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Chemical composition of city wastewater and its effect on germination of some vegetable seeds

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Abstract

Due to increasing shortage of fresh water, the use of city wastewater in agricultural purpose has become more popular day by day. This experiment was conducted to analyze the physico-chemical parameters of the city wastewater and its effect on seed germination and seedling growth of *Abelmoschus esculentus* (Lady's Finger), *Vigna unguiculata* (Yard Long Bean) and *Cucumis sativus* (Cucumber) plants during the period of January, March and May, 2023 with the application of five treatments i.e. T_0 (control), T_1 (3ml), T_2 (5ml), T_3 (7ml) and T_4 (10ml). The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Analyses included pH, EC, hardness, cations (Ca^{2+}, Mg^{2+}, Na^+, K^+, Zn^{2+}, Cu^{2+}, Mn^{2+} and Fe^{3+}), anions (CO_3^{2-}, HCO_3^-, SO_4^{2-}, PO_4^{3-} and Cl^-) and TDS (total dissolved solids), SAR (sodium adsorption ratio). The pH (6.9 ~ 7.23) was neutral to alkaline and could be suitable for agricultural uses. According to TDS and SAR values, all samples of wastewater were classified as 'Freshwater' and 'excellent' categories. T_0 (control) and T_3 (7ml) were showed the highest germination percentage (100%) for every month and T_4 (10ml) was showed the lowest germination percentage (80%). The speed of germination, relative germination ratio and germination index were also highest at T_0 (control) and lowest was in T_1 (3ml) condition and again the shoot and root length of the vegetables were gradually enhanced with increasing concentration and highest shoot and root length found in T_4 (10 ml) treatment and lowest shoot and root length observed in T_0 (control) treatment. Thus, the city wastewater, after proper dilutions can be used as a promising source of water in agricultural practice.

Keywords: City wastewater; Chemical composition; Irrigation; Seed germination; Seedling growth

1. Introduction

Bangladesh is one of the fastest urbanizing countries in South Asia, with approximately 70 million people living in municipal areas [1]. Unplanned urbanization, fast growing population, robust growth in industrialization and use of modern technology in agriculture has accelerated the water pollution in urban areas [2], [3], [4]. Municipal wastewater refers to domestic wastewater that consisting of black water-excreta, urine, sludge and grey water, kitchen and bathroom wastewater or wastewater from commercial establishments and institutions such as hospitals, industries and run-off rainwater [5]. City wastewater is generally consisting of water together with suspended and dissolved organic solids such as carbohydrates, fats, lignin, synthetic detergents, soaps, synthetic organic chemicals from the process industries and inorganic solids including dissolved salts and heavy metals like Fe^{2+}, Cu^{2+},Zn^{2+}, Mn^{2+},Ni^{2+} and Pb^{2+} together with pathogenic viruses and bacteria [5],[6].

The use of domestic wastewater for agricultural purpose has been practiced for several centuries [7]. During this century in arid and semiarid areas of many countries, the use of municipal wastewater in the irrigation purpose has

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become more common. Scarcity of good quality water resources and huge amounts of water are needed for irrigation in agriculture is likely to be forced to make increasing use of city wastewater [8]. Both the problems can be solved by using wastewater as a potential alternative water source for agriculture purpose. There are many benefits in using city wastewater in agriculture: conservation of water, recycling of nutrients (plant nutrients i.e. N, P, K, Ca, S, Cu, Mn and Zn) and delivery of a reliable water supply to farmers; prevention of pollution of surface water, the disposal of city wastewater in a cheap and hygienic way [9], [10], [11]. City waste such as sewage and industrial effluents rich in plant nutrients and organic matter are using in agricultural purpose as cheaper way of disposal [11],[12]. Wastewater irrigation provides water, N, P, organic matter to the soil [13], increased macronutrient contents and enhanced macronutrient contents of the plants [14].

Wastewater has a significant effect on seed germination and plant growth. Researcher [15] reported that domestic and industrial wastewater has considerably affected the germination and growth of seeds and seedlings of various species. According to [16] in higher concentration industrial wastewater affect seed germination rate. Researcher [17] reported that different industrial effluent has significantly affected on different types of leafy vegetables seed germination. Reduction of cell activities, inhibition of plant growth and various deficiencies of plant are noticed due to accumulation of toxic heavy metals in living plant cells [18].

The performance on seed germination, speed of germination, relative germination ratio, germination index and the overall plant growth of Lady's Finger, Yard Long Bean and Cucumber using the control water was significantly different than the filtered wastewater. An experiment reported that the germination of lady's finger (*Abelmoschus esculentus*) was adversely affected when 75% and 100% concentrations of the textile effluent were used as compared to control (water), although there was no effect up to 50% concentration [19]. It is noted that at various concentrations dyeing industry effluent influences seed germination and seedling growth of Lady's finger [20]. However, under toxic water condition Lady's Finger, Cucumber and Yard Long Bean showed the acceptable performance of growth of seedlings. Thus, the present study was conducted to analyze the physico-chemical characters of city wastewater and its effect of different concentrations level on the seed germination and to assess the impact of city wastewater on the growth characteristics of Lady's Finger, Yard long bean and cucumber seeds.

2. Materials and methods

The experiment was conducted to study the chemical composition of city wastewater and to assess the effects of city wastewater on seed germination and seedling growth of some vegetable seeds such as *Abelmoschus esculentus, Vigna unguiculata* and *Cucumis sativus.* The location of the study area is Girajanath channel of Dinajpur Sadar Upazila under Dinajpur district of Bangladesh. Water samples were collected from 6 different locations Viz. Zora Bridge, Sukhsagor, Ghagrakhal, Boropulhat, Police line and Mahamudpur dighipara jame mosque of the channel in a distance of one Km at three months i.e. January, March and May of 2023. Then the collected city wastewater samples were analyzed for their physico-chemical properties in the laboratory of Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur according to the standard methods [21]. The entire procedure was also followed as described by [22]. The physico-chemical analyses of the city wastewater include the estimation of pH, EC, temperature, TDS, DO, Sodium Adsorption Ratio (SAR), hardness etc. and major ionic constituents like Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Fe^{2+}, Mn^{2+}, Zn^{2+}, Cu^{2+}, PO_4^{3-},Cl^{-}, SO_4^{2-},CO_3^{2-} and HCO_3^{-}.

A laboratory experiment was conducted in the Department of Agricultural Chemistry,(HSTU), Dinajpur, Bangladesh, during the month of January-May 2023 to study the effects of wastewater on germination of some vegetable seeds such as *Abelmoschus esculentus, Vigna unguiculata* and *Cucumis sativus* plants with application of five treatments i.e. T_0 (control), T_1 (3ml), T_2(5ml), T_3 (7ml) and T_4 (10ml). The experiment was laid out in a Completely Randomized Design (CRD) with three replications. The seeds of these vegetables were collected from the Bangladesh Agricultural Development Corporation (BADC), Dinajpur. Pre-selected seeds were placed in a petri-dish with a population of 10 seeds per Petri dish. About 0, 3, 5,7,10 milliliters (ml) test solution was poured into each dish. Three trials were made for each crop and it was replicated three times, making nine petri dish in every trial for each crop. The germination of the seeds was observed in a span of five days. The germinated seeds were counted from third day to six day to obtain the germination percentage, relative germination ratio and germination index of the three different seed i.e. *Abelmoschus esculentus* (Lady's Finger)*, Vigna unguiculata* (Yard Long Bean) and *Cucumis sativus* (Cucumber).

The germination percentage of the seeds was calculated using the following formula described by [23]

$$\text{Germination (\%)} = \frac{\text{No of seed germinated}}{\text{No of seed placed}} \times 100$$

The speed of germination index was measured as following by [24].

$$S= [N1/1+N2/2+N3/3+\ldots\ldots Nn/n] \times 100$$

Where, N1, N2, N3………..Nn proportion of seeds which germinated on day 1, 2, 3 ………..n following setup of the experiment. S varies from 100(if all seeds germinated on the first day following setup) to 0(if no seeds germinated by the end of the experiment).

Again, the relative ratio of germination was measured following by [25].

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

The germination index (GI) was calculated as described by [26], by the following formula:

$$GI = G_1 / T_1 + G_2 / T_2 + \ldots\ldots + Gn / Tn$$

Where, G_1, G_2,…………..., Gn: number of germinated seed on the first count, second count, and so on until the last count (n), respectively, and T_1, T_2,……………..., Tn: number of days between sowing and the first count, between the sowing and the second count, and so on until the last count (n), respectively.

3. Results and discussion

In this study the city wastewater which is used for irrigation purpose of some vegetables viz. Lady's Finger, Yard Long Bean and Cucumber was analyzed to know the physico-chemical parameters of the water and its effect on seed germination.

Table 1 Physical parameters of city wastewater

Sl. no.	Parameters name	January	March	May	Mean	Standard Deviation
1	pH	7.23	7.03	6.90	7.05	0.17
2	EC	903	885	835	874	35.23
3	Temp.	23.00	26.30	30.10	26.47	3.55
4	DO	2.50	2.30	2.50	2.43	0.12

The pH value of the city wastewater samples varied from 6.90 to 7.23 (Table 1). The mean value of all samples is 7.05 that were within the normal range. The standard pH value needed for agriculture is 7-8[27].

The EC values of water samples varied from 835.00to 903.00μScm^{-1} (Table 1). According to [28] all samples in the experiment were in the group of 'Permissible limit'. The mean temperature of the sample was 26.47^{o}C (Table 1) and the Dissolved Oxygen **(**DO) of the samples was 2.43 (table 1)

Table 2 Chemical parameters of city wastewater

Sl. no.	Parameters name	Unit	January	March	May	Mean	Standard Deviation
1	Phosphorus	mg/L	0.29	0.28	0.27	0.28	0.01
2	Sulphur	mg/L	20.03	19.78	19.53	19.78	0.25
3	Chloride	mg/L	268.78	382.97	397.15	349.63	70.38
4	HCO_3^-	mg/L	5.6	5.4	5.2	5.40	0.20
5	Ca	mg/L	113.82	112.22	107.02	111.02	3.56
6	Mg	mg/L	69.11	65.05	63.08	65.75	3.07
7	Cu	mg/L	0.05	0.03	0.04	0.04	0.01

8	Mn	mg/L	0.81	0.71	0.77	0.76	0.05
9	Fe	mg/L	0.06	0.05	0.04	0.05	0.01
10	Zn	mg/L	0.05	0.04	0.04	0.04	0.01
11	K	mg/L	2.5	2.5	2.5	2.50	0.00
12	Na	mg/L	5.6	5.38	5	5.33	0.30
13	Pb	mg/L	1.75	1.24	1.12	1.37	0.33

3.1. Anionic composition of city wastewater

The concentration of PO_4^{3-} was varied from 0.27 to 0.29mg/L and the mean value was 0.28 mg/L (Table 2) that is within the recommended limit as per [29] and according to [30] the suitable limit of the concentration of PO_4^{3-} for irrigation is 6.0 mg/L. The concentration of SO_4^{2-} ion 19.53 to 20.03 mg/L and the mean value was 19.78 mg/L (Table 2). The acceptable limit of SO_4^{2-} for irrigation water is 0-20 mg/L [29].The concentration of Cl^- ion was varied from 268.78 to 397.15mg/L and the mean value was 349.63 mg/L (Table 2). According to [30], the suitable limit of Cl^- for drinking water is 150-600 mg/L. On the basis of this condition, for agricultural purposes all samples were considered as safe. The concentration of HCO_3^- ion of city wastewater varied from 5.2 to 5.6 mg/L and the mean value of city wastewater was 5.40mg/L (Table 2). All samples were suitable for agricultural purposes as mentioned by [29] and [31]

3.2. Cationic composition of city wastewater

The concentration of Calcium (Ca) varied from 107.02 to 113.82mg/L and the mean value was 111.02 mg/L (Table 2). According to [31] the Calcium (mg/L) was exceeded over the recommended concentration and [32] noted that less than the 20 $meqL^{-1}$Ca was suitable for irrigation plants. The Mg ion concentration in the sample was varied from 63.08to 69.11mg/L and the mean value was 65.75mg/L (Table 2). The water samples were contained very low amount of copper varied from 0.03 to 0.05 mg/Land the mean value was 0.04 mg/L (Table 2). According to [32], the acceptable limit of copper for irrigation purpose is less than 0.20 mg/L. The range of the concentration of Manganese for all water samples was 0.71to 0.81 mg/L with the 0.76 mg/L mean value (Table 2).The concentration of Iron value was varied from 0.04 to 0.06 mg/Land the mean value was 0.05 mg/L. According to [32], the suitable limit of Fe for irrigating crops plants is 2.4- 4.0 mg/L. The concentration of zinc value was varied from 0.04 to 0.05 mg/L and the mean value was 0.04 mg/L (Table 2).The concentration of K ion was 2.5mg/L for the month of January, March and May. The mean value was 2.5mg/L (Table 2). According to [32] the suitable concentration of K for irrigating crops is 5- 20 mg/L. The concentration of Na ion varied from 5 to 5.6 mg/L and the mean value was 5.33 mg/L (Table 2).The concentration of Pb in city wastewater samples ranged from 1.12 to 1.75 mg/ L with a mean value of 1.37 mg/L. The highest permissible limit of Pb in irrigation purposes suggested by FAO is 5 mg/L [29]

Table 3 Calculated parameters of city wastewater

Sl. no.	Parameters name	Unit	January	March	May	Mean	Standard Deviation
1	TDS	mg/L	604	606	608	606	2.00
2	SAR	mg/L	0.59	0.57	0.54	0.57	0.03
3	PI	-	0.04	0.04	0.04	0.04	0.00
4	H_T	mg/L	567.90	547.28	526.18	547.12	20.86
5	Kelly's Ratio	-	0.03	0.03	0.03	0.03	0.00
6	Gibbs Ratio for anion	-	0.98	0.99	0.99	0.99	0.01
7	Gibbs Ratio for cation	-	0.07	0.07	0.07	0.07	0.00

3.3. Total Dissolved Solids (TDS)

The TDS values varied from 604 to 608 mg/L and mean value was 606.00 mg/L (Table no. 3). According to [33], the groundwater contained 0- 1,000 mg/L TDS was classified as 'freshwater' in quality. TDS of the wastewater of Dinajpur canal was within the standard value of irrigation water recommended by FAO (450- 2000 mg/L) [29].

3.4. Sodium Adsorption Ratio (SAR)

The water samples's SAR value ranges from 0.54 to 0.59 mg/L and the mean value is 0.57 mg/L (Table 3). On the basis of SAR, [34] categorized irrigation waters into 4 groups and all the sample were categorized as 'excellent' for irrigation purpose.

3.5. Permeability Index (PI)

The water samples contain PI value is 0.04 and the mean value was 0.04 (Table 3).

3.6. Hardness (H_T)

The Hardness (H_T) of the water samples ranges from 526.18 to 567.90mg/L and the mean value was 547.12 mg/L (Table 3). Researchers [35] classified irrigation water into 4 classes based on hardness and all samples were classified as 'very hard'.

3.7. Kelly's Ratio

The Kelly's ratio of water samples was 0.03 (Table 3). According to Kelly's ratio, all the city waste water was suitable for irrigation.

3.8. Gibbs ratio for anion and cation

Gibbs ratio for anion and cation is considered as one of the important criteria for judging water quality for irrigation, drinking and industrial purposes. Table 3 shows that the Gibbs ratio of city waste water for anions were varied from 0.98 to 0.99 and the range of cations is 0.07. The average values for both ratios were 0.99 (for anions) and 0.07 (for cations).

3.9. Effect of wastewater on Seed Germination

3.9.1. Effects of wastewater on germination of Lady's Finger in Petri dish

Table 4 Effects of different wastewater treatments on germination of Lady's Finger

Treatment	Germination (%) on (6^{th} day)	Speed of germination	Relative germination ratio	Germination Index
Month: January				
T_0	100	543.33	100.08	5.43
T_1	90	448.33	84.68	4.48
T_2	90	518.33	96.23	5.18
T_3	100	498.33	92.38	4.98
T_4	80	543.33	96.23	5.43
Month: March				
T_0	100	543.33	100.08	5.43
T_1	90	448.33	84.68	4.48
T_2	90	518.33	96.23	5.18
T_3	100	498.33	92.38	4.98
T_4	80	543.33	96.23	5.43
Month: May				
T_0	100	576.67	103.93	5.77
T_1	90	465	84.68	5.65
T_2	90	501.67	92.38	5.02

T_3	100	498.33	92.38	4.98
T_4	80	543.33	96.23	5.43

Table 4 showed that T_0 (control) and T_3 (7ml) performed the highest germination percentage (100%) and T_4 (10ml) was showed lowest germination percentage (80%). The speed of germination, relative germination ratio and germination index were also high in T_0 (control) and lowest was T_1 (3ml) condition.

3.9.2. Effects of wastewater on germination of Yard Long Bean in petri dish

Table 5 Effects of different wastewater treatments on germination of Yard Long Bean

Treament	Germination (%) on (6th day)	Speed of germination	Relative germination ratio	Germination Index
Month: January				
T_0	100	543.33	100.08	5.43
T_1	90	515	92.38	5.15
T_2	90	456.67	84.68	4.57
T_3	100	511.67	92.38	5.12
T_4	80	543.33	96.23	5.43
Month: March				
T_0	100	630	111.62	6.3
T_1	90	481.67	88.53	4.82
T_2	90	501.67	92.38	5.02
T_3	100	523.33	96.23	5.23
T_4	80	543.33	96.23	5.43
Month: May				
T_0	100	518.33	96.23	5.18
T_1	90	448.33	84.68	4.48
T_2	90	481.67	88.53	4.82
T_3	100	498.33	92.38	4.98
T_4	80	543.33	96.23	5.43

From the above table 5 it is found that, T_0 (control) and T_3 (7ml) showed the highest germination percentage (100%) and T_4 (10ml) was showed lowest germination percentage (80%). The speed of germination, relative germination ratio and germination index were also high in T_4 (10ml) and lowest was in T_1 (3ml) condition.

3.9.3. Effects of wastewater on germination of Cucumber in Petri dish

Table 6 Effects of different wastewater treatments on germination of Cucumber

Treatment	Germination (%) on (6th day)	Speed of germination	Relative germination ratio	Germination Index
Month: January				
T_0	100	630	111.62	6.3
T_1	100	551.67	100.08	5.52

T_2	100	576.67	103.93	5.77
T_3	100	498.33	92.38	4.98
T_4	90	560	100.08	5.6
Month: March				
T_0	100	630	111.62	6.3
T_1	100	551.67	100.08	5.52
T_2	100	576.67	103.93	5.77
T_3	100	498.33	92.38	4.98
T_4	90	613.33	107.78	6.13
Month: May				
T_0	100	630	111.62	6.3
T_1	100	551.67	100.08	5.52
T_2	100	576.67	103.93	5.77
T_3	100	585	103.93	5.85
T_4	90	613.33	107.78	6.13

From the table 6 it is indicated that T_0 (control) and T_3 (7ml) showed the highest germination percentage (100%) and T_4 (10ml) was showed lowest germination percentage (90%).The speed of germination, relative germination ratio and germination index were high in T_0 (control) and lowest was in T_1 (3ml) condition.

So, from the above tables (table no 4, 5 and 6) it is found that the increasing rate of city waste water concentration considerably affected the germination rate of Lady's Finger, Yard Long Bean and Cucumber respectively. The highest effluent concentration (T4) resulted in the minimum germination percentage compared to the control (T_0). Similliar results were found by researchers [16], [36], [37], [38], [22], [39].

3.9.4. Effect of wastewater on growth characteristics

Shoot and Root length measurement in the month of January

Table 7 Shoot and Root length of Lady’s Finger, Yard Long Bean and Cucumber during the month of January 2023

Lady's Finger	**Shoot**			**Root**		
Treatment	**5 DAG**	**10 DAG**	**15 DAG**	**5 DAG**	**10 DAG**	**15 DAG**
T_0	8.877c	8.877c	11.31c	6.103d	6.103d	9.713e
T_1	7.780d	7.780d	9.380d	9.677c	9.677c	16.11c
T_2	12.91b	12.91b	16.38b	10.40b	10.40b	15.29d
T_3	13.16b	13.16b	18.29a	10.57b	10.57b	17.37b
T_4	15.77a	15.77a	19.00a	14.18a	14.18a	19.41a
LSD	0.31	0.87	1.74	0.56	0.56	0.49
CV (%)	1.55	3.34	1.49	3.17	2.05	1.28
Yard Long Bean						
T_0	12.66c	15.51d	19.80e	6.190d	8.967d	12.70d
T_1	10.24d	15.67d	20.70d	14.71b	19.54c	24.10c
T_2	18.87b	21.06c	28.10b	13.35c	19.71bc	26.07b

T_3	20.00a	22.93b	26.07c	15.44b	20.59ab	23.63c
T_4	19.74ab	25.00a	29.07a	20.07a	21.42a	27.30a
LSD	0.99	1.64	0.44	1.08	1.01	0.55
CV (%)	3.45	4.68	1.02	4.41	3.19	1.39
Cucumber						
T_0	5.700b	9.813d	14.97d	13.24d	19.53e	24.43d
T_1	5.423b	10.76c	16.73b	23.31b	24.62d	29.10c
T_2	10.13ab	12.44b	16.07c	21.96c	25.34c	29.03c
T_3	6.913b	12.18b	17.17b	25.54a	29.44a	34.23a
T_4	12.76a	18.75a	23.13a	24.89a	27.96b	32.90b
LSD	4.86	0.69	0.51	0.92	0.71	0.42
CV (%)	33.89	3.06	1.66	2.41	1.59	0.80

*Alphabets in the same column showed non-significant. ($P<0.05$)

Table 7 shows that the effects of wastewater on the shoot and root length of Lady's Finger at 5, 10 and 15 days after germination (DAG). Treatment T_4 (10 ml) observed the highest shoot length 15.77, 15.77 and 19.00 cm respectively and root length was 14.18, 14.18 and 19.41cm respectively in three selected days. The shortest shoot length was recorded at T_0 (control) 8.877, 8.877 and 11.31 cm respectively and root length was 6.103, 6.103 and 9.713 cm respectively in three conjugative days.

Table 7 also, shows that the effects of wastewater on the shoot and root length of Yard Long Bean at 10 and 15 days after germination (DAG). Treatment T_4 (10 ml) observed the highest shoot length 25.00 and 29.07cm respectively and root length was 21.42 and 27.30 cm respectively in selected days. The shortest shoot length was recorded at T_0 (control) 15.51 and 19.80 cm respectively and root length was 8.967 and 9.713 cm respectively in consecutive days.

From above table, it is found that the effects of wastewater on the shoot and root length of Cucumber at 10 and 15 days after germination (DAG). Treatment T_4 (10 ml) observed the highest shoot length 18.75 and 23.13 cm respectively and Treatment T_3 (7 ml) observed highest root length was 29.44 and 34.23cm respectively in selected days. The shortest shoot length was recorded at T_0 (control) 9.813 and 14.97 cm and root length was 19.53 and 24.43 cm respectively in selective days.

Shoot and Root length measurement in the month of March

Table 8 shows that the effects of wastewater on the shoot length of Lady's Finger at 10 and 15 days after germination (DAG). Treatment T_4 (10 ml) observed the highest shoot length 19.07 and 23.90 cm and root length was 18.13 and 25.87 cm. Treatment T_1 (3 ml) observed the lowest shoot length at 5, 10 and 15 days after germination (DAG) and the length were 8.213,8.637 and 14.73 cm respectively in three conjugative days. Treatment T_0 (control)observed the lowest root length at 5, 10 and 15 days after germination (DAG) and the length were 5.577,10.10 and 16.77 cm respectively in three selective days.

Table 8 also shows that the effects of wastewater on the shoot length of Yard Long Bean at 5,10 and 15 days after germination (DAG). Treatment T_4 (10 ml) observed the highest shoot length 19.01, 20.88 and 26.23 cm and Treatment T_1 (3 ml) observed the lowest shoot length 8.887, 13.81 and 12.33 cm respectively in three conjugative days. The effects of wastewater on the root length of Yard Long Bean at 5 and 10 days after germination (DAG). Treatment T_4 (10 ml) observed the highest root length 18.56 and 24.63 cm and lowest root length5.00 and 15.17 cm respectively on selective days.

Table 8 Shoot and Root length of Lady's Finger, Yard Long Bean and Cucumber during the month of March 2023

Lady's Finger	**Shoot**			**Root**		
Treatment	**5 DAG**	**10 DAG**	**15 DAG**	**5 DAG**	**10 DAG**	**15 DAG**
T_0	8.813b	12.85d	15.63c	5.577b	10.10e	16.77e
T_1	8.213b	8.637e	14.73d	9.733ab	15.62c	18.70d
T_2	12.39ab	15.82c	23.87a	10.60ab	14.81d	20.47c
T_3	21.66a	16.69b	22.73b	14.56a	16.92b	25.00b
T_4	15.84ab	19.07a	23.90a	13.14ab	18.13a	25.87a
LSD	12.20	0.31	0.40	7.96	0.47	0.47
CV (%)	52.05	1.22	1.13	42.38	1.78	1.26
Yard Long Bean						
T_0	12.58d	14.87d	18.23c	5.000e	8.810d	15.17e
T_1	8.887e	13.81e	12.33d	14.78c	18.95c	21.90c
T_2	16.98c	19.97b	20.03b	12.34d	19.77b	19.33d
T_3	18.12b	18.80c	20.23b	15.52b	20.28a	23.97b
T_4	19.01a	20.88a	26.23a	18.56a	20.11a	24.63a
LSD	0.33	0.14	0.28	0.39	0.26	0.63
CV (%)	1.25	0.45	0.82	1.69	0.85	1.72
Cucumber						
T_0	4.643e	9.720d	15.73d	13.65e	18.92e	24.13d
T_1	5.300c	9.677d	16.80b	20.87c	23.48d	27.60b
T_2	5.023d	11.87c	16.37c	19.88d	23.81c	26.43c
T_3	6.023b	12.26b	16.77bc	23.12a	26.00b	29.87a
T_4	10.85a	18.43a	22.93a	22.59b	26.59a	29.77a
LSD	0.18	0.32	0.41	0.47	0.23	0.56
CV (%)	1.55	1.49	1.35	1.35	0.55	1.16

*Alphabets in the same column showed non-significant. ($P<0.05$)

From above table, it is found that the effects of wastewater showed satisfactory performance on the shoot length of Cucumber at 5 and 15 days after germination (DAG). T_4 (10 ml) revealed the highest shoot length 10.85 and 22.93cm at 10 DAG and 15 DAG respectively andT_0 (control) observed the lowest shoot length (4.643 and 15.73 cm). Treatment T_4 (10 ml) observed the highest shoot length and root length at 10 days after germination (DAG) was 26.59and 18.92 cm respectively.

Shoot and Root length measurement in the month of May

Table 9 shows that the effects of wastewater on the shoot and root length of Lady's Finger at 5, 10 and 15 days after germination (DAG). Treatment T_4 (10 ml) observed the highest shoot length 15.76, 19.56 and 25.40 cm respectively and root length was 13.73, 19.14 and 26.03 cm respectively in three selected days. The shortest shoot length was recorded at T_1 (3 ml) 8.347, 9.157 and 14.40 cm respectively and root length was 5.437, 9.580 and 14.60 cm at T_0 (control) Treatment.

From the table 9, it also is found that the effects of wastewater on the shoot length of Yard Long Bean at 5, 10 and 15 days after germination (DAG). Treatment T_4 (10 ml) observed the highest shoot length 19.75, 22.92 and 28.70 cm respectively and T_1 (3 ml) treatment the lowest shoot length was 9.083, 15.24 and 19.93 cm respectively in three in conjugative days. In root, Treatment T_4 (10 ml) and T_0 (control) showed the highest and lowest length at 5 days after germination (DAG) was 17.57 and 5.107 cm respectively.

From Table 9 it can be said that the effects of wastewater on the shoot and root length of Cucumber at 5, 10 and 15 days after germination (DAG). Treatment T_4 (10 ml) observed the highest shoot length 12.61, 18.05 and 22.47 cm respectively and root length was 24.87, 25.88 and 30.03 cm respectively in three selected days. The shortest shoot length was recorded at T_0 (control) 4.503, 9.160 and 14.87 cm respectively and root length was 15.76, 18.86 and 24.53 cm respectively in three conjugative days.

Table 9 Shoot and Root length of Lady's Finger, Yard Long Bean and Cucumber during the month of May, 2023

Lady's Finger	**Shoot**			**Root**		
Treatment	**5 DAG**	**10 DAG**	**15 DAG**	**5 DAG**	**10 DAG**	**15 DAG**
T_0	8.723d	11.47d	16.23d	5.437c	9.580d	14.60d
T_1	8.347e	9.157e	14.40e	9.777b	16.28b	22.77b
T_2	11.95c	15.55c	22.87c	9.790b	14.89c	19.83c
T_3	12.81b	17.85b	24.27b	9.613b	17.07b	25.87a
T_4	15.76a	19.56a	25.40a	13.73a	19.14a	26.03a
LSD	0.14	0.41	0.58	0.22	0.79	0.42
CV(%)	0.67	1.62	1.61	1.31	2.94	1.11
Yard Long Bean						
T_0	11.61c	15.87c	21.00c	5.107c	8.547d	12.83d
T_1	9.083d	15.24d	19.93d	11.64b	18.83c	24.63c
T_2	16.05b	19.53b	24.00b	13.09b	19.91b	24.93c
T_3	16.95b	19.81b	23.83b	14.91ab	21.45a	27.57a
T_4	19.75a	22.92a	28.70a	17.57 a	19.69b	25.73b
LSD	1.42	0.44	0.31	4.45	0.24	0.43
CV (%)	5.53	1.35	0.75	20.39	0.77	1.05
Cucumber						
T_0	4.503d	9.160b	14.87d	15.76c	18.86c	24.53e
T_1	4.637d	10.42b	14.90d	20.97b	24.20b	27.93d
T_2	6.293c	11.84b	16.80c	20.84b	24.44b	28.77c
T_3	7.617b	9.503b	18.67b	23.81ab	26.22a	29.57b
T_4	12.61a	18.05a	22.47a	24.87a	25.88a	30.03a
LSD	0.44	4.77	0.39	3.24	0.49	0.31
CV (%)	3.52	23.07	1.27	8.72	1.17	0.63

*Alphabets in the same column showed non-significant. ($P<0.05$)

Finally, it is observed from the above tables (table 7, table 8 and table 9) that the shoot and root length of Lady's Finger, Yard Long Bean and Cucumber were gradually increased and the uppermost shoot and root length found in T_4 (10 ml) Treatment and lowest shoot and root length observed in T_0 (control) Treatment during the month of January, March and May of 2023. Similar result was found by [27], stated as the relative shoot elongation ratio of the germinated seeds increased with increasing effluent concentration. Again, in lower effluent concentration promotes the growth of plant as it contains plant nutrients [40], [39]. Similar results were also noted by [41] and [42] in many crops. City Wastewater contains essential plant nutrients such as N, P, and K, micronutrients like iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) and a significant amount of organic matter for plant growth [43]. This makes wastewater a good source of fertilizer that improves soil fertility and productivity [44]. It is also noted that seedling (root & shoot) lengths decreases with increasing concentration and seedling growth were inhibited at 100 % concentration, this is due to some of the nutrients present in the effluents are essentials but at high concentration, they become hazardous [4]. In this study we use lower effluent concentrated wastewater that significantly increases seedling (root & shoot) lengths.

4. Conclusion

The experiment indicates that the physico-chemical analysis of wastewater of Girajanath channel of Dinajpur city, Bangladesh is highly polluted. The performance on seed germination, speed of germination, relative germination ratio, germination index and the overall plant growth of some vegetables viz. *Abelmoschus esculentus* (Lady's Finger), *Vigna unguiculata* (Yard Long Bean) and *Cucumis sativus* (Cucumber) using the control water was significantly different than the filtered wastewater. It was noticed that the decreasing rate of seed germination percentage, speed of germination, relative germination ratio, germination index and the overall plant growth were found with increasing effluent concentrations. It also can be suggested that the city wastewater is a prospective source of different plant nutrients. Thus, the wastewater of Girajanath channel of Dinajpur city can be used for irrigation purposes in agricultural practices after proper dilutions and resistant varieties should be used.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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