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Analysis of Family Health Problems Related to Groundwater Use around the Kebon Kongok Landfill, Lombok: A Cross-sectional Study

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ABSTRACT

Introduction: The presence of landfills can threaten groundwater quality because the decomposition process of waste containing hazardous chemicals can cause surrounding groundwater pollution. As the amount of waste increases, the risk of environmental pollution around the landfill also increases, especially to groundwater sources used by the local community. The study aims to analyze family health problems related to the use of groundwater located near landfills.

Methods: The study used a cross-sectional design around the Kebon Kongok landfill, West Lombok, West Nusa Tenggara (WNT), Indonesia. The sample amounted to 300 respondents who met the inclusion criteria. Data analysis was performed descriptively, chi-square test, and binary logistic regression by analyzing the adjusted odds ratio (AOR) results, p-value <0.05, and 95% confidence interval.

Results: 164 respondents (54.7%) used well water for their daily needs. The results of the study based on binary logistic regression tests showed a significant relationship between history of diarrhea in children (p=0.002; AOR=3.65), nutritional status of the child (p=0.001; AOR=3.95), maternal history of fetal miscarriage (p<0.001; AOR=4.08), family history of skin disease (p=0.010; AOR=2.75), family history of ARI (p=0.011; AOR=2.72), disability status in the family (p<0.001; AOR=4.10), family history of chronic disease (p<0.001; AOR=4.79), history of mother giving birth to a low birth weight (LBW) infant (p=0.003; AOR: 2.97), and history of mother giving birth to a premature infant (p=0.009; AOR=2.64) with the use of groundwater in families around the landfill.

Conclusions: Groundwater use near contaminated waste disposal sites is closely related to family health issues related to diarrhea, nutritional status, fetal miscarriage, skin diseases, ARI, disability, chronic diseases, LBW, and history of mother giving birth to a premature infant. This indicates the need for significant health and environmental interventions to protect surrounding communities from the health risks of using polluted groundwater.

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INTRODUCTION

Environmental problems caused by solid waste were increasing along with population growth, and growing human activities. One common way to deal with solid waste is to collect it in landfills (1). Landfills serve as a waste management area that aims to accommodate waste generated by the community. However, despite its important function, the existence of landfills often causes various problems, especially related to environmental impacts and the health of the surrounding communities (2). Landfills are a critical infrastructure in urban waste management. However, its existence often brings negative impacts to the environment and the health of the surrounding communities (3). The presence of landfills can threaten groundwater quality because the decomposition process of waste containing hazardous chemicals can cause groundwater pollution in the vicinity (4). This pollution can cause various health problems for people who rely on the groundwater for their daily needs (5).

One of the main negative impacts of landfills is groundwater pollution. Groundwater around landfills is susceptible to contamination by leachate, a liquid formed from the decomposition of waste and the percolation of rainwater through waste piles (6). Leachate often contains a variety of harmful chemicals, including heavy metals, organic compounds, and pathogenic microorganisms (7). Groundwater pollution by leachate can damage water quality and have a direct impact on the health of people who rely on groundwater as their main source of water (8). Groundwater is the main source of clean water supply for people living around the Kebon Kongok landfill. The use of groundwater polluted by waste from the landfill can have serious health impacts, especially if the water is used for daily needs such as cooking, drinking and bathing (9). Groundwater pollution is often caused by leachate seepage from waste piles in landfills (6). Leachate can contain various toxic substances such as heavy metals, pathogenic bacteria, and other harmful chemical compounds that can trigger health problems in humans (10).

Several previous studies have shown that people living around landfills have a higher risk of health problems, such as respiratory infections, skin diseases, digestive disorders, and more serious diseases such as cancer due to long-term exposure to toxic substances (11). Therefore, it is very important to analyze the health problems of groundwater users around the landfill. The study aims to understand the extent of the impact of groundwater pollution on public health, as well as to provide policy recommendations for better landfill management and health risk reduction for residents (12).

The results of a study conducted by Alao et al. (2023) showed that the potential of Hydrogen (pH) of borehole water tends to be more stable and within the safe range for consumption (pH 6.5-8.5). This is influenced by the depth of the borehole, which is far from the ground surface, so it is less affected by surface pollution (13). Meanwhile, the pH of dug well water varies more widely, especially in areas close to domestic or agricultural activities. Such activities can lower or raise the pH, depending on the type of chemicals or wastes that may seep into the soil and affect the dug well water (6). The total dissolved solids (TDS) value of dug well water is generally higher than that of borehole water. This is due to the nature of dug well water which is more susceptible to infiltration from the surrounding environment, including organic and inorganic materials from the ground surface. High TDS can potentially make water taste bad or even be dangerous, as it indicates high levels of dissolved substances that may come from contamination (14).

The content of heavy metals such as iron (Fe) and manganese (Mn) tends to be higher in dug well water compared to boreholes. Factors such as shallow depth and proximity to surface pollution sources of domestic waste can lead to high concentrations of heavy metals in dug wells (15). Long-term consumption of heavy metals can cause various health problems, such as kidney, liver and developmental disorders in children. At several sampling points, Pb concentrations exceeding the threshold were found in dug well water, especially in areas with industrial or urban activities (16). Heavy metals are very dangerous, especially for pregnant women and children, as they can cause fetal, brain, and intellectual developmental disorders (17).

Dug well water shows higher levels of Escherichia coli contamination than borehole water. Such contamination often occurs due to the proximity of dug wells to sources of human or animal waste (7). E. coli is an indicator of fecal contamination, indicating that the water is unsafe for consumption without further treatment. Consumption of water contaminated with E. coli can cause gastrointestinal illnesses, such as diarrhea, vomiting, and even severe dehydration, especially in children and the elderly with weakened immune systems (5).

Consumption of water contaminated with pathogenic bacteria increases the risk of gastrointestinal diseases in the community. This is a significant health concern, especially in rural areas where dug well water is widely used

as the main source of drinking water (8). Dug well water containing heavy metals has the potential to cause metal accumulation in the human body. Long-term exposure to heavy metals such as lead and manganese can result in kidney damage, nervous system damage, and developmental disorders in children (18). Water used for bathing or washing from contaminated dug wells also has the potential to cause skin infections and other disorders such as dermatitis. These infections can arise due to high levels of bacterial or heavy metal contamination in the water (12).

Kebon Kongok Landfill, located in the West Lombok District of West Nusa Tenggara (WNT), Indonesia, serves as a processing site for waste from various regions, including dense urban areas. As the amount of waste increases, the risk of environmental pollution around the landfill also increases, especially to groundwater sources used by the local community. No studies have been conducted on the use of groundwater in relation to the health of families living near the Kebon Kongok landfill, making this study very important as a health promotion effort for communities living near the landfill. It is important to conduct studies on health issues among groundwater users around landfills in order to identify health effects caused by pollution. Using this method, it is hoped that this study can provide a clear picture of the relationship between health and groundwater use around landfills. This study aims to analyze the health conditions of groundwater users around landfills.

METHODS

Study Design

The study used an observational study with a cross-sectional design. This design allows researchers to measure the association between exposure to polluted groundwater and community health conditions at one point in time. With this design, researchers can describe health conditions in groundwater users. The study was conducted around the Kebon Kongok landfill in West Lombok, NTB, Indonesia from January to August 2024. The population in the study amounted to 650 people. The number of samples was determined using Sample Size Determination in Health Studies: A Practical Manual version 2.0 software with a 95% confidence level and a 5% margin of error. The sampling technique used is simple random sampling to ensure that the selected subjects are in accordance with the inclusion and exclusion criteria of the study, totaling 300 respondents.

The study subjects were people living around the landfill with the following inclusion criteria: Respondents who live within ≤ 500 m from the landfill site. This distance was based on the possibility of groundwater contamination due to waste percolation. Residents who routinely use groundwater (wells and boreholes) as the main source of water for daily purposes (drinking, bathing, washing and others). Respondents aged ≥ 18 years who can independently provide information related to health conditions and water use. Residents who have lived in the area around the landfill for at least 1 year, to see if there are long-term effects of exposure to groundwater quality. Respondents who are willing to sign an informed consent to participate in this study. The exclusion criteria were as follows: Residents who use water from the regional drinking water company (RDWC) or bottled water sources as the main source of water, as they are not directly affected by groundwater quality around the landfill. Respondents who have lived in the area for less than 1 year, as exposure to groundwater quality may not yet be significant enough to affect health. Residents who refused to participate in the study or were not willing to sign the informed consent.

Variables

Groundwater users were categorized into two, namely the use of dug wells and boreholes. Well water use is defined as the use of well water in this study of community activities that draw water from dug wells with a depth of 8 meters. The use of borehole water is defined as the activity of taking water from wells made by drilling methods using drilling equipment with a depth of more than 30 meters. History of diarrhea in children is a condition that indicates whether a child has or has not experienced diarrhea in the last six months. Diarrhea is defined as defecation with a liquid consistency three or more times a day.

Children's nutritional status is a condition that shows the balance between nutrient intake and the needs of the child's body, which can be measured through anthropometric indicators, namely the body mass index (BMI) of children according to age. Malnutrition if BMI/age is below -3 Standard Deviation (SD) and good nutrition if BMI/age is within the range of -2 SD to +1 SD (19). Maternal history of fetal miscarriage is information regarding the experience of mothers who have or have not lost a pregnancy before the fetal age reaches 20 weeks of gestation. Miscarriage is defined as the spontaneous, non-medical termination of pregnancy, resulting in fetal loss.

Family history of skin disease is a record of immediate family members who have or have not had a diagnosed skin disease, such as dermatitis, psoriasis, eczema, or other skin infection. Family history of acute respiratory infection (ARI) is a record of whether or not a nuclear family member has had an ARI, such as flu, bronchitis, pneumonia, or laryngitis, in the past 6 months. Disability status in the family is a record of whether or not a nuclear family member has a physical or mental disability that has an impact on daily functioning in the long term or permanently.

Family history of chronic illness is a record of an immediate family member who has or has not had a chronic disease (diabetes, hypertension, heart disease, asthma, or cancer) in the past 6 months and requires long-term treatment or special management. A history of low birth weight (LBW) is a record of a baby being born in a family with a birth weight of less than 2.500 grams, whether the baby was born prematurely or full-term. Maternal history of preterm delivery is a record of a mother's experience of delivering a baby before 37 weeks of gestation, either in one or more previous pregnancies.

Data Collection

Primary data was collected through a survey using a structured questionnaire that included questions on the respondents' history of health problems, as well as their use of groundwater. The questionnaire was designed according to the needs of the study. Instrument reliability was tested using Cronbach's Alpha to ensure consistency of the instrument with a result of 0.778 or 78%. Based on this value, the questionnaire used in the study was reliable. According to Pallant (2020), a questionnaire is suitable for use if the percentage is 70% (20). Direct observation was carried out to determine the environmental conditions around the landfill, especially those related to potential sources of groundwater pollution.

Data Analysis

Data obtained from the survey results and water sample testing were analyzed quantitatively using statistical package for the social sciences (SPSS) version 26. Descriptive analysis was conducted to describe the characteristics of respondents, as well as the prevalence of well water users, and health problems in the community living around the landfill. Correlation tests were conducted to describe the relationship between the use of dug well water and borehole water with health problems in the community analyzed by the Chi-square test and binary logistic regression by analyzing the results of the adjusted odds ratio (AOR), significant level of p-value <0.05, and 95% confidence interval.

Ethical Approval

The study prioritized research ethics by maintaining the confidentiality of respondents' data, providing an explanation of the objectives and procedures of the study to each participant, and ensuring informed consent from each participating respondent. The study was approved by the Medical and Health Research Ethics Committee (MHREC), Politeknik Medica Farma Husada Mataram, Indonesia with Number: 39/MHREC/2024.

RESULTS

The total sample used in this study amounted to 300 respondents. The results of the frequency distribution in Table 1 show that many people still use ordinary well water with 54.7% of the respondents using it. In addition, many people still have health problems related to the use of groundwater, namely, the incidence of diarrhea in children (62.7%), poor nutritional status in children (56%), and the incidence of mothers who have had miscarriages (51%). Other health problems were also found in the community around the Kebon Kongok landfill, namely the incidence of skin diseases that occurred (63.3%), the incidence of ARI (42.7%), and there were families with disability status (46.3%).

People living around the landfill still experience many health problems, namely the incidence of chronic diseases (48.7%), the incidence of mothers who give birth to babies with LBW (49%), and the incidence of mothers who give birth prematurely amounted to 50.7% (Table 1). Table 2 explains that the use of groundwater is associated with the incidence of diarrhea in children, nutritional status in children, the incidence of miscarriages, the incidence

of skin diseases, the incidence of ARI, disability status, the incidence of chronic diseases, the incidence of mothers who give birth to babies with LBW and mothers who give birth prematurely with a p-value <0.001.

Table 1. Frequency distribution of health impacts of groundwater use (n=300)

Variables	Frequency	%
Types of Groundwater Use		
Wells	164	54.7
Boreholes	136	45.3
History of diarrhea in children		
Ever	188	62.7
Never	112	37.3
Nutritional status of the child		
Severe	168	56
Good	132	44
Maternal history of fetal miscarriage		
Ever	153	51
Never	147	49
Family history of skin disease		
Ever	190	63.3
Never	110	36.7
Family history of ARI		
Ever	128	42.7
Never	172	57.3
Disability status in the family		
Yes	139	46.3
No	161	53.7
Family history of chronic disease		
Ever	146	48.7
Never	154	51.3
History of mother giving birth to a LBW infant		
Ever	147	49
Never	153	51
History of mother giving birth to premature		
Ever	152	50.7
Never	148	49.3

Table 2. Results of bivariate analysis related to the association between family health and groundwater use (n=300)

Variables	Types of Groundwater Used		x^2	P Value
	Wells	Boreholes		
	n (%)	n (%)		
History of diarrhea in children				
Ever	134 (71.3)	54 (28.7)	56.06	<0.001*
Never	30 (26.8)	82 (73.2)		
Nutritional status of the child				
Severe	126 (75)	42 (25)	63.70	<0.001*
Good	38 (28.8)	94 (71.2)		
Maternal history of fetal miscarriage				
Ever	113 (73.9)	40 (26.1)	46.40	<0.001*
Never	51 (34.7)	96 (65.3)		
Family history of skin disease				
Ever	126 (66.3)	64 (33.7)	28.38	<0.001*
Never	38 (34.5)	72 (65.5)		

Family history of ARI			67.46	<0.001*
Ever	105 (82)	23 (18)		
Never	59 (34.3)	113 (65.7)		
Disability status in the family			45.53	<0.001*
Yes	105 (75.5)	34 (24.5)		
No	59 (36.6)	102 (63.4)		
Family history of chronic disease			59.297	<0.001*
Ever	113 (77.4)	33 (22.6)		
Never	51 (33.1)	103 (66.9)		
History of mother giving birth to a LBW infant			60.91	<0.001*
Ever	114 (77.6)	33 (22.4)		
Never	50 (32.7)	103 (67.3)		
History of mother giving birth to premature			30.75	<0.001*
Ever	107 (70.4)	45 (29.6)		
Never	57 (38.5)	91 (61.5)		

*p < 0.001. x^2= Chi-square test

There was a significant association between groundwater use and the incidence of diarrhea in children (p=0.002), and AOR: 3.65. The results showed that the use of well water can increase the risk by 3.65 times of experiencing diarrhea in children. There was a significant association between groundwater use and the nutritional status of children (p=0.001), and AOR= 3.95. This indicates that the use of well water can increase the risk of child malnutrition by 3.95 times. In addition, there was a significant association between groundwater use and the incidence of fetal miscarriage in pregnant women (p<0.001), and AOR: 4.08. This indicates that the use of well water can increase the risk of 4.08 times of experiencing fetal miscarriage in pregnant women (Table 3).

The results of the study showed that there was a significant association between groundwater use and the incidence of skin diseases in people living around the landfill (p=0.010), and an AOR: 2.75. This indicates that the use of well water can increase the risk of skin disease by 2.75 times. In addition, there was a significant association between groundwater use and the incidence of ARI (p=0.011), and AOR: 2.72. This can be interpreted as the use of well water can increase the risk by 2.72 times to experience ARI. The study results explained that there was a significant association between groundwater use with the incidence of disability in families using groundwater for daily needs (p<0.001) and an AOR: 4.10. Thus, the use of well water can increase the risk by 4.10 times to suffer from disability in well water users around the landfill (Table 3).

The study results in Table 3 also show that there is a significant association between groundwater use and the incidence of chronic diseases in the community around the landfill (p<0.001) and AOR: 4.79. Based on this, the use of well water can increase the risk by 4.79 times to suffer from chronic diseases in the community around the landfill. There was a significant association between groundwater use and the incidence of LBW in infants living near the landfill (p=0.003) and AOR: 2.97. This indicates that the use of well water can increase the risk by 2.97 times for the incidence of LBW babies. The study results also showed that there was a significant association between groundwater use and the birth of preterm infants living around the landfill (p=0.009) and an AOR: 2.64. Based on this, the use of well water can increase the risk by 2.64 times for the occurrence of preterm infants living around the landfill.

Table 3. Results of binary logistic regression analysis related to the association between family health and groundwater use around landfills (n=300)

Variables	AOR	95% CI	P Value
History of diarrhea in children (ref: never) ever	3.65	1.640 - 8.158	0.002*
Nutritional status of the child (ref: good) severe	3.95	1.787 - 8.739	0.001*
Maternal history of fetal miscarriage (ref: never) ever	4.08	1.924 - 8.657	<0.001**

Family history of skin disease (ref: never) ever	2.75	1.277 - 5.953	0.010*
Family history of ARI (ref: never) ever	2.72	1.258 - 5.880	0.011*
Disability status in the family (ref: no) yes	4.10	1.921 - 8.750	<0.001**
Family history of chronic disease (ref: never) ever	4.79	2.288 - 10.036	<0.001**
History of mother giving birth to a LBW infant (ref: never) ever	2.97	1.436 - 6.155	0.003*
History of mother giving birth to premature (ref: never) ever	2.64	1.275 - 5.497	0.009*

AOR= adjusted odds ratio; 95% CI= 95% confidence interval.
* p< 0.05. ** p < 0.001.

DISCUSSION

The study showed that groundwater users near the landfill were associated with higher odds of diarrhea in children. The findings of this study are in line with an epidemiological study in Sumbawa District, West Nusa Tenggara, Indonesia conducted by Maliga et al. (2022), which revealed that there is a strong correlation between water quality and the risk of diarrheal disease. The study explained that out of 100 case groups of toddlers, 42% who experienced diarrhea in the last two months had unsafe drinking and clean water sources (21). Contaminated groundwater can pose a threat to water quality as many toxins produced by the bacteria pose a major threat to human health that can cause symptoms such as vomiting, diarrhea, and skin irritation (22).

Landfills serve as a shelter for various types of waste, both organic and inorganic waste. Studies conducted in Pakistan by Javaid et al. (2022) explained that organic waste from household waste can produce leachate that has the potential to seep into the soil, especially in areas with poor waste management systems. This liquid contains various pathogenic microorganisms, including Fecal Coliforms and E. coli that can cause intestinal infections (9). Groundwater around the landfill was at high risk of being contaminated with these pathogens, especially in shallow wells, which are often the main source of water for local communities. Children who consume or come into contact with this groundwater are at a higher risk of developing gastrointestinal infections, which are mainly characterized by symptoms of diarrhea (1).

Studies have identified an association between groundwater use and the nutritional status of children living near landfills. Groundwater use in areas close to landfills has the potential to affect children's health and nutritional status, as groundwater in these areas is contaminated with chemical pollutants and pathogenic microorganisms from the waste. The results of this study are supported by a study conducted by Swart et al. (2022) in South Africa, which explained that there is a relationship between exposure to polluted water and impaired nutritional status in children (23). Children living in areas with poor water quality showed higher levels of stunting, wasting, and anemia than children who had access to clean water. This indicates that water quality directly affects nutritional status, especially in areas close to pollution sources such as landfills (8).

A study conducted by Fadili et al. (2024) in Morocco explained that exposure to polluted groundwater around landfills has the potential to increase the incidence of gastrointestinal infections in children. Recurrent diarrhea in children not only causes dehydration but also disrupts the absorption of nutrients that are important for growth. This condition has an associated on the nutritional status of children because the incoming nutrients are not optimally absorbed by the body. This makes children vulnerable to nutritional problems, such as protein energy deficiency (PEM) or even stunting if diarrhea occurs frequently over a long period of time (24). Children who consume contaminated groundwater or use the water for daily needs are at high risk of exposure to parasitic infections that cause anemia and malabsorption of nutrients (9). In addition, children infected with helminth parasites are at greater risk of iron and other essential vitamin deficiencies, contributing to poor nutritional status (25).

The study showed a significant association between groundwater use in the vicinity of the landfill and the increased risk of miscarriage in pregnant women. Previous research in the field of environmental health that has been conducted shows a correlation between exposure to environmental pollutants, especially heavy metals and organic

compounds, with the risk of reproductive disorders and miscarriage. This is due to exposure to toxic chemicals and pathogenic microorganisms derived from waste in landfills, which contaminate groundwater and potentially jeopardize fetal health. Another study conducted stated that women who live near pollution sources, such as landfills, have a higher risk of miscarriage than those who live far from landfills (26).

The results of the study showed an association between the use of groundwater around the landfill and the incidence of skin diseases in the local population. Groundwater in the area around the landfill is contaminated with chemicals and pathogenic microorganisms derived from waste in the landfill, which can cause various skin diseases, especially for people who use the water for their daily needs. Previous studies conducted confirmed the correlation between poor water quality and the risk of skin diseases in communities living near pollution sources, such as landfills. Studies have shown that exposure to chemicals and microorganisms contained in contaminated groundwater is associated with increased incidence of skin infections, irritation, and chronic skin diseases (27).

Direct exposure to heavy metals through the water used for bathing can cause skin reactions such as itching, irritation, rashes, and more serious skin disorders such as dermatitis or skin allergies. Prolonged exposure to heavy metals can also lead to cumulative effects that damage skin tissue, exacerbating the risk of chronic skin diseases (14). Leachate from organic waste in landfills contains ingredients that can damage the skin. The leachate contains chemical compounds that can irritate and disrupt the skin's natural balance. Continuous exposure to groundwater contaminated with leachate can dry the skin, making it cracked and more susceptible to infection. In the long run, this exposure can lead to chronic skin inflammation that is difficult to manage (28). Decomposing organic waste in landfills can produce organic compounds that are pungent and irritating. Volatile compounds such as ammonia and hydrogen sulfide from these wastes have the potential to cause allergic skin reactions when exposed directly or through contaminated water. People who bathe or wash with groundwater exposed to such waste may experience skin reactions such as itching, eczema and allergic rashes (29).

Studies have shown an association between groundwater use around landfills and increased incidence of ARI. Although groundwater is rarely directly associated with ARI, the location of waste disposal sites that pollute the environment causes disturbances in groundwater quality, which in some aspects may increase the risk of respiratory health problems. A study conducted revealed that people who live in areas with environmental pollution, including around landfills, have a higher risk of developing ARI than those who live far from the source of pollution. The risk is higher in vulnerable groups, such as children and the elderly, who are more easily affected by air pollution and pathogens spread in the surrounding environment (30).

The association between groundwater use near landfill sites and ARI incidence is primarily related to indirect health effects from environmental pollution occurring near landfill sites. Another study conducted explained that gases, chemical particles, and pathogenic microorganisms originating from waste in landfills are additional risks that can increase the incidence of ARI in the surrounding population. Landfills have become a gathering place for various types of waste, including domestic and industrial waste containing heavy metals, hazardous chemicals, and pathogenic microorganisms (22). These contaminants can contaminate groundwater and produce toxic gases, such as hydrogen sulfide, methane, and volatile organic compounds (VOCs) that can be released into the air. These gases and chemical compounds can cause respiratory problems for people living near waste disposal sites, especially those who depend on polluted groundwater, and use it for their daily needs (8).

Groundwater use around landfills was significantly associated with potential long-term health risks, including disability. The study as described revealed that groundwater around landfills can be polluted by various hazardous substances derived from domestic, industrial, and medical waste, containing toxic chemicals, heavy metals, and pathogenic microorganisms. Prolonged exposure to these contaminants can cause a variety of health problems, including neurological disorders, physical disabilities, and other chronic health conditions that can potentially lead to disability (7). Another epidemiological study conducted explained that people living in areas with high environmental pollution, such as around landfills, have a higher risk of experiencing health problems that can lead to disability. This risk was especially elevated in children, pregnant women, and the elderly, who are more vulnerable to environmental toxin exposure. Several studies have also confirmed that chronic exposure to pollutants can cause long-term effects that increase the risk of permanent defects in organs (29).

The results of the study indicate that the use of groundwater around the landfill is associated with a history of chronic diseases in families who depend on this water as their main source of daily needs. Studies conducted

explained that waste accumulated in landfills contains various hazardous substances, including heavy metals, toxic chemicals, and pathogenic microorganisms that can contaminate groundwater. Long-term exposure to these contaminants can cause chronic health problems, such as cardiovascular disease, cancer, liver and kidney disorders, and respiratory problems (25). The landfill becomes a disposal site for waste containing heavy metals. When these heavy metals enter the groundwater, residents who use the water are at risk of being exposed to toxins that accumulate in their bodies (28). Studies conducted revealed that continuous exposure to heavy metals can lead to impaired kidney function which can eventually lead to chronic kidney damage. In addition, heavy metals such as lead are known to increase the risk of high blood pressure, which is a major factor in cardiovascular disease and can affect the heart and blood vessels (31).

Studies conducted explained that landfills contain chemicals from various types of industrial and domestic waste that can leach into groundwater, such as pesticides, phthalates ($C_6H_4(CO_2H)_2$), and VOCs. Some of these chemicals are carcinogenic, which can cause genetic mutations that lead to the development of cancer in the human body. Volatile organic compounds exposed through the use of polluted groundwater may increase the risk of cancer, especially cancers of the lungs, gastrointestinal tract, or skin. Exposure to pesticides that settle in groundwater has also been linked to an increased risk of leukemia and lymph cancer, especially in children (32). Pathogenic microorganisms such as bacteria, viruses, and parasites present in landfills seep into groundwater, causing various infectious diseases that have the potential to become chronic. Studies conducted revealed that infection by Helicobacter pylori, which can be found in polluted water, can cause chronic gastric diseases, including gastritis and even gastric cancer. In addition, infection by parasites such as Schistosoma or the protozoan Giardia can cause long-term complications in the digestive system and lead to diseases that are difficult to cure completely (18).

Leachate from landfill waste often contains various organic and inorganic chemicals that are toxic to the liver. If the leachate seeps into groundwater and is used for domestic purposes, these substances can enter the body and accumulate in the liver, increasing the risk of chronic liver diseases such as liver fibrosis, fatty liver or cirrhosis. Long-term liver damage can occur, and long-term accumulation of these harmful chemicals can damage liver cells and cause chronic inflammation (12). Some chemicals in landfills, such as phthalates, bisphenol A (BPA), and other additives, are known endocrine disruptors. These substances can leach into groundwater and when exposed to humans, can disrupt hormone function in the body (33). Such disruptions can lead to insulin resistance, impaired thyroid function, and obesity that can potentially lead to type 2 diabetes. Endocrine system disorders also risk causing reproductive problems in men and women, such as infertility or menstrual cycle disorders, which can interfere with quality of life and long-term health (34).

The study results show that the use of groundwater around landfills that are not properly managed can have a significant association on the health of pregnant women and fetuses, including increasing the risk of LBW babies. Landfills are usually the disposal sites for various types of waste, including household, industrial and medical waste, which contain chemicals, heavy metals and pathogenic microorganisms that have the potential to seep into groundwater. If this polluted groundwater is used by the surrounding community, pregnant women become vulnerable to exposure to harmful substances that can affect fetal development (7).

Studies conducted explained that groundwater around landfills is potentially contaminated with heavy metals such as Pb, Hg, and Cd from waste. These heavy metals can penetrate the placental barrier and affect fetal development. Exposure to heavy metals during pregnancy can disrupt the fetal growth process, causing a decrease in birth weight because heavy metals can inhibit blood flow to the placenta. This causes nutritional disorders in the fetus, resulting in LBW and potential long-term health complications (5). Another study conducted showed that toxic chemicals found in landfills, such as pesticides, phthalates, and VOCs that can seep into groundwater and negatively affect pregnant women and fetuses. These compounds can interfere with pregnant women's metabolism and absorption of nutrients that are important for fetal development, such as iron, folic acid, and other vitamins. As a result, the fetus may not get enough nutrients for optimal growth, which can lead to LBW. Chemicals also have endocrine disruptor effects, which disrupt the balance of hormones essential for fetal development (8).

Another study conducted revealed that heavy metals present in groundwater around landfills can increase the risk of pregnancy complications. Heavy metals can enter the body of pregnant women through the use of polluted groundwater, and have a direct effect on fetal health. High exposure to heavy metals can disrupt fetal growth and accelerate labor, increasing the risk of premature birth. Such exposure can trigger hypertension in the mother, which

is one of the main risk factors for preterm birth (18). Toxic chemicals are found in many wastes in landfills. Chemicals can contaminate groundwater and enter the bodies of pregnant women, disrupting metabolic and hormonal health (35). Chemicals that are teratogenic or interfere with fetal development, which can induce premature birth. VOC compounds and pesticides inhaled or absorbed by pregnant women can trigger the body's inflammatory response that triggers preterm birth (7).

Cross-sectional research designs only describe relationships at a single point in time, so they cannot confirm a causal relationship between groundwater exposure and health problems. Public health data is mostly collected through interviews and questionnaires, which can potentially lead to recall bias. In addition, limited access to comprehensive groundwater quality data from relevant agencies can limit the depth of analysis. Longitudinal studies are needed to understand the effects of chronic use of contaminated groundwater from landfills on public health. This study could include continuous monitoring of public health over a period of time to detect diseases that develop due to exposure to contaminated groundwater. Mapping groundwater quality and disease incidence around the landfill could help determine areas of highest health risk. The use of Geographic Information System (GIS) technology for spatial analysis can map the distribution patterns of contaminants in groundwater and identify the most vulnerable populations. Further research is needed to find effective, and affordable groundwater treatment or filtration methods, especially for communities around landfills that rely on groundwater as a primary source. This method should be able to remove specific contaminants that are commonly found in the area around the landfill. The study did not account for potential confounding factors such as hygiene habits, alternative water sources, socioeconomic status, and household sanitation factors that cannot be fully controlled in the analysis, which may affect the results of the study.

CONCLUSIONS

Studies show that the use of groundwater around landfills can pose various health risks to the community, especially those living in nearby areas. This is because groundwater in the area around the landfill is at high risk of being contaminated with toxic substances, pathogens and heavy metals due to poorly managed waste seepage. The use of contaminated groundwater can result in a number of health problems in the communities living around the landfill such as diarrhea, malnutrition, fetal miscarriage, skin diseases, ARI, disability, chronic diseases, birth of low-weight babies, and premature birth.

AUTHOR'S CONTRIBUTION STATEMENT

IH and MH: Conception and designing of work, data acquisition and analysis, along with manuscript writing, and revision. MH and P: Conception of work, data analysis, and data acquisition. All authors critically reviewed the manuscript and gave final approval of the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

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