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Assessment of Nickel and Chromium Contamination in Agricultural Irrigation Water in Lakardowo, Mojokerto

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Keywords

Heavy metal;
Industry;
Phytoremediation;
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Abstract

Industrial activities in Mojokerto have raised concerns over heavy metal contamination in agricultural irrigation water. This study aimed to determine nickel (Ni) and chromium (Cr) concentrations in rice field irrigation water in Lakardowo Village. A descriptive method was applied, with water samples collected using purposive sampling from nine irrigation points and analyzed using Nickel HR-Checker and Chromium VI HR-Checker. Cr concentrations at all nine sites were below the permissible limit. However, Ni concentrations at six sites exceeded the threshold, with the highest level recorded at point 5, a stagnant water location. This finding indicates serious nickel contamination, which arises from suboptimal waste treatment activities and has the potential to degrade soil quality, reduce crop yields, and threaten food safety. Phytoremediation using lotus plants is recommended as a potential solution to reduce Ni levels in irrigation water.

INTRODUCTION

Water is an essential element in crop cultivation because it significantly influences plant growth and harvest success. Harvest success and yield stability are influenced, in part, by the quality of water used for irrigation (Li et al., 2022). Deteriorating water quality is heavily influenced by human activities in the surrounding area, such as industrial operations. One of the negative impacts of industrial activities is water pollution resulting from the discharge of wastewater that still contains hazardous elements such as heavy metals, which is disposed of indiscriminately and contaminates both soil and water (Akhtar et al., 2021; Chia et al., 2022; García-Ávila et al., 2022).

Heavy metals are generally present in water and soil, but in small amounts or below threshold levels, so they have no impact on human life or the environment. Increased human activities, such as industrial and agricultural practices that are not environmentally friendly, have led to a rise in heavy metal accumulation, thereby threatening the health and survival of plants, animals, and humans (Timothy & Williams, 2019). If water contaminated with heavy metals is used for irrigation, it will affect soil fertility, reduce crop yields, render land marginal, and potentially kill aquatic and soil biota; it may even accumulate in plants and fruits (Luo et al., 2021; Mahmoud & Ghoneim, 2016; Rajeshkumar et al., 2018). Mojokerto Regency is one of the industrial areas in East Java. Data published by the Central Statistics Agency (BPS) (BPS, 2020) shows that 154 companies are operating with official permits in Mojokerto Regency. High levels of factory activity inevitably lead to several negative environmental impacts, whether resulting from production processes, transportation activities and vehicle traffic associated with the factories, or the disposal of industrial waste that has not been managed optimally (Ridwan, 2016; Xu et al., 2021; Yang et al., 2018).

Pollution in Lakardowo Village, Jetis Subdistrict, is caused by the activities of PT. Putra Restu Ibu Abadi (PT. PRIA), a facility that manages solid and liquid hazardous waste (B3) from various industries, including medical waste from

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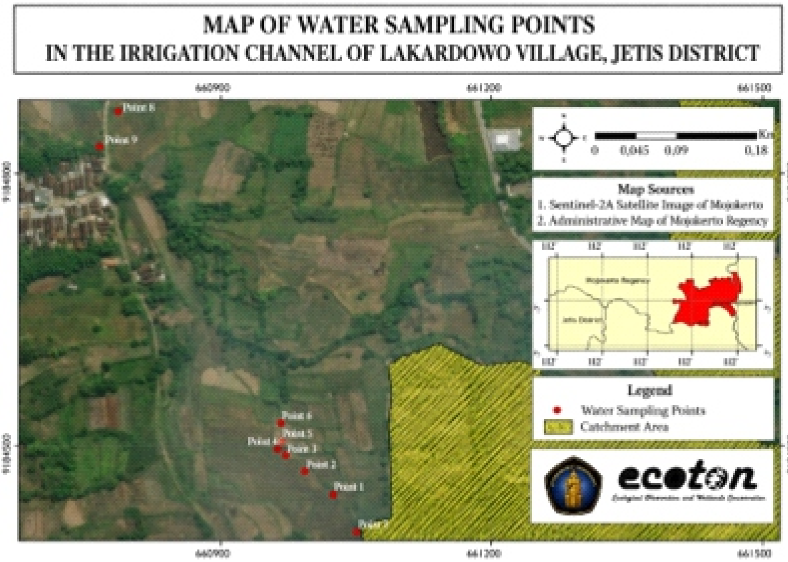
hospitals (Mardhiyah, 2022). PT. PRIA's operations in Lakardowo Village are suspected of damaging the environment due to the disposal of hazardous waste into rice fields, as well as leachate seeping from waste buried underground and entering irrigation channels. Additionally, incineration activities produce ash and smoke that are carried by wind and rainwater into irrigation channels, thereby contaminating irrigation water in surrounding agricultural lands. As a result, rice, corn, and chili pepper yields have declined, and some fertile land has turned into marginal land (Maulidia & Basid, 2019; Wardani et al., 2021). The heavy metal that has the potential to contaminate irrigation water in rice fields in Lakardowo Village is nickel.

Nickel is a hard, tough, silvery-white transition metal (Genchi et al., 2020). Nickel (Ni) is an essential micronutrient that is fundamentally required by plants for growth, even in small amounts. High concentrations of nickel can cause toxicity, classifying it as a heavy metal (Bharti & Sharma, 2022). Nickel contamination in irrigation water can reduce crop yields, disrupt photosynthesis and respiration, and cause chlorosis in plants. In addition, nickel also has negative impacts on aquatic life and human health, such as causing allergies and respiratory disorders, and has the potential to enter the food chain (Hayyat et al., 2020; Shahzad et al., 2018). Another heavy metal that has the potential to contaminate irrigation water is chromium. Chromium (Cr) is a heavy metal that is found in the environment in various oxidation states, with the most stable forms being Cr(III) and Cr(VI) (*et al*.., 2015). Chromium (Cr) is widely used in various industries, such as leather tanning, stainless steel production, electroplating, drilling mud, catalysts, specialty chemicals, as well as metalworking, cooling towers, and wood preservation (*et al*., 2017). Other sources that often contain traces of hazardous metal oxides such as Cr(VI) are fly ash and bottom ash; these wastes represent a small fraction of the approximately 60 types of waste processed by PT. PRIA (Georgaki et al., 2024; Mardhiyah, 2022).

A study by Ali et al. (2022) on heavy metal contamination reported high concentrations of Cr and Ni in irrigation water, paddy field soil, and plant tissues, including roots and rice grains. Irrigation water from industrial canals contains heavy metal concentrations that exceed WHO and FAO standards for agricultural water. The accumulation of heavy metals in plants leads to reduced vegetative growth in rice and decreased grain yield. A similar study was also conducted by Gurnita *et al*. (2022), which tested for the presence of several heavy metals including manganese, iron, lead, and chromium in irrigation water in the industrial area of Margaasih Subdistrict, Bandung Regency. The results showed that the concentrations of manganese and iron exceeded the quality standards set by the FAO and Government Regulation of the Republic of Indonesia No. 22 of 2021. Regarding research in Lakardowo Village, Mojokerto, there have been no specific studies identifying the levels of nickel (Ni) and chromium (Cr) in irrigation water. Based on the above description, there is a need for a study to examine the effects of heavy metal contamination in irrigation water for rice fields. The objective of this study is to identify the levels of nickel (Ni) and chromium (Cr) contamination in rice field irrigation water, specifically in Lakardowo Village, Mojokerto Regency.

RESEARCH METHOD

This study on the presence of heavy metals in irrigation water was conducted in Lakardowo Village, Jetis Subdistrict, Mojokerto Regency, in July 2025. The study area was selected based on its proximity (70–600 m) to a hazardous waste (B3) treatment facility, which was suspected to be a potential source of heavy metal contamination in irrigation water. Water samples were collected from irrigation canals within the rice fields. Samples were taken from nine different points, categorized based on the distance of the irrigation canals from PT. PRIA.



Source: Processed Primary Data (2025)

Figure 1

Irrigation Water Sampling Points in Lakardowo Village

The equipment and materials required for this study included glass bottles, labels, writing utensils, a Nickel HR-Checker, a Chromium VI HR-Checker, pipettes, and a camera.

This study is a descriptive study involving water sampling using the purposive sampling method, with 500 ml collected at each point. Water samples were taken from the right, left, and center sections of the canal and then pooled. Water samples were collected directly from the irrigation flow using labeled glass bottles, samples were then transported to the ECOTON laboratory to measure the heavy metals nickel and chromium. Heavy metal testing was performed using a Nickel HR-Checker and a Chromium VI HR-Checker by placing 10 mL of the water sample into a cuvette and adding reagent, the mixture was then homogenized, and the cuvette was cleaned with a tissue. Once the cuvette was thoroughly clean and the reagent had dissolved completely, it was inserted into the instrument, and the results appeared on the screen after a few minutes. The obtained data were then processed using Microsoft Excel for tabulation, converted to mg/L, and presented in graph form. Subsequently, the data were compared with Government Regulation No. 22 of 2021 on the Implementation of Environmental Protection and Management. The data were analyzed using descriptive statistics to represent the chromium and nickel concentrations at the 9 sampling points.

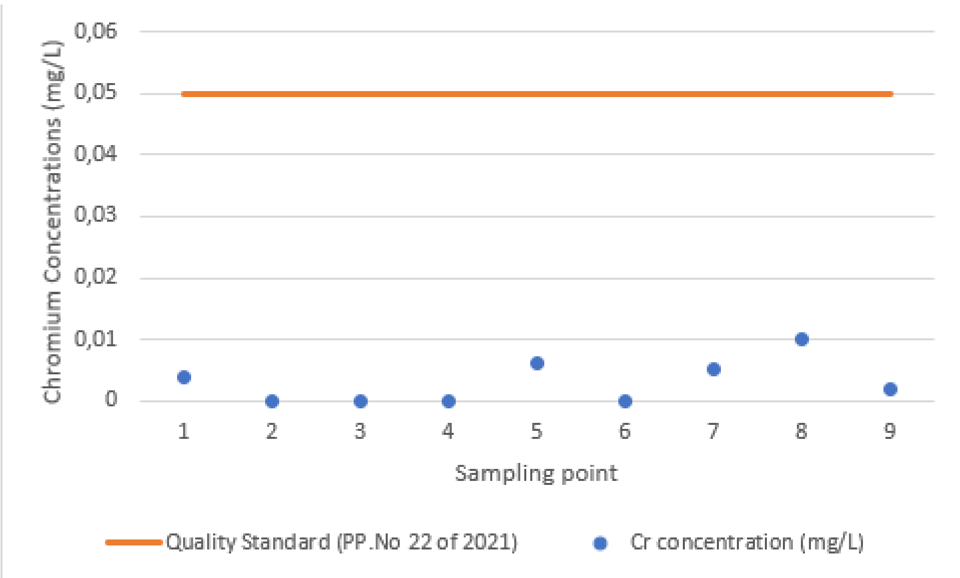
RESULTS AND DISCUSSION

The results of the heavy metal tests in the irrigation channels in Lakardowo Village showed varying values, and several points indicated the accumulation of heavy metals. This accumulation is likely associated with the leaching of phosphate- and nitrate-based fertilizers from agricultural soils, activities at hazardous waste treatment facilities, and stagnant water conditions. The results of the tests for chromium (Cr-VI) and nickel (Ni) concentrations in the water are shown in Figures 2 and 3. The data showed in Figure 2 indicate the presence of chromium (Cr) in 5 out of 9 sampling points. The chromium levels in this irrigation water are relatively low and safe for use in irrigating crops, as they remain below the quality standard of 0.05 mg/L set by Government Regulation No. 22 of 2021. The chromium (Cr) content in this irrigation water ranges from 0 mg/L to 0.01 mg/L; all tested samples show chromium (Cr) levels that remain below the quality standard threshold set by the government and therefore do not fall into the category of water pollution.

The presence of chromium (Cr) in this irrigation water is believed to result from the leaching of nitrate and phosphate fertilizers; chromium is not required by plants but can be found in some types of phosphate and nitrate fertilizers (Rodríguez-Eugenio et al., 2018). Chromium (Cr) concentrations in water, as reported, are generally low due to chromium's low solubility in water; however, under certain conditions, high levels of chromium contamination may occur in the water due to the discharge of chromium-containing wastewater into the water (Karunanidhi et al., 2021). Maintaining chromium concentrations in water below established thresholds is essential, as elevated levels may adversely affect crop yields and potentially result in economic losses for farmers. Chromium toxicity in plants causes a reduction in root diameter, root surface area, root hairs, metabolism, and photosynthesis; chromium also reduces the uptake of iron (Fe), sulfur (S), and phosphorus (P), which are important cofactors in photosynthesis (Gomes et al., 2017).

Based on Figure 2, chromium (Cr) in water are similar to those reported by Hussain *et al*. (2017) in the Godavari River, India. The Cr concentrations in that river ranged from 0.036 to 10.12 µg/L; the presence of Cr in the river water is believed to be due to industrial activity in the river basin. A similar study was also conducted by Karunanidhi *et al*. (2021), which tested chromium levels in the Palar River in Tamil Nadu, India. The results showed chromium concentrations of 0.01–0.19 mg/L; the presence of chromium in this water is believed to be due to wastewater discharge from industrial activities near the river. The results of the study indicate that the water in this river has exceeded the quality standards set by the WHO.

The second heavy metal observed was nickel (Ni); as shown in Figure 3, the Ni concentration in the water exceeds the established quality standards, rendering this irrigation water unsuitable for use in agricultural fields. The data obtained show variations in Ni concentrations. These variations are likely due to the water's constant and relatively fast flow, which affects the distribution of heavy metals (Gurnita et al., 2022). Observation point 5 had the highest Ni concentration compared to the other observation points, at 260 mg/L. The high Ni concentration at this sampling point may be associated with stagnant water conditions, as limited water circulation can promote heavy metal accumulation. The test results indicate that, of the 9 sampling points tested, 6 had



Source: Processed Primary Data (2025)

Figure 2

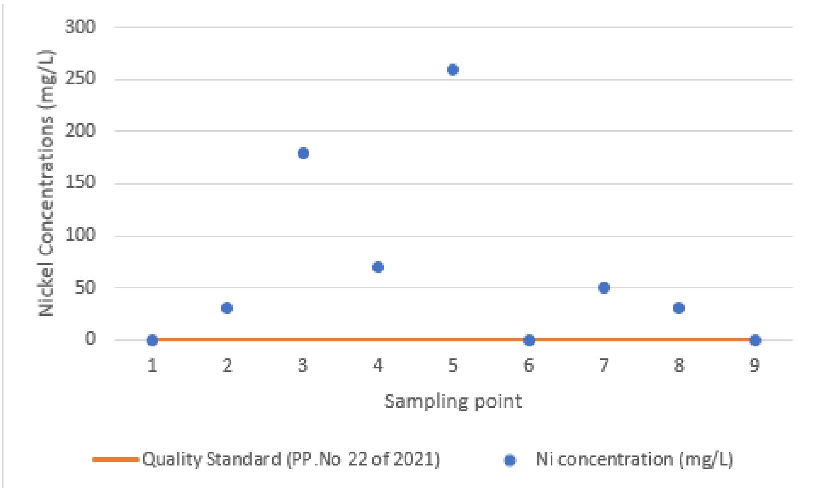
Chromium Levels in Irrigation Water in Rice Fields at Lakardowo Village

nickel concentrations that far exceeded the established threshold for water, which is 0.05 mg/L.

The detection of high nickel (Ni) levels in this water is highly dangerous due to the adverse effects it causes on both plants and humans. Nickel (Ni) itself is essentially a micronutrient that plants do require, albeit in small amounts. Excessive amounts of Ni in water or soil can negatively impact the productivity of cultivated plants (Gupta et al., 2024; Thapa et al., 2021). Heavy metal nickel (Ni) is generally present in water but in small amounts. The high Ni concentration is suspected to be due to the operations of PT. PRIA's hazardous waste (B3) treatment plant. The accumulation of large amounts of nickel in water generally stems from industrial activities and the discharge of industrial wastewater that has not been treated according to standards, thereby potentially becoming a source of pollution (Begum et al., 2022; Hussain et al., 2017).

The results of the Ni heavy metal test on irrigation water in Lakardowo Village show values that are significantly higher than those from previous studies conducted on water. Heavy metal testing of water was conducted by Hussain *et al.* (2017) on the Godavari River in India, the results showed that the river water contained nickel, with concentrations ranging from 1.47 to 17.29 µg/L. The presence of nickel in the Godavari River in India is believed to be due to the increasing number of settlements and industrial activities along the river. A similar study was also conducted by Laksono *et al.* (2020) on water from reclaimed nickel mine land in Mohoni Village, East Petasia, North Morowali. The results of the study showed an average nickel contamination level of 0.125 mg/L. This heavy metal levels remains below the BML value for nickel, which is 1 mg/L.

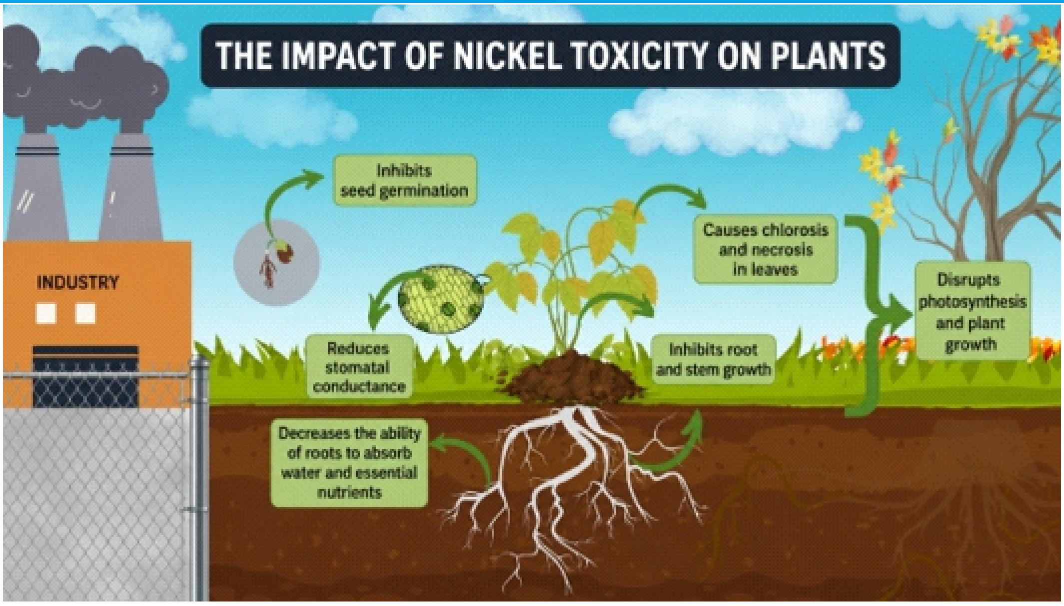
These findings regarding the levels of the heavy metals nickel (Ni) and chromium (Cr) are supported by reports from farmers in the Lakardowo area, who have complained of a decline in crop yields, both in terms of quality and quantity. High levels of nickel (Ni) in the irrigation water used will certainly have a significant impact on the amount of nickel in the soil and the amount that could potentially be absorbed by plants. The use of heavy metal-contaminated water for irrigation can lead to the accumulation of heavy metals in agricultural soils. High levels of Ni in the soil will have adverse effects on the growth of cultivated plants, such as reduced seed germination and impaired plant metabolism, causing chlorosis and necrosis in leaves, inhibiting root and stem growth which directly affects the plants' ability to absorb water and nutrients and reduced stomatal conductance, which ultimately disrupts photosynthesis and plant growth (Hassan et al., 2019).



Source: Processed Primary Data (2025)

Figure 3

Nickel Levels in Irrigation Water at Rice Fields of Lakardowo Village



Source: Processed Primary Data (2025)

Figure 4
Impact of Nickel Toxicity on Plants

One way to reduce heavy metal concentration in water is through phytoremediation. Phytoremediation itself is a technology that uses various plants to degrade, extract, retain, or immobilize contaminants, including metals, pesticides, hydrocarbons, and chlorinated solvents from soil and water (Ekta & Modi, 2018). Results from a study by Fillah *et al.* (2023) show that Lotus is capable of reducing the concentration of various water pollutants. Lotus can also reduce heavy metal levels, such as nickel and chromium, by up to 55.47% and 61.13%, respectively. Lotus's success in this phytoremediation process is due to its ability to absorb metal ions and organic compounds through its roots, as well as its role in supporting microbial activity that aids in the breakdown of pollutants in the root zone. The use of organic fertilizers in agricultural land is also recommended to reduce heavy metal contamination. Organic fertilizers contain humic acid, which immobilizes heavy metal ions, ensuring they remain bound in the soil and preventing them from being leached out or absorbed into plant tissues (Wijayanti et al., 2018).

CONCLUSION

The results of this study indicate the presence of the heavy metals nickel (Ni) and chromium (Cr) in the irrigation water of rice fields in the village of , Lakardowo. The chromium levels at 9 sampling points were found to be relatively low and safe when compared to quality standards. Nickel concentrations at several sampling points were quite high, far exceeding established quality standards; the highest value was recorded at point 5, likely due to heavy metal accumulation resulting from waterlogged conditions. Potential solutions to reduce nickel levels in this irrigation water include phytoremediation and the application of organic fertilizers. Plants such as lotus can reduce nickel and chromium levels through the absorption of metal ions and organic compounds by the roots, as well as through microbial activity in the root zone. Another recommendation is to reduce the use of inorganic fertilizers and replace them with organic fertilizers, as organic fertilizers help retain heavy metals in the soil, preventing them from being leached or absorbed into plant tissues. Future research could involve a statistical analysis of the relationship between heavy metal contamination levels and crop yield. The number of samples collected could be increased to reduce errors in the analysis phase.

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