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Assessment of Soil Degradation Due to Dyeing Effluents in Thangallapally area, Rajanna Siricilla, Telangana

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ABSTRACT

This study investigates the impact of untreated textile dye effluents on soil in Thangallapally village, located 6 kilometers from Siricilla district headquarters. The village is surrounded by textile industry that discharges wastewater directly into open land, subsequently, it impacts the near area soil fertility. Soil samples were collected from agricultural fields which impacted with dying effluents and analyzed for their physicochemical properties. Parameters such as pH, Electrical Conductivity (EC), Water Holding Capacity (WHC), Organic Carbon (OC), Organic Matter (OM), Bicarbonates, Calcium (Ca), Magnesium (Mg), Sodium (Na), Phosphates, and Potash were examined using standard protocols. The results revealed significant differences between contaminated (dying impacted area) and non-contaminated (Not impacted by dying effluents) soils. Contaminated soil exhibited higher pH, EC, bicarbonates, calcium, magnesium, and sodium levels, and slightly elevated organic matter, reflecting the adverse effects of effluent irrigation. In contrast, non-contaminated soil demonstrated balanced pH, reduced salinity, and lower concentrations of potentially harmful elements, making it more suitable for agriculture. This study emphasizes the need for effective management strategies, including effluent treatment and soil remediation, to mitigate environmental impacts and preserve soil health in industrially influenced agricultural regions.

Keywords: *Physico chemical properties, Thangallapally, Textile industries, Sustainable Agriculture, Environmental impact*

1.0. Introduction

Soil is one of the most vital resources on Earth, supporting life and exhibiting a heterogeneous nature. The use of effluents for irrigating agricultural land is a common practice worldwide, particularly in developing countries where the cost of water treatment remains prohibitive. Irrigation with sewage effluents provides water, nitrogen (N), phosphorus (P), and organic matter to the soil, all of which have beneficial effects on soil biota. Additionally, it offers a practical method for sewage disposal through land treatment, helping to mitigate potential health and environmental hazards caused by the uncontrolled discharge of wastewater. Wastewater is also a valuable source of plant nutrients and organic matter, essential for maintaining soil fertility and productivity (1-4).

However, among all industrial sectors, textile processing wastewater is recognized as one of the most polluted sources in terms of both quantity and composition. Numerous studies have documented the adverse effects of various industrial effluents on plant growth, with dye wastewater proving toxic to several crop plants. This investigation focuses on assessing the impact of dye industry effluent on soil quality, aiming to better understand its effects and implications.

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2.0. Materials and methods

The study area chosen for this research was Thangallapally, located approximately 6 kilometers from the Siricilla district headquarters in Telangana state. This village is situated near several textile dye industries, which require large quantities of water for dye processing. The untreated wastewater generated by these industries is directly discharged into local drains. This wastewater is then utilized for crop irrigation, adversely impacting the nearby agricultural land.

The primary objective of this study was to analyze the physicochemical properties of soil and water in agricultural areas affected by untreated textile effluents. The analysis also extended to irrigation water to identify potential environmental impacts. Soil samples were collected from agricultural fields irrigated with untreated industrial effluent. The triplicate samples were taken from three different locations at a depth of 0–25 cm. These samples were air-dried, gently crushed with a wooden roller, and sieved through a <2 mm mesh. The sieved soil samples were then stored in plastic bags for subsequent analysis. (5-9)

Effluent samples were also collected and analyzed to determine their physicochemical properties. Both soil and water samples were gathered during March and April 2022. Temperature and pH measurements were taken on-site. The soil samples were analyzed for pH, electrical conductivity (EC), Water Holding Capacity (WHC), organic carbon (OC), organic matter (OM), available phosphate (P), potash (K), sodium (Na), bicarbonates (HCO_3), calcium (Ca), and magnesium (Mg). Effluent samples were tested for pH, electrical conductivity (EC), and the concentration of Cations and Anions. Standard protocols were used for analyzing the physicochemical parameters of the wastewater and soil samples

3.0. Results and discussions

The effluent sample analysis from Thagallapally village industries provided insight into the water quality based on several parameters.

The pH values indicate a slightly alkaline nature, ranging from 7.76 to 8.2 across the samples. Electrical Conductivity (EC) values, measured in µS/cm, show variability in salinity, with S2 exhibiting the highest conductivity at 441.09 µS/cm. Bicarbonate concentrations are relatively high but decrease from S1 (406.33 mg/l) to S3 (368.33 mg/l). Higher bicarbonate concentrations can hinder plant uptake of essential nutrients such as potassium and phosphorus. It may also cause bicarbonate toxicity in sensitive crops, manifesting as chlorosis (yellowing of leaves) (10).

Table: 3.1: Effluent Sample of Thagallapally Village Industry

S. No.	Parameter	S1	S2	S3
1	**pH**	7.76	8.2	7.93
2	**EC µS/cm**	287.48	441.09	416.46
3	**Bicarbonates mg/l**	406.33	383.66	368.33
4	**Cl mg/l**	635.36	520.33	467.66
5	**Ca mg/l**	354.66	351.5	346.83
6	**Mg mg/l**	117.66	28.39	27.95
7	**K mg/l**	39.1	34.97	36.75
8	**Na mg/l**	73.20	57.95	65.36

Chloride levels are significant, with S1 showing the highest concentration of 635.36 mg/l. Calcium levels are consistently high across all samples, ranging from 346.83 mg/l to 354.66 mg/l, while Magnesium shows a notable decline from S1 (117.66 mg/l) to S2 (28.39 mg/l) and S3 (27.95 mg/l). High calcium and magnesium levels (346.83–354.66 mg/l and 27.95–117.66 mg/l, respectively) are critical for soil structure but may lead to soil hardness and water infiltration issues when excessive.(12) Potassium levels are fairly consistent, with values ranging from 34.97 mg/l to 39.1 mg/l. Sodium concentrations vary, with S1 having the highest at 73.20 mg/l. High sodium concentrations (up to 73.20 mg/l) can deteriorate soil structure and cause sodicity, whereas potassium levels (34.97–39.1 mg/l) contribute to plant nutrition but are less problematic(11). Overall, the data highlights differences in the effluent composition across samples, with some parameters showing significant variability.

The analysis of Soil Sample (contaminated) reveals that, the pH levels indicate an alkaline nature, ranging from 7.15 in S3 to 8.5 in S1, suggesting variation in acidity and alkalinity across the samples. Electrical Conductivity (EC) values, measured in µS/cm, show slight differences, with S2 having the highest value (399.33 µS/cm) and S3 the lowest (377 µS/cm). Water holding capacity varies, with S2 showing the highest capacity (65.33%) and S3 the lowest (58.33%).

Bicarbonate concentrations are significantly high, peaking in S1 (516.66 mg/l) and decreasing in S2 and S3. Calcium levels vary notably, with S2 having the highest concentration (282 mg/l) and S3 the lowest (198 mg/l). Magnesium levels show a substantial decline from S1 (46.53 mg/l) to S3 (8.07 mg/l). Total organic carbon content is consistent, ranging from 0.34% in S1 to 0.50% in S3, which aligns with organic matter percentages (0.5% to 0.52%).

Table: 3. 2: Soil Sample Collected From (Contaminated) Area

S. No.	Parameter	S1	S2	S3
1	**pH**	8.5	7.95	7.15
2	**EC µS/cm**	383	399.33	377
3	**Water holding capacity (%)**	61	65.33	58.33
4	**Bicarbonates mg/l**	516.66	450	456.33
5	**Ca mg/l**	243.66	282	198
6	**Mg mg/l**	46.53	14.94	8.07
7	**Total organic carbon Carbon % by mass**	0.34	0.49	0.50
8	**Organic matter % by mass**	0.5	0.51	0.52
9	**Phosphate mg/kg**	0.86	0.92	0.84
10	**K mg/l**	54.27	46.9	50.13
11	**Na mg/l**	77.87	78.31	73.06

Phosphate concentrations are low, varying slightly from 0.84 mg/kg in S3 to 0.92 mg/kg in S2. Potassium levels are moderately consistent, ranging between 46.9 mg/l and 54.27 mg/l, while Sodium levels are relatively high, with minor fluctuations from 73.06 mg/l in S3 to 78.31 mg/l in S2. This data provides a comprehensive view of the contamination and nutrient profile of the soil samples.

Table: 3. 3: Soil Sample Collected From (Non-Contaminated) Area

S. No.	Parameter	S1	S2	S3
1	**pH**	7.13	6.73	7.14
2	**EC µS/cm**	235	221	258.33
3	**Water holding capacity (%)**	52.33	55.33	52
4	**Bicarbonates mg/l**	352	283	350.66
5	**Ca mg/l**	95.73	60.5	78.66
6	**Mg mg/l**	4.38	7.19	4.17
7	**Total organic carbon Carbon % by mass**	0.39	0.24	0.22
8	**Organic matter % by mass**	0.43	0.31	0.32
9	**Phosphate mg/kg**	0.64	0.73	0.76
10	**K mg/l**	36.73	31.61	29.68
11	**Na mg/l**	43.49	37.03	46.96

The analysis of Soil Sample-2 (non-contaminated) provides insight into its chemical and physical properties. The pH levels indicate a neutral to slightly acidic nature, ranging from 6.73 in S2 to 7.14 in S3, suggesting balanced soil conditions. Electrical Conductivity (EC) values, measured in µS/cm, are low, reflecting reduced salinity, with S3 showing the highest value (258.33µS/cm) and S2 the lowest (221 µS/cm). Water holding capacity is relatively stable across samples, ranging between 52% and 55.33%.

Bicarbonate concentrations are moderate, with S1 having the highest value (352 mg/l) and S2 the lowest (283 mg/l). Calcium levels are significantly lower compared to contaminated samples, varying from 60.5 mg/l in S2 to 95.73 mg/l in S1. Magnesium levels are minimal, ranging from 4.17 mg/l in S3 to 7.19 mg/l in S2. Total organic carbon content is low, varying from 0.22% in S3 to 0.39% in S1, while organic matter percentages follow a similar trend, with slight variations from 0.31% to 0.43%.

Phosphate levels are low but consistent, ranging from 0.64 mg/kg in S1 to 0.76 mg/kg in S3, indicating limited availability of this nutrient. Potassium concentrations are modest, with values between 29.68 mg/l in S3 and 36.73 mg/l in S1. Sodium levels are relatively low, ranging from 37.03 mg/l in S2 to 46.96 mg/l in S3. This data reflects the non-contaminated nature of the soil, characterized by lower salinity, balanced pH, and reduced concentrations of potentially harmful elements.

The comparison between the contaminated soil sample (Soil Sample-1) and the non-contaminated soil sample (Soil Sample-2) highlights significant differences in their chemical and physical properties. The pH levels of the contaminated soil are more alkaline, ranging from 7.15 to 8.5, compared to the neutral to slightly acidic pH of 6.73 to 7.14 observed in non-contaminated soil. Electrical Conductivity (EC) is notably higher in the contaminated soil (377–399.33 µS/cm), indicating elevated salinity, while the non-contaminated soil exhibits lower EC values (221–258.33 µS/cm), reflecting minimal salinity levels. The water holding capacity is slightly higher in the contaminated soil, ranging from 58.33% to 65.33%, compared to 52% to 55.33% in non-contaminated soil, which is attributed to altered soil structure due to contamination.

Bicarbonate levels are significantly elevated in the contaminated soil (450–516.66 mg/l) compared to the moderate levels in non-contaminated soil (283–352 mg/l). Similarly, calcium and magnesium concentrations are higher in the contaminated soil, with calcium ranging from 198 to 282 mg/l and magnesium from 8.07 to 46.53 mg/l, whereas the non-contaminated soil has calcium levels between 60.5 and 95.73 mg/l and magnesium levels between 4.17 and 7.19 mg/l. These elevated concentrations can disrupt nutrient balance and soil structure. Organic carbon and organic matter percentages are slightly higher in the contaminated soil, potentially due to effluent deposits, but contamination may degrade the quality of organic matter. Phosphate levels are moderate in both soils, with contaminated soil showing slightly higher concentrations (0.84–0.92 mg/kg) compared to non-contaminated soil (0.64–0.76 mg/kg). Potassium and sodium levels are also elevated in the contaminated soil, with sodium concentrations particularly higher (73.06–78.31 mg/l) than in the non-contaminated soil (37.03–46.96 mg/l), contributing to salinity and potential soil degradation.

Contaminated soils exhibit higher salinity, alkalinity, and nutrient concentrations, indicating potential soil degradation and risks to crop health. Non-contaminated soils have balanced pH, lower salinity, and better overall quality, supporting sustainable agricultural practices. (13-15)

4.0. CONCLUSIONS

The contaminated soil shows clear signs of industrial effluent impact, including higher salinity, alkalinity, and concentrations of bicarbonates, calcium, magnesium, and sodium, which can hinder plant growth by reducing nutrient availability and causing osmotic stress. In contrast, the non-contaminated soil exhibits balanced properties, making it more suitable for agriculture. To restore the fertility of contaminated soil, treatment measures such as gypsum application for sodium removal, pH adjustment, and organic amendments are recommended. This comparison underscores the importance of monitoring and managing soil health, especially in areas affected by industrial activity.

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