

# Well Water Quality Assessment Around Ciangir Landfill, Tasikmalaya City, Using the Pollution Index

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## ABSTRACT

Shallow groundwater around landfill should be monitored because landfill leachate may transport dissolved solids, organic matter, and metals into residential water sources. This study evaluated well water quality around the Ciangir Landfill, Tasikmalaya City, using pH, temperature, iron (Fe), manganese (Mn), and turbidity, and determined water quality status using the Pollution Index. Nine wells were purposively selected at 0 m, 50 m, and 100 m from the landfill area and were sampled during dry and rainy seasons. The results showed that pH was acidic at several points, while Fe generally remained below the 1 mg/L standard. Mn exceeded the 0.5 mg/L standard at point A1, particularly in the dry season, and high turbidity occurred at several points during the rainy season. The average Pollution Index was 0.8991, indicating compliance with the standard, although the dry-season value reached 1.0394 and was classified as slightly polluted. Periodic monitoring and improved leachate management are required to prevent further deterioration of local well water.

**Keywords:** Ciangir landfill, leachate, Pollution Index, shallow groundwater, well water quality

## 1. INTRODUCTION

Shallow groundwater and household wells are important domestic water sources for communities living near waste disposal facilities. In landfill areas, the main environmental risk is leachate, a complex liquid containing organic matter, dissolved salts, nitrogen compounds, metals, and emerging contaminants, whose composition depends on waste characteristics, landfill age, rainfall, and landfill operation practices (Naveen et al., 2017; Teng et al., 2021; Wijekoon et al., 2022).

Leachate pollution potential is dynamic because it may vary with climate, waste stabilization, and site management. Therefore, index-based methods are useful for integrating several water quality parameters into simpler categories that can support environmental assessment and decision-making (Abunama et al., 2021; Podlasek et al., 2023; Saghi et al., 2024).

Contaminant migration from landfills to groundwater does not always decrease linearly with distance from the waste body, since hydraulic gradient, soil texture, aquifer permeability, preferential flow, seasonal recharge, and well construction may cause spatial differences in water quality among sampling points (Chen et al., 2019; Dávalos-Peña et al., 2021; Lu et al., 2025; Przydatek & Kanownik, 2019). This condition makes site-specific monitoring important, particularly in settlements that still rely on shallow wells for daily water needs. In the Ciangir area, household wells are still used for daily domestic activities, while the landfill may generate leachate that can interact

with shallow groundwater through local drainage, infiltration, and near-surface flow pathways. However, site-specific seasonal information on well water quality around Ciangir remains limited. This gap is important because seasonal recharge and local well conditions may change the concentrations of selected physicochemical parameters even when sampling points are located at similar distances from the landfill.

Parameters such as pH, temperature, Fe, Mn, and turbidity can provide an initial indication of changes in well water quality. pH affects metal solubility and redox processes, while Fe and Mn may increase under reducing conditions and cause color, taste, and deposits. Turbidity may also increase during the rainy season due to suspended particles, runoff, or the entry of fine materials into wells (Qi et al., 2018; Tangahu et al., 2021; Wang et al., 2025).

This study aimed to evaluate well water quality around the Ciangir Landfill, Tasikmalaya City, based on pH, temperature, Fe, Mn, and turbidity during dry and rainy seasons. The water quality status was determined using the Pollution Index. The novelty of this study lies in the seasonal interpretation of well water quality around Ciangir and its integration with recent studies on landfill leachate, shallow groundwater, and index-based water quality assessment.

## 2. RESEARCH METHOD

### 2.1. Study Area and Sampling Design

The study was conducted in residential areas around the Ciangir Landfill, Tamansari District, Tasikmalaya City. Water samples were collected from community wells used for domestic purposes. Sampling points were selected by purposive sampling based on well use, proximity to the landfill, and representation of distance variation from the landfill area.

Nine sampling points were grouped into three distance classes: A1-A3 at 0 m, B1-B3 at 50 m, and C1-C3 at 100 m from the landfill area. Sampling was carried out under two seasonal conditions, namely dry and rainy seasons, to observe possible differences caused by dilution, runoff, or mobilization of materials around the wells. At each sampling point, water was collected directly from wells used by residents for domestic activities. Field parameters were measured immediately to minimize changes during sample transport, while samples for laboratory analysis were placed in clean sampling bottles and transported to the laboratory for analysis. Because the study was designed as an initial screening assessment, the interpretation emphasizes descriptive comparison among seasons, sampling points, and quality standards rather than statistical inference or definitive source attribution.

### 2.2. Parameters, Standards, and Data Analysis

The analyzed parameters were pH, temperature, Fe, Mn, and turbidity. pH and temperature were measured as field parameters, whereas Fe, Mn, and turbidity were analyzed in the laboratory. The results were compared with Indonesian water quality standards for hygiene and sanitation purposes, namely pH 6.5-8.5, Fe 1 mg/L, Mn 0.5 mg/L, and turbidity 25 NTU; temperature was interpreted using the deviation approach applied in the Pollution Index calculation.

Water quality status was calculated using the Pollution Index method according to the Indonesian guideline for determining water quality status (Ministry of Environment of the Republic of Indonesia, 2003). For each parameter, the ratio between the measured concentration and its corresponding quality standard was calculated. The Pollution Index was then obtained using Equation (1).

$$PI_j = \sqrt{\frac{(C_i/L_{ij})_M^2 + (C_i/C_{ij})_R^2}{2}} \quad (1)$$

where  $PI_j$  is the Pollution Index for water use class  $j$ ,  $C_i$  is the measured concentration of parameter  $i$ ,  $L_{ij}$  is the corresponding water quality standard,  $(C_i/L_{ij})_M$  is the maximum concentration-to-standard ratio, and  $(C_i/C_{ij})_R$  is the average concentration-to-standard ratio. The water quality status was classified as meeting the quality standard when  $0 \leq PI_j \leq 1.0$ , slightly polluted when  $1.0 < PI_j \leq 5.0$ ,

moderately polluted when  $5.0 < PI_j \leq 10.0$ , and heavily polluted when  $PI_j > 10.0$  (Ministry of Environment of the Republic of Indonesia, 2003).

### 3. RESULTS AND ANALYSIS

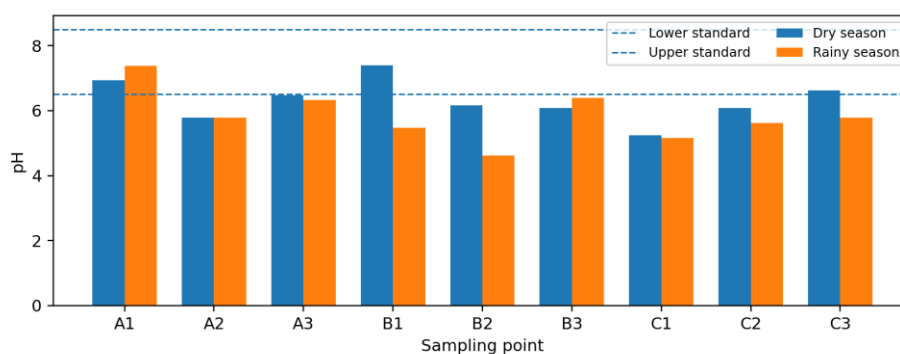
#### 3.1. General Characteristics of Well Water Quality

The measurement results showed seasonal variation in well water quality. During the dry season, pH ranged from 5.24 to 7.40, Fe from 0.02 to 0.52 mg/L, Mn from 0.01 to 3.12 mg/L, and turbidity from 0.24 to 17.87 NTU. During the rainy season, pH ranged from 4.62 to 7.38, Fe from 0.01 to 0.24 mg/L, Mn from 0.01 to 1.21 mg/L, and turbidity from 0.19 to 80.01 NTU. These data indicate that water quality parameters did not respond uniformly to seasonal change; therefore, interpretation should be performed for each parameter and not only according to distance from the landfill. A summary of the measured parameters during the dry and rainy seasons is presented in Table 1.

**Table 1.** Summary of well water quality around the Ciangir Landfill

Season	Statistic	pH	Temperature (deg C)	Fe (mg/L)	Mn (mg/L)	Turbidity (NTU)
Dry	Minimum	5.24	27.20	0.02	0.01	0.24
Dry	Mean	6.30	28.98	0.14	0.42	4.42
Dry	Maximum	7.40	31.40	0.52	3.12	17.87
Rainy	Minimum	4.62	25.80	0.01	0.01	0.24
Rainy	Mean	5.83	28.36	0.14	0.20	14.61
Rainy	Maximum	7.38	29.90	0.24	1.21	80.01
Standard/reference	-	6.5-8.5	Deviation 3	1	0.5	25

Based on Table 1, exceedances were not distributed evenly across all parameters. Fe remained below the standard in both seasons, whereas pH frequently fell below the recommended range. Mn exceedance was concentrated at point A1, while turbidity exceedance occurred mainly during the rainy season. This pattern indicates that the assessment should consider both seasonal variability and parameter-specific exceedance, rather than relying only on seasonal average values. pH tended to be acidic at several points, especially during the rainy season. Low pH may enhance the mobility of some metals and alter geochemical reactions in shallow groundwater; thus, pH is an important parameter for interpreting well water quality near landfills. Similar studies have reported that redox and chemical conditions in groundwater may control contaminant mobility from landfill environments (Chen et al., 2019; Dávalos-Peña et al., 2021; Wang et al., 2025). The comparison of pH values at each sampling point during the dry and rainy seasons is shown in Figure 1.

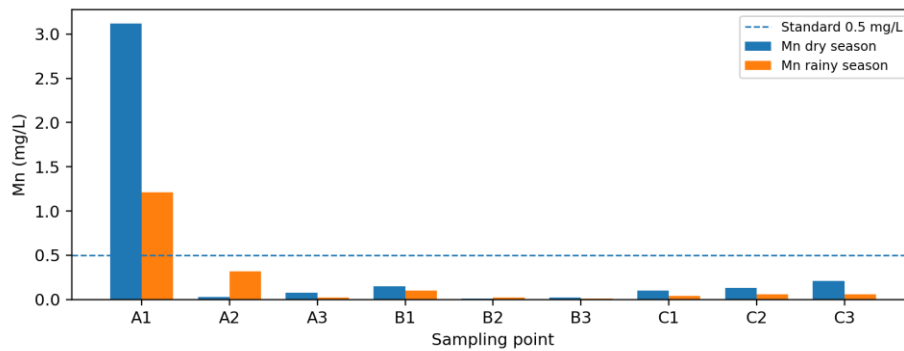


**Figure 1.** pH profile of well water during dry and rainy seasons

Fe concentrations at all sampling points remained below the 1 mg/L standard in both seasons. However, Fe should still be monitored because reducing conditions, organic matter input, and aquifer properties may alter metal solubility from soil and sediment. Landfill groundwater studies have shown that metal concentrations should be interpreted together with other chemical indicators and hydrogeological information to avoid premature source attribution (Lu et al., 2025; Przydatek & Kanownik, 2019; Tangahu et al., 2021). The absence of Fe exceedance does not necessarily indicate the absence of landfill-related influence because Fe mobility is strongly controlled by pH, dissolved oxygen, redox potential, and aquifer mineralogy. Therefore, Fe results should be interpreted together with Mn, turbidity, and additional leachate-related indicators in future monitoring.

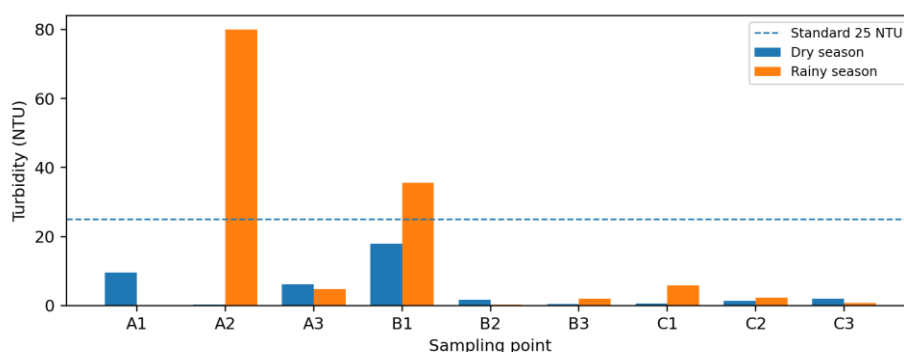
### 3.2. Manganese, Turbidity, and Seasonal Effects

Mn showed an important anomaly, particularly at point A1. As shown in Figure 2, Mn concentrations varied among sampling points and between seasons, indicating that Mn distribution was not solely controlled by distance from the landfill. In the dry season, Mn at A1 reached 3.12 mg/L, far exceeding the 0.5 mg/L standard, while in the rainy season it reached 1.21 mg/L. High Mn near the landfill may be associated with reducing conditions, organic matter, and possible leachate contribution, although the pattern did not consistently occur at all points. This result supports the view that contaminant distribution around landfills is governed by local groundwater flow and media heterogeneity rather than horizontal distance alone (Abunama et al., 2021; Morabet et al., 2024; Saghi et al., 2024).



**Figure 2.** Mn concentration profile of well water around the Ciangir Landfill

Turbidity showed a strong seasonal difference. As shown in Figure 3, turbidity increased markedly at several sampling points during the rainy season, especially at A2 and B1. In the dry season, all turbidity values were below the 25 NTU standard, whereas in the rainy season turbidity reached 80.01 NTU at A2 and 35.58 NTU at B1. Increased turbidity in the rainy season may result from suspended particles entering wells through runoff, disturbance of well sanitation, or mobilization of fine materials around residential areas. This interpretation is consistent with the literature indicating that rainfall and hydrological dynamics may intensify water quality variation around landfill sites, including physical parameters such as turbidity (Alizamir et al., 2023; Podlasek et al., 2023; Tan Pei Jian et al., 2020).



**Figure 3.** Turbidity profile of well water during dry and rainy seasons

### 3.3. Water Quality Status Based on the Pollution Index

Although the average Pollution Index indicated that the overall well water status met the quality standard, the result should be interpreted as a screening-level indication rather than definitive evidence that the wells were unaffected by landfill leachate. The study did not include upgradient control wells, groundwater flow direction, leachate characterization, well depth, well construction condition, or repeated sampling over longer periods. Therefore, the high Mn at A1 and high turbidity at A2 and B1 should be regarded as early warning signals that require follow-up monitoring rather than as conclusive proof of leachate intrusion.

The Pollution Index calculation showed that the dry-season PI was 1.0394, classified as slightly polluted, whereas the rainy-season PI was 0.7587, classified as meeting the standard. When both seasons were averaged, the PI was 0.8991, indicating that the general status of well water around the Ciangir Landfill met the quality standard. Nevertheless, this average value should not obscure exceedances of specific parameters, particularly Mn and turbidity at certain sampling points. These Pollution Index results are summarized in Table 2, which shows the classification of well water quality for each season and the overall average.

**Table 2.** Pollution Index values of well water around the Ciangir Landfill

Condition	Maximum $C_i/L_{ij}$	Average $C_i/L_{ij}$	PI value	Water quality status
Dry season	1.6186	0.6777	1.0394	Slightly polluted
Rainy season	1.2504	0.6421	0.7587	Meeting the standard
Two-season average	-	-	0.8991	Meeting the standard

The Pollution Index is useful as a summary indicator because several parameters can be integrated into one interpretable value. For environmental management, however, parameters exceeding their standards must remain management priorities even when the average PI is low. This interpretation is consistent with landfill and leachate studies that recommend reading index values together with the dominant parameters contributing to risk (Arunbabu et al., 2017; Wdowczyk et al., 2024; Wdowczyk & Szymańska-Pulikowska, 2021). This finding also shows one limitation of index-based assessment. A low or acceptable composite index can mask localized exceedances when only a few parameters or sampling points show high values. For this reason, environmental management should not rely solely on the final PI category but should also examine the dominant contributing parameters and their spatial distribution. In this study, Mn and turbidity deserve priority attention because they showed clear exceedances at specific sampling points and seasons.

Spatially, the data did not show a consistent pattern in which pH, Fe, Mn, or turbidity improved with increasing distance from the landfill. This condition is reasonable because leachate and groundwater contaminants can move along hydraulic gradients, fractures, soil porosity, and preferential pathways. Future monitoring should therefore include additional parameters such as COD, BOD, TDS, ammonium, nitrate, chloride, sulfate, and other metals, while also mapping

groundwater flow direction and well construction (Kotowska et al., 2020; Qi et al., 2018; Wowkonowicz & Kijeńska, 2017).

From a management perspective, periodic well monitoring should be prioritized at points where exceedances occurred, especially A1 for Mn and A2 and B1 for turbidity. Wellhead protection, drainage control around wells, and prevention of direct runoff entry are important, particularly during the rainy season. At the landfill scale, leachate collection and treatment facilities should be evaluated to reduce the potential for uncontrolled infiltration. For household use, acidic water should not be used without proper treatment, and neutralization or other treatment options should be considered only after repeated testing confirms the persistence of low pH.

#### 4. CONCLUSION

Well water around the Ciangir Landfill showed spatial and seasonal variation. Fe concentrations remained below the 1 mg/L standard in both seasons, whereas pH was acidic at several sampling points. Mn exceeded the 0.5 mg/L standard at A1, and turbidity exceeded the 25 NTU standard at A2 and B1 during the rainy season. The dry-season Pollution Index was 1.0394 and indicated slightly polluted status, while the rainy-season value was 0.7587 and met the quality standard. The two-season average PI of 0.8991 suggests that the general water quality status met the standard; however, this composite value should not obscure localized exceedances of Mn and turbidity. The results indicate that distance from the landfill alone did not explain well water quality variation. Future monitoring should include groundwater flow direction, well construction, leachate characterization, and additional parameters such as COD, BOD, TDS, electrical conductivity, ammonium, nitrate, chloride, sulfate, and broader metal profiles.

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