of plants grown in ground water, treated water and untreated water respectively. Dry weight of leaves is  $0.0256 \pm 0.0081$ ,  $0.0233 \pm 0.0063$ , and  $0.0886 \pm 0.0074$  gm of plants grown in ground water, treated water, untreated water respectively figure-2. Effects of different percentages of effluent irrigation with wastewater on corn yield<sup>19</sup>. Results showed, the highest grain yield and total biomass were observed in 100% urban treatment and with reduction of wastewater, the yield decreased too<sup>20</sup>. Cotton yield irrigated with wastewater was more than that in irrigation with typical water<sup>21</sup>.

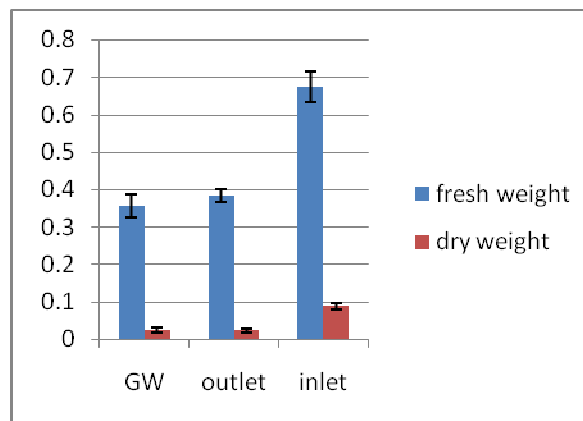
Stem length is the highest of plants irrigated with treated water  $1.79 \pm 0.871$  cm, followed by height of plants irrigated with treated water  $1.63 \pm 0.560$  cm and minimum height  $1.38 \pm 0.565$  cm of plants grown in ground water figure-6. Root length is the highest of plants irrigated with treated water  $19.1 \pm 0.77$  cm, followed by height of plants irrigated with treated water  $17.4 \pm 0.258$  cm and minimum height  $11 \pm 0.840$  cm figure-5.

**Table-1**  
**Showing comparison of morphological characters in plants irrigated with ground water, treated water and untreated water industrial waste water**

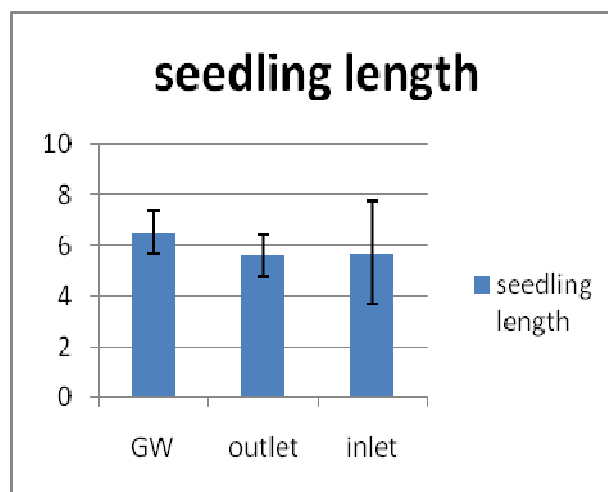
S No.	characterstics	Ground water	Treated (outlet)	Untreated (inlet)
1	Stem length	1.38 ±0.871	1.79 ±0.560	1.63 ±0.565
2	Root length	11±0.840 cm	17.4 ±0.757 cm	19.1 ± 0.770cm
3	Leaf length	2.96 ± 0.343 cm	2.27 ±0.194 cm	3.74 ± 0.380 cm
4	Leaf breadth	1.54 ±0.194 cm	0.74 ±0.258 cm	1.81 ±0.293 cm
5	Petiole length	2.26 ±0.509 cm	1.73 ± 0.245 cm	2.93 ±0.330 cm
6	Leaf shape	ovate	ovate	Curling in leaf margin
7	Leaf colour	green	Green +yellowing	Green with brown spot
8	Seed size	3.7*2.0 mm	3.6*2.0mm	3.8*2.1mm
9	Germination %	80%	64%	56%
10	Seedling length	6.52±0.852	5.62±0.825	5.7±2.05
12	Vigour index	521.6 cm	359.68 cm	319.2 cm
13	Fresh weight	0.3565 ±0.031gm	0.383 ±.018 gm	0.6745 ±0.04gm
14	Dry weight	0.02566 ±.0081 gm	0.0233±0.0063 gm	0.08866 ±0.0074 gm
15	Leaf area	126.3±13.05 cm <sup>2</sup>	158.85±25.65 cm <sup>2</sup>	202.2±32.08 cm <sup>2</sup>

Shoot length showed a significant higher value in waste water irrigated plants as compared to the controls. This in support of the earlier studies in *Hardwic kia binata* and in *Wheat*<sup>22-23</sup>. Irrigation with sewage water caused increasing tailoring, stem length, root length, panicle length and number of spikes in rice<sup>24</sup>. And similar results weret observed in barley in the Boyerahmad region of Iran<sup>25</sup>. However there was increase in certain parameters like root - stem length, length of leaf and fresh and dry weight etc. in the present investigation also. But this is due to industrial waste water which generally contains heavy metals. And literature reveals that micronutrients found in waste water may be beneficial for plant growth but several micronutrients which are heavy metals may produce undesirable effects on plants at higher concentration<sup>26</sup>. And this is supported by present data which indicated that visible symptoms of toxicity appeared in untreated plants, such as brown spots on leaf and chlorosis and ovate shape with curling in leaf margin. Colour of leaf as green with yellow and ovate shape is observed in plants irrigated with treated waters. These symptoms were not observed in plants grown in ground water figure-11,12. The retardation in growth and development of plants could be due to high uptake of heavy metals and their accumulation in plants<sup>27-28</sup>.

Seed colour is greyish light brown in plants grown in ground water, brownish black coloured and black coloured in plants grown in of treated water and untreated water respectively Figure-9. Seed size are 3.7 ×2mm, 3.6 ×2mm, 3.5 ×2.0 mm respectively of plants growing in ground water , treated water and untreated water which is non significant. However the seed surface patterns as revealed by Scanning electron microscope showed warty, net like and prickly surface with flaty elevated muri of thin strands in seeds from plant irrigated with ground water. The flaty elevated muri become regular and much condensed in treated water palnts and densly populated with irregular arrangements and condensed populations in plants grown in untreated waste water.



**Figure-2**  
**Fresh and dry weight of plants grown in ground water, treated water (outlet) and untreated water (inlet)**



**Figure-3**  
**Seedling length of plants grown in ground water, treated water (outlet) and untreated water (inlet)**

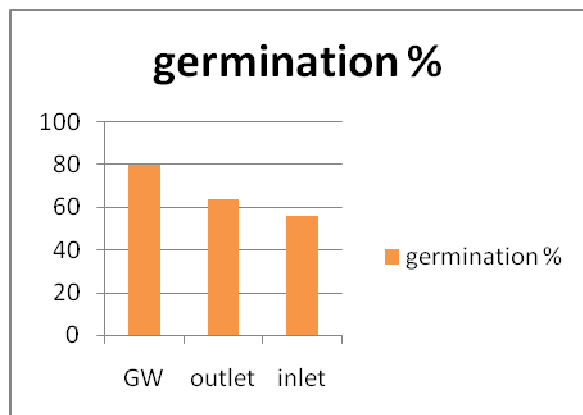


Figure-4

Germination percentage of plants grown in ground water, treated water (outlet) and untreated water (inlet)

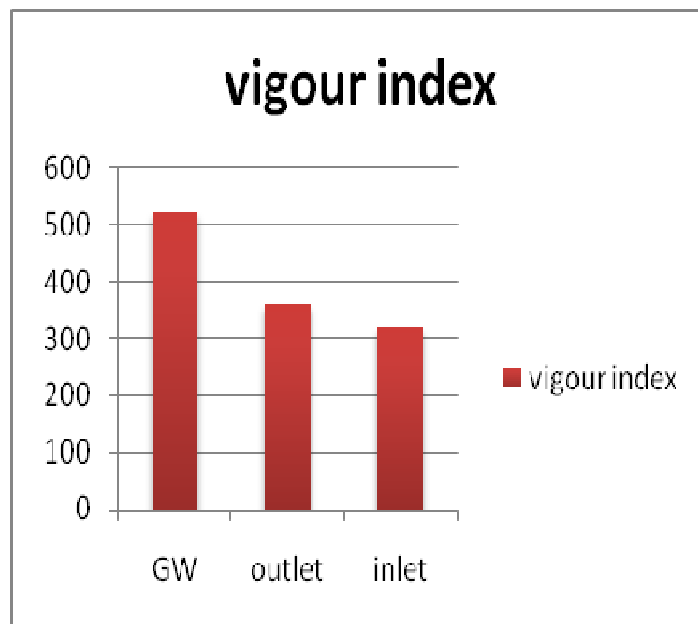


Figure-7

Vigour index of plants grown in ground water, treated water (outlet) and untreated water (inlet)

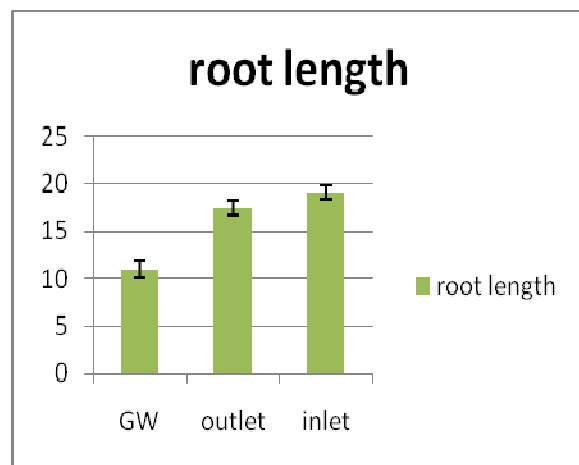


Figure-5

Root length percentage of plants grown in ground water, treated water (outlet) and untreated water (inlet)

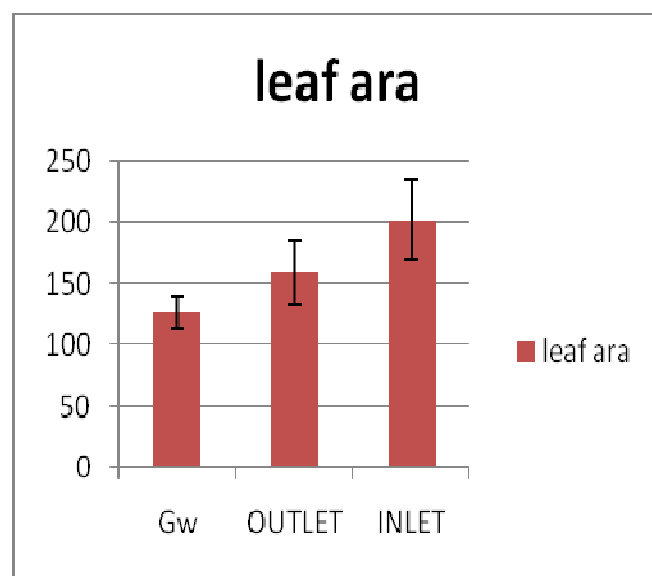


Figure-8

Leaf area of palnts grown in ground water, treated water (outlet) and untreated water (inlet)

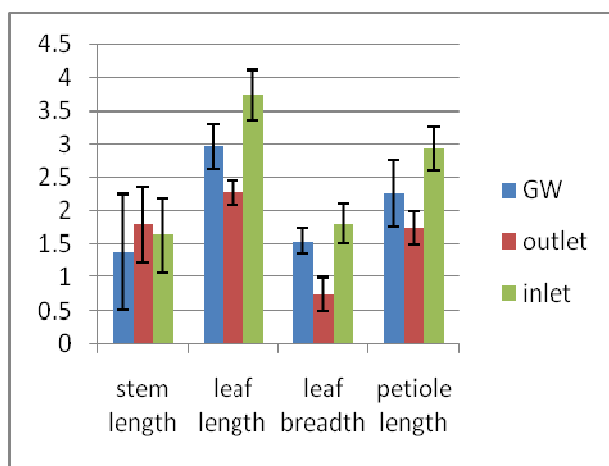


Figure-6

Stem length, leaf length, leaf breadth, petiole length of plants grown in ground water, treated water (outlet) and untreated water (inlet)

### Conclusion

The data presented here seem to reveal that industrial waste water used for crop irrigation significantly affected quality parameters of spinach as compared to ground water irrigation. Seedling growth, germination percentage and other morphological characters may be considered as an indicator of metal stress on plant vigour.



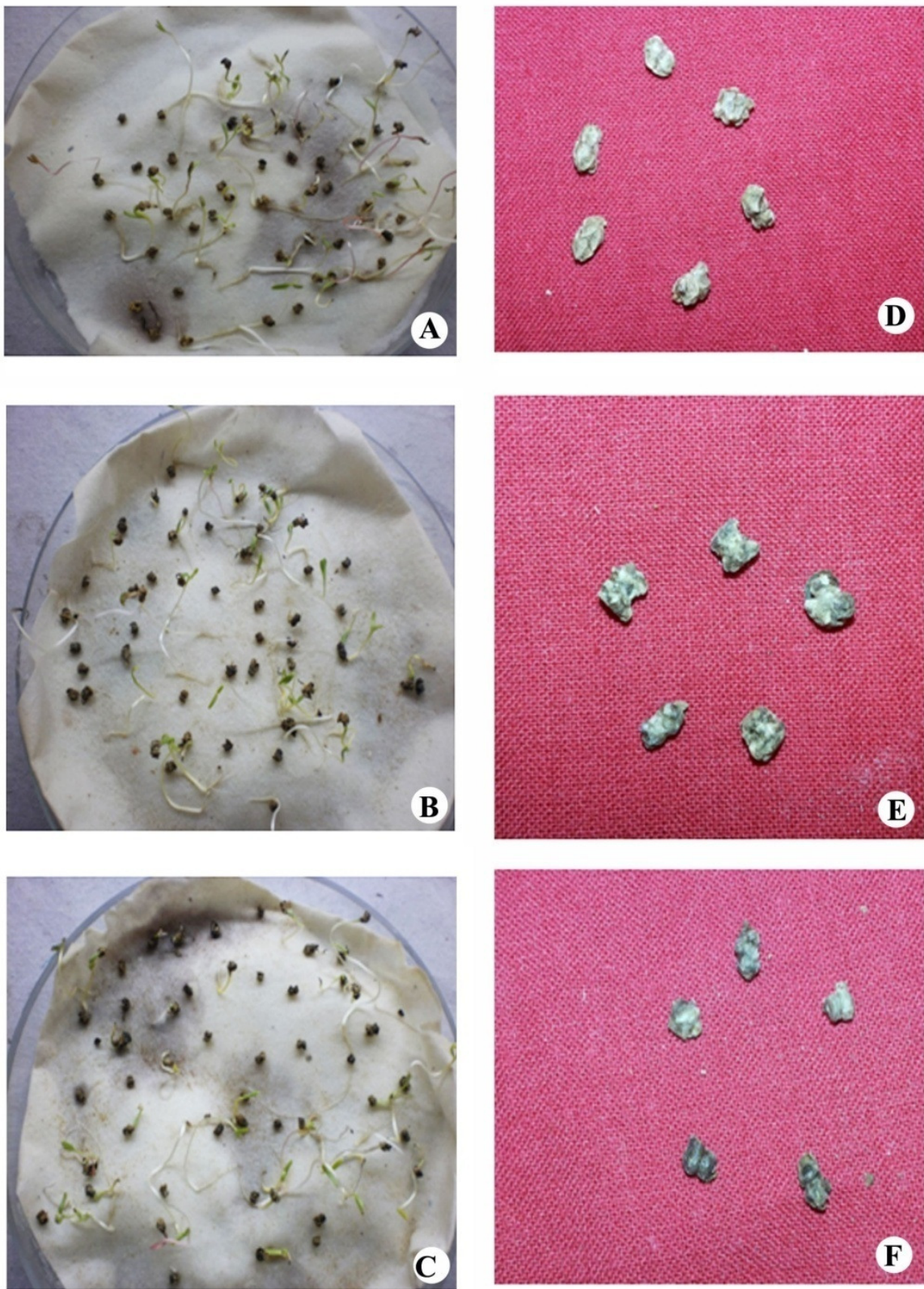


Figure-9

Showing seed germination in ground water, treated and untreated water figure A-C and seeds obtained after harvesting from the experimental palnts irrigated respectively ground water treated and untreated water D-F





**Figure-10**  
Showing plants grown in ground water figure A-B and plants grown in treated water C-D



**Figure-11**  
Showing plants grown in untreated water



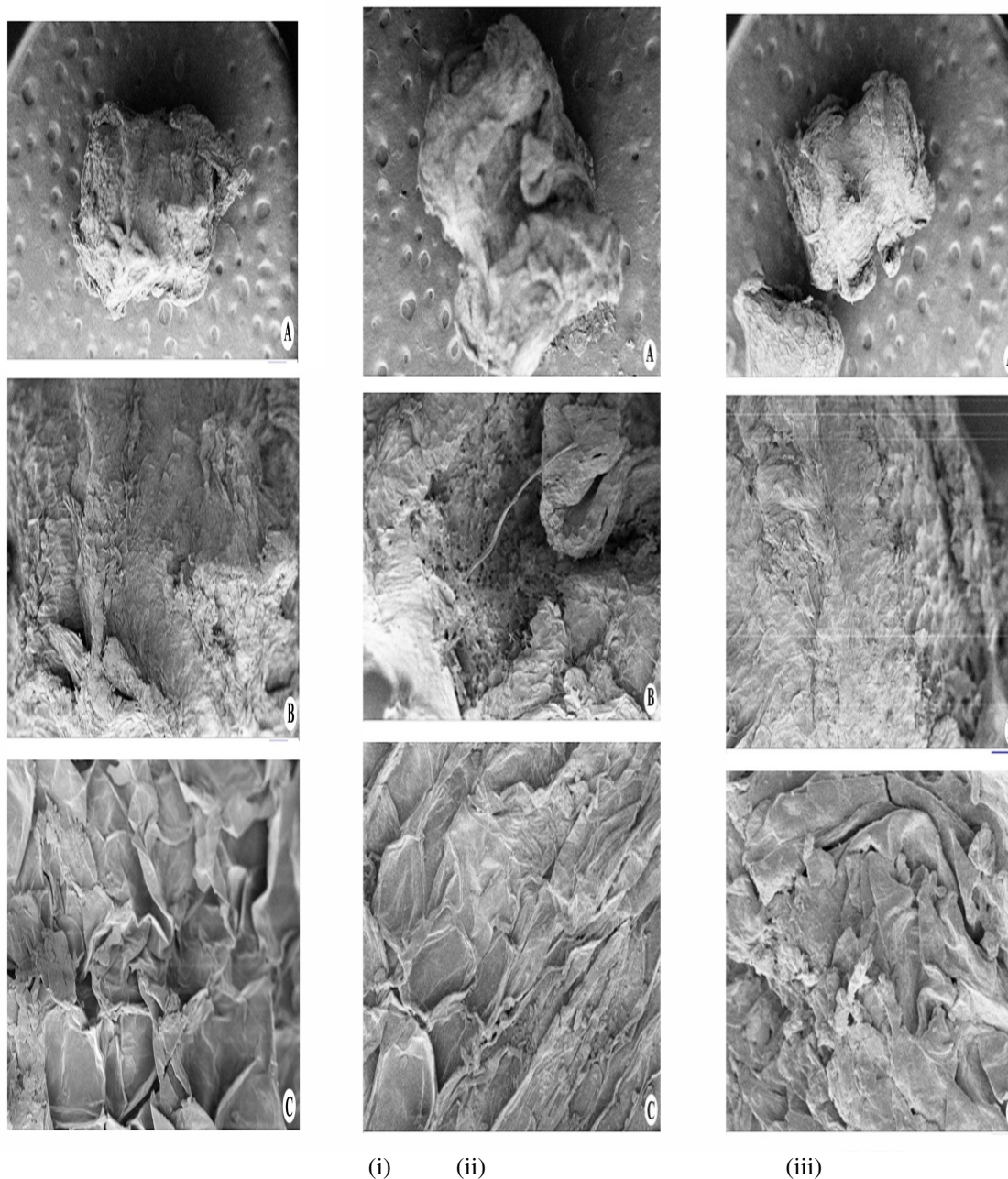


Figure-12

SEM images of seeds of plants grown in ground water, treated and untreated water A-C ( i,ii,iii)

## References

1. Chandra R., Kumar K., and Singh L., Impact of an aerobically treated and untreated (raw) distillery effluent irrigation on soil microflora, growth, total chlorophyll and protein contents of *Phaseolus aureus* L., *J. Environ. Bio.*, **25(4)**, 381-385 (2004)
2. Sahu R.K., Katiyar S., Tiwari J, Kiskum G. C., Assessment of drain water receiving effluent from tanneries and its impact on soil and plants with particular emphasis on bioaccumulation of heavy metals, *J. Environ. Biol.*, **28(3)**, 685-690 (2007)
3. Yadav A., Nerliya S., Gopesh., Acute toxicity levels and ethological responses of *Channa striatus* to fertilizer industrial wastewater, *J. Environ. Biol.*, **28(2)**, 159-162 (2007)
4. Pandey S.N., Nautiyal B.D. and Sharma C.P., Pollution level in distillery effluent and its phytotoxic effect on seed germination and early growth of maize and rice, *J. Environ. Biol.*, **(29)**, 267-270 (2008)

5. Mangukiya R, Bhattacharya T. and Chakraborty S. Quality Characterization of Groundwater using Water Quality Index in Surat city, Gujarat, India, *International Res. J. of Env.Sci.* **1(4)**, 14-23 (2012)
6. Kumar M.and Kumar R.Assessment of Physico-Chemical Properties of Ground Water in Granite Mining Areas in Goramachia, Jhansi, UP, India, *International Res. J. of Env.Sci.* **2(1)**, 19-24,(2012)
7. Thoker Farook A., Manderia S. and Manderia K. Impact of Dye Industrial Effluent on Physicochemical Characteristics of Kshipra River, Ujjain City, India, *International Res.J. of Env.Sci.* **1(2)**, 41-45.(2012)
8. Sharma R.K, Agrawal M. and Marshall F.M., Heavy metals contamination of soil and vegetables in suburban areas of Varanasi, India, *Ecotoxicol Environ. Saf.*, **(66)**, 258 (2007)
9. Nath K., Singh D., Shyam S. and Sharma Y.K., Phytotoxic effects of chromium and tannery effluent on growth and metabolism of Phaseolus mungo Roxb., *J. Environ. Biol.*, **(30)**, 227-234 (2009)
10. Nagajyothi P.C., Dinakar N., Suresh S., Udaykiran Y., Suresh C. and Damodharam T.,Effect of industrialeffluent on the morphological parameters and chlorophyll content of green gram (Phaseolus aureus Roxb), *J. Environ. Biol.*, **(30)**, 385-388 (2009)
11. Ladwani Kiran D., Ladwani Krishna D., Manik Vivek S. and Ramteke Dilip S. Impact of Industrial Effluent Discharge on Physico-Chemical Characteristics of Agricultural Soil , *International Res.J. of Env.Sci.* **1(3)**, 32-36,(2012)
12. Mir Tariq A., Manderia S. and Manderia K. Influence of dye industrial effluent on physico chemical characteristics properties of soil at Bhairavgarh, Ujjain, MP, India, *International Res.J. of Env.Sci.* **1(1)**, 50-53,(2012)
13. Baki A., Anderson J D.,Vigour determination soyabean seed by multiple criteria,*Crop. Sci.***3**, (1973)
14. Day D., Tucker T.C., Efects of treated municipal wastewater on growth, fiber, protein and amino acid content of sorghum grain, *J. Environ.*, **(6)**, 325-327 (1977)
15. Goldbold D.L. and Kettner C., Lead influences on root growth and mineral nutrition of picea abies seedling, *Plant physiology*, **(139)**, 95- 99 (1991)
16. Sharifah B.A. and Hishashi O., 1992, Effect of lead, cadmium and zinc on the cell elongation of impatiens balsamina, *environ, experi. Bot.*, **(3)**,439-448 (1992)
17. Chauhan A., tiwari N., Effect Of Lysimetric Treated Effluent On Seed Germination, Radicle Length and Plumule Length of wheat plants, *New York Science Journal* **(3)**, (2010)
18. Singh A., Agrwal S. B, Rai JNP. Effluent of paper industry effluent on growth, yield and nutrient quality of wheat plants at various soil column height, *Environmental Biology and Conservation*, **(8)**, 50-56 (2003)
19. Hernandez T.J., Moreno F., J J and Costa ,Influence of sewage sludge application on crop yields and heavy metals availability, *Soil Sci. plant Nutr.*, **(37)** 201-210 (1991)
20. Yaghmaei A., Corn yield in irrigation with household waste water and its consequences. M .Sc. thesis, Faculty of agriculture, University of Ferdowsi Mashhad (2000)
21. Papadopoulos, Stylianon Y.,Trickle irrigation of sunflower with municipal waste water Agric., *Water Manage*, **(19)**, 67-75 (1991)
22. Paliwal K., Karunaichamy K.S. T .K and Ananthavalli M., Effect of sewage water irrigation on growth performance, biomass and nutrient accumulation in Hardwic kia binata under nursery conditions. *Bioresource Technol.*, **(66)**,105-111 (1998)
23. Kaushik P., Garg V. K., and Singh B., Effect of textile effluents on growth performance of wheat cultivars. *Biores. Technol.*, **(96)** 1189-1193(2005)
24. Yoon C.G, Kwun S.K., Feasibility study of reclaimed wastewater irrigation to paddy rice culture in Korea, 127-136 (2001)
25. Rahimi A. and Pouzesh H.,Effect of waste water and phosphorus on physiological and morphological characteristics of Barley in the Boyerahmad region of Iran, *Annals of biological research*, **3(6)**, 2745-2749 (2012)
26. Kocak S., Tokusoglu O., and Aycan S.,Some heavy metal and trace essential element detection in canned vegetable foodstuffs by differential pulse polarography (DPP), *Electronic J. Environ. Agric. Food Chem*, **(4)**, 871-878 (2005)
27. Pandey S.N., Accumulation of heavy metals (Cd, Cr, Ni, Cu, and Zn) in Raphanus sativus and Spinacea oleracea L. plants irrigated with industrial effluents, *J. Environ. Biol.*, **(27)** 381-384 (2006)
28. Shadma Naaz and Pandey S. N., Effects of industrial waste water on heavy metal accumulation, growth and biochemical responses of lettuce (Lactuca sativa L.), *Journal of Environmental Biology*, **(31)**, 273-276(2010)