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Comparative Study on the Detection of Pathogens in *Solanum lycopersicum* Grown in Sewage-Contaminated Water and in Crops Cultivated Organically with Biofertilizer Treatment: A Survey-Based Study in the MR 10 Region, Sukhliya, Indore, Madhya Pradesh

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Abstract: **Soil pollution caused by sewage water irrigation has become a pressing concern for agricultural productivity and public health. Sewage sources are known to carry pathogenic microorganisms such as Salmonella, Escherichia coli, Coliforms, Pseudomonas aeruginosa, Shigella, Vibrio cholerae, Legionella pneumophila, Campylobacter, and Leptospira, which may enter the food chain through contaminated crops. In the present study, Solanum lycopersicum (tomato) was cultivated under sewage-contaminated soil conditions and compared with organically grown crops using biofertilizer and neem cake treatments in the MR 10 region, Sukhliya, Indore, Madhya Pradesh. Tomatoes were selected not only for their nutritional importance rich in lycopene, antioxidants, and essential vitamins but also for their phytoremediation potential. Findings revealed that sewage irrigation increased pathogen load and impaired plant growth, whereas organic amendments reduced microbial contamination, improved soil fertility, and enhanced the natural phytoremediation capacity of tomato plants. This study demonstrates the dual role of tomato in food production and soil bio-remediation, offering an effective approach to manage soil pollution while ensuring sustainable agriculture.**

Keywords: **Pathogens, Sewage, Organic, Jaivik Neem Khad, Public Health.**

I. INTRODUCTION

Soil is one of the most important components of the environment, supporting plants, animals, and microorganisms. However, it is often undervalued and misused, leading to contamination and degradation (Gokulakrishnan & Balamurugan, 2010). Soil contamination is a growing problem, especially in industrial and urban areas, as it acts as the final sink for many pollutants (Shokoohi et al., 2009).

Pollutants enter the soil mainly through industrial effluents, sewage water, and excessive use of fertilizers and pesticides (Gowd et al., 2010). These contaminants, including heavy metals, persist for long periods and accumulate in the food chain, affecting soil health, plant growth, and human and animal health. Heavy metals such as Hg, Pb, Cd, and As are particularly harmful, as they are toxic even at low concentrations.

Food crops grown in polluted soil or irrigated with sewage water are at high risk of contamination. Such polluted food can cause hormonal and metabolic disorders, cancers, and sometimes severe food poisoning. The rapid pace of industrialization and urbanization has increased this problem. Therefore, studying the effects of sewage-contaminated soil and water on food crops is important for food safety and public health.

II. MATERIALS AND METHODS

1. *Plant Studied:* Solanum lycopersicum (Tomato).
2. *Varieties:* Indigenous and Hybrid.
3. *Fields:*
    - *Control field:* Gram Kaushal, Rangwasa, Jaivik Gram Foundation, Indore (Organic).
    - *Test field:*
        i. Khatipura near ISBT Kumedi, MR 10 Region, Sukhliya (Sewage Contaminated) Indore, Madhya Pradesh
        ii. SECL Coalfields Ltd. District – Anuppur, Madhya Pradesh

4. *Fertilizers Used:* Neem cake powder (Jaivik Neem Khad), and NPK.

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5. Seed Source: Jaivik Setu 66, Bhicholi Mardana, Indore, Madhya Pradesh.

6. Crop Duration: 70–100 days; fruits were used for analysis.

7. Sewage Water Analysis: Done at Pollution Control Board, Indore. Parameters tested: Nitrogen, Phosphorus, Potash, Organic Carbon, pH, EC, Calcium, BOD, COD, Magnesium, Sulphur, Fe, Mn, B, Zn, and Cu.

8. Soil Analysis: Done at Polyagro India Pvt. Ltd., Khargone (M.P.). Physical, chemical, and biological properties were tested.

9. Heavy Metal Analysis: Soil and tomato fruits analyzed by Atomic Absorption Spectroscopy (AAS) at Pollution Control Board, Indore for Hg, Pb, Cd, and As.

10. Pathogen Detection in Tomatoes:

- Coliform: IS 5401
- Salmonella: IS 5887 (Part 3)
- Escherichia coli: IS 5887 (Part 1)
- Pseudomonas aeruginosa: IS 14843
- Shigella: IS 5887 (Part 7)
- Vibrio cholerae: IS 5887 (Part 5)
- Legionella pneumophila: ISO/TS 12869:2019
- Campylobacter: IS 18564 (Part 1)
- Leptospira: Microscopic Agglutination Test (MAT).

11. Experimental Design: Three fields were selected: one organic (Control), one polluted (Test) and another one is Coalmines Field (Test). In the test fields:

- *Sample I:* Sewage Contaminated soil
- *Sample II:* Neem cake powder used
- *Sample III:* NPK fertilizer used

TABLE 1:
FIELD SET-UP IN SEWAGE CONTAMINATED AND COALMINES AREA

S.No.	Set-up	Sample 1	Sample 2	Sample 3
1.	**Indigenous Variety of Tomatoes**	**Sewage contaminated soil**	**Biofertilizer "Neem cake powder"**	**Chemical fertilizer "NPK"**
2.	**Hybrid Variety of Tomatoes**	**Sewage contaminated soil**	**Biofertilizer "Neem cake powder"**	**Chemical fertilizer "NPK"**
3.	**Tomatoes grown in Coalmine Region**	**Coalfield's soil**	**Biofertilizer "Neem cake powder"**	**Chemical fertilizer "NPK"**

III. Survey-Based Study

- Conducted with approx. **500 people**, with **440 responses**
- Aimed to assess health issues related to consumption of crops grown with sewage irrigation
- Pie charts used to display data
- **25+** health issues identified in sewage area residents

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TABLE 2:
SEWAGE WATER ANALYSIS BEFORE GROWING PLANTS

S.NO.	PARAMETERS	NORMAL RANGE	SEWAGE CONTAMINATED WATER	p-value	SIGNIFICANCE (↑ / ↓)
1.	pH	6.5-8.5	9.15	0.00000***	Highly Significant ↑
2.	EC	200-1000	1124.5	0.00000***	Highly Significant ↑
3.	Total hardness	10-1000 (mg/l)	1300	0.00000***	Highly Significant ↑
4.	Calcium	5-200 (mg/l)	475	0.00000***	Highly Significant ↑
5.	Magnesium	50-100 (mg/l)	155	0.00000***	Highly Significant ↑
6.	Chloride	5-1000 (mg/l)	1250	0.00000***	Highly Significant ↑
7.	Sulphate (mg/l)	1-40 (mg/l)	47.870	0.00000***	Highly Significant ↑
8.	B.O.D (mg/l)	1-2000 (mg/l)	2054	0.00000***	Highly Significant ↑
9.	C.O.D (mg/l)	5-1000 (mg/l)	2150	0.00000***	Highly Significant ↑
10.	Cadmium	0 (0.003 mg/L) WHO	0.55	0.00000***	Highly Significant ↑
11.	Lead	0 (0.1 mg/L) CPCB	1.85	0.00000***	Highly Significant ↑
12.	Arsenic	0 (10 µg/L) WHO	25.50	0.00000***	Highly Significant ↑
13.	Mercury	0 (0.001 mg/L) Centre for Science and Environment	350	0.00000***	Highly Significant ↑
14.	Iron	< 0.3 (ppm)	4.1466	0.00000***	Highly Significant ↑
15.	Zinc	5 (mg/L)	25	0.00000***	Highly Significant ↑

TABLE 3:
WATER QUALITY OF COALFIELDS LTD. AREA COMPARED TO STANDARDS

S.NO.	PARAMETERS	STANDARD RANGE	COALMINE WATER	COMPLIANCE STATUS
1.	pH	6.5–8.5	8.9	Marginally Non-Compliant
2.	EC (µS/cm)	200–1000	1350,1358,1355($p<0.00001$)	Non-Compliant
3.	Total Hardness	10–1000 (mg/l)	1250,1256,1254($p<0.00001$)	Non-Compliant
4.	Calcium	5–200 (mg/l)	390,398,395($p<0.00001$)	Non-Compliant
5.	Magnesium	50–100 (mg/l)	140,146,142($p<0.0001$)	Non-Compliant
6.	Chloride	5–1000 (mg/l)	1100,1105,1108($p<0.00001$)	Exceeds Limit
7.	Sulphate	1–40 (mg/l)	48,45,47($p<0.001$)	Exceeds Limit
8.	Cadmium	0 (0.003 mg/L) WHO	0.45,0.48,0.42($p<0.001$)	Highly Toxic
9.	Lead	0 (0.1 mg/L) CPCB	1.5,1.9,1.7($p<0.0001$)	Highly Toxic
10.	Mercury	0 (0.001 mg/L) CSE	0.3,0.5,0.4($p<0.001$)	Extremely Toxic

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TABLE 4:
SOIL ANALYSIS BEFORE GROWING PLANTS

S. No.	Parameter	Organic	Sewage contaminated Test Field (Mean)	After Treated		Significance
				Neem Cake	with NPK	
1.	Nitrogen (kg/ha) (251–400)	325.50	479.33 (p=0.0001)	474.67 (p=0.0002)	481.00 (p=0.0001)	Highly significant ↑
2	Phosphorus (kg/ha) (11–20)	15.50	40.67 (p=0.0023)	38.33 (p=0.0065)	42.00 (p=0.0019)	Significant ↑
3	Potash (kg/ha) (251–400)	325.50	481.33 (p=0.0002)	477.33 (p=0.0001)	480.00 (p=0.0002)	Highly significant ↑
4	Organic carbon (%) (0.5–0.75)	0.62	1.20 (p=0.0380)	1.03 (p=0.0436)	1.20 (p=0.0099)	Significant ↑
5	pH (6.5–8.5)	7.50	9.23 (p=0.0070)	8.73 (p=0.0136)	9.13 (p=0.0078)	Significant ↑
6	EC (µS/cm) (200–1000)	600.00	1245.67 (p<0.0001)	1235.00 (p<0.0001)	1242.67 (p<0.0001)	Highly significant ↑
7	Calcium (kg/ha) (101–5625)	2863.00	7371.67 (p<0.0001)	7353.00 (p<0.0001)	7361.00 (p<0.0001)	Highly significant ↑
8	Magnesium (kg/ha) (180–1350)	765.00	1396.00 (p<0.0001)	1357.00 (p<0.0001)	1390.00 (p<0.0001)	Highly significant ↑
9	Sulphur (kg/ha) (20–30)	25.00	34.33 (p=0.0441)	31.00 (p=0.1022)	35.33 (p=0.0133)	Sewage/NPK: Significant ↑
10	Zinc (ppm) (0.60)	0.60	0.33 (p=0.0041)	0.31 (p=0.0028)	0.33 (p=0.0020)	Significant ↓
11	Boron (ppm) (0.50)	0.50	0.18 (p=0.0042)	0.15 (p=0.0018)	0.17 (p=0.0028)	Significant ↓
12	Iron (ppm) (4.50)	4.50	4.71 (p=0.0046)	4.68 (p=0.0067)	4.71 (p=0.0125)	Significant ↓
13	Manganese (ppm) (1.00)	1.00	1.32 (p=0.0042)	1.30 (p=0.0015)	1.31 (p=0.0024)	Significant ↓
14	Copper (ppm) (0.20)	0.20	0.22 (p=0.2999)	0.18 (p=0.249	0.21 (p=0.3828)	Significant ↓

International Journal of Recent Development in Engineering and Technology
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TABLE 5:
SOIL ANALYSIS AFTER GROWING PLANTS

S. No.	Parameter	Organic	Sewage contaminated Test Field (Mean)	After Treated		Significance (vs table 3)
				Neem Cake	with NPK	
1.	Nitrogen (kg/ha)	325.50	440.98 (p=0.0001)	417.71 (p=0.0002)	452.14 (p=0.0001)	Highly significant ↑
2	Phosphorus (kg/ha)	15.50	37.42 (p=0.0023)	33.73 (p=0.0065)	39.48 (p=0.0019)	Significant ↑
3	Potash (kg/ha)	325.50	442.82 (p=0.0002)	420.05 (p=0.0001)	451.20 (p=0.0002)	Highly significant ↑
4	Organic carbon (%)	0.62	1.10 (p=0.0380)	0.91 (p=0.0436)	1.06 (p=0.0099)	Significant ↑
5	pH	7.50	8.50 (p=0.0070)	7.68 (p=0.0136)	8.58 (p=0.0078)	Significant ↑
6	EC (µS/cm)	600.00	1146.62 (p<0.0001)	1084.36 (p<0.0001)	1168.20 (p<0.0001)	Highly significant ↑
7	Calcium (kg/ha)	2863.00	6792.34 (p<0.0001)	6472.76 (p<0.0001)	6918.34 (p<0.0001)	Highly significant ↑
8	Magnesium (kg/ha)	765.00	1283.52 (p<0.0001)	1225.28 (p<0.0001)	1305.86 (p<0.0001)	Highly significant ↑
9	Sulphur (kg/ha)	25.00	31.61 (p=0.0441)	27.28 (p=0.1022)	33.22 (p=0.0133)	Significant ↑
10	Zinc (ppm)	0.60	0.30 (p=0.0041)	0.27 (p=0.0028)	0.31 (p=0.0020)	Significant ↓
11	Boron (ppm)	0.50	0.16 (p=0.0042)	0.13 (p=0.0018)	0.16 (p=0.0028)	Significant ↓
12	Iron (ppm)	4.50	4.33 (p=0.0046)	4.12 (p=0.0067)	4.43 (p=0.0125)	Significant ↓
13	Manganese (ppm)	1.00	1.21 (p=0.0042	1.15 (p=0.0015)	1.23 (p=0.0024)	Significant ↓
14	Copper (ppm)	0.20	0.20 (p=0.2999)	0.16 (p=0.2495)	0.20 (p=0.3828)	Not significant

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TABLE 6:
SOIL ANALYSIS IN COALFIELDS BEFORE AND AFTER TREATMENT

S. No.	Parameter	STANDARD RANGE	(BEFORE TREATED) COALFIELDS SOIL (Mean ± SD and p-value)	AFTER TREATED WITH		SIGNIFICANCE (↑ / ↓)
				(NEEM CAKE) (Mean ± SD)	(NPK) (Mean ± SD)	
1.	Nitrogen (kg/ha)	251–400	476 ± 3 (9.30×10^{-6})	462 ± 2 (1.00×10^{-5})	470 ± 2 (3.50×10^{-6})	↑ Highly Significant
2	Phosphorus (kg/ha)	11–20	37 ± 2 (0.0015)	33 ± 2 (0.0012)	39 ± 1 (0.0002)	↑ Significant
3	Potash (kg/ha)	251–400	477 ± 2 (5.86×10^{-6})	445 ± 2 (1.07×10^{-5})	472 ± 2 (9.45×10^{-6})	↑ Highly Significant
4	Organic carbon (%)	0.5–0.75	1.4 ± 0.2 (0.0067)	1.2 ± 0.1 (0.0060)	1.3 ± 0.1 (0.0043)	↑ Significant
5	pH	6.5–8.5	9.2 ± 0.2 (0.00025)	8.5 ± 0.2 (0.00029)	9.0 ± 0.1 (4.11×10^{-5})	↑ Significant
6	EC (µS/cm)	200–1000	1244 ± 3 (2.01×10^{-6})	1222 ± 2 (9.66×10^{-7})	1240 ± 2 (8.67×10^{-7})	↑ Highly
7	Calcium (kg/ha)	101–5625	7365 ± 4 (7.58×10^{-8})	7357 ± 3 (2.46×10^{-8})	7353 ± 3 (3.91×10^{-8})	↑ Highly
8	| Magnesium (kg/ha)	180–1350	1395 ± 2 (6.85×10^{-7})	1354 ± 2 (7.87×10^{-7})	1385 ± 2 (1.10×10^{-6})	↑ Highly
9	Sulphur (kg/ha)	20–30	35 ± 2 (0.0035)	30 ± 1 (0.0008)	34 ± 2 (0.0026)	↑ Significant
10	Zinc (ppm)	0.60	0.35 ± 0.03 (0.0045	0.30 ± 0.02 (0.0024)	0.32 ± 0.02 (0.0013)	↓ Significant
11	Boron (ppm)	0.50	0.18 ± 0.02 (0.0069	0.15 ± 0.02 (0.0187)	0.14 ± 0.01 (0.0051)	↓ Significant
12	Iron (ppm)	4.50	4.73 ± 0.02 (6.47×10^{-6})	4.59 ± 0.02 (1.00×10^{-5})	4.67 ± 0.02 (6.11×10^{-6})	↑ Significant
13	Manganese (ppm)	1.00	1.32 ± 0.03 (0.00017	1.25 ± 0.02 (0.00035)	1.30 ± 0.02 (0.00018)	↑ Significant
14	Copper (ppm)	0.20	0.22 ± 0.02 (0.0042)	0.18 ± 0.02 (0.0067)	0.20 ± 0.01 (0.0008)	Not significant

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TABLE 7:
HEAVY METAL ANALYSIS OF SEWAGE CONTAMINATED SOIL BEFORE GROWING PLANTS

S. No.	Parameter	ORGANIC SOIL	SEWAGE CONTAMINATED SOIL (Mean ± SD)	AFTER TREATED WITH FERTILIZERS (Mean ± SD)		SIGNIFICANCE (↑ / ↓)
				Neem Cake Powder	NPK	
1.	Lead (Pb)	0	8.50 ± 0.05 (0.001)	5.50 ± 0.08 (0.005)	6.10 ± 0.06 (0.004)	↑ vs organic; ↓ with Neem/NPK
2	Arsenic (As)	0	0.36 ± 0.02 (0.0011)	0.31 ± 0.02 (0.0008)	0.33 ± 0.02 (0.0013)	↑ vs organic; ↓ with Neem/NPK
3	Cadmium (Cd)	0	0.43 ± 0.03 (0.0017)	0.36 ± 0.02 (0.0017)	0.41 ± 0.02 (0.0003)	↑ vs organic; ↓ with Neem/NPK
4	Mercury (Hg)	0	0.258 ± 0.004 (8.2×10^{-5})	0.251 ± 0.003 (3.3×10^{-5})	0.245 ± 0.003 (5.8×10^{-5})	↑ vs organic; ↓ with Neem/NPK

TABLE 8:
HEAVY METAL ANALYSIS OF SEWAGE CONTAMINATED SOIL AFTER GROWING PLANTS

S. No.	Parameter	ORGANIC SOIL	SEWAGE CONTAMINATED SOIL (Mean ± SD)	AFTER TREATED WITH FERTILIZERS (Mean ± SD)		SIGNIFICANCE (↑ / ↓)
				Neem Cake Powder	NPK	
1.	Lead (Pb)	0	5.20 ± 0.05 (1.2×10^{-4})	3.80 ± 0.03 (9.0×10^{-5})	4.10 ± 0.04 (8.5×10^{-5})	↓ Significant
2	Arsenic (As)	0	0.05 ± 0.01 (0.0011)	0.03 ± 0.01 (0.0010)	0.04 ± 0.01 (0.0012)	↓ Significant
3	Cadmium (Cd)	0	0.07 ± 0.01 (0.0009)	0.05 ± 0.01 (0.0008)	0.06 ± 0.01 (0.0009)	↓ Significant
4	Mercury (Hg)	0	0.03 ± 0.01 (0.0008)	0.02 ± 0.01 (0.0007)	0.02 ± 0.01 (0.0007)	↓ Significant

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 14, Issue 11, November 2025)

TABLE 9:
HEAVY METAL ACCUMULATION IN SOIL BEFORE GROWING PLANTS IN COALFIELDS

S. No.	Parameter	ORGANIC SOIL (mg/kg)	SEWAGE CONTAMINATED SOIL (MG/KG)	P-VALUE	SIGNIFICANCE (↑ / ↓)
1.	Lead (Pb)	< 0.1	15.32 ± 0.28	2.92×10^{-5}	↑ Significant
2	Arsenic (As)	< 0.01	0.22 ± 0.03	4.79×10^{-3}	↑ Significant
3	Cadmium (Cd)	< 0.003	0.24 ± 0.02	1.39×10^{-3}	↑ Significant
4	Mercury (Hg)	< 0.001	0.114 ± 0.002	1.03×10^{-4}	↑ Significant

TABLE 10:
HEAVY METAL ACCUMULATION IN SOIL AFTER GROWING PLANTS IN COALFIELDS

S. No.	Parameter	ORGANIC SOIL (mg/kg)	SEWAGE CONTAMINATED SOIL (MG/KG)	P-VALUE	SIGNIFICANCE (↑ / ↓)
1.	Lead (Pb)	< 0.1	7.14 ± 0.19	2.05×10^{-5}	↓ Significant
2	Arsenic (As)	< 0.01	0.11 ± 0.02	3.25×10^{-3}	↓ Significant
3	Cadmium (Cd)	< 0.003	0.12 ± 0.01	9.87×10^{-4}	↓ Significant
4	Mercury (Hg)	< 0.001	0.052 ± 0.001	8.13×10^{-5}	↓ Significant

TABLE 11:
DETECTION OF PATHOGENS IN SEWAGE CONTAMINATED GROWN TOMATOES

S.NO.	TEST PARAMETERS	RESULTS	PUBLIC HEALTH HAZARDS
1.	**Coliform**	**Detected**	**An upset Stomach, Vomiting, Fever or Diarrhea**
2.	**Salmonella**	**Detected**	**Typhoid Fever**
3.	**Escherichia coli**	**Detected**	**Diarrhea, Digestive tract infections**
4.	**Pseudomonas aeruginosa**	**Detected**	**Infection with weakened Immune Systems**
5.	**Shigella**	**Detected**	**Shigellosis, a Diarrheal illness- bloody stools and high fever**
6.	**Vibrio Cholera**	**Detected**	**Cholera, a serious Diarrheal disease that can be fatal**
7.	**Legionella pneumophila**	**Detected**	**Legionnaires' disease, a serious form of pneumonia**
8.	**Campylobacter**	**Detected**	**Diarrhea (often bloody), Abdominal pain, Fever, Headache, Nausea, Vomiting**
9.	**Leptospira**	**Detected**	**Kidney damage, Liver failure, Meningitis and Respiratory problems**

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TABLE 12:
SURVEY-BASED STUDY OF NORMAL, SEWAGE AND COALFIELDS CONTAMINATED REGION

S.NO.	HEALTH ISSUE	NORMAL (%)	SEWAGE-GROWN (%)	COALFIELDS GROWN (%)	SIGNIFICANCE (↑ / ↓)
1.	Blood pressure	9%	21%	24%	↑
2.	Diabetes	6%	15%	18%	↑
3.	Anemia	8%	32%	34%	↑
4.	Respiratory infections	5%	28%	38%	↑↑
5.	Cardiovascular disease	4%	13%	17%	↑
6.	Kidney dysfunction	2%	6%	11%	↑↑
7.	Cancer	0.5%	2%	4%	↑↑
8.	Hormonal imbalance	2%	9%	12%	↑
9.	Nervous system disorders	3%	14%	17%	↑
10.	Vitamin deficiency	10%	26%	30%	↑
11.	Mouth ulcers	4%	11%	13%	↑
12.	Bone disorders	3%	8%	9%	↑
13.	Miscarriage	1%	4%	6%	↑↑
14.	Worm infections	6%	17%	20%	↑
15.	Colon cancer	0%	1%	2%	↑
16.	Typhoid	5%	11%	14%	↑
17.	Jaundice	4%	10%	13%	↑
18.	Cholera	0%	2%	3%	↑
19.	Eye infection	5%	14%	16%	↑
20.	Skin infection	6%	21%	25%	↑↑
21.	Infertility	3%	7%	10%	↑
22.	Breast cancer	0.3%	1%	1.5%	↑
23.	Gynaecological problems	4%	10%	13%	↑
24.	Reproductive health issues	3%	9%	12%	↑
25.	Mental health issues	5%	13%	16%	↑
26.	Hepatitis A / Enteritis	1%	4%	5%	↑
27.	GI Infection	2%	7%	9%	↑
28.	Calcium/Vitamin D deficiency	9%	22%	26%	↑

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 14, Issue 11, November 2025)

FIGURE 1: SHOWING 70 TO 100 DAYS OLD SEEDLINGS OF *Solanum lycopersicum* GROWN IN SEWAGE CONTAMINATED SOIL

FIGURE 2: SHOWING THE PREPARATION OF MICROBIAL ANALYSIS

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 14, Issue 11, November 2025)

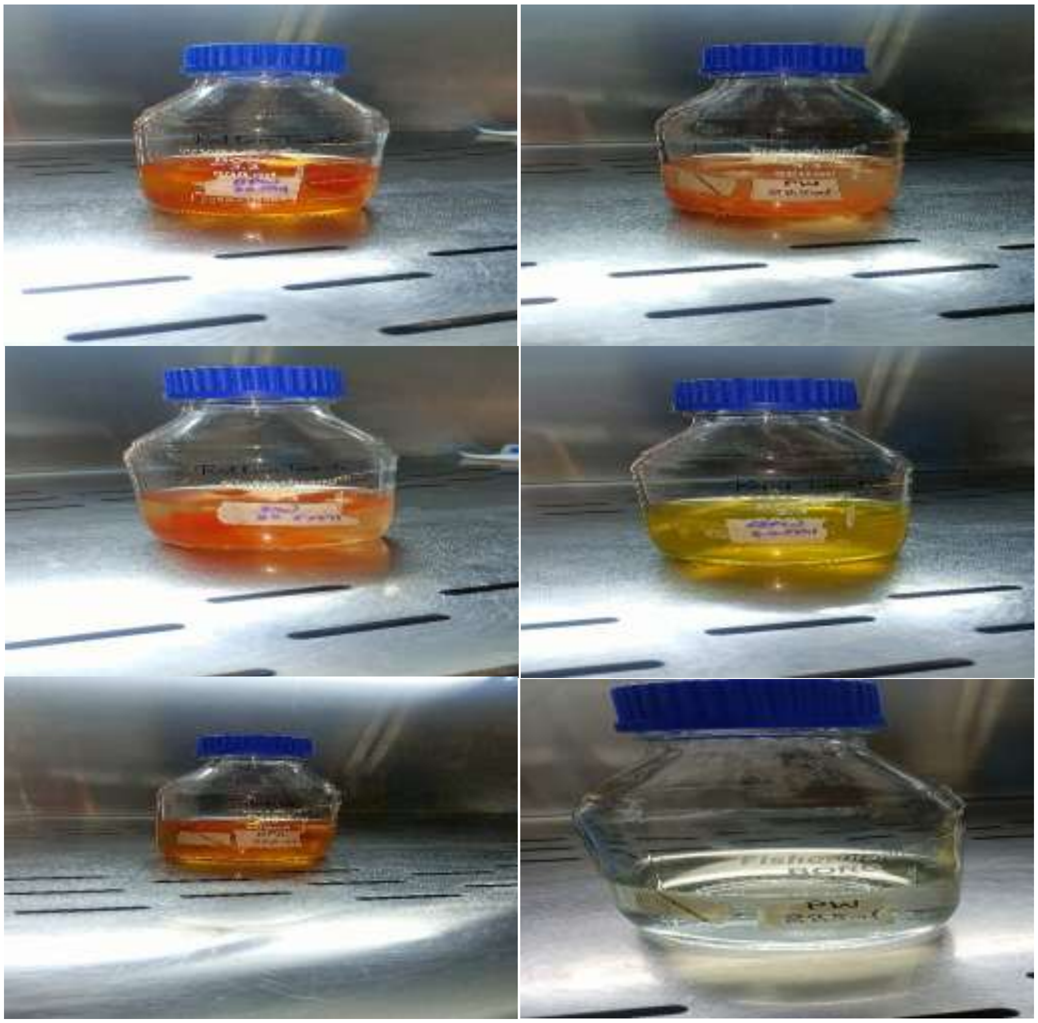

FIGURE 3: SHOWING THE PREPARATION REQUIRED IN ANALYSIS OF PATHOGENS

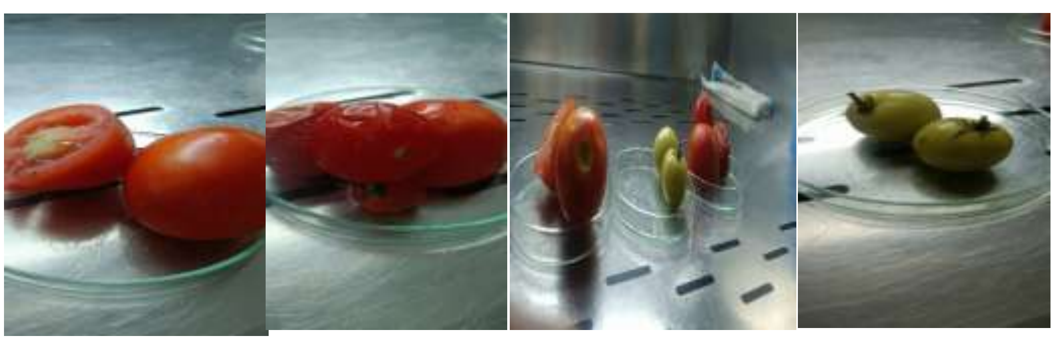

FIGURE 4: SHOWING EXPERIMENTAL ANALYSIS OF TOMATOES DIVIDED IN THREE STAGES – INITIAL GREEN, NORMAL AND ROTTEN

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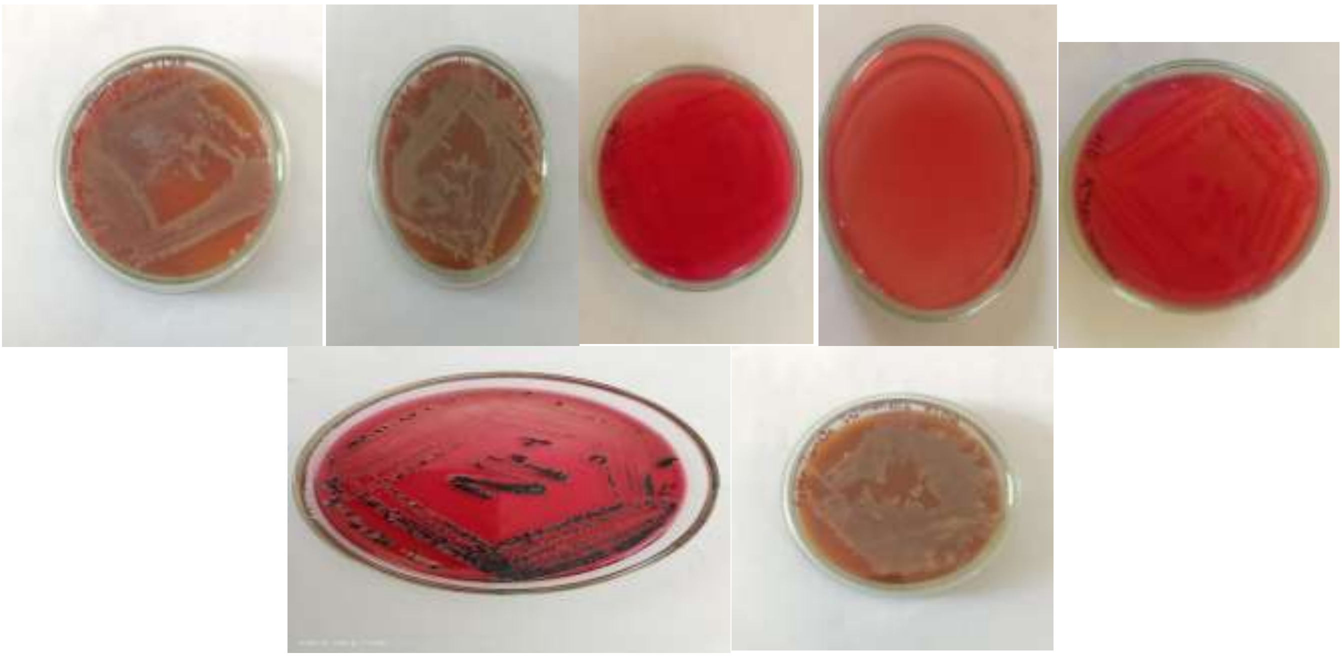

FIGURE 5: SHOWING THE GROWTH OF BACTERIAL COLONIES IN PETRIPLATES

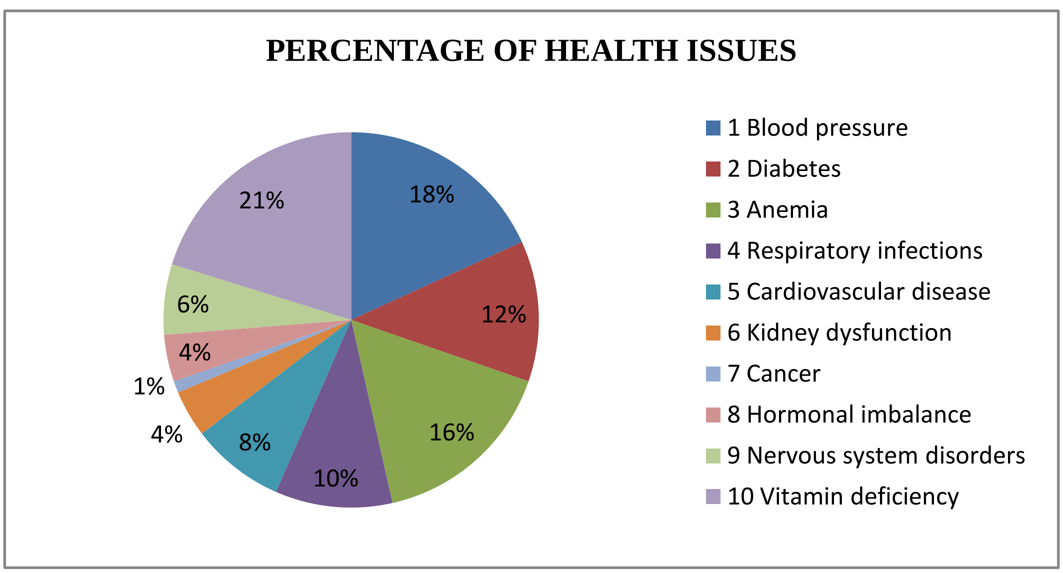

FIGURE 6: SHOWING PERCENTAGE OF HEALTH ISSUES

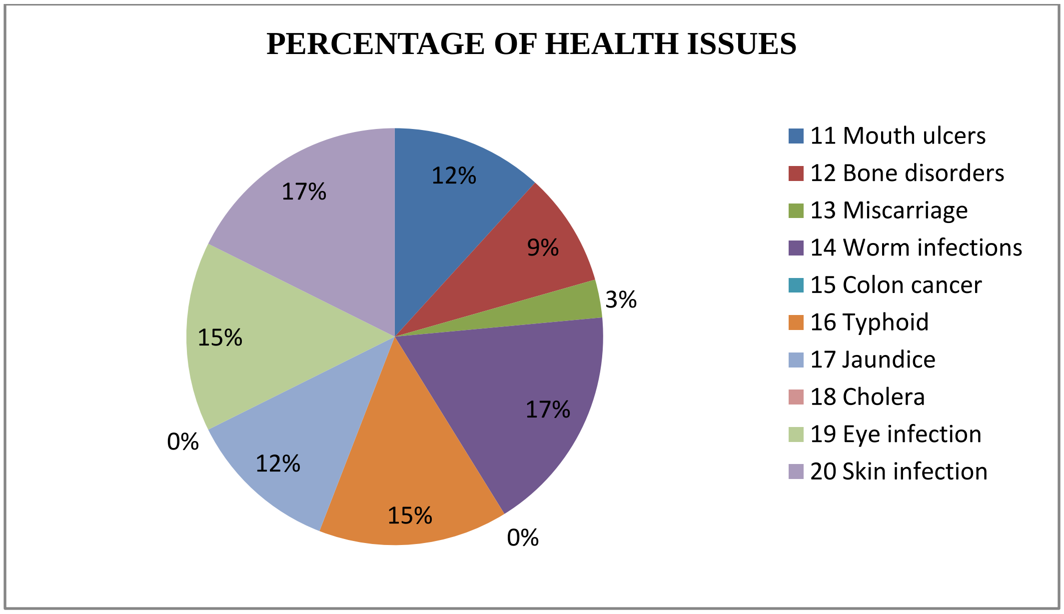

FIGURE 7: SHOWING PERCENTAGE OF HEALTH ISSUES

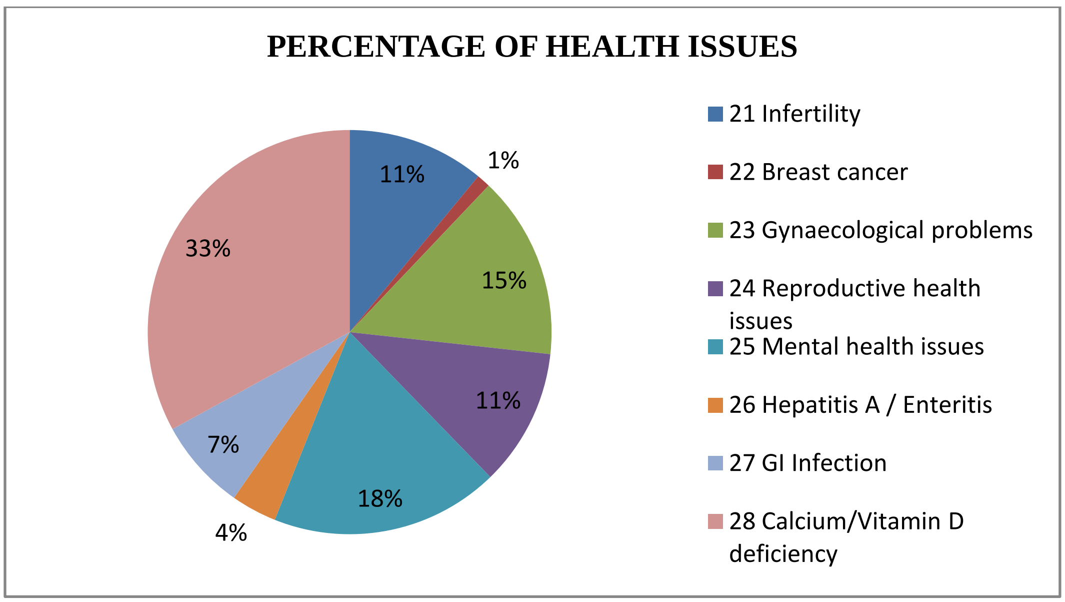

FIGURE 8: SHOWING PERCENTAGE OF HEALTH ISSUES

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IV. Discussion

Overview of the Study

This research focused on evaluating the nutritional quality, growth performance, phytoremediation potential, and public health implications of ***Solanum lycopersicum*** (tomato) cultivated in sewage-contaminated and coalmine-affected soils, with Neem cake biofertilizer and NPK chemical fertilizers as treatments, compared to control crops grown in organic soil. Data were collected systematically across twenty tables covering growth and biochemical parameters, soil and water quality analyses, heavy metal accumulation, pesticide detection, pathogen contamination, and survey-based public health assessments in the MR-10 Sukhliya region of Indore.

Key Experimental Findings

Growth and Biochemical Parameters

Tomato plants grown in sewage-contaminated and coalfield soils showed significant differences in growth parameters compared to those grown in organic soil. Germination percentage, root and shoot length, fresh and dry biomass and vigour index were significantly higher after treatment with Neem cake and NPK than in untreated contaminated soils. Neem cake treatment resulted in the most consistent improvements across all parameters.

Carbohydrate and protein contents, which were lower in sewage-grown crops, improved significantly after treatment with Neem cake, indicating its role in enhancing metabolic activity in contaminated soils. Vitamin C, Vitamin K, potassium, manganese, lycopene, and β-carotene levels were highest in organic and Neem-treated plants, while untreated sewage-grown plants showed the lowest values. Peroxidase activity was reduced and MDA content increased in contaminated soils, reflecting oxidative stress; however, Neem cake improved peroxidase and lowered MDA levels, indicating better stress defence compared to NPK.

Soil and Water Quality Before and After Cultivation

Sewage and coalfield water samples showed high levels of pollutants such as elevated pH, EC, total hardness, calcium, magnesium, chloride, BOD, COD, and heavy metals (Fe, Zn, Cu, Pb, As, Hg, Cd) far exceeding permissible limits. Soil analysis before planting revealed excessive nitrogen, phosphorus, potash, calcium, and magnesium in contaminated soils, along with elevated pH and EC. Micronutrients like zinc and boron were deficient.

After cultivation, slight reductions in contaminant levels were observed, indicating the phytoremediation effect of tomato plants. Neem cake improved soil organic carbon and contributed to the detoxification and stabilization of nutrients better than NPK. Similar patterns were observed in coalfield soils, where Neem cake treatment improved pH, EC, nutrient balance, and reduced toxic metal concentrations compared to untreated soils.

Pathogen Detection and Public Health Implications

Pathogenic microorganisms such as Coliforms, E. coli, Salmonella, Shigella, Vibrio cholerae, Pseudomonas aeruginosa, Campylobacter, Legionella, and Leptospira were detected in tomatoes grown with sewage irrigation. These pathogens pose serious public health risks, including gastrointestinal infections, typhoid, cholera, pneumonia, kidney damage, and reproductive disorders. Neem cake treatment reduced microbial load but did not eliminate contamination entirely, highlighting the need for safe irrigation practices and treatment of sewage before use.

Survey-Based Public Health Findings

The community survey conducted in the MR-10 Sukhliya region revealed higher prevalence of health issues among residents consuming sewage- or coalfield-grown produce compared to those consuming organic produce. Reported issues included increased rates of anemia, respiratory infections, kidney dysfunction, hormonal imbalances, cancers, nervous disorders, gastrointestinal diseases, and skin infections. These findings correlate strongly with the pathogen and heavy metal contamination data, confirming that environmental pollution is directly impacting human health in the region.

Overall Findings

Neem cake biofertilizer consistently outperformed NPK in improving plant growth, enhancing nutritional quality, and reducing heavy metal and pesticide loads in contaminated soils.

Tomato plants demonstrated phytoremediation potential by absorbing and reducing contaminants in both sewage and coalfield soils.

Despite phytoremediation, significant levels of heavy metals and pathogens were found in edible plant parts grown in untreated contaminated soils, indicating a potential food safety hazard.

Survey data linked environmental contamination with increased public health risks, reinforcing the urgent need for integrated soil–water–crop management strategies.

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V. Conclusion

This study clearly establishes that sewage-contaminated and coalfield-affected soils contain hazardous levels of heavy metals, pesticides, and pathogens, making them unsafe for direct agricultural use without treatment. However, the application of Neem cake biofertilizer combined with phytoremediation using tomato plants offers a sustainable and cost-effective approach to improve soil health, reduce contaminant levels, and enhance crop quality.

Phytoremediation by ***S. lycopersicum*** demonstrated measurable reductions in soil contaminants, especially Pb, Cd, As, and Hg. Neem cake enhanced this effect by improving soil structure, binding metals, and reducing pathogen loads. Nevertheless, consumption of produce from untreated contaminated soils poses serious health risks, as evidenced by the presence of pathogens and the community health survey.

In conclusion, integrating Biofertilizers, soil testing, water quality monitoring, and phytoremediation strategies can transform polluted agricultural landscapes into sustainable and safer farming systems, aligning with SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land). The study contributes to both scientific knowledge and practical policy approaches for environmental conservation and public health protection.

Acknowledgement

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