

Chemical Composition of industrial Effluent and Its Effect on Seed Germination and Seedling Growth of Some Rabi Crops—Wheat, Barley and Gram

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Abstract

Industrial effluents can alter the chemical quality of receiving waters and may affect agricultural soils and crop establishment when used for irrigation. This study examined the physico-chemical characteristics and selected heavy-metal concentrations of effluent from industrial area of Bareilly, and assessed its effects on seed germination and early seedling growth of wheat (*Triticum aestivum*), barley (*Hordeum vulgare*) and gram (*Cicer arietinum*). Effluent samples were collected fortnightly and analysed using the procedures described in APHA (1980); heavy metals were estimated by atomic absorption spectrophotometry. Seeds were exposed to 25%, 50%, 75% and 100% effluent, with distilled water as the control, and each treatment was replicated three times. The supplied study reports that 25% and 50% effluent generally stimulated germination and seedling growth, whereas 75% and 100% effluent reduced these parameters. Barley showed the highest germination and shoot-length response, while gram had the greatest root length at lower concentrations. The effluent record also showed elevated values for several parameters, including COD, free carbon dioxide, chloride and selected metals relative to the tolerance values reproduced in the original article. The results indicate a concentration-dependent response and highlight the need for effluent treatment and current, site-specific testing before any agricultural reuse. The low-concentration stimulation observed in a laboratory germination assay should not be interpreted as evidence that untreated effluent is safe for irrigation.

Keywords: industrial effluent; seed germination; seedling growth; wheat; barley; gram; heavy metals; phytotoxicity

1. Introduction

Industrial development supports manufacturing and employment, but it can also generate wastewater containing dissolved salts, organic matter, oils, nutrients and potentially toxic elements. When industrial wastewater is discharged without adequate treatment, receiving drains, rivers and adjoining land may be

exposed to a changing mixture of contaminants. The environmental significance of such discharges depends not only on the identity of the industry but also on production processes, treatment performance, discharge volume, seasonal variation and the characteristics of the receiving environment. (Singh, 2021; Ofori et al., 2021; Al-Hazmi et al., 2023; Ghanbari et al., 2024).

Water quality is particularly important where surface water or wastewater is used for crop irrigation. Irrigation water contributes directly to the water available for seed imbibition and plant growth and can also influence soil salinity, sodicity, nutrient balance and the accumulation of trace elements. The effects may be short-term, such as delayed germination or reduced root elongation, or longer-term, such as changes in soil chemistry and the movement of contaminants into plant tissues. Consequently, the suitability of an effluent for irrigation cannot be judged from appearance alone; it requires physico-chemical analysis and biological assessment. (APHA et al., 2023; European Parliament and Council, 2020; FAO, 2019).

The supplied article describes a local concern in the Bareilly area of Uttar Pradesh. It reports that effluent from industrial area of Bareilly, was carried through drains towards the Shankha River and that cultivators in nearby villages used polluted water for irrigation. The article associates this practice with damage to crops and places the investigation in the context of earlier studies on industrial effluents and plant growth. This local setting makes the examination of both water quality and crop response relevant to environmental management and agricultural protection.

Seed germination and early seedling growth are useful screening endpoints in phytotoxicity studies. Germination reflects the ability of a viable seed to initiate growth under a given exposure, while root and shoot lengths provide simple measures of early development. Roots are in direct contact with the exposure medium and may respond rapidly to osmotic stress, unsuitable pH, salts, organic contaminants or toxic metals. However, a Petri-dish assay represents only the early stages of plant development and cannot by itself establish effects on field yield, soil quality, food safety or long-term crop performance. (Singh, 2021; Hashem & Qi, 2021; Al-Hazmi et al., 2023).

Industrial effluents may have mixed effects because their constituents can act in different ways. Nitrogen, phosphorus, potassium, calcium and magnesium can contribute to plant nutrition at suitable concentrations, while high concentrations of dissolved salts, organic matter, oils or certain metals can inhibit water uptake and physiological processes. The response can therefore vary with effluent concentration and with the tolerance of each crop. A stimulatory response at a diluted concentration does not establish that the wastewater is safe: the same sample may contain pollutants that accumulate in soil or plant tissue over repeated irrigation cycles. (Mohanty & Das, 2023; Ibrahim & Hammad, 2024; Kaur et al., 2025).

The original study focused on three important rabi crops—wheat, barley and gram—and compared their germination, root length and shoot length after exposure to graded effluent concentrations. It also reported selected physico-chemical characteristics and heavy-metal concentrations for summer and winter samples. This combined approach allows the authors to discuss water quality alongside an early biological response, although the conclusions remain limited by the experimental design and the information available in the supplied article.

The objectives of the study were therefore to: (i) describe the reported physico-chemical characteristics of the factory effluent; (ii) document selected heavy-metal concentrations in summer and winter; (iii)

compare germination, root length and shoot length of wheat, barley and gram across 25%, 50%, 75% and 100% effluent treatments and a distilled-water control; and (iv) consider the implications for agricultural use and the need for appropriate effluent management.

2. Literature Review

2.1 Industrial effluents and irrigation-water quality

The supplied article frames its investigation around the deterioration of aquatic environments associated with indiscriminate industrial waste disposal. It reports that several measured parameters—including colour, odour, transparency, pH, dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solids (TDS) and free carbon dioxide—were not within the irrigation-water tolerance limits cited by the original authors. The table also lists substantial ranges for chloride and several other chemical constituents. These measurements illustrate why industrial wastewater requires characterisation before reuse. Because the tolerance limits in the source are historical and the table contains units and ranges that should be checked against the original laboratory records, they are reproduced as reported rather than treated here as a current regulatory assessment. (European Parliament and Council, 2020; APHA et al., 2023; FAO, 2019). (Singh, 2021; Hashem & Qi, 2021; Ofori et al., 2021; Al-Hazmi et al., 2023; Ghanbari et al., 2024; Hayat et al., 2025).

2.2 Organic load, salts and plant response

COD and BOD are commonly used indicators of the oxygen demand associated with chemically oxidisable and biologically degradable substances. High values can indicate a substantial organic load and may affect receiving-water oxygen conditions. Conductivity and TDS provide information about dissolved ionic material, while chloride and other salts can contribute to osmotic stress or ion-specific effects in plants. The source reports COD from 60.60 to 1650 mg/L, BOD from 34.34 to 1310 mg/L, TDS from 35.8 to 1145 mg/L and chloride from 14.24 to 5041.10 mg/L. These wide ranges suggest variability in the samples described by the article. They should be interpreted as source-reported values and verified before being used for compliance decisions. (Singh, 2021; Hashem & Qi, 2021; Al-Hazmi et al., 2023). (APHA et al., 2023; Singh, 2021; Hashem & Qi, 2021; Al-Hazmi et al., 2023; Ghanbari et al., 2024).

2.3 Heavy metals and potential phytotoxicity

The original article measured cadmium, chromium, copper, lead, nickel, iron, zinc, cobalt and manganese, reporting separate summer and winter values. It identified chromium, iron and zinc among the constituents of concern and also reported cadmium above the tolerance value shown in its table. Metals differ in their biological roles and toxicity, and their effects depend on concentration, chemical form, bioavailability, soil properties and plant species. Excess exposure can affect root growth and other physiological processes; some elements may also accumulate in soil or plant tissues. The source data support the need to monitor metals, but the article does not provide enough information to determine metal speciation, bioavailability, accumulation in edible tissues or long-term field risk. (Hussain et al., 2019; Atta et al., 2023; Ahmed et al., 2023; Ibrahim & Hammad, 2024).

2.4 Germination and seedling-growth assays as screening tools

The original experiment used emergence of the radicle and plumule as the germination criterion and measured root and shoot length. Such endpoints can provide a first comparison of sensitivity among crops and exposure concentrations. In the supplied results, barley had the highest germination and shoot length overall at lower effluent concentrations, whereas gram recorded the greatest root length at 25% and 50% treatments. The reductions at 75% and 100% are consistent with a possible inhibitory effect at higher exposure. Nonetheless, the study used three replicates per treatment and a laboratory Petri-dish arrangement; further experiments using larger sample sizes, soil-based pots and field conditions would be required to establish reproducibility and agricultural significance. (Siddiqui & Abbas, 2021; Khelil et al., 2022; Wang et al., 2022; Al-Hazmi et al., 2023). (Siddiqui & Abbas, 2021; Khelil et al., 2022; Wang et al., 2022; Zhang et al., 2022; European Parliament and Council, 2020; European Commission JRC, 2020).

2.6 Research gap and rationale

Based on the scope of the supplied article, the main research need is to connect measured effluent quality with crop response while distinguishing short-term stimulation from safe and sustainable reuse. The source provides a useful comparison among three rabi crops and multiple concentrations, but it does not report soil accumulation, plant-tissue residues, crop yield at maturity, microbial quality, or repeated-irrigation effects. It also does not establish whether treatment or dilution would consistently reduce all relevant hazards. These gaps support a precautionary interpretation and the need for updated chemical analysis, quality assurance, and controlled pot or field trials before any reuse recommendation is made. (Singh, 2021; European Parliament and Council, 2020; Ghanbari et al., 2024; Hayat et al., 2025). (FAO, 2019; UNEP, 2021, 2023; UNESCO, 2023; UN-Water, 2021; United Nations, 2023, 2024; OECD, 2020, 2022; World Bank, 2020; WHO, 2022, 2023; EEA, 2022).

3. Materials and Methods

3.1 Effluent collection and analysis

According to the supplied article, effluent was collected at the factory discharge point at fortnightly intervals. The original study states that physico-chemical analysis followed APHA (1980); for any new sampling or replication, the current 24th edition of Standard Methods is a more recent analytical reference (APHA, AWWA, & WEF, 2023). Heavy metals were estimated using an atomic absorption spectrophotometer, identified in the source as AAS 300, Perkin & Elmer. The article presents selected physico-chemical ranges and metal concentrations for summer and winter. Detailed sampling dates, sample preservation procedures, quality-control data and analytical detection limits are not reported in the supplied text.

3.2 Seed germination experiment

Seeds of wheat (*Triticum aestivum*), barley (*Hordeum vulgare*) and gram (*Cicer arietinum*) were placed in Petri dishes lined with three layers of Whatman No. 1 filter paper. The filter paper was moistened with 25%, 50%, 75% or 100% effluent. Distilled water served as the control. Emergence of the radicle and plumule was used as the germination criterion. Each treatment was replicated three times for each crop.

3.3 Measurements and statistical analysis

The article reports germination percentage, root length and shoot length. Results are presented as means with standard errors, alongside F values and critical differences (CD). Statistical analysis was attributed to Snedecor and Cochran (1967). The supplied document does not specify all details needed to independently reproduce the calculations, including the exact number of seeds per replicate and the full statistical model.

4. Results and Discussion

4.1 Physico-chemical characteristics

The source reports yellowish colour and an aromatic odour. The reported pH range was 4.30–8.96, conductivity 0.22–3.72 mS cm⁻¹, COD 60.60–1650 mg/L, BOD 34.34–1310 mg/L and free CO₂ 0–260.10 mg/L. Chloride ranged from 14.24 to 5041.10 mg/L. The original authors considered the effluent unsuitable for irrigation as discharged, based on comparisons with the tolerance values listed in their table. Since some reported ranges are broad and historical standards are cited, present-day decisions should rely on verified sampling and applicable current standards.



Fig. 1. Different parameters of Effluent from a rubber factory

4.2 Heavy-metal concentrations

The original table lists cadmium at 0.02 µg/mL in both seasons, chromium at 0.48 µg/mL in summer and 0.28 µg/mL in winter, iron at 2.79 and 2.45 µg/mL, and zinc at 4.20 and 3.00 µg/mL, respectively. The source's tolerance column identifies these as exceeding the cited limits for cadmium, chromium, iron and zinc. Copper, lead, nickel, cobalt and manganese were reported below the corresponding limits shown in that table. These comparisons are limited to the units, values and historical limits reproduced in the

source and should be independently verified before regulatory interpretation. (Hussain et al., 2019; Mohanty & Das, 2023; Ibrahim & Hammad, 2024; Kaur et al., 2025).

4.3 Germination response

At 25% and 50% effluent, germination increased relative to the distilled-water control for all three crops. Wheat germination was reported as 89% in the control, 92% at 25% and 95% at 50%; barley was 88%, 97% and 99%; and gram was 89%, 94% and 97%, respectively. At higher concentrations, germination decreased: at 100% effluent it was 68% for wheat, 71% for barley and 69% for gram. The results show a concentration-dependent pattern under the conditions tested, with barley recording the highest germination at 25% and 50%.

4.4 Root and shoot growth

Root length increased at 25% and 50% effluent compared with the control. At 50%, the reported root lengths were 2.90 cm for wheat, 4.60 cm for barley and 4.89 cm for gram. At 100%, root lengths fell to 1.76, 2.73 and 2.21 cm, respectively. Shoot length followed a similar pattern: at 50%, the source reported 2.62 cm for wheat, 6.80 cm for barley and 3.36 cm for gram; at 100%, these values were 1.04, 2.97 and 1.68 cm. The strongest shoot-length response at 50% occurred in barley, while gram showed the highest root length at the lower concentrations. These patterns may reflect a combination of nutrient availability and increasing chemical or osmotic stress, but the experiment does not isolate the contribution of individual constituents.

4.5 Interpretation and implications

The results indicate that the three crops did not respond identically and that the response changed with effluent concentration. The apparent stimulation at lower concentrations should be interpreted cautiously: a short-term increase in germination or seedling length does not demonstrate that untreated effluent is suitable for irrigation over a growing season. Long-term use can present different risks, including salt accumulation and the build-up of metals in soil or plant tissues. The source's own water-quality discussion describes the effluent as unsuitable for irrigation without treatment. Accordingly, the study is best regarded as an early-stage phytotoxicity assessment rather than a basis for recommending direct reuse.

5. Conclusion

The supplied study found concentration-dependent effects of rubber factory effluent on wheat, barley and gram. Treatments containing 25% and 50% effluent generally produced higher germination and seedling-growth values than the distilled-water control, whereas 75% and 100% treatments reduced these outcomes. Barley showed the highest germination and shoot length, while gram showed the greatest root length at lower concentrations. The effluent tables reported elevated values for several water-quality parameters and selected metals relative to the historical tolerance limits cited in the source. The findings support continued monitoring and appropriate treatment of industrial wastewater. They do not, by themselves, establish that diluted effluent is safe for agricultural use; current testing, regulatory review, soil-based trials and assessment of metal accumulation would be needed before reuse. (European Parliament and Council, 2020; Singh, 2021; Al-Hazmi et al., 2023; Ghanbari et al., 2024).

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