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Research paper

Impact of Industrial Effluents on the Morphology of Some Agricultural Plants Growing in Kharagpur Sub-Division of West Bengal, India

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ABSTRACT

Kharagpur Subdivision is one of the important industrial belts in west Bengal. Many industries in this area discharge their effluents directly or indirectly into many water bodies as well as soil and agricultural land. In the present study, the impact of industrial effluents, leaching from Carbo and TATA Metalics factory of Kharagpur on morphological characters of some agricultural plants has been analysed. For the study, some important agricultural plants species - Solanum tuberosum, Saccharum officinarum and Lycopersicon esculenta were selected. The aim of this study highlighted the strong emphasis on examining how harmful industrial effluents are severely affecting the morphological characters of these selected plants. The objectives have helped in exploring the study's goal to examine the key drivers responsible for the increase in industrial effluents in Kharagpur's subdivision. Similarly, morphological characters of these plants were analyzed and were found comparatively leaf number and size as well as length of root shoot and petiole were lower in irrigated field with effluent contaminated water than that of irrigated field with uncontaminated water. In the present work the effect of distillery effluent on leaf size and number as well as length of root, stem and petiole of three different crops (*Solanum tuberosum*, *Saccharum officinarum* and *Lycopersicon esculenta*) were assessed. It was found that industrial effluents had inhibitory effects. It was also observed that root growth was highly affected than shoot and leaf growth. Thus, roots of the tested crops were highly sensitive to effluent treatment than shoots. Quantitative analysis of some major morphological parameters of these selected agricultural plants growing on land irrigated with effluent contaminated water revealed that there were drastic changes of morphological features observed in respect to the plants growing on land irrigated with uncontaminated water. Thus, in future the analysis of morphological features of these plant species will play an important role in the study of green development as well as crop productivity in urban area.

1. Introduction

Industrialization plays an important role in the development of a nation by utilizing the resource available which help in expansion of business as well as generating employment (Holkar et al., 2018). Rapid industrialization causes the addition of toxic substances to the environment that are responsible for altering the ecosystem were studied by various authors from different corners of the world (Mudd and Kozlowski, 1975; Niragau and Davidson, 1986; Kaur and Nagpal, 2017). The increase in industrialisation has created a major impact on the environment as well as on neighbouring plants even though it has helped in economic development (Yadav and Pandey, 2020). The indiscriminate and untreated discharge of industries and municipal solid waste is the principal source of surface water contamination (Abbasi et al., 2020). Heavy industrialisation has also led to the discharge of harmful chemicals and effluents and thereby changes the properties of the soil (Sethy and Ghosh, 2013; Liu et al., 2014). This is the reason that they tend to severely impact the soil quality of agricultural lands, further making the environment infertile to grow crops (Pokharel et al., 2000). The Kharagpur sub-division is known for producing the best agricultural crops, and the main occupation in this area is farming. This is the reason that their main source of income is through growing crops. However, growing numbers of industries and increasing rate of industrial effluents are directly affecting the morphology of several aquatic plants (Basar et al., 2025). The main aim of this study is to investigate the impact of industrial effluents on the morphology the agricultural plants in the region of Kharagpur's subdivision.

To suggest effective solutions to resolve the issues of industrial effluents that impact the rate of agricultural productivity in the Kharagpur subdivision.

Hence, the present study is undertaken to record the effects of pollutants on various morphological characteristics of some selected agriculture plants like - *Solanum tuberosum*, *Saccharum officinarum* and *Lycopersicon esculenta*. Kharagpur is one of India's most important industrialized subdivisions, suffering from different pollutants from nearby Carbo and TATA-Metalics industries. The pollutants become deposited in the aquatic as well as terrestrial habitats, producing a significant effect on local plants. Therefore, in the present study, the morphological changes in some selected plants were taken into account, which were severely affected by the water and soil pollutants leaching from the Carbo and TATA Metallics factory of Kharagpur.

2. Material and Methods

2.1 Materials

The three agricultural important plants that were selected for conducting this study are *Solanum tuberosum, Lycopersicon esculentum,* and *Saccharum officinarum.*

Solanum tuberosum is also referred to as the potato, is a perennial herbaceous plant in the Solanaceae family. It is distinguished by having compound leaves and tubers below ground, which are storage organs. The plant has white to purple flowers and is grown all over the world for its nutritional content. Tubers of potatoes are high in carbohydrates, specifically starch, and have proteins, vitamins (most importantly vitamin C and B6), and minerals like potassium and magnesium. Medicinally, potato skins have been investigated for their antimicrobial and antioxidant activity (Virginia and Jordi, 2001; Sampai et al., 2020).

Lycopersicon esculentum, or the tomato, is a highly cultivated member of the Solanaceae family. The plant is a short-lived perennial but is frequently grown as an annual and is sprawling in growth habit with compound leaves. It bears yellow flowers and fleshy red, nutrient-rich fruit. Tomatoes are a great source of vitamins C and K, folate, potassium, and the antioxidant lycopene. The phytochemical composition of tomatoes is responsible for their health benefits bearing the *antioxidant, antimicrobial, and anticancer* activities as well as control oxidative stress, and microbial infection (Mendez et al., 2011; Ahmed et al., 2021).

Saccharum officinarum, or sugarcane, is popularly recognised as a tall perennial grass belonging to the family Poaceae and is grown mostly for its sucrose content. The jointed, fibrous stalks of the plant are highly sugary and may grow as tall as 6 meters. Sugarcane is an important source of raw material for sugar manufacturing and the production of bioethanol. The aqueous ethanolic bark extracts of *Saccharum officinarum* has antimicrobial activity reflecting its use in traditional medicine for infection treatment (Karthikeyan and Simipillai, 2010; Molina-Cortes et al., 2023).

2.2 Methods

2.2.1 Study area

Two industrial zones i.e., Carbo and TATA Metallics factory and their adjoining area under the Kharagpur subdivision were selected for the study, which was extended from latitude 22° 22' 46.5" to 22°23'10.1" N and longitude 87°16'53.5'' to 87°17'13.0" E.

2.2.2 Collection of samples

Some healthy seedlings of each selected species, i.e., *S. tuberosum, L. esculentum,* and *S. officinarum* were collected from their native habitat in the year 2023 and transferred to pots. with 4 ft in diameter and 2 ft in depth residing at an experimental site located at latitude 22° 36'90.4" N and longitude 87°55'44.2'' E. The experimental site was the Debra College Campus under the Kharagpur subdivision. Two sets of pots for each species were prepared. One set bears the soils with industrial effluents collected from the selected industrial zones treated as (P), and another set bears the soil collected from nonpolluted zones of Kharagpur subdivision treated as control (NP). Four to six healthy seedlings of above said species were sown in each pot.

Mature plants at their flowering and fruiting stage were collected from the polluted (P) demarcated pots and some control (NP) demarcated pots. The morphological characters, such as the length of the root, shoot, leaf, and petiole, as well as the width and number of leaves, were taken into account and measured by scales. A student's T-test is used to test the significance of the test.

3. Result

In the present study, there were significant variations in root length, shoot length, leaf number, leaf length and breadth, as well as petiole length, noted in all of the selected plants growing in the pots (P) containing soil with industrial effluents in respect to control (NP).

In *S. tuberosum*, the length of root, shoot, and petiole in the plants grown in the polluted soil reduced to 10.1 cm from 16.2 cm and 36.0 cm from 41.0 cm and 3.0 cm from 7.0cm, respectively, with respect to the non-polluted area. Similarly, leaf number, length, and breadth were also reduced to 3.0 from 7.0, 10.5 cm from 18cm, and 4.5 cm from 9.0cm, respectively, in the plants grown in polluted areas (Table 1).

In *S. tuberosum*, the statistical analysis showed that the variation in root length, leaf length and leaf number was significant only at the 1% level and petiole length only at the 5% level (Table 1).

Table 1 Morphological parameters of polluted and non-polluted of *S. tuberosum*

Parameter (cm)	Control (NP) Mean ±SD	Polluted (P) Mean ±SD	t-test
Root length	16.2 ± 1.5	10.1 ± 1.8*	4.50
Shoot length	41.0 ± 5.0	36.0 ± 3.7 ^{NS}	1.39
Leaf length	18.0 ± 1.9	10.5 ± 0.6*	4.51
Leaf breadth	9.0 ± 0.5	4.5 ± 0.3	6.36
Leaf number	34 ± 8	15 ± 1.2*	4.06
Petiole length	7.0 ± 0.3	3.0 ± 0.1**	2.60

* Significant at 1%, ** Significant at 5%, NS-Non significant

In *S. tuberosum*, the statistical analysis showed that the variation in root length, leaf length and leaf number was significant only at the 1% level and petiole length only at the 5% level (Table 1). In contrast shoot length of the species grown between control and polluted soil remained statistically insignificant.

In *L. esculentum*, the length of root, shoot, and petiole in the plants grown in the polluted area reduced to 12.0 cm from 19.0 cm and 37.0 cm from 70.0 cm and 2.5cm from 5.5 cm, respectively, with respect to the non-polluted area. Similarly, leaf number, length, and breadth also reduced to 10.0 from 35.0, 13.0 cm from 17.0 cm, and 3.8 cm from 7.0 cm, respectively, in the plants grown in polluted soil (Table 2).

The statistical analysis in *L. esculentum* showed that the variation in root length and leaf length were significant only at the 1% level and petiole length at the 5% level (Table 2). In contrast, the variations in leaf breadth and leaf number between the control and the polluted samples remained statistically insignificant.

Table 2 Morphological parameters of polluted and non-polluted of *L. esculentum*

Parameter (cm)	Control (NP) Mean ±SD	Polluted (P) Mean ±SD	t-test
Root length	19.0 ± 1.6	12.0 ± 1.0*	2.49
Shoot length	70.0 ± 5.5	37.0 ± 2.7	7.32
Leaf length	17.0 ± 1.4	13.0 ± 1.1*	3.89
Leaf breadth	7.0 ± 0.6	3.8 ± 0.2 ^{NS}	1.62
Leaf number	35 ± 3.5	10 ± 1 ^{NS}	1.89
Petiole length	5.5 ± 0.5	2.5 ± 0.2**	2.64

* Significant at 1%, ** Significant at 5%, NS-Non significant

In *S. officinarum*, the length of root, shoot, and petiole in the plants grown in polluted areas reduced to 15.5 cm from 27.0 cm and 112.0 cm from 145.0 cm and 1.9 cm from 4.0 cm, respectively, with respect to the nonpolluted area. Similarly, leaf number, length, and breadth also reduced to 7 from 12, 75.0 cm from 107.0 cm, and 3.0 cm from 8.0 cm, respectively, in the plants grown in polluted areas (Table 3).

In *S. officinarum*, the statistical analysis showed that the variation in shoot length was significant only at the 1% level whereas root length and leaf number significant only at the 5% level (Table 3). The variation of leaf breadth between the control and the polluted samples remained statistically insignificant (Table 3).

Table 3 Morphological parameters of polluted and non-polluted of *S. officinarum*

Parameter (cm)	Control (NP) Mean ±SD	Polluted (P) Mean ±SD	t-Test
Root length	27.0 ± 5.0	15.5 ± 1.7**	4.07
Shoot length	145.0 ± 15.0	112.0 ± 7.0*	3.75
Leaf length	107.0 ± 6.0	75.0 ± 2.7	8.42
Leaf breadth	8.0 ± 0.3	3.0 ± 0.2 ^{NS}	1.01
Leaf number	12 ± 3	7 ± 2.0 **	2.40
Petiole length	4.0 ± 0.1	1.9 ± 0.1	8.71

* Significant at 1%, ** Significant at 5%, NS-Non significant

4. Discussion

The changes in morphological characteristics of these selected agricultural plants- *S. tuberosum, L. esculentum, and S. officinarum* growing in polluted industrial areas in our study were reasonable and consistent with many earlier reports from different corners of the world regarding the changes of root, shoot and leaf morphology with respect to accumulation of industrial effluents in soil (Liu et al., 2014; Crowe et al., 2002; Ghani, 2010). Similar kind of morphological changes of agricultural crops were noted in China due to rapid industrialization in the recent years (Zhang et al., 2015). Similar type of changes in root growth and the number or root per bulb in onion growing in industrial effluents as compared to the control (Pokharel et al., 2000). There were similar morphological changes found in some agricultural plants growing around Sokoto Cement Company in Nigeria (Warrah et al., 2021). There were reports on the influence of toxic pollution that has affected the production of Potatoes, sugarcane and tomatoes in agricultural regions (Behera et al., 2024). There were drastic changes found in morphological characters of some aquatic plants growing in the industrial belt of Kharagpur's subdivision of West Bengal in India (Basar et al., 2025).

Therefore, in the study, it has seen that morphological characters of the selected agricultural plants were affected by soil and water containing industrial dust from the Kharagpur industry, which might be due to the presence of different toxic pollutants. Similar kind of deterioration in the quality of soil due to industrial pollutants was noted in various industrial area (Rai and Mishra, 2013). The waste materials of industries have high concentration of heavy metal which degrades the physical, chemical and biological properties of plants (Sethy and Ghosh, 2013; Jaglan et al., 2022). This highlights the need for tracking and regulating industrial waste in order to curb its impact on major agricultural crops grown in sensitive regions like industrial belts of West Bengal of India.

5. Conclusion

The observations recorded in the present study indicated that effluents emitted from the Carbo and TATA Metallics factory exercised a decisive influence on the morphology of the selected agricultural plants. From the present data, it is apparent that the contaminated soil exerted negative effects on the length of root, shoot and petiole as well as the number of leaves of the selected agricultural plants grown in the soil contaminated by industrial effluents. The present investigation suggests that the Carbo and TATA Metallics factory should take much care in discharging effluents reduce the contaminants in the soil of adjoining areas. This can be performed by setting up a pre-treatment plant for these effluents or by recycling the chemicals present in the effluents into their processing plants.

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Authors' contributions

All authors contributed equally.

Conflict of interest

The authors declare no conflict of interest

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