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RESEARCH ARTICLE

Evaluation of Groundwater Quality Status Around Gunung Tugel Landfill In Kedungrandu Village, Patikraja District, Banyumas Regency, Central Java, Indonesia.

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Abstract

Gunung Tugel Disposal Site (GTDS) is one of the final land disposal sites established in 1983 in the Banyumas Regency, and it operates with an open-dumping system. In this system, the base of the disposal site is neither coated with an impermeable layer nor equipped with leachate collection and drainage channels, for which leachate can percolate through the soil and pollute groundwater. In March 2016, GTDS was closed because its capacity had been exceeded. The closure of GTDS was not followed by appropriate waste and environmental management, prompting the formation of leachate that can contaminate the environment, particularly groundwater. This research set out to identify the leachate quality of GTDS, assess the groundwater quality, and determine the groundwater quality status around the disposal site. It employed a field survey and mapping to plot and display the groundwater well points in the study area, laboratory analysis to identify the groundwater quality, and pollution index calculation to determine the groundwater quality status. The groundwater samples were tested in the laboratory for their physical (turbidity and TDS), chemical (pH, COD, BOD, iron (Fe), cadmium (Cd)), and biological properties (total coliform). The results showed that the cadmium (Cd) levels in several groundwater well points had exceeded the quality standards. Based on the analysis and calculation results, the groundwater quality status in the study area is mildly contaminated, with the pollution index ranging between 2.571 and 4.099.

Keywords: Groundwater, Groundwater Quality Status, Pollution Index

1. Introduction

Water is one of the natural resources needed by humans. Most people make use of groundwater to meet their daily needs because it contributes to more than 97% of the total freshwater worldwide. Nowadays, population growth causes more complex human activities and generates a higher amount of waste, especially solid waste. For these reasons, the volume of waste piled up in land disposal sites persistently rises. The ramifications include elevated groundwater pollution risk and deteriorated groundwater quality due to leachate production. In this study, the risk of contamination by leachate is attributable to the open-dumping system implemented in Gunung Tugel Disposal Site (GTDS). Open dumping is the simple disposal of refuse or waste materials to a location that is left open without any protection and abandoned when all full up (Oyiboka, 2014). If improperly managed, leachate can contaminate groundwater because it contains a variety of organic and inorganic substances that, in some cases, are toxic.

GTDS is the final disposal site for the residents of Purwokerto City. It was established in 1983 in Kedungrandu Village, Patikraja District, Banyumas Regency, with an area of about 6.7 ha. Daily, it receives approximately 317 m3 of organic and inorganic waste materials from the city. Most of this waste comes from households, markets, supermarkets/shops, open spaces, and industrial buildings or factories. GTDS is intended for waste collection only because it is not equipped with proper facilities and infrastructure for liquid and solid waste treatment. It uses the open-dumping system, which does not include waste treatment. The base of this disposal site is not coated with impermeable layers and is not equipped with leachate collection and drainage channels, meaning that leachate can directly percolate through the soil and contaminate groundwater.

In March 2016, GTDS was closed following an exceeded capacity, but this closure did not necessarily initiate proper waste management. This disposal site was only filled with soil and has been used as cassava farms. Underneath today's layer is a pile of untreated waste, which inevitably increases the risk of leachate production and groundwater contamination. According to Nugroho (2009), 8 out of 10 groundwater samples taken from domestic wells around GTDS contain cadmium (Cd) that is above a maximum threshold of 0.01 mg/L. Cadmium (Cd) is a heavy metal that is toxic and accumulative. It is believed to be one of the causes of cancer in humans, or commonly called as a carcinogen. Furthermore, cadmium (Cd) can interfere with and damage the renal system and, if inhaled, Cd vapor and dust can harm the lungs and disturb their respiratory functions. Cadmium (Cd) poisoning leads to bone fragility, and the toxicity of this metal can affect the reproductive system and its organs (Aziz et al., 2013). In other terms, cadmium (Cd) turns out to have a hazardous effect if it enters the human body.

The research location is in Kedungrandu Village, Patikraja District, Banyumas Regency, the Province of Jawa Tengah. This study was designed to determine the quality of leachate in GTDS, assess the groundwater quality, and analyze the severity of the groundwater pollution around GTDS based on the quality status. Most people in Kedungrandu Village heavily rely on groundwater to meet their daily needs, warranting the necessity of this research.

2. Methodology

Leachate was collected by purposive sampling technique, wherein the leachate sampling took into account the conditions of the study area. Because GTDS does not have a leachate reservoir, leachate was collected by looking for streams or puddles of water leaching out the disposal site. In this study, leachate was sampled at one point. The sample was transported to the Office of PIPBPJK Yogyakarta and then tested for quality. The parameters tested were turbidity, BOD, COD, iron (Fe), cadmium (Cd), and total coliform. Turbidity and pH were measured directly in the field using EC meters and pH strips. As for the leachate quality, the test results were evaluated and compared to the wastewater quality standards stated in the Regulation of the Minister of Environment and Forestry No. 59 of 2016 on Leachate Quality Standards for Waste Treatment Activities and/or Businesses and the Regional Regulation of the Province of Jawa Tengah No. 5 of 2012 on Wastewater Quality Standards for Industrial Activities and Other Business Activities.

This research also employed survey and mapping, as well as laboratory tests, to obtain groundwater quality data. The survey and mapping aimed to plot and display the existing well points at the research location, while the groundwater samples were tested for their quality in the laboratory. Similar to the leachate collection, the groundwater sampling points were determined by purposive sampling and based on groundwater flow maps and land use maps. In this study, the groundwater samples were taken from seven wells. The parameters tested were turbidity, TDS, pH, COD, BOD, iron (Fe), cadmium (Cd), and total coliform. Turbidity is a physical parameter that affects the aesthetics of water. TDS represents the amounts of dissolved particles attributable to inorganic materials, and, therefore, this measure can be used as a parameter for pollution. COD, BOD, and total coliform indicate organic contamination from waste materials generated by domestic activities. Iron is a major metallic component that is widely distributed on the surface of the earth and, if found at a concentration of > 0.3 mg/L (exceeding the quality standard), can reduce water quality. Cadmium (Cd) is a dangerous heavy metal that indicates contamination by leachate from discarded batteries.

The groundwater quality data obtained from the survey and laboratory tests were then analyzed using the Pollution Index to determine their status. There are several methods to determine the pollution index on groundwater as explain in (Abou Zakhem and Hafez, 2015) using Heavy metal pollution index (HPI), (Egbueri, 2020) using pollution index of groundwater (PIG). The quality standards used in the calculations referred to the Indonesian Government Regulation No. 82 of 2001 on Water Quality Management and Water Pollution Control for Class I Water. This class includes water that can be used as the raw water for drinking and/or other purposes that requires equal water quality. The Pollution Index was calculated using the formula determined in Kepmen LH No. 115 Year 2003 as can be seen in Equation 1.

$$PIj=\sqrt{\frac{(Ci/Lij)_M^{\,2}-(Ci/Lij)_R^{\,2}}{2}} \quad (1)$$

Where,

PIj = Pollution Index
Ci = the parameter value of tested water samples
Lij = the parameter value stated in the quality standard
(Ci/Lij)M = the maximum (highest) Ci/Lij ratio of each water sample
(Ci/Lij)R = the average Ci/Lij ratio of each water sample

Afterward, the pollution index was analyzed according to the conditions below.

Evaluations of PI values:

Pij Values	Water Quality Status
$0 \le PI_j \le 1.0$	within the quality standard (good condition)
$1.0 \le PI_j \le 5.0$	mildly polluted
$5.0 \le PI_j \le 10$	moderately polluted
$PI_j > 10$	heavily polluted

Source: Kepmen LH no. 115 Year 2003

3. RESULTS AND DISCUSSIONS

3.1. Leachate Quality

Leachate was characterized by testing its quality using several parameters, namely turbidity, TDS (total dissolved solids), pH, iron (Fe), cadmium (Cd), COD, BOD, and total coliform. The leachate quality test results in GTDS were evaluated and compared to two wastewater quality standards. These standards are the Regulation of the Minister of Environment and Forestry No. 59 of 2016 on Leachate Quality Standards for Waste Treatment Activities and/or Businesses and the Regional Regulation of the Province of Jawa Tengah No. 5 of 2012 on Wastewater Quality Standards for Industrial Activities and Other Businesses. The regional and ministerial regulations are combined because the Province of Jawa Tengah, where GTDS is located, does not have legal texts and other documents that specifically regulate leachate quality standards. The leachate quality test results are summarized in Table 1.

Table 1. Leachate Quality Test Results in Gunung Tugel Disposal Site (GTDS)

No.	Parameters	Measurement Units	Test Results	Quality Standards
1	Turbidity	NTU	457.5	-**
2	TDS	mg/L	3305	2000**
3	pH	-	7	6 – 9*
4	Iron (Fe)	mg/L	3.3	5**
5	Cadmium (Cd)	mg/L	0.06	0.05*
6	COD	mg/L	1278	300*
7	BOD	mg/L	355.24	150*
8	*Total coliform*		≥2400	-

(Source: Office of PIPBPJK Yogyakarta and the Environmental Laboratory of the Faculty of Biology UNSOED 2018)

Where,

* : The Regulation of the Minister of Environment and Forestry No. 59 of 2016 on Leachate Quality Standards for Waste Treatment Activities and/or Businesses

** : The Regional Regulation of the Province of Jawa Tengah No. 5 of 2012 on Wastewater Quality Standards for Industrial Activities and Other Businesses.

(grey shading): marks the parameter that has exceeded the quality standard

During field observations, the leachate found in GTDS was physically dark brown and had a strong odor. The waste in GTDS was composed of 65% organic waste and 35% inorganic waste. Most of them came from households, industries, and markets. The dominance of organic waste was believed to be the cause of high COD and BOD in leachate (exceeding the quality standard). COD and BOD indicate the amount of oxygen needed to break down the organic substances contained in the organic waste. High levels of COD and BOD reflect a sizable proportion of microorganisms in water.

When present in a large number, the amount of oxygen needed to decompose organic matter increases, creating an anaerobic state (lack of oxygen). This state provides a suitable environment for the degradation of organic materials and, consequently, produces the odors in waste disposal sites. Microorganisms that are commonly found in domestic waste are from the group of coliform bacteria. In other terms, leachate contains excessive total coliform.

High cadmium (Cd) levels that exceed the quality standard are associated with the presence of inorganic waste. Inorganic waste in GTDS consisted of, among others, plastic, paper, metal, wood, glass, cloth (textile), and rubber. These waste materials were transported from Purwokerto City and its surroundings. However, there was no further information on whether or not these materials had been treated before their disposal to GTDS. Most importantly, the refuse and other discarded matters in GDTS were piled together. Aside from COD-BOD, Cd, and total coliform, inorganic and organic waste can also cause high levels of TDS in leachate. Metallic compounds (e.g., cadmium (Cd) and iron (Fe)) and organic matters (e.g., leaves, vegetable residues, and mud) can affect TDS.

The test results showed that TDS, cadmium, COD, BOD, and total coliform in leachate were above their acceptable levels. In other words, if leachate manages to seep into the ground, it will most likely deteriorate groundwater quality. At the same time, GTDS only uses an open-dumping system without installing impermeable layers underneath the waste piles, exposing the groundwater to contamination.

3.2. Groundwater Quality

wells. The parameters used in groundwater quality assessment included physical properties (consisting of turbidity, and TDS), chemical properties (i.e., COD, BOD, iron (Fe), cadmium (Cd), and pH), and one biological property, namely total coliform. The parameters that had exceeded the quality standards were pH (in wells 5, 6, 13, and 15), Cd (in wells 5, 6, and 16), BOD (in wells 1, 2, 5, and 6), and COD. As for iron (Fe), the test revealed that this component was within the quality standard, indicating the absence of contamination from GTDS and the leachate it produces. Iron (Fe) can exist in high concentrations due to the conditions of the well, including the subsurface rocks and soil. The same case applies to pH. The average depth of dug wells was <30 meters so that the groundwater was relatively close to the soil surface wherein the fermentation of organic materials such as leaves, carcasses, or plants takes place and leads to lowered water pH. The groundwater quality test results are presented in Table 2.

Table 2. The Groundwater Quality Test Results in the Study Area

No.	Parameters	Units	Well 1	Well 2	Well 5	Well 6	Well 13	Well 14	Well 15	Max. Level*
Physical Parameters										
1	Turbidity	NTU	0.96	4.26	12.3	4.45	24.7	3.4	1.21	5
2	TDS	mg/L	179	111	63	120	63	205	57	1000
Chemical Parameters										
3	pH	-	6	6	5	5	5	6	5	6 – 9
4	Iron (Fe)	mg/L	0.74	0.72	1.25	0.8	1.08	0.06	0.5	0.3
5	Cadmium (Cd)	mg/L	0.002	0.001	0.013	0.02	0.01	0.01	0.015	0.01
6	COD	mg/L	78	66	40	10.6	70	62	70	10
7	BOD	mg/L	3.84	3.22	2.72	3.9	2	1.06	2	2
Biological Parameter										
8	*Total coliform*	-	≥2400	≥2400	≥2400	≥2400	≥2400	≥2400	≥2400	1000

(Source: Office of PIPBPJK Yogyakarta and the Environmental Laboratory of the Faculty of Biology UNSOED 2018)
Where,
* : The Governmental Regulation No. 82 of 2001 on Water Quality Management and Water Pollution Control
: marks the parameter that has exceeded the quality standards
S1 : Well 1

Groundwater pollution in the study area depends on the distance of sampled wells to GTDS and groundwater flow direction, as seen in the distribution of cadmium (Cd). Cadmium (Cd) was found the highest in well 6 (i.e., 0.02 mg/L), and its levels decreased from 0.013 to 0.001 mg/L in wells 5, 14, and 2. As a conclusion, the farther the distance to GTDS, the lower the cadmium level present in the well.

Cadmium (Cd) is one of the parameters used to determine the distribution pattern of pollution by leachate. COD, BOD, and total coliform are not directly used to identify the distribution pattern of pollution by leachate because these three parameters are general indicators of pollutants originating in waste materials that are generated by the activities on the surface, for example, sanitation (domestic waste), fertilizer application, and animal husbandry. Moreover, cadmium is one of the heavy metals potentially release from the leachate to groundwater (Ardani et al., 2015; Aziz et al., 2013; Badr and Agrama, 2011; Przydatek and Kanownik, 2019; Wahyuning and Muryani, 2018)

According to Table 2, all laboratory test results of the groundwater quality are described below.

3.2.1 Turbidity

Turbidity describes the optical properties of water according to the amount of light absorbed and emitted by materials contained in a body of water. High turbidity can disrupt osmoregulation, e.g., difficulty in breathing and low visibility in aquatic organisms, and inhibit the penetration of light into the water column. Furthermore, it can complicate filtering activity and reduce the effectiveness of disinfection in the water purification process (Oyiboka, 2014)

Suspended materials in the form of colloids and fine particles are the cause of turbidity in many water bodies. As shown in Fig. 1a, the turbidity levels of two out of the seven samples had exceeded the quality standard (> 5 NTU), namely well 13 (24.7 NTU) and well 5 (12.3). The highest turbidity was found in well 13 (24.7 NTU), while the lowest one was in well 1 (0.96 NTU).

These figures prove that turbidity is not correlated with the distance of the well to GTDS. Instead, it is influenced by the surrounding environment, such as the presence of suspended fine matters (mud), microorganisms like plankton, and colloidal substances derived from extracted plant leaves that make waters cloudy or opaque.

3.2.2 Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) measure the presence of dissolved matters (diameter <10-6 mm) and colloids (d= 10^{-6} - 10^{-3} mm) in the form of chemical compounds and other materials. The laboratory tests revealed that the TDS in the study area ranged between 57 mg/L and 205 mg/L. The highest TDS, 205 mg/L, was identified in well 14, while the lowest (57 mg/L) was in well 15. According to the quality standard, the TDS values of the eight groundwater samples were acceptable (i.e., <1000 mg/L), as shown in Fig. 1b.

TDS refers to any inorganic materials in the form of ions that are commonly dissolved in water. It is strongly affected by rock weathering, runoff on the soil surface, and anthropogenic activities that generate domestic and industrial waste.

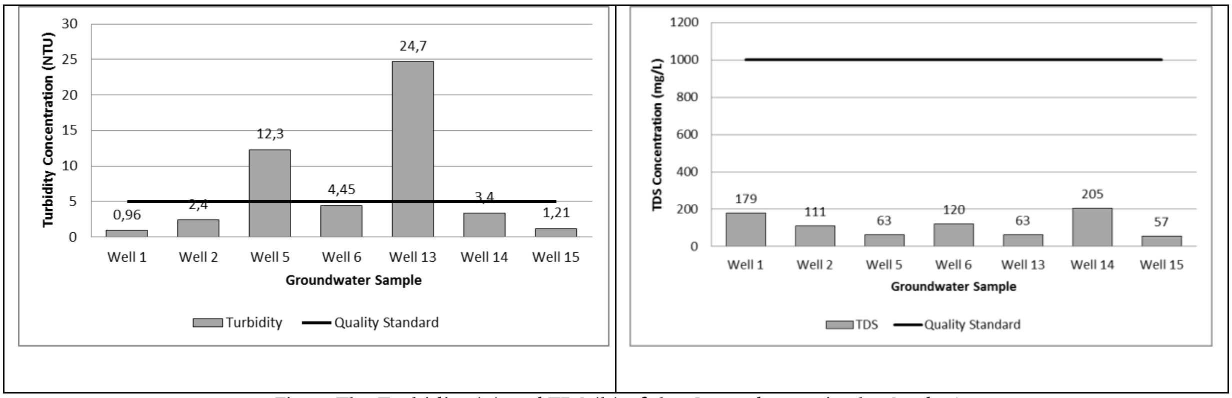

Fig. 1. The Turbidity (a) and TDS (b) of the Groundwater in the Study Area

3.2.3 pH

pH is a quantitative measure of hydrogen ion concentrations in water. It depends on the content of waste materials, both organic and inorganic, and gas emissions from acid rain. A higher pH value means higher alkalinity and lower free carbon dioxide content. Acidic solutions (low pH) are corrosive (Oyiboka, 2014).

Measurements in the field showed that the pH values of the groundwater samples were in the range of 5-6, as depicted in Fig. 2a. The pH levels of wells 5, 6, 13, and 15 were 5 or below the quality standard (6-9). In this case, distance to GTDS does not influence groundwater pH. Furthermore, based on the pH values, the leachate is categorically within the quality standard, meaning that it does not affect the acidity or alkalinity of the groundwater in the surrounding wells. In well water, low pH is associated with environmental conditions, such as the fermentation of organic matters like leaves, carcasses, and plants, which causes a decrease in water pH.

3.2.4 Iron

As presented in Fig. 2b, the water quality test results showed iron (Fe) contents between 0.06 and 1.25 mg/L. The highest iron (Fe) concentration was detected in well 5 (1.25 mg/L), while the lowest was in well 14 (0.06 mg/L). All groundwater samples contained iron (Fe) levels that had exceeded the quality standard (> 0.3 mg/L), except for well 14. Iron is the heavy metal that potentially release form the leachate as also found in (Aziz et al., 2013) especially from the mature landfill area.

Even though the iron (Fe) level of the leachate is still within the quality standard, it can cause high levels of iron (Fe) in groundwater. In this case, the leachate contained 3.3 mg/L of iron (Fe). At this level, the iron (Fe) in the leachate can contaminate the environment. Aside from the leachate, the high iron (Fe) concentrations detected in water are believed to originate in deep groundwater with anaerobic state or the bottom layers of waters that no longer contain oxygen . The presence of iron (Fe) in groundwater is also influenced by the surrounding environment (rock and soil conditions).

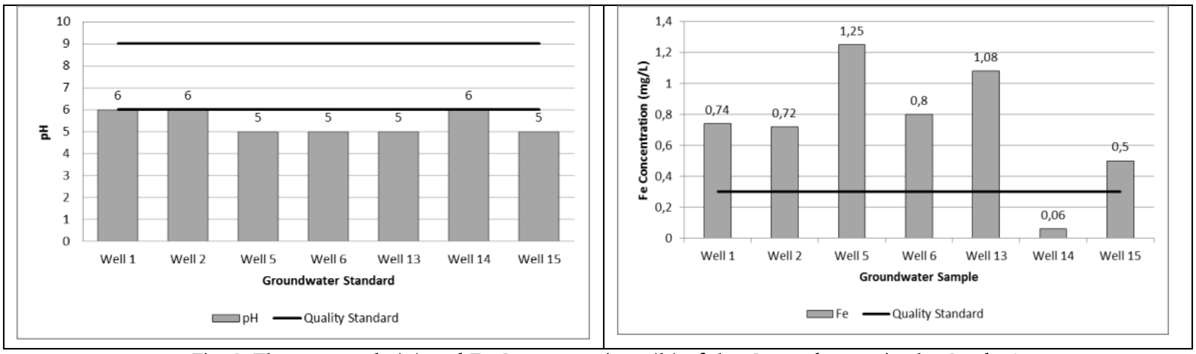

Fig. 2. The pH Levels (a) and Fe Concentrations (b) of the Groundwater in the Study Area

3.2.5 Biochemical Oxygen Demand (BOD)

BOD represents the composition of organic matters in a body of water based on the amount of oxygen needed by aerobic microbes to oxidize organic matters into carbon dioxide and water (Widodo et al., 2019). BOD refers to the weight of organic materials that are biologically degraded and the amount of oxygen used to oxidize inorganic materials. High BOD signifies a body of water that is rich in organic materials that can provide a substrate for microorganisms. It also leads to the reduction of dissolved oxygen (Wahyuning and Muryani, 2018; Widodo et al., 2019).

As presented in Fig. 3a, the water quality test results showed that BOD was in the range of 1.06-3.9 mg/L. The highest BOD, 3.09 mg/L, was identified in well 6, while the lowest (1.06 mg/L) was in well 14. The BOD of all groundwater samples had exceeded the quality standard (> 2 mg/L), except for well 6.

These high levels of BOD did not come from the leachate in GTDS but the surrounding environment. Most residents in the study area withdraw groundwater from wells to carry out their daily activities, e.g., washing clothes and household appliances. Usually, these activities take place around the well and, therefore, the waste is discarded close to it. The majority of household waste contains organic matters that can affect the levels of BOD in water.

3.2.6 Chemical Oxygen Demand (COD)

COD quantifies the oxygen levels needed for the oxidation of chemicals in waste materials (Hidayat, 2016). COD is the amount of oxygen that can be consumed by a chemical oxidation process. COD will always be higher than BOD because most compounds are more prone to chemical rather than biological oxidation (Widodo et al., 2019).

As depicted in Figure 3b, the water quality test results showed that the COD varied between 10.6 mg/L and 78 mg/L. The highest COD was found in well 1, whereas the lowest was in well 6. In all seven groundwater samples, the COD had exceeded the quality standard (> 10 mg/L). Similar to BOD, COD levels are not influenced by the leachate coming from GTDS but, instead, the environment around the well. Domestic waste can affect COD levels because it contains organic matters.

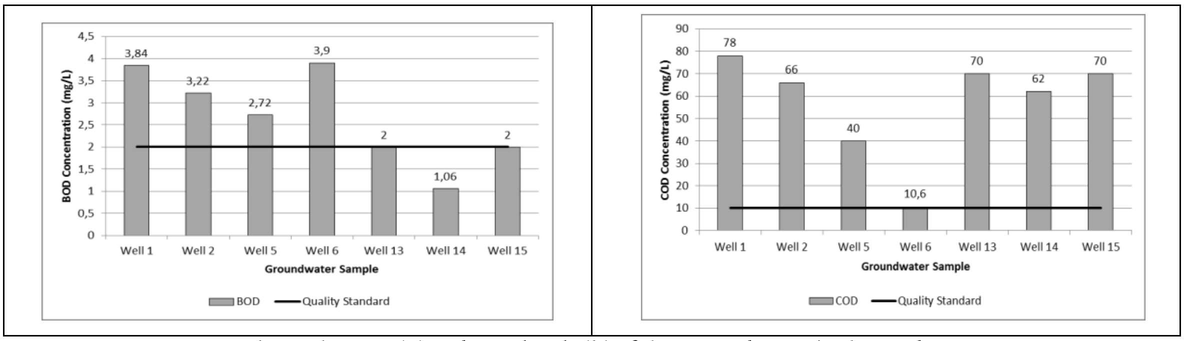

Fig. 3. The BOD (a) and COD levels (b) of the Groundwater in the Study Area

3.2.7 Cadmium (Cd)

In the environmental strata, cadmium (Cd) and its compounds are found in many layers. Other than in wastewater, this metal is common in areas in and around landfills and rainwater flows (Aziz et al., 2013).

As illustrated in Fig. 4a, the test results showed that the groundwater samples contained cadmium (Cd) in the range of 0.001-0.02 mg/L. The highest cadmium (Cd) was detected in well 6, while the lowest was in well 2. In some of the tested water samples, the cadmium (Cd) levels had exceeded a maximum threshold of 0.01 mg/L. These samples were collected from well 5 (0.013 mg/L), well 6 (0.02 mg/L), and well 15 (0.015 mg/L).

Cadmium (Cd) levels are negatively correlated with distance to GTDS, and its distribution is affected by the direction of groundwater flow. The highest cadmium (Cd) concentration was found in well 6 (i.e., 0.02 mg/L), and it dropped from 0.013 to 0.001 mg/L in wells 5, 14, and 2. As a conclusion, the cadmium decreases in line with the increase in distance to GDTS and the direction of the groundwater flow.

3.2.8 Total Coliform

Based on the water quality test results, the total coliform in the seven water samples was averagely ≥ 2400 per 100 mL sample (see Fig. 4b). These figures indicate that the total coliform in the observed groundwater had exceeded the quality standard (1000/100 mL sample).

High total coliform in well water is not affected by leachate from GTDS, which is close to the settlement areas. This condition is contrary to cadmium (Cd), which was found to be above its acceptable concentration in some wells (> 0.01 mg/L) and threaten the groundwater quality. These findings are in line with Ariyanti (2017), which has identified the presence of lead (Pb) in an excessive number—i.e., above the maximum threshold of 0.03 mg/L—around the Putri Cempo Disposal Site in Surakarta. Mustikasari (2018) has found that the groundwater quality in a textile industrial complex in Sragen Regency is categorically poor due to the waste generated by the industry. At some of the groundwater well points, copper (Cu) levels have exceeded the quality standard (> 2 mg/L). Also, in 11 of the 12 groundwater samples, the phosphate content is above its allowable presence (> 0.2 mg/L)

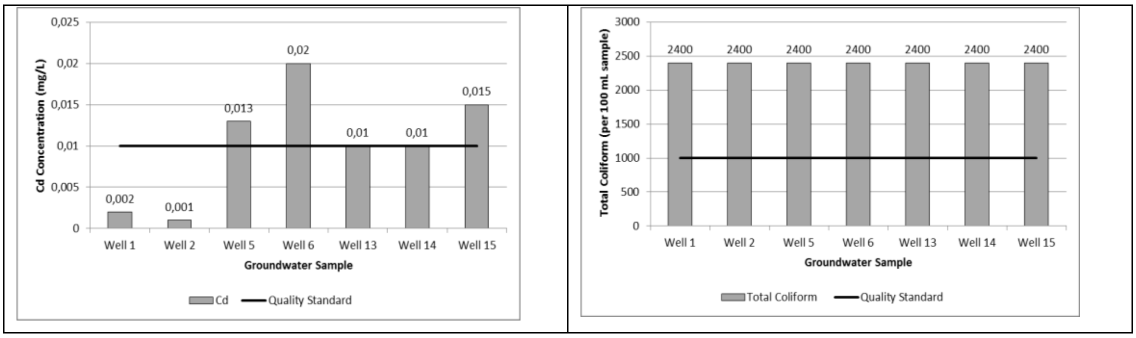

Fig. 4. The Cd Concentrations (a) and Total Coliform (b) of the Groundwater in the Study Area

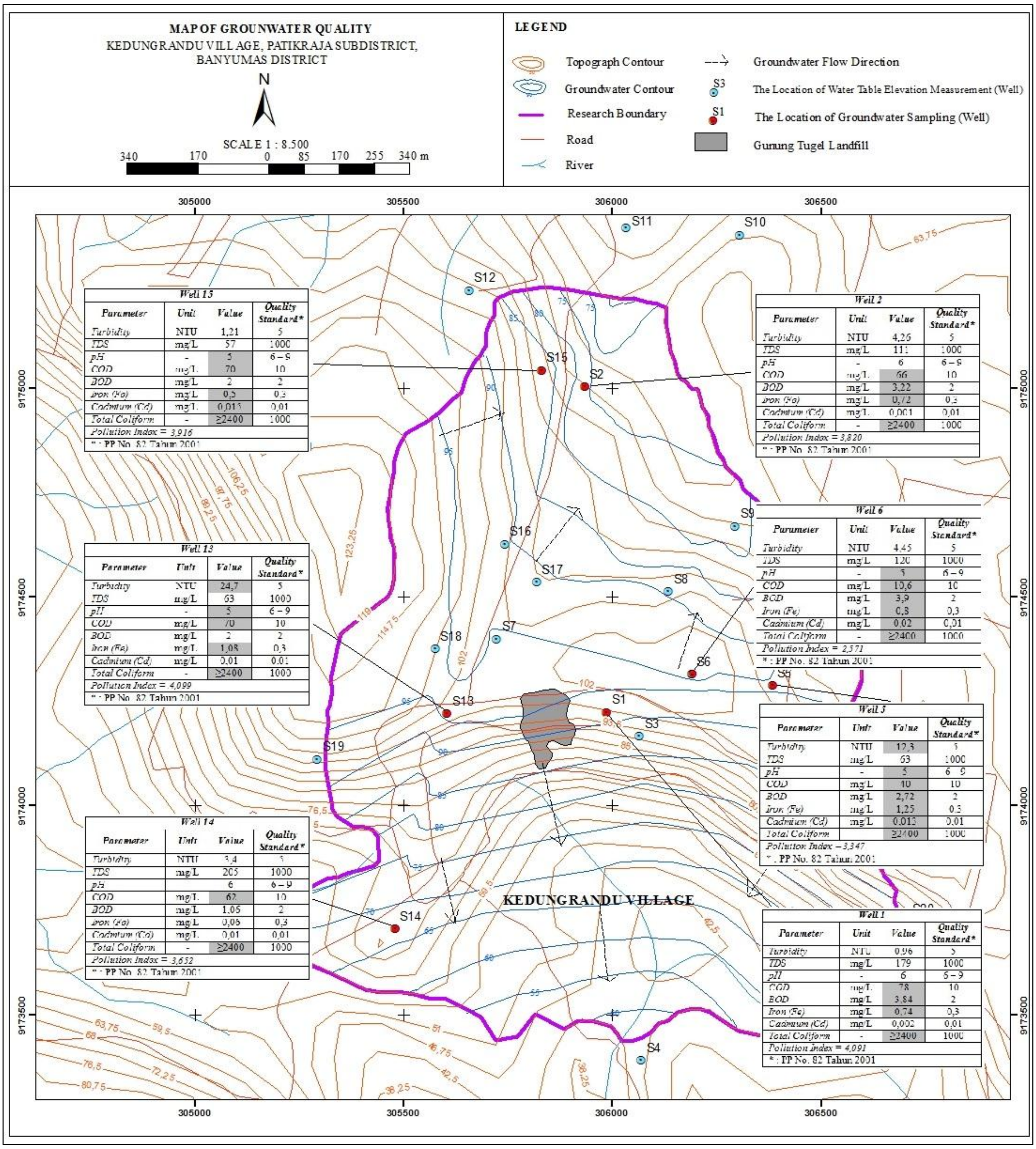

Fig. 5. Water Quality Map

Fig. 5 shows the map of the groundwater quality around GTDS. The environment has been proven to be the strongest determinant of groundwater quality at the research site. In this study, GTDS, which is located close to residential areas, increases some groundwater quality parameters up to the points where they have exceeded the quality standards, especially cadmium (>0.01 mg/L). These findings are in line with Ariyanti (2017), which has identified the presence of lead (Pb) in an excessive number—i.e., above the maximum threshold of 0.03 mg/L—around the Putri Cempo Disposal Site in Surakarta.

The status of the groundwater pollution was determined using the pollution index. This index categorizes groundwater into polluted or not polluted. Based on the pollution index, the groundwater in the study area was classified into mildly polluted, with PIJ values ranging between 2.571 and 4.099. The highest pollution index (4.099) was detected at well 1, with Fe, COD, BOD, and total coliform as the parameters that had exceeded the quality standards. Meanwhile, the lowest pollution index (2.571) was found at well 6, with pH, Fe, Cd, BOD, COD, and total coliform as the parameters that had exceeded the quality standards. The pollution index and groundwater quality status are listed in Table 3.

Table 3. Groundwater Quality Status

Wells	PI_j Values	Notes
1	4.091	mildly polluted
2	3.820	mildly polluted
5	3.347	mildly polluted
6	2.571	mildly polluted
13	4.099	mildly polluted
14	3.652	mildly polluted
15	3.916	mildly polluted

Where,
PI_j = pollution index

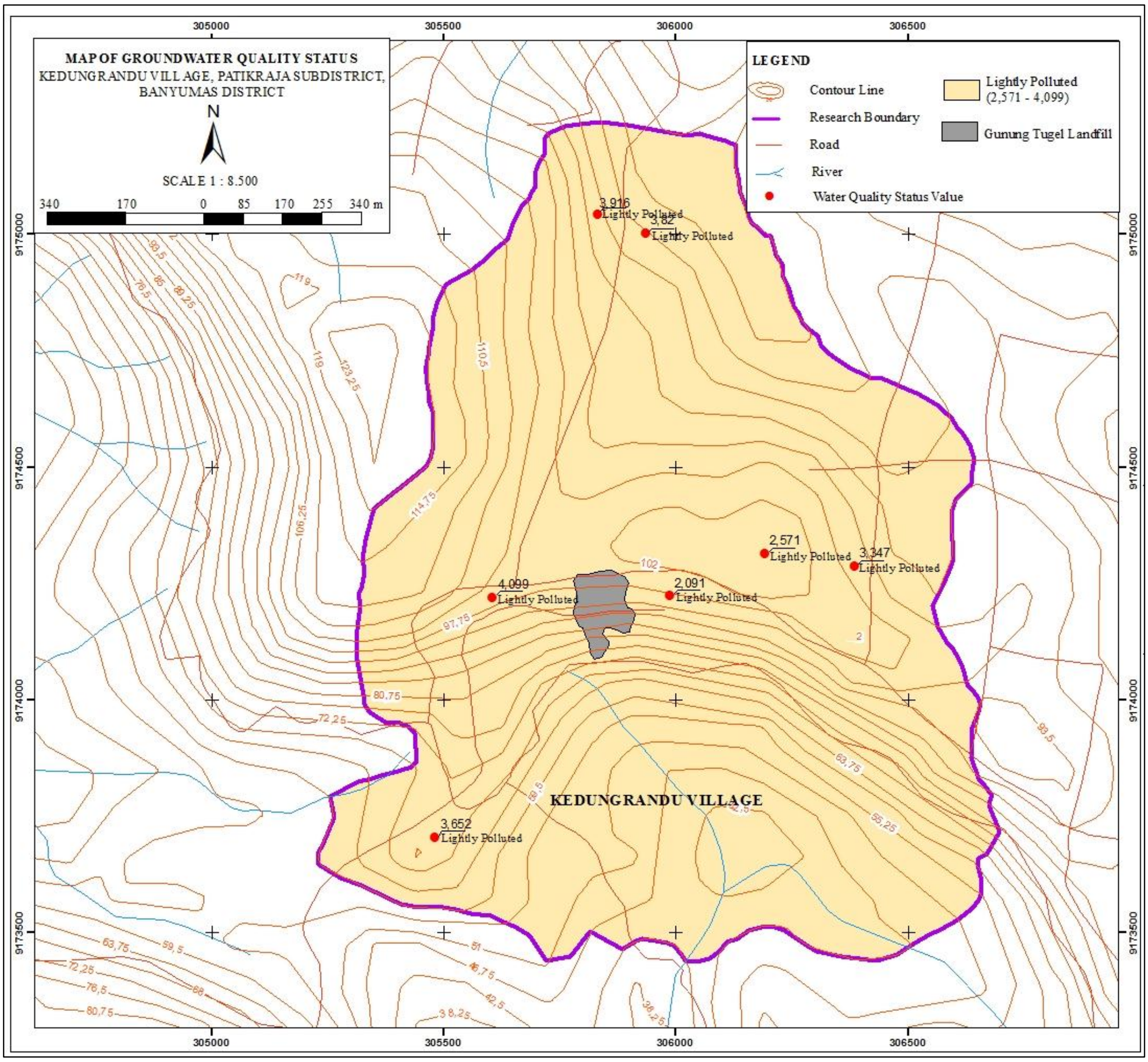

Fig. 6. Map of Groundwater Pollution Level

Fig. 6 shows the map of the groundwater pollution level. According to the pollution index, the groundwater in the study area is mildly polluted even though, in some of the sampled wells, many parameters have exceeded the quality standards. The difference between the parameter values and the quality standards also affects the groundwater quality status. For instance, if the range of the parameter values is not significantly different or far from the quality standard, then the groundwater quality status is perceived as better (not polluted). Research conducted by (Wahyuning and Muryani, 2018) categorized the groundwater quality around the Jetis Disposal Site in Purworejo into mildly polluted because two of the eight parameters tested have exceeded their allowable levels, namely BOD and COD.

The pollution index has been widely used to determine water quality status (heavily polluted, moderately polluted, mildly polluted, and within the quality standards). Nevertheless, analyzing groundwater quality using this index has a disadvantage. It only calculates single data without classifying the calculated parameter. Therefore, every water quality parameter is considered as having equal weight, e.g., whether it is heavy metal or organic matter. It disregards the fact that every parameter has a different impact on the environment. As a result, the data often insufficiently represent the actual water quality because this method only takes into account the severity level of pollution.

4. Conclusions

a) The leachate water quality in Gunung Tegal Disposal Site is composed of turbidity= 457.5 NTU, TDS= 2205 mg/L, iron (Fe)= 3.3 mg/L, cadmium (Cd)= 0.06 mg/L, COD= 1278 mg/L, BOD= 355.24 mg/L, and total coliform ≥2400. Except for iron (Fe), six of the seven parameters tested in the study have exceeded the wastewater quality standards. These standards are the Regulation of Minister of Environment and Forestry No. 59 of 2016 on Leachate Quality Standards for Waste Treatment Activities and/or Businesses and the Regional Regulation of the Province of Jawa Tengah No. 5 of 2012 on Wastewater Quality Standards for Industrial Activities and Other Business Activities.

b) In several groundwater wells, the cadmium (Cd) level has exceeded its allowable presence. Cd is a dangerous heavy metal. The total coliform in all wells has exceeded the quality standard, whereas the total dissolved solids (TDS) in all wells are still within the acceptable levels. At some of the wells, the turbidity, pH, iron (Fe), BOD, and COD levels are above their maximum thresholds.

c) The groundwater pollution level in the study area is relatively mildly polluted, as evidenced by the pollution index that ranges between 2.571 and 4.099.

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