Impact of pharmaceutical industry effluent on seed germination and seedling growth of some common crops of Bangladesh

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Abstract

This project was carried out to investigate the effect of pharmaceutical industry effluents on seed germination and seedling growth of some common cultivated crops of Bangladesh. Four varieties of crops such as Okra, Data shak, Ridge gourd, and Black mustard were selected to grow in this effluent. Concentrations used for the effluents in terms of seed germinations were 0%, 25%, 50%, 75% and 100% respectively. The optimum condition of seed germination obtained for Okra, Data shak and Ridge gourd were 25%, 100% and 50% respectively. However, in terms of Black mustard the germination percentage was same in all condition. At lower dilutions the crops exhibited favorable effect on seed germination, seedling growth, shoot length and root length. Among all 100% concentrations of the effluent caused inhibitory effect in terms of all crops except Black mustard. Based on the present investigations, it can be concluded that pharmaceutical effluent which is discharging as waste can be used for irrigation purpose, after proper dilution.

Keywords: Effluents; Irrigation; Seed germination; Seedling growth; Dilution; Shoot length

Introduction

Bangladesh is an agrarian country. It’s fertile land is suitable to grow different vegetables. Vegetables are not only an important part of human diet but also providing important functional food component by contributing iron, vitamins, calcium etc. which have significant health value (Arai et al., 2002). Day by day, consumers demand for high quality vegetables are enhancing. But it is inhibiting by different industrial activities at an alarming rate. Now a days a large amount of effluents are discharging to the surface. While the developed countries discharge their industrial effluents with proper treatment but the developing countries such as India, Bangladesh and Pakistan are discharging different industrial effluents without further treatment. These effluents are either released to the water bodies or throwing to the agricultural land. Sometimes these effluents are used for agricultural purpose due to the scarcity of water (Ghafoor et al., 1994). Treating waste effluents is very much significant for cultivation of crops and environment. Moreover, the economy of Bangladesh is predominantly based on agriculture but, in the race towards industrialization, industries are taking place in a gradual increasing phase. The important industries are paper, oil refinery, chemical, pharmaceutical, lather tanning, textiles, fertilizer, and sugar industry and so on. Effluents generated by industries are one of the major sources of pollution. Contaminated air, water and soil by effluents from the industries are associated with many diseases (WHO, 2002) and this could be part of the reasons for the current shorter life expectancy (WHO, 2003) when compared to the developed nation. Presently less than 10% of the effluent generated is treated and the rest of the untreated waste water is discharged into the nearby water bodies. The use of industrial effluents for irrigation has emerged in the recent past as an important way of utilizing waste water, taking the advantage of the presence of the considerable quantities of N, P, K and Ca along with other essential nutrients (Niroula et al., 2003).

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But there might be beneficial and detrimental effects of waste water irrigation of crops including vegetables (Ramana et al., 2002; Saravanamooorthy et al., 2007). Recently, many researchers worked on the effect of different industrial effluents on seed germination and seedling growth of different varieties of crops (Iqbal et al., 2021; Sankar et al., 2014; Rena et al., 2020; Amina et al., 2020; Rupa et al., 2018; Islam et al., 2017). Therefore, it is necessary to study the impact of these effluents on crop system before they are recommended for irrigation (Thamizhiniyan et al., 2009). The present investigation was carried out to study the impact of untreated effluents from pharmaceutical industry on seed germination and early growth of four common crops of Bangladesh. The effect of these effluents on root and shoot lengths were also investigated. Besides the physico-chemical parameters of this effluent were also studied.

Materials and methods

Collection of the effluents

The effluents used in this study were collected in a pre-cleaned plastic bottle from SILCO pharmaceutical company limited which is situated at Khadimnagar in Sylhet city. The effluents were stored at 4°C temperature to avoid the changes of physic-chemical features. Different physico-chemical features were studied at the organic chemistry research laboratory of Shahjalal University of Science and Technology (SUST), Sylhet, Bangladesh.

Characterization of the effluent

According to previously reported procedure of American Public Health Association (APHA, 1989) the physico-chemical properties of the effluent samples were studied.

Collection of seed materials

The seed materials were collected from a local market. Four varieties of seeds such as Okra, Amaranthus, Ridge gourd and Black mustard were collected for germination purpose. Experiments were designed according to the reported literature (Nawaz et al., 2006).

Germination study

The healthy and uniform seeds were selected and surface sterilized with 0.1% HgCl₂ and thoroughly washed with distilled water to avoid surface contamination. The germination test was carried out in a sterile petridishes of 9, 10, 11, 12 cm in size placing a double ring filter paper on each petridishes. Different concentration such as 0%, 25%, 50%, 75% and 100% of collected waste water were prepared with respect to the distilled water and stored for seed treatment. The waste water of each concentration was added to each petridish of respective treatment daily in such an amount just to allow the seeds to get favorable moisture for germination and growth. The control was treated with distilled water only. 20 seeds of each agricultural crop and in case of Ridge Gourd 15 seeds were placed in the petridishes. The petridishes were set at organic chemistry research laboratory at room temperature (30±2°C). The experiment extended over a period of nine days to allow the last seed germination and measurement of the root and shoot length. The results were determined by counting the number of germinated seeds, measuring the length of primary root and main shoot at the 9th day of the experiment. The data were subjected to analysis of Duncan’s Multiple Range Test (DMRT) (Duncun et al., 1957). The ratio of germination and elongation were calculated as previously reported method (Hoque et al., 2003; Rao et al., 1983).

Germination percentage

Different parameters used for germinations are given here:

Here,

\[ C_0 = \text{Seeds of receptor plants grown in distilled water only (control)} \]

\[ C_1 = \text{Seeds of receptor plants grown in waste water of 25% concentration} \]

\[ C_2 = \text{Seeds of receptor plants grown in waste water of 50% concentration} \]

\[ C_3 = \text{Seeds of receptor plants grown in waste water of 75% concentration} \]

\[ C_4 = \text{Seeds of receptor plants grown in waste water of 100% concentration} \]

\[ A = \text{Number of seeds in each petri dish, B = Number of seeds Germinated} \]

\[ C = \text{percent of germination, D = Percent of inhibitory effect.} \]

(-ve inhibitory effect and +ve indicates stimulatory effect).
Calculation of D

D can be calculated by using the following equation as,

\[ D = \frac{(C_2 - C_1)}{C_1} \times 100 \] [for the first value D]
\[ D = \frac{(C_3 - C_1)}{C_1} \times 100 \] [for the second value of D]

Where, \( C_1, C_2 \) and \( C_3 \) are the first, second and third value of C [e.g. germination percentage]

Other values of D were calculated in the same way.

Results and discussion

The effluent was dark brown in color with an unpleasant smell. It was acidic in nature and consists of high amounts of total dissolved and suspended solids. The physico-chemical properties of the pharmaceutical effluent have been displayed in Table I.

After collecting the pharmaceutical industry effluents, its physico-chemical parameters were studied and its impact was investigated on seed germination, seedling growth, root length, shoot length etc. According to a previous report (Rodosevich et al., 1997) seed germination control plants populations, ensure reproduction and crop productivity. From the experimental outcome we may bioassay that for okra and Ridge Gourd, the rates of germination is decreased with increasing the concentration of the effluent. It means that high concentration of the pharmaceutical effluent is not suitable for these two species. In case of Data Shak the rates of germination is increased with increasing the concentration of the effluent. It seems that there are some essential organic compounds in waste waters which may alleviate some part of negative impacts. According to the method described by Panasker et al. (2011), 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 contained some essential organic compound which increase growth of crop (Pathak et al., 2009; Lubello et al., 2004). In terms of Black Mustard there is no inhibitory effect of effluent on seed germination, it might be because of some organic matter present in polluted water which can alleviate the negative effect of toxic materials and may improve their rate of

| Sl. No. | Parameters                              | Values      | Standards   |
|--------|----------------------------------------|-------------|-------------|
| 1      | Color                                  | Dark brown  | Colorless   |
| 2      | Odor                                   | Unpleasant  | Odorless    |
| 3      | Temperature (°C)                       | 27          | 40          |
| 4      | pH                                     | 6.5         | 5.5-9       |
| 5      | Electrical conductivity (S/m)          | 0.423       | 0.3         |
| 6      | Total solids (mg/L)                    | 2000        | 3500-4000   |
| 7      | Total Suspended Solids (mg/L)          | 1000        | <50         |
| 8      | Total Dissolved Solids (mg/L)          | 1000        | <3000       |
| 9      | Dissolved oxygen (mg/L)                | 3.05        | 5-6         |
| 10     | Biochemical Oxygen Demand (mg/L)       | 1.28        | <20         |
| 11     | Chemical Oxygen Demand (mg/L)          | 22          | <150 ppm    |
The healthy and uniform seeds were selected and surface treated, ensuring a uniform purpose. Experiments were designed according to the method described by et al., 2017. Collections of seed materials are essential in ensuring the viability of plants. Characterization of the effluent is critical in understanding its impact on the environment. Effluents from agricultural and industrial activities are a significant source of pollution. Studies have shown that the effect of these effluents on crop systems is crucial before recommending them for use. Therefore, it is necessary to study the impact of these effluents on crop systems before they are recommended for use. According to the method described by et al., 2018; Islam et al., 2021; Sankar et al., 2014, the effect of these effluents on crop systems has been investigated to study the impact of effluents on the environment and crop productivity. The effect may vary from crop to crop, indicating the need for specific treatments for different crops.

Results and discussion

Other values of D were calculated in the same way.

\[
D = \frac{(C_3 - C_1)}{C_1} \times 100 \quad \text{[for the second value of D]}
\]

\[
D = \frac{(C_2 - C_1)}{C_1} \times 100 \quad \text{[for the first value of D]}
\]

Calculation of D

Here, C1, C2 and C3 are the first, second and third value of C, respectively.

Table II. Percent of seed germination for some cultivated crops

| Treatment | Okra | Data shak | Ridge gourd | Black mustard |
|-----------|------|-----------|-------------|--------------|
|           | A    | B         | C           | D            | A    | B   | C    | D          | A    | B   | C    | D            |
| C0        | 20   | 16        | 80          | -            | 20   | 8   | 40   | -          | 15   | 11  | 73   | -            |
| C1        | 20   | 15        | 75          | -6.25        | 20   | 9   | 45   | 12.5       | 15   | 7   | 47   | -35.6        |
| C2        | 20   | 14        | 70          | -12.5        | 20   | 9   | 45   | 12.5       | 15   | 8   | 53   | -27.3        |
| C3        | 20   | 10        | 50          | -37.5        | 20   | 10  | 50   | 25.0       | 15   | 5   | 33   | -54.8        |
| C4        | 20   | 10        | 50          | -37.5        | 20   | 11  | 55   | 37.5       | 15   | 3   | 20   | -72.6        |

Table III. Effect of pharmaceutical effluent on shoot length

| Treatment | Okra | Data shak | Ridge gourd | Black mustard |
|-----------|------|-----------|-------------|--------------|
|           | A    | B         | C           | A    | B   | C    | A    | B   | C    | A    | B   | C    |
| C0        | 2.06 | -         | -           | 2    | -   | -    | 1.78 | -   | -    | 2.72 | -   | -    |
| C1        | 1.22 | 59.22     | -40.8       | 0.6  | 30   | -70  | 1.24 | 69.7 | -30.3 | 0.86 | 31.6 | -68.3 |
| C2        | 0.82 | 39.80     | -60.2       | 0.62 | 31   | -69  | 0.94 | 52.8 | -47.2 | 0.68 | 25   | -75  |
| C3        | 1.1  | 53.39     | -46.6       | 0.8  | 40   | -60  | 1.10 | 38.2 | -61.8 | 0.72 | 26.5 | -73.5 |
| C4        | 0.76 | -36.9     | -63.1       | 0.54 | 27   | -73  | 0.5  | 28.0 | -71.9 | 0.60 | 43.3 | -54.7 |

Table IV. Effect of pharmaceutical effluent on root length

| Treatment | Okra | Data shak | Ridge gourd | Black mustard |
|-----------|------|-----------|-------------|--------------|
|           | A    | B         | C           | A    | B   | C    | A    | B   | C    | A    | B   | C    |
| C0        | 6.34 | -         | -           | 2.24 | -   | -    | 6.36 | -   | -    | 7.86 | -   | -    |
| C1        | 7.6  | 119.8     | 19.87       | 3.1  | 138.4| 38.4 | 6.1  | 127.3| 27.35 | 6.7   | 115.7| 16 |
| C2        | 6.66 | 105.0     | 5.04        | 2.68 | 119.6| 19.7 | 5.7  | 126.1| 26.10 | 5.98  | 102.0| 2.0 |
| C3        | 7.92 | 124.9     | 24.92       | 2.75 | 1  | -2.67 | 7.2   | 83.3 | -16.67 | 7.99  | 89.67| -11 |
| C4        | 4.36 | 0.69      | -31.23      | 2.26 | 100.9| 0.89 | 2.76 | 43.3 | -56.6 | 3.98  | 67.91| -32 |
The healthy and uniform seeds were selected and surface reported literature (Nawaz, et al., 2020; Rupa et al., 2020; Amina et al., 2003; Rao et al., 2011). Each experiment was designed according to the previously reported procedure of American Municipal- treated waste water reuse for plant growth and metabolism of Phaseolus stenocarpa and P. vulgaris (Pathak, 2004). In terms of some essential organic compound which increase growth of Phaseolus vulgaris and P. stenocarpa (Sankar NS and Dipak P, 2014), impact of Jute mill waste effluent on growth and metabolism of Phaseolus stenocarpa. In addition to that, we also conducted experiment to study the impact of these compounds in waste waters which may alleviate some part of the problem (Karim et al., 2020; Momen et al., 2021).

The impact of the pharmaceutical industry effluents on root and shoot length for various crops has been displayed in Table III-IV as well as in Figure 2-3. In terms of Okra the highest shoot length (2.06 cm) was recorded in control compared to all other treatment and the lowest one (0.76 cm) was recorded in 100% of effluent concentration. For Data

**Fig. 1.** Percent of seed germination with effluent concentrations for various crops [Here O, D, R and B stands for Okra, Data Shak, Ridge Gourd and Black Mustard respectively]

**Fig. 2.** Variation of shoot length with effluent concentrations for various crops [Here O, D, R and B stands for Okra, Data Shak, Ridge Gourd and Black Mustard respectively]
The healthy and uniform seeds were selected and surface purpose. Experiments were designed according to the seed materials were collected from a local market. Collection of seed materials to avoid the changes of physico-chemical features. Differ-
Sylhet city. The effluents were stored at 4˚C temperature also studied.

2009). The present investigation was carried out to study the impact of waste water irrigation of crops including vegetables by counting the number of germinated seeds, measuring different parameters used for germinations are given here:

Germination percentage

\[ C = \text{percent of germination} \]

\[ D = \left( \frac{C_2 - C_1}{C_1} \right) \times 100 \] [for the first value D]

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2004). In terms of compounds in waste waters which may alleviate some part of the impact of the pharmaceutical industry effluents on root

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Fig. 3. Variation of root length with effluent concentrations for various crops [Here O, D, R and B stands for Okra, Data Shak, Ridge Gourd and Black Mustard respectively]

shak the highest shoot length was recorded at control (2 cm) and the lowest shoot length was recorded at 100% concentration (0.54 cm), the trend was similar as Okra. Also a similar trend was observed in terms of Ridge gourd and Black mustard. The overall finding reveals that most elongated shoot was counted for Black mustard (2.72 cm). Similar trend was observed for shoot length of all of the selected plants. But a point to be noted that the most elongated root was observed for Okra (7.92 cm).

**Conclusion**

This study concludes that physico-chemical parameters such as pH, electrical conductivity, COD, TS, TDS, and TSS were relatively high in pharmaceutical effluent and severely affected seed germination. The untreated pharmaceutical effluent could possibly lead to soil deterioration and low productivity. The effect may vary from crop to crop because each plant species has its own tolerance of the different effluent concentrations. So as the effluents are toxic, finally it is suggested that long term experiments should be conducted to explore the effect of wastewater on above suggested aspects before its use for irrigation. This study contributes to enhance the knowledge about how the pharmaceutical industry effluents effects on seed germination, seedling growth, root and shoot length of some common cultivated crops which might be a milestone for future researchers to do same kind of works.

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