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GIS-based mapping of illegal waste disposal sites to support waste management in Alam Barajo subdistrict

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Abstract

Background: llegal waste disposal sites are an environmental problem that affects public health and the aesthetics of urban areas. **Objective**: This study aims to map the locations of illegal waste disposal sites in Alam Barajo District, Jambi City, and analyze the factors that influence their existence. **Methods:** The research method uses a descriptive approach with field survey techniques, direct observation, and geographical coordinate documentation using GPS. The data is analyzed with the help of a Geographic Information System (GIS) to visualize the distribution of illegal waste disposal sites. **Results:** The results of the study show that there are 10 points of illegal waste disposal site distribution that are almost evenly spread across 7 villages in Alam Barajo Subdistrict, namely 1 point in Kenali Besar Village, 1 point in Rawasari Village, 6 points in Pinang Merah Village, 1 point in Simpang Rimbo Village, and 1 point in Mayang Village. Most (70%) illegal waste disposal sites are located on neighborhood roads. Thus, the existence of these illegal waste disposal sites has a high potential to pollute the environment because they are located close to residential areas. **Conclusion:** This study recommends the need to add official waste collection sites from the Environmental Agency or from existing waste managers in the sub-district that are evenly distributed, increase public awareness about waste management, and consistently enforce environmental regulations to reduce the existence of illegal waste collection sites in the Alam Barajo sub-district.

Keywords: Alam Barajo; Geographic Information System; Jumantik; TPA.

Cite This Article

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INTRODUCTION

Waste is an inevitable result of human activity and must be managed properly. The issue of waste is currently one of the major problems in Indonesia and other developing countries. The existence of waste is one of the consequences of human activity. Population growth and the habit of littering are among the main factors contributing to the increase in waste [1]. Environmental problems caused by waste can start from the source of waste, where waste producers prefer to dispose of waste in places not far from their homes, either in nearby yards, in waterways, or by burning it directly, thereby polluting the surrounding environment [2,3]. The impact of improper waste disposal is known to cause severe environmental damage, especially around illegal waste disposal sites. What often happens in the waste disposal process is soil and groundwater pollution, because waste is not managed properly and correctly. In addition to the impact of improper waste management, environmental aesthetic issues, odors, and negative health effects will arise, and it can also disrupt the sustainability of environmental functions [4,5].

The waste problem began with the increase in the number of humans and animals producing waste, with the increasing population density in an area. In rural areas where the population is still relatively small, the waste problem is not so noticeable because the waste produced can still be managed in simple ways, such as burning, burying, or leaving it to dry on its own. In densely populated areas (settlements, urban areas) where open spaces are limited, waste has become a problem in its own right [6–8]. The habit of littering is practiced by almost all segments of society, not only the poor, but even those with higher education. This is very saddening because of the lack of knowledge about waste and its impact. This bad behavior is exacerbated by the lack of easily accessible sanitation facilities in public places [9]. In addition, the increase in people's purchasing power for various types of basic commodities and technological products also contributes significantly to the quantity and quality of waste produced [10–12].

This habit causes the accumulation of waste outside the legal waste disposal sites provided by the government. The determination of the location and distribution of waste disposal sites does not yet have clear guidelines and strategies. The limited availability of land for the construction of waste disposal sites that meet the standards causes serious problems such as scattered waste, which results in a decline in the aesthetics of the environment [13,14]. This accumulation of waste will eventually become the location of illegal dumping sites. The insufficient number and lack of strategic locations of legal dumping sites also contributes to the increase in the number of illegal dumping sites [9].

Waste management conditions in Alam Barajo District, Jambi City, face similar problems, where the waste management system is not yet optimal, especially in terms of the provision of adequate and safe TPS facilities, which has not yet been fulfilled. This can be seen in the results of the study, which found 33 TPS locations owned by the DLH [4]. Based on preliminary surveys conducted by researchers, several illegal waste collection sites were still found near the Alam Barajo Subdistrict Office. The existence of these waste collection sites is one of the impacts caused by the lack of waste collection facilities in the Alam Barajo Subdistrict. The study also revealed that the illegal waste collection sites were located less than 15 meters from rivers/waterways and in the middle of residential areas, making them highly susceptible to causing environmental pollution.

A map is (spatial) information about the environment. Mapping is the process of presenting factual (real-world) information about the earth's surface, both its shape

and its natural axes, based on the map scale, map projection system, and symbols representing the elements of the earth's surface being presented [15]. The main purpose of mapping is to provide a description of a geographical phenomenon, spatial and non-spatial information, information about feature types, points, lines, and polygons [10]. Based on these issues, it is necessary to map the locations of illegal waste disposal sites in the Alam Barajo District of Jambi City as an effort to monitor the growth of illegal waste disposal sites so that they do not give rise to other illegal waste disposal sites in the future that could endanger the environment and the livelihoods of the community. This will also serve as advice and consideration for the Jambi City government, particularly the Alam Barajo District, in determining the best policy for waste management in the future. The purpose of this study is to determine the distribution of illegal waste disposal sites in the Alam Barajo District and to describe the factors that contribute to the distribution of illegal waste disposal sites (volume and distance from river locations).

METHODS

Study design and setting

This study used an observational method, in which a survey was conducted to collect the coordinates of illegal waste collection sites in the Alam Barajo subdistrict of Jambi City and illegal waste collection sites whose initial number was unknown, using a Global Positioning System (GPS) device.

Population, samples and sampling

This research was conducted in Alam Barajo District, Jambi City, with the research area limited by the administrative boundaries of each sub-district. The administrative map of Alam Barajo District was used as the basis for determining the survey area for the distribution of illegal polling stations in Alam Barajo District. This study will identify illegal TPS locations in the Alam Barajo Subdistrict, namely Kenali Besar Village, Rawasari Village, Bagan Pete Village, Pinang Merah Village, Beliung Village, and Mayang Mangurai Village. The population used in this study is all illegal TPS located in the Alam Barajo Subdistrict according to predetermined criteria. The sampling technique used is totality sampling, where all locations are taken as samples.

Instruments and criteria

The instruments or tools used for data collection include the Global Positioning System (GPS) and the ArcGIS 10.3 application for mapping.

Procedure and data collection

The stages of this research are as follows: Literature study, data collection, and base map creation: primary data was collected through field observations to determine the location of the TPS, the technical feasibility of the TPS, and the measurement of the TPS volume. Secondary data in the form of literature studies included population data, TPS data, and Shapefile data on administrative boundaries, rivers, and roads. The data was then entered into GIS software to create a base map and data tabulation: Tabulation of TPS location survey data using GPS. This tabulation was used to facilitate data input into ArcGIS 10.3 as vector data (point), which was then used to create a TPS distribution map, and data processing and analysis: primary data from GPS plotting was first input and processed using Microsoft Excel, then the processed data was input into the ArcGIS 10.3 application for mapping.

Statistical analysis

This study is a descriptive study reinforced by the results of mapping illegal TPS in the Alam Barajo District of Jambi City based on Global Positioning System (GPS) data using Geographic Information System (GIS).

RESULTS

Alam Barajo Subdistrict is one of the subdistricts in Jambi City, which is divided into several administrative areas. This subdistrict was formed from the division of Kota Baru Subdistrict and currently consists of seven villages, namely Kenali Besar, Bagan Pete, Mayang Mangurai, Rawa Sari, Beliung, and two newly formed villages, namely Simpang Rimbo and Pinang Merah.

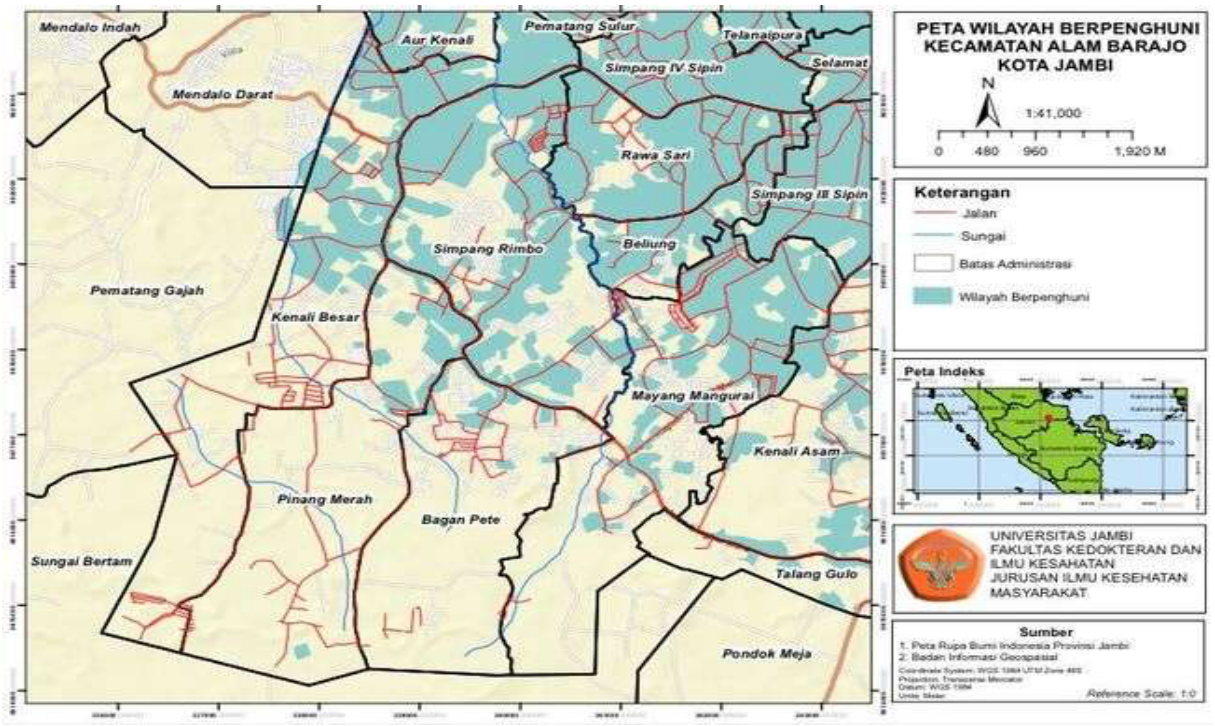

Figure 1. Map of Alam Barajo Subdistrict

Based on data from the Jambi City Environment Agency, Alam Barajo District is recorded as the area with the highest volume of waste in Jambi City. In 2022, the amount of waste reached 443.56 tons per day with a transportation frequency of twice a week by the cleaning fleet. The population in this district is recorded at 111,132 people. Based on Indonesian National Standards (SNI), the ideal distance between a waste source and a temporary waste storage site (TPS) is less than 300 meters. Assuming that one TPS serves around 500 households and that each household consists of an average of four people, Alam Barajo District ideally needs around 54 legal TPS. However, in reality, there are only nine official TPS in this area, so this situation has the potential to lead to the emergence of illegal TPS in several locations.

Waste is one of the environmental problems that always arises as the population and community activities increase. If not managed properly, waste can cause unpleasant odors, pollute the environment, and become a source of disease for humans. According to data from the Ministry of Environment and Forestry (KLHK), waste generation in Indonesia reaches more than 64 million tons per year, and only a small portion is properly processed. The city of Jambi itself contributes a significant amount of waste every day, especially from the household sector.

To mitigate this impact, the government usually provides temporary disposal sites (TPS) as locations for collecting waste before it is transported to final disposal sites (TPA). These official TPS should have adequate facilities, be easily accessible to the public, and be managed regularly so as not to cause disruption. However, in reality, the availability of official TPS is often not proportional to the population and the volume of waste produced. Limited resources and weak supervision often lead to illegal waste disposal sites, which are unofficial waste disposal locations that appear without permission and lack proper management facilities. Illegal waste disposal sites usually have a wide range of impacts, from poor environmental aesthetics, soil and water pollution due to seepage, air quality disturbances, to increased risks of environment-based diseases. This condition is in line with Law Number 18 of 2008 concerning Waste Management, which emphasizes the prohibition of indiscriminate waste disposal because it can threaten public health and safety.

In this study, the identification of illegal temporary storage sites (TPS) was carried out through direct field surveys in each sub-district within the research area, utilizing road access and vehicles. The coordinate data obtained in the field used a geographic coordinate system (GPS) with a Geographic Information System (GIS). Based on the results of the observations, 14 illegal TPS locations were found in the Alam Barajo sub-district, which was the focus of the study. Further analysis focused on factors such as volume, distance from rivers, land use type, type of road occupied, and population density. A map showing the distribution of TPS locations in Alam Barajo Subdistrict can be seen in the following figure 2.

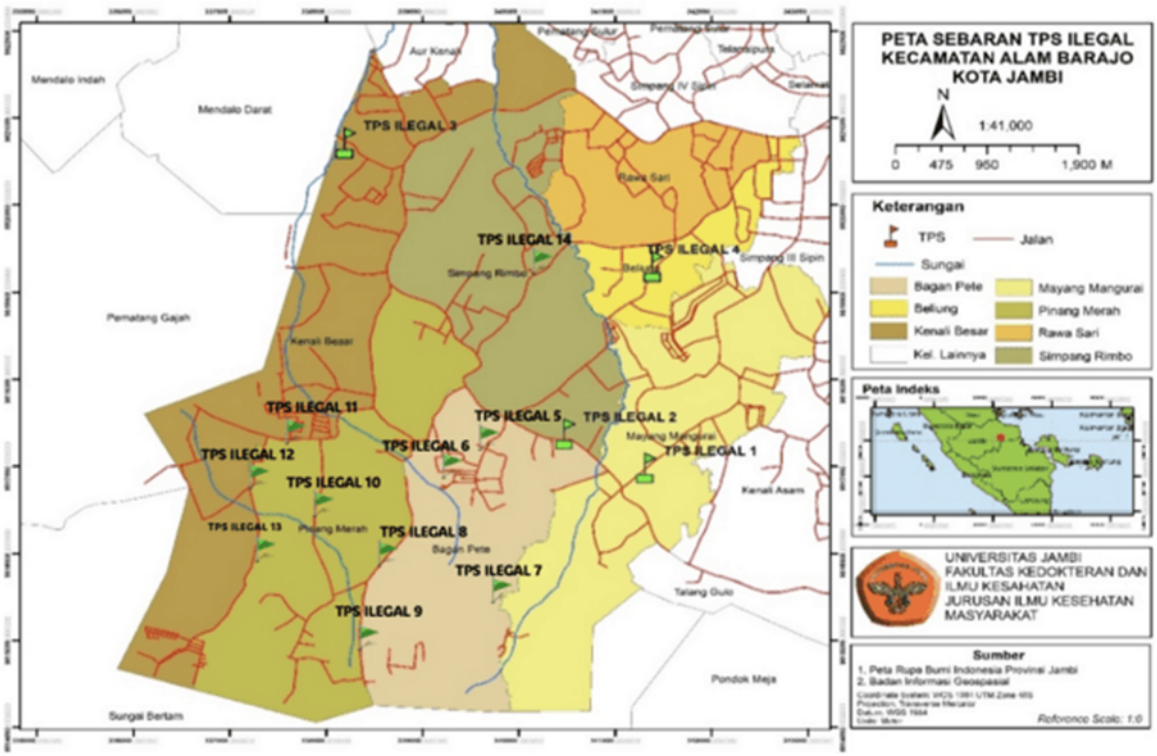

Figure 2. Distribution of illegal TPS in Alam Barajo Subdistrict

Mayang Mangurai Village is one of seven villages in Alam Barajo District, Jambi City, which was established in 2002. Mayang Mangurai Village, Alam Barajo District, Jambi City, is divided into 49 neighborhood associations (RT) with an area of 380.76 hectares. It can be reached by public transportation, approximately 10 km from the commercial center of Jambi City. Based on observations, piles of household waste were

found dumped indiscriminately on the side of Jalan K. H. Ismail Malik, Mayang Mangurai Village, Alam Barajo District, Jambi City. The exact location is around the Mutiara Mayang Housing Complex, which is adjacent to the Barcelona Regency Housing Complex and Villa Kenali Permai, as indicated by the coordinates on the map. The accumulated waste consists of plastic, food scraps, and various other household waste placed in white, black, red, and transparent plastic bags.

This condition has a number of negative impacts, including damaging the aesthetics of the environment, potentially polluting the soil and water, and causing unpleasant odors. In addition, this pile of garbage can become a breeding ground for flies, mosquitoes, and rats that carry diseases, thereby endangering the health of the surrounding community. From a social perspective, the presence of garbage on the side of the road reduces the comfort of residents and road users, and even has the potential to disrupt traffic access in the area. Bagan Pete subdistrict has an area of approximately 17.67 km², with a population of around 10,642, consisting of 5,448 men and 5,194 women. The geographical coordinates of Bagan Pete are approximately 1°39′0″S 103°33′38″E (~ -1.6500°, 103.5606°). The Bagan Pete area is directly adjacent to several other subdistricts in the Barajo region.

Kenali Besar Village is part of Alam Barajo District, Jambi City, Jambi Province. This village has an area code of 15.71.09.1001 and a postal code of 36129. Its area is approximately 11.28 km². According to the latest data from the Central Statistics Agency (BPS) (base year 2023), the population of Kenali Besar is around ±39–42 thousand people, with more than 11 thousand households spread across 73 neighborhood associations (RT). The population consists of a relatively equal number of men and women. Based on observations, an area covered with banana trees was found to be used by the community as an illegal waste disposal site. The waste dumped there is dominated by household waste such as plastic and food scraps.

Based on field observations, the illegal dump site was found on the side of the main road in Beliung Village, Alam Barajo District, Jambi City. The accumulated waste consisted mostly of household waste, such as plastic, food scraps, paper, and used bottles. The site was untidy and the waste continued to accumulate, reducing the cleanliness and aesthetics of the surrounding environment. The piles of waste cover part of the road shoulder, creating a dirty and unsightly impression for both motorists and pedestrians passing by. Observations also show that the waste not only causes a pungent odor, but some of it has begun to rot, attracting flies and wild animals such as cats and rats. This has the potential to become a major source of infectious diseases. The location of the illegal waste disposal site, which is close to residential areas and places of worship, adds to the residents' concerns, as the smell of garbage often reaches their homes and mosques.

This illegal dump site is located on the side of the main road in Beliung Village, close to residential areas and public facilities. Most of the accumulated waste comes from household waste such as plastic, food scraps, paper, and disposable diapers. The waste is not neatly piled up, so some of it is scattered on the roadside, causing a pungent odor. Some parts of the waste appear to be rotting and secreting fluids that could potentially contaminate the surrounding soil. The presence of this waste also attracts flies and rats, posing additional health risks to the community. The location of the waste collection point on a main traffic route means that every driver passing by is affected by the unpleasant odor and unsightly view. Based on field measurements, the volume of each TPS can be classified as shown in the following table 1.

Table 1. Overview of illegal landfill volume in Alam Barajo Subdistrict

No	Subdistrict	Illegal TPS Volume			Total
		1 – 5m³	6 – 10m³	10 – 15m³	
1	Mayang Mangurai	1	-	-	1
2	Rawasari	-	-	-	0
3	Bgan Pete	1	1	2	4
4	Kenali Besar	1	-	-	1
5	Beliung	1	-	-	1
6	Simpang Rimbo	-	1	-	1
7	Pinang Merah	3	3	-	6
Amount		**7**	**5**	**2**	**14**

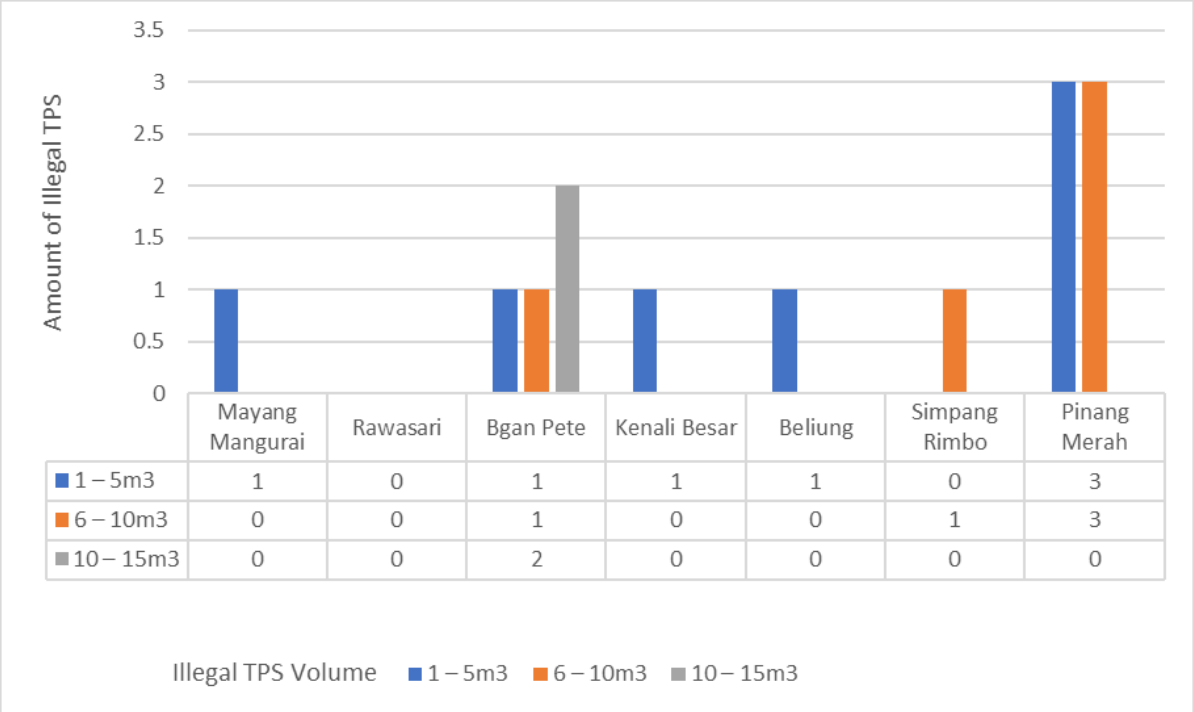

Figure 3. Histogram of Illegal TPS Volume in Alam Barajo Subdistrict, Jambi City

Based on the results of the study in Figure 7, the histogram diagram shows that the highest number of illegal TPS is in Pinang Merah Village, namely 6 illegal TPS, consisting of 3 illegal TPS with a volume of 1-5m3 and 3 illegal TPS with a volume of 6-10m3. The results of the study show that the volume of waste collected at illegal temporary waste storage sites (TPS) in Alam Barajo Subdistrict is quite high. This condition is caused by the limited number of legal TPS available compared to the amount of daily waste generated and the population density in the area. Based on data from the Jambi City Environment Agency in 2022, waste generation in Alam Barajo District reached 443.56 tons per day, while there were only nine official TPS available. This number is not proportional to the ideal requirement of around 54 TPS, in accordance with SNI regulations regarding the distance of TPS service from the source of waste (< 300 meters) and service capacity per 500 households.

The limited facilities have prompted the community to dispose of waste in easily accessible open areas, resulting in the formation of illegal waste collection sites with increasing volumes of waste every day (9). Illegal waste collection sites are commonly found in vacant lots, roadsides, areas between sub-districts, and riverbanks with

minimal supervision. The volume of waste in illegal dumping sites increases rapidly, especially in areas with high population density, such as Kenali Besar and Bagan Pete neighborhoods.

The phenomenon of increasing volumes of illegal landfills also illustrates the weakness of community-based waste management. Public awareness and participation in sorting and reducing household waste is still low, so that most waste ends up in illegal landfills. This shows the need to increase institutional capacity at the village level, strengthen the role of sanitation workers, and educate the public about sustainable waste management [16]. The increase in the volume of illegal waste disposal sites in Alam Barajo Subdistrict is not only a technical issue of waste management, but also a reflection of the imbalance between population growth, available management facilities, and community behavior towards environmental cleanliness. Collaborative efforts between the government, environmental cadres, and the community are key to reducing waste generation and preventing the emergence of new illegal waste disposal sites in the future. The following data shows the distance of each polling station from the river, as presented in the figure 4.

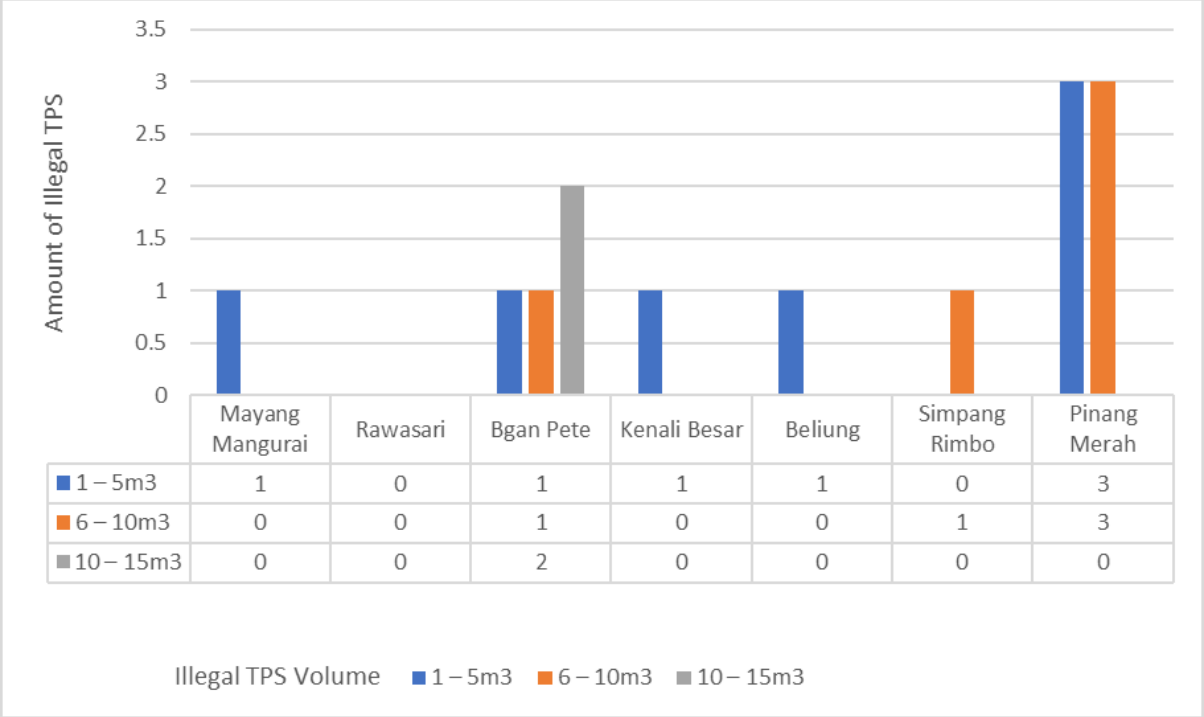

Figure 4. Diagram of TPS Point Percentage Based on Distance from the River

Based on the analysis results, it was found that 14% of illegal waste disposal sites were located less than 15 meters from rivers, while 86% of illegal waste disposal sites in Alam Barajo Subdistrict were located more than 15 meters from rivers.

DISCUSSION

Based on the analysis results, it was found that 14% of illegal TPS were located less than 15 meters from rivers, while 86% of illegal TPS in Alam Barajo Subdistrict were located more than 15 meters from rivers. This study is in line with research conducted by Siswandi in 2020, which found that 60.46% of illegal TPS found in Mataram Subdistrict were located more than 15 meters from rivers [13]. The existence of rivers is one of the factors in determining the cause of illegal waste disposal sites, because to date most of the waste produced by the community is dumped into rivers, and/or

dumped in vacant areas such as riverbanks, thereby disturbing the aesthetics of the environment [19]. This is in line with the results of this study, which show that the closer the distance between illegal dumping sites and rivers, the greater the spread of illegal dumping sites. This indicates that the number of illegal dumping sites is greatly influenced by the distance to rivers. This situation also shows that public awareness in Mataram Subdistrict is quite low in terms of not dumping waste into rivers [15].

One important factor affecting the existence of illegal temporary waste storage sites is their distance from water bodies, especially rivers. Based on field observations in Alam Barajo Subdistrict, most illegal TPS are located around rivers or tributaries. This condition shows that the community tends to use riverbanks as waste disposal sites because of their easy access, lack of strict supervision, and the belief that waste will be "eliminated" naturally through water flow [14]. This phenomenon is in line with Fauroq's findings in 2025, which explain that communities in urban areas with limited waste management facilities often use riverbanks as alternative disposal sites due to the lack of official waste disposal sites and a lack of awareness of the environmental impact. Illegal waste disposal sites located too close to rivers (< 50 meters) have the potential to cause water pollution due to leachate seepage containing organic matter, heavy metals, and pathogenic microorganisms. Polluted river water can then affect the quality of shallow groundwater and surrounding aquatic ecosystems [13].

From a hydrological perspective, the distance between the source of pollution and the water body is a determining factor in the level of pollution risk. According to Government Regulation No. 38 of 2011 concerning Rivers, riverbanks should be protected areas with a minimum distance of 15-100 meters from the river edge, depending on the physical condition of the river and the spatial layout of the area. However, in Alam Barajo Subdistrict, many illegal waste disposal sites were found within this buffer zone, indicating weak spatial supervision and low public compliance with environmental regulations [16]. Overall, the proximity of illegal waste disposal sites to rivers reflects the interrelationship between spatial factors, community behavior, and weaknesses in the waste management system. Therefore, control efforts must include increasing the number of legal waste disposal sites in strategic locations, enforcing river boundary regulations, and empowering communities through environmental cadres or environmental volunteers so that they are able to identify and prevent the formation of new illegal waste disposal sites around rivers.

CONCLUSIONS

The main factor driving the formation of illegal waste disposal sites is the lack of adequate legal waste disposal sites compared to the volume of daily waste generated. Based on data from the Jambi City Environment Agency, the Alam Barajo sub-district produces the highest amount of waste in Jambi City, reaching more than 440 tons per day, with limited availability of official waste disposal sites. This situation causes the community to tend to dispose of waste in open locations such as vacant lots, roadsides, or riverbanks. In addition to the lack of facilities, low public awareness of environmental cleanliness and suboptimal waste collection schedules by officials further exacerbate this problem. The application of GIS technology in this study proved effective in identifying and mapping the spatial distribution of illegal waste disposal sites. The analysis map was able to illustrate the relationship between waste disposal locations and geophysical factors (such as distance to rivers and settlements), anthropogenic factors (human activities), and population density. This spatial information can serve as a basis for local governments in planning more effective waste management, including determining the location of new legal TPS that are strategic

and environmentally friendly. Thus, the use of GIS not only plays a role in mapping the locations of illegal waste disposal sites, but also serves as a strategic analysis tool to support decision-making in sustainable urban waste management. The integration of GIS mapping results, local government policies, and active community participation is an important step towards creating a clean, healthy environment free from illegal waste disposal in Alam Barajo District.

CONFLICT OF INTEREST

This research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

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