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Effect of industrial effluents on morphological characters evaluated through green technology in edible vegetables

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Abstract
In the present work, the effect of heavy metals were observed on morphological changes in the green vegetables grown in the vicinity of field area near to discharge of dravyawati waste water. It was observed experimentally that there are adverse effects over the radish and brinjal vegetables. These attributes were studied in terms of morphological changes w.r.t. control plants including seed germination %, seed vigor index(SVI), Length of root/shoot (cm), ratio of R/S, Length of cotyledon(cm), Number of cotyledon (%),color of cotyledon, total length of seedling(cm), modified seedlings (twisted, stunted or seedlings with lateral roots).

Keywords: green vegetables, morphological changes, seedlings, waste water

Introduction
The control sites were Department of Botany, University of Rajasthan (Site-I) and Shikarpura, Sanganer (Site - II) and the polluted sites were Govindpura (Jotadawala), Sanganer (Site - III) and near Shikarpura Flyover, Sanganer (Site-IV) of Amanishah Nalla. The whole experiments were carried out during the period of May 2009 to May 2012. Water and soil samples from control and polluted sites were collected for performing water and soil analysis. Plant materials were collected from the plants raised both from control as well as polluted sites for various aspects namely seed germination, morphology of seedlings and mature plants; cytological, biochemical and heavy metal analysis. These experiments were performed on radish and brinjal separately by considering average values for different parameters. Each experiment consisted of 100 seeds per treatment. The plants were raised in randomized block designs. The space between two plants in a row as well as between rows was one feet. Detailed methodologies of different aspects were mentioned in their respective sections.

Materials and Methods
Seed germination was carried out through Roll-paper- towel method (Anonymous 1990). 100 certified seeds each of brinjal (S. melongena var. esculentum) and radish (R. sativus var. daikon, Japani white) per replicate were taken for the experiment. Seeds were soaked overnight in tap water and considered as control ones. Seeds were soaked overnight in industrial effluent polluted water of Nalla. 100 seeds per replicate and three replicates for each species were used. After soaking, they were placed on the blotter sheets for germination and data for seed germination % and seedling morphological characteristics were gathered after 6th day. Each experiment was carried out in three replicates. Seed germination % and seedling morphological characteristics include comparative study of parameters like number of days of initiation of germination, type of germination, day of maximum germination, germination percentage, length of root, length of shoot, root-shoot ratio, length of cotyledon, number of cotyledon, colour and nature of cotyledon, total length of seedling, seed vigour index and seedling abnormalities. These parameters were studied in both radish and brinjal after the treatments of tap water and Nalla water with industrial effluents. The data of comparative study of seedling morphological characters are summarized in Table. 1 and Table. 2.

Results and Discussion
Seedling Morphological characteristics in Brinjal
Germination of seeds began on 2nd day after seed wetting in all the types of seed treatments. Germination of seeds continued up to 8th day after the initiation of germination. Maximum germination occurred on 4th day after radicle emergence.
Germination percentage was found to be 92% at control site (site I) which becomes reduced at Nalla water treated sites (site III -75 % and site IV-63%. Seeds showed epigeal type of germination.
Seed Vigour Index (SVI) was found to be 603.60 in control site (site I), 520.75 in site III and 539.02 in site IV (Table - 1).
The average length of root in control seedlings at Site I was 5.19 cm. In Nalla water-treated seedlings, the length was 5.45 cm at site III and reduced (4.76 cm) at site IV (Fig. l).
The average length of shoot of seedling was 3.87 cm at site III, 4.12 cm in control at site I and 2.87 cm at site IV (Fig. 1).
In control seedlings at site I, root-shoot ratio was found to be 1:1.26; while at site III, it was 1:1.41 and 1:1.69at site IV.
The average length of cotyledons in control seedlings at site I was 0.83 cm, 0.61 cm at site III and 0.72 cm at site IV (Fig. 1). 4.2% of seedlings at site IV were found to be of tricotyledonous type. (Table 1) Generally seedlings were dicotyledonous and smooth in nature.

Seedling Morphological Characteristics in Radish
Germination began on 4th day after seed wetting and continued up to 6th day after radicle emergence in all the three types of seedling treatments. Maximum germination occurred on the 3rd day after radicle emergence.
Germination percentage was found to be 93% at control site (site I) which became reduced at Nalla water treated site (site IV 85 % and site III 82 %). Germination was epigeal.
Seed Vigour Index (SVI) was found to be 714.52 at control site (site I), 591.58 at site III and 510.34 at site IV.
The average length of root in Nalla water treated seedlings at site IV and III was 5.09 cm and 6.03 cm respectively. Whereas it was found 6.34 cm in control at site I (Fig. 3).
The average length of shoot of seedling was 3.15 cm at site III and 4.17 cm in control at site I and 3.88 cm at site IV (Fig. 3).
In control seedlings at site I, root-shoot ratio was 1:1.534; while it was 1:1.925 and at site III and 1:1.42 at site IV (Table 2).
The average length of cotyledons was 0.63 cm at site I, 0.72 cm at site III and 0.71cm at site IV (Fig. 3).
The percentage of seedlings with green cotyledons was 74%, 78.3 % and 94 % at site IV, site III and site I respectively (Table 4.3.1). Seedlings with pale yellow cotyledons were 21.7%, 16% and 6 % at sites III, IV and I respectively (Table 1).
The total length of seedlings was 6.55cm, 6.93cm and 8.54 cm at site I, site III and site IV respectively (Fig. l).
Seedlings were broadly categorized as normal and modified types. The latter type was further categorized as stunted seedlings, seedling with lateral roots and twisted seedlings (Fig. 5).
The maximum percentage (49.64%) of twisted seedlings was observed at site IV, followed by site III (45.23%) and control site I (20.29%).Seedlings with lateral roots were found 15.64%, 3.45% and 1.4 % at site IV, site III and at control site I respectively. 3.61 %, 12.95 % and 20.40 % seedlings were stunted at site I, site III and site IV respectively (Fig. 2) (Table. 1).

Seedling morphological characteristics in radish

Germination began on 4th day after seed wetting and continued up to 6th day after radicle emergence in all the three types of seedling treatments. Maximum germination occurred on the 3rd day after radicle emergence.
Germination percentage was found to be 93% at control site (site I) which became reduced at Nalla water treated site (site IV 85 % and site III 82 %). Germination was epigeal.
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The average length of cotyledons was 0.63 cm at site I, 0.72 cm at site III and 0.71cm at site IV (Fig. 3).
2.4% of seedlings at site IV were of tricotyledonous type (Table 2). Generally seedlings were dicotyledonous and smooth in nature.
The percentage of seedlings with green cotyledons was 58%, 79 % and 96 % at site IV, site III and site I respectively (Table 2).
21%, 42% and 4 % seedlings were with pale yellow cotyledons at site III, site IV and site I respectively (Table 2).
The total length of seedlings was 7.64 cm, 7.19 cm and 5.98 cm at site I, site III and site IV respectively (Fg. 3).
Seedlings were broadly categorized into normal and modified types. Modified types of seedlings were further categorized as stunted seedlings, seedlings with lateral roots and twisted seedlings (Fig. 6).
The maximum percentage (15.44%) of twisted seedlings was observed at site IV, followed by site III (7.34%) and control site I (2.3%).Seedlings with lateral roots were 23.00 %, 9.67 % and 2.73 % at site IV, site III and at control site I respectively. 9.12 %, 18.61 % and 27.10 % seedlings were stunted at site I, site III and site IV respectively (Fig. 4) (Table 2).

Morphology of mature plants

No major variations were noticed in general morphology of mature plants grown in control and polluted water irrigated sites. Only minor difference between height of control and polluted water irrigated plants was noticed. Average height of plants grown in control and polluted water sites was 61.6 cm and 68.1 cm in brinjal and 83.2 cm and 88.4 cm in radish respectively. In brinjal, fruits size measured about 7.65 x 6.50 (L x B) cm2 and 8.50 x 7.24 (L x B) cm2 in plants grown in control and polluted water sites I and IV respectively. Length of fruits in radish measures about 4.65 cm and 5.23 cm respectively in control and polluted water sites I and IV respectively.

Table 1: Seedling Morphology of Brinjal after treatment with control water and Nalla water

Characters	Site-I (Control)	Site-III	Site-IV
1. Seed germination %	92%	75%	63%
2. Seed Vigour Index (SVI)	603.6	520.75	539.02
3. Length of root (cm)	5.19	5.45	4.76
4. Length of shoot (cm)	4.12	3.87	2.87
5. Ratio of R/S	1:1.26	1:1.41	1:1.69
6. Length of cotyledon (cm)	0.83	0.61	0.72
7. Number of cotyledon (%)	2	2	3(4.2%)

8. Colour of cotyledon	Green (94%), Pale yellow (6%)	Green (78.3%), Pale yellow (21.7%)	Green (74%), Pale yellow (16%)
9. Total length of seedling (cm)	6.55	6.93	8.54
10. Modified seedlings (A) Twisted seedling	20.29%	45.23%	49.64%
(B)Seedling with lateral roots	1.4%	3.45%	15.64%
(C)Stunted seedling	3.61%	12.95%	20.4%

Table 2: Seedling Morphology of Radish after treatment with control water and Nalla water

Characters	Control (Site-I)	Site-III	Site-IV
1. Seed germination %	93%	82%	85%
2. Seed Vigour Index (SVI)	714.52	591.58	510.34
3. Length of root (cm)	6.34	6.03	5.09
4. Length of shoot (cm)	4.17	3.15	3.88
5. Ratio of R/S	1:1.534	1:1.925	1:1.42
6. Length of cotyledon (cm)	0.63	0.72	0.71
7. Number of cotyledon (%)	2	2	3(2.4%)
8. Colour of cotyledon	Green (96%), Pale yellow (4%)	Green (79%), Pale yellow (21%)	Green (58%), Pale yellow (42%)
9. Total length of seedling (cm)	7.64	7.19	5.98
10. Modified seedlings A. Twisted seedling	2.3%	7.34%	15.44%
B. Seedling with lateral roots	2.73%	9.67%	23%
C. Stunted seedling	9.12%	18.61%	27.1%

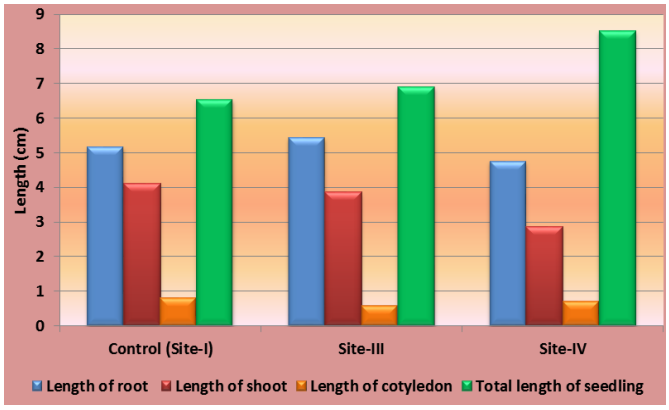

Fig 1: Comparative seedling morphology in Brinjal

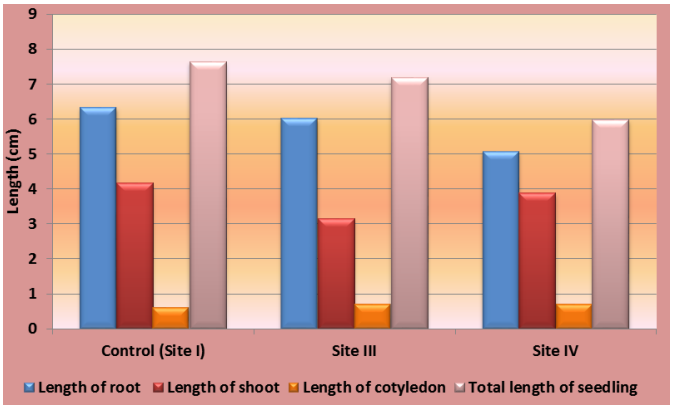

Fig 3: Comparative seedling morphology in Radish

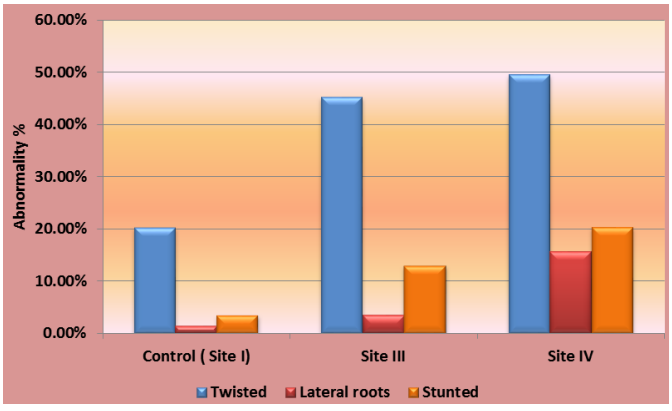

Fig 2: Different type of seedling (%) in Brinjal

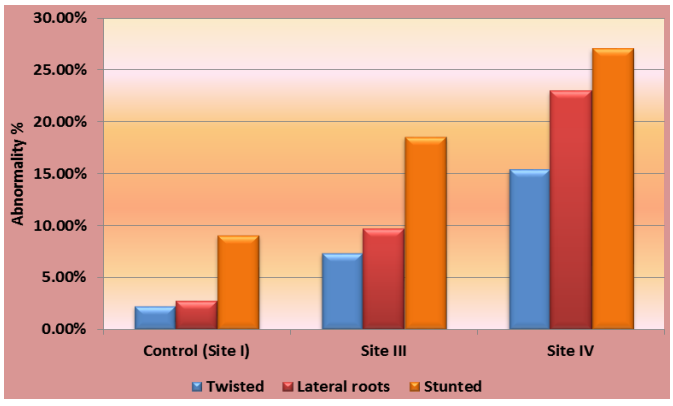

Fig 4: Different type of seedling (%) in Radish

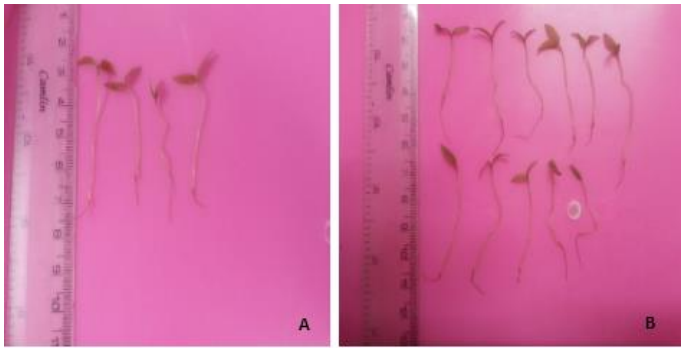

Fig 5: Different types of seedlings in Brinjal grown in (A) Control water (site I), and (B) Polluted water (site IV)

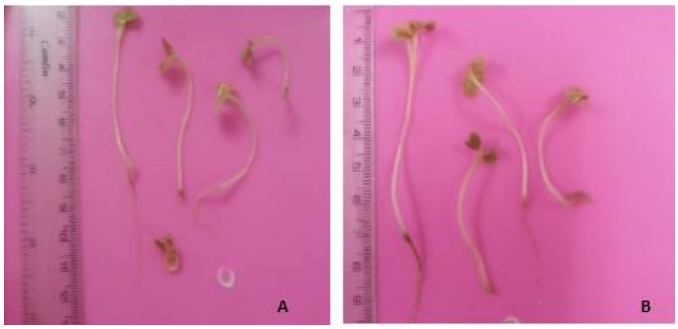

Fig 6: Different types of seedlings in Radish grown in (A) Control water (site I), and (B) Polluted water (site IV)

Fig 7: Radish and Brinjal Seeds

Conclusion

Effects of effluent on morphological characters of plants

Maximum seed germination and higher Seed Vigour Index (SVI) were found in controls and these were reduced in Nalla treated seed of both plants at sites III and IV. Similar results were obtained by Singh and Mishra (1987) who reported the higher concentration of fertilizer factory effluent inhibited the percentage of seed germination in corn and rice and Sharma and Sing (1999) who found that rubber factory effluent and city waste water caused a significant reduction in seed germination, and seed fertility in black gram (Vigna mungo). Polluted water reduced the length of root and shoot in both of plants at site IV. In Brinjal, the total length of seedling was found higher at site IV as compared to control. But radish seedlings showed higher seedling length at control site. Rajannan and Oblisami (1979) studied in rice the effect of paper factory effluents on soil and crop plants and observed that diluted effluent (25 to 50 per cent) enhanced growth of plant. A reverse order of cotyledon length was seen in brinjal and radish seedlings studied here. The increased average length of cotyledon in brinjal was observed at control site whereas in radish it decreased at site III. i.e. the polluted site. The data fail to establish any correlation.

Industrial effluent (present in water samples of sites III and IV) treatment caused significant reduction in the colour pigments of cotyledon. In both plants, the percentage of pale yellow coloured cotyledons was found to be higher in Nalla water treated seedlings as compared to control. Singh and Singh (1997) also assessed the phytotoxic effect of city waste on the growth and chlorophyll content in pigeon pea and fond significant reduction in growth parameters i.e.

Germination, pigment content, seedling height etc. Sharma et al. (2002) also assessed the effect of distillery effluent on seed germination, early seedling growth and pigment content of sugar beet (Beta vulgaris).

Different type of seedling modifications in both plants, were found in higher percentage in Nalla water treated seedlings at both sites III and IV. Seedlings become twisted, stunted and showed more lateral roots in both the plants when grown in Nalla water. In site IV 4.2% seedlings of brinjal plants showed tricotyledony and in radish seedlings 2.4% of tricotyledonous type. Polluted water of Nalla enhanced the plant height in both plants. But Singh and Mishra (1987) found that the fertilizer factory effluent in the lower concentration enhanced the growth and development of corn and rice. But, higher concentration of effluent (10% and above), caused deleterious effects on the dry matter production and on the yield (quantitative and qualitative). Increased size of brinjal and radish fruits was observed in plants grown in polluted water as compared to those of control ones. However, Sheekh et al. (2000) found that the lower concentration of oils stimulated growth, whereas, high concentrations had an inhibitory effect. During the present investigation, there was no significant difference found in the cytological parameters during mitosis and meiosis of brinjal and radish plants grown in control and polluted sites.

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