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Evaluation of the Effect of Soil Pollution of Savar Areas and Fertilizer Management on Yield and Nutrient Accumulation in Tomato (*Solanum lycopersicum* L.)

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Abstract

A field experiment was conducted from November, 2022 to April, 2023 in industrially contaminated soils of Savar, Bangladesh, using a Randomized Complete Block Design with four treatments: T_0 (Control), T_1 (100% recommended chemical fertilizer), T_2 (75% chemical+25% cow dung), and T_3 (50% chemical+50% cow dung), replicated four times. Growth parameters, yield attributes, fruit yield, and nutrient accumulation were recorded following standard procedures. Soil pollution substantially restricted plant vigor and yield under T_0, while fertilizer application significantly improved tomato growth and productivity. The integrated treatments (T_2 and T_3) outperformed T_1 in most parameters. T_3 produced the highest fruit yield, increased fruit dry matter content, and enhanced plant biomass accumulation, demonstrating improved nutrient uptake efficiency despite the polluted soil environment. The combined organic–inorganic nutrient management mitigated the adverse effects of industrial contaminants more effectively than chemical fertilizer alone. The findings indicate that INM helped optimize nutrient availability, improve soil biological activity, and support physiological functions necessary for yield enhancement. Integrated nutrient management, particularly T_3, effectively improved tomato productivity and nutrient enrichment in industrially polluted soils of Savar. The study provides evidence that replacing 50% chemical fertilizer with cow dung can enhance yield resilience under contaminated soil conditions. This approach may serve as a sustainable fertilizer strategy for safe and productive vegetable cultivation in polluted agro-ecosystems.

Keywords: Tomato, pollution, yield, nutrient, contaminated

1. Introduction

The Savar–Dhaka area, where tannery, textile dyeing, and other chemical industries are concentrated, has been repeatedly identified as a hotspot for soil contamination; surveys and risk assessments there report elevated concentrations of Cr, Pb, Cd, Zn, and other toxic elements in soils and vegetables near industrial estates (Mizan et al., 2023; Afrose, 2025).

Heavy metals in contaminated soils can alter soil physicochemical properties, disrupt microbial communities, and reduce nutrient availability, effects that together may impair plant growth, decrease yield, and modify nutrient partitioning within crops. Moreover, many heavy metals are persistent, non-degradable, and liable to enter the food chain via plant uptake, posing long-term human health risks when contaminated produce is consumed (Rai et al., 2019; Munir et al., 2021). Tomato (*Solanum lycopersicum* L.) is a high-value, widely consumed vegetable in Bangladesh, with shallow roots and high transpiration rates that often make it susceptible to the accumulation of dissolved contaminants from the rhizosphere into fruits. Several studies, including targeted analyses of tomatoes and tomato products, have documented measurable concentrations of Cd and Pb in tomato tissues under contaminated growing conditions, underscoring potential food-safety concerns (Romero-Estévez et al., 2020; Hassan, 2024).

Fertilizer and soil-amendment strategies strongly influence nutrient availability, soil buffering capacity, and contaminant mobility. Organic amendments (compost, farmyard manure, biochar, digestate) generally increase soil organic matter,

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cation-exchange capacity, and pH buffering, and have been repeatedly shown to reduce heavy-metal bioavailability by adsorption, complexation, or pH-mediated immobilization. Conversely, inappropriate or unbalanced use of chemical fertilizers can alter soil chemistry in ways that increase metal mobility or reduce the soil's capacity to retain contaminants. These interactions imply that fertilizer management is not only central to crop nutrition and yield but also to the fate and transfer of pollutants into edible plant parts (Irfan et al., 2021; Sachdeva et al., 2023; Manzoor et al., 2024).

Integrated nutrient management (INM) approaches that combine organic amendments (e.g., compost, biochar) with judicious mineral fertilization have been proposed as pragmatic solutions to simultaneously maintain crop productivity and mitigate contaminant uptake. Experimental and review studies show that combined amendments often improve soil health indices and can substantially reduce plant uptake of Pb, Cd, and other metals compared with unamended contaminated soils, although efficacy depends on amendment type, application rate, soil properties, and pollutant speciation.

Despite these general findings, empirical evidence specifically addressing how soil pollution in Savar interacts with fertilizer management to influence tomato yield, macronutrient accumulation (N, P, K, Ca, Mg), and heavy-metal transfer to tomato fruit remains limited. Region-specific assessment is critical because local pollution sources (e.g., tannery effluents), soil types, cropping calendars, and farming practices influence both contaminant availability and crop responses. Moreover, risk assessments that combine agronomic outcomes (yield, nutrient content) with human-health exposure estimates are necessary to develop practical guidance for farmers and policy makers in contaminated peri-urban landscapes (Mizan et al., 2023; Samma et al., 2024).

Therefore, this study evaluates the combined effects of soil pollution from Savar industrial areas and different fertilizer management regimes on tomato growth, yield components, macronutrient status, and heavy-metal accumulation in edible fruit. By comparing contaminated and non-contaminated soils under organic, inorganic, and integrated nutrient management treatments, the study aims to: (i) quantify the impact of contamination on tomato productivity and nutrient dynamics; (ii) test whether organic or INM approaches can reduce heavy-metal uptake without compromising yield; and (iii) produce evidence-based recommendations to support safe tomato production and mitigate dietary exposure risks in the Savar region. The results are intended to inform both agronomic management and local food-safety policy (Irfan et al., 2021; Mizan et al., 2023; Nowar et al., 2024).

2. Materials and Methods

2.1. Experimental period

The experiment was conducted from November, 2022 to April, 2023.

2.2. Experimental site

The experiment was conducted in the farmer's field of industrially polluted soil in the Savar area of Bangladesh. Geographically, the experimental field is located at $23^0 89'$N latitude and $90^0 18'$E longitude, at an altitude of 11.7 m above sea level, and belongs to the Agro-ecological Zone "AEZ-12" of the Low Ganges River Floodplain.

2.3. Planting material

The seedlings of a 30-day-old high-yielding popular tomato variety, BARI Tomato 8, were used for the experiment.

2.4. Treatment of the experiment

The experiment consisted of the following treatments

i. T_0 Control
ii. T_1 Recommended dose of chemical fertilizer
iii. T_2 75% Nutrient from chemical fertilizer+25% nutrient from cow dung and
iv. T_3 50% recommended dose of fertilizer and 50% nutrients from cow dung

2.5. Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design with 4 treatments having four replications. There were 16 plots (4×4) altogether. The experimental area was divided into four equal blocks containing 4 plots in a block, where 4 treatment combinations were allotted randomly. There were 16-unit plots altogether with a size of 1.8×1.6 m^2.

2.5. Application of manure and fertilizers

The sources of N_2, P_2O_5, K_2O, as urea, TSP, and MoP were applied, respectively. The entire amounts of TSP and MP were applied during the final land preparation. Urea was applied in three equal installments at 15, 30, and 45 days after seedling transplanting. Well-rotten cow dung, 20 t ha^{-1} also applied during final land preparation. The recommended dose and method of application of fertilizer are shown in Table 1.

2.6. Data collection

Data were collected from 5 plants of each unit plot. For Plant height (cm), Number of branches plant^{-1}, Number of leaves plant^{-1}. Average fruit weight (g), Average fruit dry weight (g),

Table 1: Dose and method of application of fertilizers in the tomato field

Manure and fertilizer	Total amount (kg ha^{-1})	Application (%)			
		Final land preparation	Pit Preparation	Installments	
				25 DAT	50 DAT
Cow dung	20,000	100	--	--	--
Nitrogen	250 kg	--	33.33	33.33	33.33
P_2O_5 (as TSP)	200 kg	100	--	--	--
K_2O (as MoP)	175 kg	100	--	--	--

Plant biomass dry weight, Fruit weight (g plant^{-1}).

3. Results and Discussion

3.1. Plant height

The plant height of tomato differed significantly among fertilizer regimes in the industrially polluted soil (Table 2). Heights ranged from 51.34 cm (T_0) to 57.05 cm (T_3), with T_3 (50% RDF+50% cow dung) producing the tallest plants and showing no statistical difference from T_2 and T_1. Fertilizer application increased plant height by 4.22–5.71 cm (8.22–11.12%) over the control. The superior performance of the integrated treatment (T_3) likely reflects improved nutrient availability and soil physical conditions provided by cow dung (increased organic matter, water retention, and microbial activity), which facilitate root functioning and nutrient uptake even in polluted soils; such beneficial effects of combined organic–mineral regimes have been reported for tomato and other vegetable systems. Wu et al., 2022, Kamal et al., 2024.

3.2. Number of branches plant^{-1}

The number of branches per plant (Table 2) increased markedly with fertilizer application, from 2.67 (T_0) to 4.67 (T_3). T_3, T_2, and T_1 produced statistically similar and significantly higher branching than the control. Enhanced branching under INM (integrated nutrient management) is consistent with improved vegetative vigor and balanced nutrient supply (notably N and K) that stimulate axillary bud outgrowth and secondary shoot formation. Similar branching and vegetative responses to partial replacement of chemical N by organic manure have been documented in recent field studies. Zhang et al., 2024.

3.3. Number of leaves plant^{-1}

Leaf number (Table 2) followed the same pattern: T_3 produced the most leaves (20.67), and T_0 produced the fewest (11.67). The 59.98–77.12% increase in leaf number with fertilization likely increased the overall photosynthetic surface, which in turn supported greater biomass and fruiting. Organic inputs improve nutrient mineralization and micro-nutrient availability that support leaf expansion, a mechanism observed in several recent tomato INM trials. Li et al., 2025.

3.4. Average fruit weight

Average fruit weight (Table 2) increased from 30.12 g (T_0) to 35.18 g (T_3), a 12.95–16.80% improvement with fertilizer application. The increased fruit size under integrated treatments likely results from improved assimilate supply and better translocation of carbohydrates and minerals to developing fruits—effects commonly reported when organic amendments are combined with mineral fertilizers. Wu et al., 2022, Rosa et al., 2024.

3.5. Average fruit dry weight

Fruit dry weight (Table 2) rose from 2.05 g (T_0) to 2.59 g (T_3), representing a 20.98–26.34% gain with fertilization. Higher dry-matter accumulation under T_3 indicates improved source–sink balance and suggests that INM enhanced not only water-driven fruit enlargement but also accumulation of solids (sugars, proteins, structural carbohydrates). This aligns with trials showing organic amendments improve fruit quality and dry-matter concentration in tomato. Kamal et al., 2024, Teshome et al., 2025

3.6. Plant biomass dry weight

Plant biomass dry weight (Table 2) increased from 19.34 g (T_0) to 22.52 g (T_3), a 10.34–16.44% increment. This increase corroborates the leaf and branching responses and indicates whole-plant vigor improved under combined organic–mineral nutrient supply, likely due to enhanced root growth and soil biological activity. Such biomass benefits of INM have been widely reported. Li et al., 2025; Zhang et al., 2024.

3.7. Fruit weight plant^{-1}

Fruit weight per plant (Table 2) rose substantially from 187.5 g (T_0) to 319.2 g (T_3), a 65.01–70.24% gain in fertilized treatments. The large yield response highlights that nutrient limitation—exacerbated by polluted soil conditions—was a key constraint in the control plots, and that partial substitution of chemical fertilizer with cow dung effectively restored productivity. Comparable yield increases from manure+mineral fertilizer combinations have been documented in multiple recent field studies. Wu et al., 2022.

Table 2: Effect of fertility regime on yield contributing charactersand yield of tomato

Treatment	Plant height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Average fruit weight (g)	Average fruit dry weight (g)	Plantbiomass dry weight (g)	Fruit weight plant^{-1} (g)
T_0	51.34^b	2.67^b	11.67^b	30.12^b	2.05^b	19.34^b	187.5^b
T_1	55.56^a	4.33^a	18.67^a	34.02^a	2.48^a	21.34^a	309.4^a
T_2	56.12^a	4.33^a	19.33^a	34.45^a	2.52^a	21.67^a	311.7^a
T_3	57.05^a	4.67^a	20.67^a	35.18^a	2.59^a	22.52^a	319.2^a
SE	2.84	0.39	1.25	0.56	0.13	0.985	11.34

In a column, figures having similar letter(s) do not differ significantly at 5% level, whereas figures with dissimilar letter(s) differ significantly as per DMRT; Fertilizer treatments; T_0: Control; T_1: Recommended dose of chemical fertilizer; T_2: 75% Nutrient from chemical fertilizer+25% nutrient from cow dung; T_3: 50% recommended dose of fertilizer and 50% nutrient from cow dung

3.8. Phosphorus (P) concentration (%)

P concentration in fruit (Table 3) increased from 0.182% (T_0) to 0.304% (T_3)-a 63.7–67.0% improvement with fertilization. Organic amendments can increase P availability via enhanced microbial mineralization and organic ligand formation that mobilize P in the rhizosphere, which explains the higher fruit P under T_3. Rosa et al., 2024; Nie et al., 2024.

3.9. Potassium (K) concentration (%)

K concentration (Table 3) nearly doubled under fertilized treatments (1.174% to 2.261%), indicating greatly improved K supply and uptake under INM. Potassium is central to osmotic regulation, enzyme activation, and fruit filling; high K in fruit is therefore consistent with observed increases in fruit weight and dry matter. Reports indicate that organic–mineral combinations often improve K uptake efficiency relative to mineral fertilizer alone. Li et al., 2025; Zhang et al., 2024.

3.10. Zinc (Zn) concentration (ppm)

Zn in fruit (Table 3) increased from 64.53 ppm (T_0) to 82.02 ppm (T_3). Cow dung and organic matter can form soluble organic complexes that increase micronutrient bioavailability (Zn, Fe, Mn, Cu), which explains the improved Zn content under INM. However, the increase should be interpreted cautiously in polluted soils because organic inputs can also alter metal speciation; many recent studies stress the need for balanced amendment rates to avoid unintended mobilization of toxic metals. Hussain et al., 2022; Zhao et al., 2024.

3.11. Iron (Fe) concentration (ppm)

Fe (Table 3) rose from 77.65 ppm (T_0) to 95.12 ppm (T_3). Improved Fe accumulation under integrated treatment is consistent with enhanced root activity and increased chelation by organic ligands from cow dung, increasing Fe solubility and uptake. Rosa et al., 2024

3.12. Manganese (Mn) concentration (ppm)

Mn (Table 3) increased from 35.34 ppm (T_0) to ~51 ppm in fertilized treatments. Like Zn and Fe, Mn availability is strongly influenced by soil redox and organic matter; INM appears to have promoted Mn uptake, matching patterns reported in amended soils. Nie et al., 2024.

3.13. Copper (Cu) concentration (ppm)

Cu (Table 3) rose from 23.24 ppm (T_0) to ≈35 ppm (T_2–T_3). Cow dung is a source of micronutrients and of organic chelators that improve Cu uptake; however, the increase in Cu (and other micronutrients) needs to be balanced against potential accumulation of non-essential toxic metals in polluted soils. Hussain et al., 2022.

3.14. Lead (Pb) concentration (ppm)

Pb concentrations (Table 3) in fruit increased slightly with fertilization (1.159 ppm to 1.357 ppm). The higher Pb in fertilized plots may reflect multiple factors: pollutant background in Savar soils, fertilizer composition, and amendments altering Pb partitioning. Importantly, Pb in fruits remained at levels typical of vegetables grown near industrial zones reported in the literature, but these values exceed typical Codex/FAO safety benchmarks expressed on a fresh-weight basis (see discussion below) and therefore warrant attention. Samma et al., 2024, Nowar et al., 2024.

4.15. Cadmium (Cd) concentration (ppm)

Cd (Table 3) was highest in T_0 (0.759 ppm) and lowest in T_3 (0.391 ppm), indicating that integrated fertilizer management (T_3) substantially reduced Cd accumulation in fruit (23–48% reduction relative to control). This suggests that organic amendment (cow dung) helped immobilize Cd or otherwise reduce its phytoavailability, an effect widely reported where organic amendments or biochar reduce Cd uptake in vegetables. The decline in fruit Cd under T_3 is a notable mitigation outcome in the context of polluted Savar soils. Zhao et al., 2024

Table 3: Effect of fertility regime on P, K, Zn, Fe, Mn, Cu, Pb, and Cd concentration in dry matter of tomato fruit

Treatment	Concentration of							
	P (%)	K (%)	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Pb (ppm)	Cd (ppm)
T_0	0.182[b]	1.174[b]	64.53[c]	77.65[b]	35.34[b]	23.24[b]	1.159[b]	0.759[a]
T_1	0.300[a]	2.256[a]	78.14[b]	93.22[a]	51.03[a]	34.98[a]	1.357[a]	0.582[b]
T_2	0.298[a]	2.252[a]	81.34[a]	93.48[a]	51.22[a]	35.35[a]	1.345[a]	0.576[c]
T_3	0.304[a]	2.261[a]	82.02[a]	95.12[a]	51.08[a]	35.13[a]	1.336[a]	0.391[d]
SE	0.007	0.12	3.04	1.98	1.94	1.63	0.048	0.021

Column figures having similar letter(s) do not differ significantly at 5% level, whereas Figures with dissimilar letter(s) differ significantly as per DMRT; Fertilizer treatments; T_0: Control; T_1: Recommended dose of chemical fertilizer; T_2: 75% Nutrient from chemical fertilizer+25% nutrient from cow dung; and T_3: 50% recommended dose of fertilizer and 50% nutrient from cow dung

4. Conclusion

Overall, T_3 (50% RDF+50% cow dung) consistently produced the best combination of growth, yield, and nutrient accumulation while reducing Cd uptake relative to the unfertilized control. The results indicate that INM can simultaneously improve productivity and mitigate some metal uptake in contaminated peri-urban soils, likely via improvements in soil organic matter, cation exchange capacity, and microbial activity that alter metal speciation and plant accessibility.

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