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Effect of Industrial Effluents on Germination of Summer Leafy Vegetables

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Abstract

An experiment was conducted under laboratory condition to investigate the effect of different industrial effluents on germination of five different leafy vegetables seed. The effect of three effluents was compared with control water. The results stated that the industrial effluents significantly affect germination, root and shoot elongation of vegetable seeds. Indian spinach, Jute vegetables and stem amaranth was highly affected by dyeing and Pharmaceutical effluent. Germination percentages of Indian spinach in dyeing and pharmaceutical effluent treatment were 76% and 79%, respectively. In Kangkong, jute and stem amaranth germination percentage was 82%, 80% and 84% for dyeing effluent and 85%, 79% and 84% for pharmaceutical effluent treatment, respectively. Beverage effluent shows less toxic effect than other effluent for all leafy vegetables. Root length, shoot length was also significantly affected by the effluents. It has been concluded that dyeing and Pharmaceutical effluent significantly affected the germination and growth of seeds and seedlings of various vegetables.

Keywords: Beverage, dyeing, pharmaceutical, effluents, germination, leafy vegetables.

Introduction

Vegetables are an important part of human's diet. In addition to a potential source of important nutrients vegetables constitute important functional food components by contributing protein, vitamins, iron and calcium which have marked health effects[1]. Now a day's Consumers' demand for better quality vegetables is increasing. But the external morphology of vegetables cannot give the guarantee for better quality vegetables. Because, advanced industrialization processes have provided comforts to human beings but it has also pollute the environment of biological system by indiscriminate release of gasses and liquids. Now a day's large amount of effluents is being discharged for disposal[2] on the surface. These wastes (effluents) are released in the environment after treatment (developed countries) or mostly without treatment (developing countries such as Bangladesh, Pakistan and India etc). These effluents are either released into some water body or directly on to the lands, which are mostly agricultural. Sometimes these effluents are purposely used for irrigation due to scarcity of water, especially for raising vegetables and fodder etc[3]. In Bangladesh, very few industries are equipped with satisfactory operating treatment facility set up, so that industries dispose untreated effluents via open and covered routes into the water ways which degrade water quality[4]. Hence these industrial effluents are the most potential source of water and soil pollution. These effluents contain heavy metals as well as nutrients, which affect plant and soil in variety of ways[5]. Different heavy metals are accumulated in the living cells of plants and causing a reduction of cell activities, inhibition of growth and various deficiencies/ diseases in plants[6-8]. Germination is a critical stage which ensures reproduction and consequently controls the dynamics of population, so it is a critical test for the probable crop productivity[9]. Leafy vegetables have high metal accumulating capability and sensitive to industrial effluents. The use of industrial effluents for irrigation has emerged in the recent past, taking the advantage of the presence of considerable quantities of N, P, K and Ca along with other essential nutrients[10]. But there can be both beneficial and damaging effects of waste water irrigation on crops including vegetables[11,12]. Therefore, it is necessary to study the impact of these effluents on crop system before they are recommended for irrigation[13]. Most of the studies conducted so far are to investigate the effects of different industrial effluents on vegetable crops and cereals. Information regarding the effect of effluents on leafy vegetables is still scanty. Considering the importance of pollution and lack of knowledge regarding the effects of effluents on germination and growth of seedlings of leafy vegetables, present study was carried out.

Material and Methods

Collection of industrial effluents: The experiment involves three industrial effluents from pharmaceutical, beverage and dyeing industries. Industrial effluent samples were collected from discharge points of pharmaceutical, beverage and dyeing industries of Rajendrapur and Monipur bazar at Mirzapur Union of Gazipur Sadar under Gazipur district. The control water was collected from a deep tube well of BSMRAU, Gazipur. After collection various chemical properties of the effluents were analyzed at the soil science laboratory of Bangabandhu Sheikh Mujibur Rahman University, Gazipur, Bangladesh by using Digital pH meter and Atomic Absorption Spectrophotometer (AAS).

Germination test: The experiment with the effluent treatment includes germination test and evaluation of seedling quality. The experiment of germination test was carried out in sterilized petri dishes (10 cm diameter) with filter paper Whatman No. 41 at 26 ± 2^0C in the dark condition. Twenty five seeds from each type of vegetable seeds (Indian spinach, kangkong, jute, stem amaranth and leafy amaranth) were kept for germination in each petri dishes. The petri dishes contained 5 ml of different effluent and distilled water[14] for control treatment, So that the seeds get favorable moisture for germination and growth. Five independent experiments were carried out consisting of four replications in completely randomized design (CRD). Total number of germinated seeds was counted from the 3rd day of sowing up to 10 days at an interval of 24 hours.

Morphological Studies: Germination percentage: The number of seeds germinated in each treatment was counted on 10th day after sowing and the germination percentage was calculated by using the following formula:

$$\text{Germination \%} = \frac{\text{No. of germinated seeds}}{\text{Total No. of seeds sown}} \times 100$$

Shoot length, Root length and Seedling length: Five seedlings were taken from each treatment and their shoot, root and seedling lengths in cm were measured by using a measuring ruler and the values were recorded. The ratio of germination and elongation were calculated as suggested by Begum *et al.*[15]

Relative germination ratio = (mean germination of tested plant ÷ germination rate of control) × 100.

Relative shoot elongation ratio = (mean shoot length of tested plant ÷ mean shoot length of control) × 100.

Relative root elongation ratio = (mean root length of tested plant ÷ mean root length of control) × 100.

Statistical analysis: The values were subjected to one-way analysis of variance (ANOVA) and LSD for comparison of means to determine statistical significance. Statistical analysis was performed using MSTAT-C program developed by Gomez and Gomez[16].

Results and Discussion

Chemical properties of industrial effluents: The analytical results of chemical parameter are presented in the table-1. All chemical parameters of different effluents were detected. The pH range of effluent samples were within safe limit that was 6.25 to 8.85 except for pharmaceutical effluent which was 9.23. Ayers and Westcot[17] mentioned that normal pH range of irrigation water would vary from 6.0 to 8.5. These findings were in good agreement with the findings of Tiwari *et al.*[18] and Begum *et al.*[15] who reported that the higher pH of waste water was harmful for soils and vegetable crops. In all the effluents the concentrations of Fe, Mn, Cu, Ni, Cd, Cr and Pb were found higher than the safe limit.

Germination Percentage: Germination assessment of different plant species in control and industrial effluent revealed unexpected results. Indian spinach showed 92% germination in control condition while dyeing effluents significantly decreased germination percentage by 24% and pharmaceutical industry waste water reduced germination percentage by 21% (table-2). In kangkong, similar result was found where control water gave the highest percent germination of 97. Dyeing and pharmaceutical effluents showed statistically similar the lowest germination percentage of 82 and 85 respectively. In case of jute vegetables the result showed that the maximum germination percentage was obtained from control water treatment of 94%. Here dyeing industry effluent gave 80% germination but the lowest germination percentage of 79 was found in pharmaceutical industry effluent.

Table-1
Chemical properties of different industrial effluents

Parameters	Types of Effluents				
	Control	Pharmaceutical	Beverage	Dyeing	Safe limit**
pH	7.15	9.23	6.25	8.85	6-9
Iron (mg/L)	1.78	5.15	2.97	4.28	2.0
Manganese (mg/L)	0.12	1.32	0.48	1.60	0.20
Copper (mg/L)	0.09	0.87	0.24	1.04	0.20
Zinc (mg/L)	0.24	1.78	0.27	1.97	2.0
Nickel (mg/L)	0.03	0.37	0.12	0.44	0.20
Cadmium (mg/L)	0.001	0.13	0.09	0.28	0.01
Chromium (mg/L)	0.003	0.16	0.11	0.24	0.10
Lead (mg/L)	0.10	4.05	1.02	3.42	0.50

** The safe limit of heavy metals in irrigation water for agricultural purpose[19]

In stem amaranth maximum germination percentage of 95 was obtained from control water treatment. The lowest germination percentage of 84 were recorded from Dyeing and pharmaceutical industry effluent. Beverage industry effluent gave 88% germination of seed which was statistically similar with Dyeing and pharmaceutical industry effluent. In case of Leafy amaranth the maximum germination (94%) was obtained from beverage industry effluent treatment which was followed by control water treatment (93%). This was occurred may be due to presence of some ion in the effluent which influenced the germination of seed. Pharmaceutical and Dyeing industry effluent treatment recorded the lower germination of 83% and 80% respectively.

Shoot Length (cm): Shoot length was affected significantly by the different types of effluent in all types of leafy vegetables. In Indian spinach, control water gave the shoot length of 4.96 cm. The pharmaceutical and beverage effluents decreased shoot length than the control water by 1.29 and 1.21 cm, respectively. The dyeing industry effluent gave the lowest shoot length of 2.98 cm (table-3). In kangkong, similar result was found where control water gave the highest shoot length of 5.81cm. Dyeing effluents showed the lowest shoot length of 3.68 cm. In case of jute vegetables, control and beverage effluent water gave the highest shoot length of 4.19 and 3.80 cm. Dyeing and pharmaceutical effluents showed the lowest shoot length of 3.09 and 3.29 cm respectively. In stem amaranth, the highest shoot length of 6.15 cm was recorded in control water treatment. The lowest shoot length of 3.83 cm was recorded in dyeing effluent treatment. Similarly in case of Leafy amaranth, the highest shoot length of 4.64 cm recorded in control water treatment. Dyeing effluent recorded the lowest shoot length of 3.83 cm.

Root Length (cm): Root length was also affected significantly by the tested effluent in all types of crops. In Indian spinach, control water produced a root length of 3.66 cm (table-4). Dyeing effluents gave the lowest root length of 2.14 cm. In kangkong, similar result was found where the control water gave the highest root length of 3.15 cm. Dyeing effluents gave the lowest root length of 1.99 cm. In jute plant highest root length of 3.73 cm was recorded in control water treatment. Beverage and dyeing effluents decreased in root length than the control water by 0.76 and 1.21 cm respectively. Pharmaceutical effluents gave the lowest root length of 2.25 cm. In case of stem amaranth, the highest root length of 4.09 cm was recorded in control water treatment. Lowest root length of 2.62 cm was recorded in pharmaceutical effluent treatment. In leafy amaranth, the highest root length of 3.16 cm was found in control water treatment. Pharmaceutical and dyeing effluent produced the lowest root length of 2.04 and 1.85 cm, respectively.

Table-2
Seeds germination percentage of five plants grown in control and industrial effluent water

Types of effluents	Germination (%)				
	Indian Spinach	Kangkong	Jute	Stem Amaranth	Leafy Amaranth
Control	92a	97a	94a	95a	93a
Pharmaceutical	79b	85c	79c	84b	83b
Beverage	87a	90b	86b	88b	94a
Dyeing	76b	82c	80c	84b	80b
CV (%)	4.57	2.67	3.54	3.20	3.23

Different letter present within the same column shows significant at 5% level

Table-3
Shoot length (cm) of five plants grown in control and industrial effluent water

Types of effluents	Shoot length(cm)				
	Indian Spinach	Kangkong	Jute	Stem Amaranth	Leafy Amaranth
Control	4.96a	5.81a	4.19a	6.15a	4.64a
Pharmaceutical	3.67b	3.90bc	3.09b	4.01c	3.12c
Beverage	3.75b	4.31b	3.80a	4.53b	3.74b
Dyeing	2.98c	3.68c	3.29b	3.83c	2.99c
CV (%)	3.51	6.60	8.13	4.11	5.53

Different letter present within the same column shows significant at 5% level

Table-4
Root length (cm) of five plants grown in control and industrial effluent water

Types of effluents	Root length(cm)				
	Indian Spinach	Kangkong	Jute	Stem Amaranth	Leafy Amaranth
Control	3.66a	3.15a	3.73a	4.09a	3.16a
Pharmaceutical	2.83b	2.09bc	2.25c	2.62d	2.04c
Beverage	3.03b	2.45b	2.97b	3.79b	2.71b
Dyeing	2.14c	1.99c	2.52bc	3.17c	1.85c
CV (%)	7.20	10.05	11.07	4.88	8.55

Different letter present within the same column shows significant at 5% level

Seedling length (cm): In Indian spinach, highest seedling length of 8.62 cm was recorded in control water treatment. Beverage and pharmaceutical effluent treated plant produced decreased seedling length of 1.84 and 2.13 cm than the control treatment. Dyeing industry effluent gave the lowest seedling length of 5.11 cm (table-5). Similar trend of results were found in Kangkong where control water treatment gave highest seedling length of 8.96 cm. Dyeing and pharmaceutical effluents showed lower seedling length of 5.67 and 5.99 cm respectively which were statistically similar. In jute the results were similar with Kangkong and the control water treatment gave highest seedling length of 7.93 cm. Dyeing and pharmaceutical effluents showed lower seedling length of 5.82 and 5.34 cm respectively. In stem amaranth, seedling length of 10.24 cm was highest recorded by the control water treatment and followed by beverage effluent. Pharmaceutical effluents showed lowest seedling length of 6.63 cm. In leafy amaranth, control water treatment gave highest seedling length of 7.80 cm followed by beverage effluent. Dyeing and pharmaceutical effluents showed statistically similar lower seedling length of 4.84 and 5.16 cm respectively. These differences in seedling length may be due to higher concentrations of effluents containing different organic and inorganic materials.

Relative Germination Ratio (RGR): In all types of vegetable crops, beverage effluent recorded the highest RGR (figure-1). The RGR due to beverage effluent in Indian spinach, kangkong, jute, stem amaranth and Leafy amaranth was 95, 93, 92, 93 and 101% respectively. In all crops Dyeing effluent recorded lowest RGR of 83, 85, 85, 88 and 86% respectively. This result was indicating that RGR was sensitive to dyeing effluent.

Relative Shoot Elongation Ratio (RSER): In all types of vegetable crops, beverage effluent recorded the highest RSER (figure-2). The RSER due to influence of beverage effluent in Indian spinach, kangkong, jute, stem amaranth and Leafy amaranth was 76, 74, 91, 74 and 81% respectively. In all vegetable crops except jute lowest value of RSER was recorded in Dyeing effluent treatment. In jute, Pharmaceutical effluent recorded lowest RSER of 74%.

Table-5
Seedling length (cm) of five plants grown in control and industrial effluent water

Types of effluents	Seedling length(cm)				
	Indian Spinach	Kangkong	Jute	Stem Amaranth	Leafy Amaranth
Control	8.62a	8.96a	7.93a	10.24a	7.80a
Pharmaceutical	6.49b	5.99c	5.34c	6.63d	5.16c
Beverage	6.78b	6.76b	6.78b	8.32b	6.45b
Dyeing	5.11c	5.67c	5.82c	7.0c	4.84c
CV (%)	4.01	7.08	6.77	2.52	4.85

Different letter present within the same column shows significant at 5% level

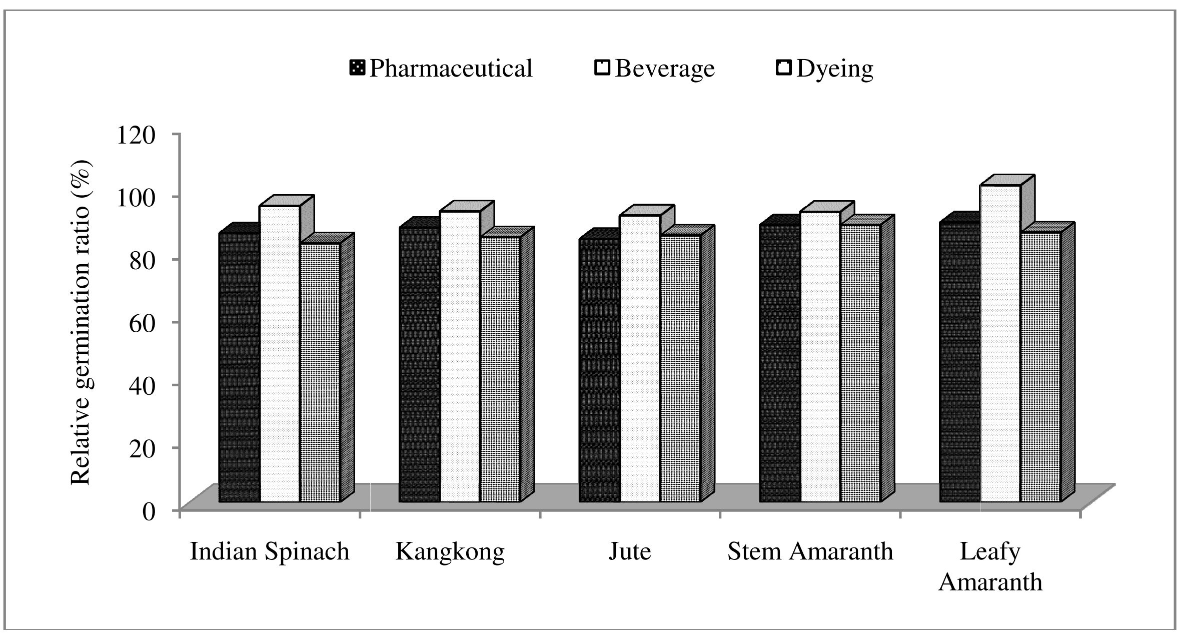

Figure-1
Effects of effluents on Relative Germination Ratio (%) of different vegetables

Relative Root Elongation Ratio (RRER): In all types of vegetable crops, beverage effluent recorded the highest RSER of 83, 77, 80, 93 and 86% respectively (figure-3). In Indian spinach, Kangkong and Leafy amaranth dyeing effluent recorded lowest RRER of 58, 63 and 59% respectively. In jute and stem amaranth pharmaceutical effluent recorded lowest RRER of 60 and 64 % respectively.

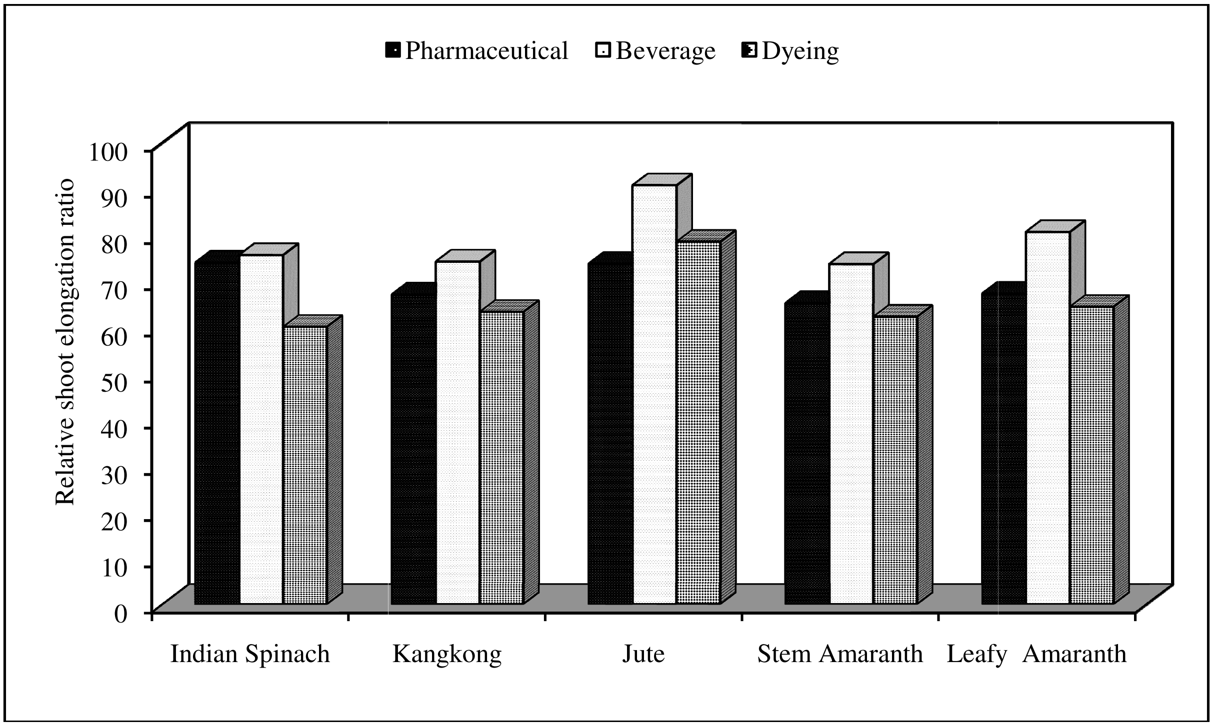

Figure-2
Effects of effluents on Relative Shoot Elongation Ratio of different vegetables

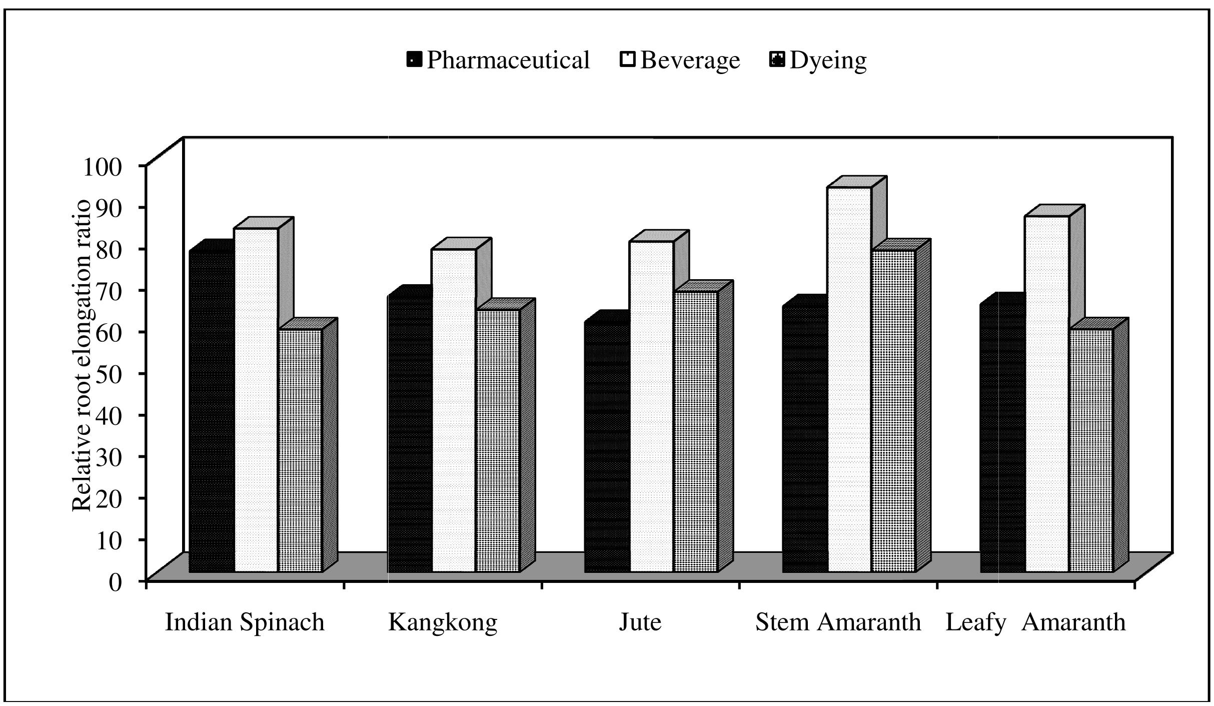

Figure-3
Effects of effluents on Relative Root Elongation Ratio of different vegetables

Discussion: According to Rodosevich *et al.*[9] seed germination control plants populations, ensure reproduction and crop productivity. In this present investigation, wide variation was observed according to the studied effluents and control water, regarding the germination percentage as well as other germination attributes of all vegetables. The results revealed that industrial effluents had negative impact on seed germination of Indian spinach, Kangkong, Jute and Stem Amaranth. It was also stated by Khan *et al.*[20] and Nagda et al.[21] that in higher concentration industrial effluent reduce seed germination rate. Leafy amaranth showed the highest seed germination in beverage effluent. It seems that there are some essential organic compounds in waste waters which may alleviate some part of negative impacts. According to Panasker and Pawar[22,23] polluted water at low concentration does not inhibit the seedling growth but at higher concentration germination of seeds and seedlings growth will be affected. Other researcher also reported that waste water contain some essential organic compound which increase growth of crop[24-26]. A considerable decreased in shoot length was found in the pharmaceuticals and dyeing industries effluent. Those effluents contained the high amounts of Fe, Mn, Cu and Pb which exerted toxic effect on seedling plants leading to decreased shoot growth. A similar observation was made by Yanaguchi and Aso[27]. These results show similarity with the results of Bazai and Achakazai[28] who suggested that plumule length is decreasing in higher concentration of polluted water. Due to different types of effluent treatment all vegetable crops produced short root length than the control treatment.

The pH value of industrial effluent was high which may be the reason for decreasing root length[29]. Moreover, heavy metals toxicity inhibiting the functions of essential enzymes[30,31]. In all treatment the average root length was smaller than the average shoot length. Same results were found by Ramamoorthy *et al.*[32]. Due to the application of effluents with high concentration reduced the root length of leafy vegetables[15]. Inhibition of root growth was more pronounced by effluent toxicity than shoot growth of the seeds. The trace elements toxicity of effluent water was more on roots than hypocotyls[33].

Heavy metals are toxic for root growth because they accumulate on the root[34] and retard cell elongation and cell division probably by blocking the hormonal system[35]. The effluent water was highly sensitive to Seed germination, seeding length of all the leafy vegetable crop seeds. But nature of their sensitivity depends on the types of seeds and concentrations of effluent. Previous research results depict that the effect of high osmotic levels on seed germination and growth is due to toxicity of individual ions[31] or due to osmotic inhibition of water absorption.

It is clear from the present investigation that all morphological parameters are highly sensitive to the industrial effluent as compared to control. The result of Relative Germination Ratio (RGR) indicated that RGR was sensitive to dyeing effluent. Begum *et al.*[15] reported that the germination rate decreased with increasing the concentration of industrial effluents. These results are inconformity with the results found by Bazai *et al.*[28] and Nawaz *et al.*[29]. Begum et al.[15] showed that the relative shoot elongation ratio of the germinated seeds increased with increasing concentration of effluents. Ramamoorthy *et al.*[32] were also found the similar result. The relative root elongation ratio of all vegetables was lowest in case of dyeing and pharmaceuticals effluent. The average root elongation ratio of mustard (*Brassica campestris*), amaranth stem (*Amaranthus gangeticus*) and radish (*Raphanus sativus*) decreased with increasing concentration of effluents[15]. Similar results were reported by Rao *et al.*[36].

The industrial effluents possess various organic and inorganic chemical compounds. The presence of these chemicals will show detrimental effects on the germination process, development of plant and growth of seedlings. Therefore, neutralization stage of effluents water should be considered for crop production and reuse for sustainable agriculture. In this consequence, continuous researches on environmental hazards of effluents are very essential.

Conclusion

It is concluded that, different industrial effluent have significant effect on different types of leafy vegetables seed germination. It may be said that, dyeing and pharmaceutical effluents have deleterious effect on vegetables and beverage effluents are less harmful. Irrigation of vegetable with untreated effluents cause accumulation of heavy metals in plants that affects seed germination and lowers crop yield. The leafy vegetables should be irrigated with effluents only after proper treatment.

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