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(Research Article)

# Analysis of dumpsites and their potential health risks to residents of Jahi District, Federal Capital Territory (FCT), Nigeria

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## Abstract

Open uncontrolled solid waste disposal has become prevalent in Nigeria due to economic limitations, inefficient organizational frameworks, inappropriate technology, unplanned development, and insufficient waste management capacity. This improper waste management has led to numerous health problems in the environment. The study aimed to identify the locations of dumpsites within the study area and their proximity to residents. Spatial data was collected using GPS, a camera, Google Earth, and Google Maps, while questionnaires were administered using a random sampling technique. Geospatial techniques were used to determine high-risk areas for health issues. Buffer analysis, using the proximity tool at distances of 30m, 50m, and 70m based on field observations and measurements, revealed that residents living within 30m of dumpsites reported a high presence of disease vectors and the highest incidence of vector-borne diseases such as malaria, diarrhea and dysentery. They also experienced pollution from foul odors and smoke from burning waste. Disease incidences decrease with distance from the dumpsites, with those living 50m away experiencing fewer diseases and those at 70m having the least occurrences. The study concludes that dumpsites in neighborhoods pose significant health risks to the community. It recommends establishing a standard transfer station at a suitable location in the study area and evacuating the existing dumpsites.

**Keywords:** Dumpsites; Health Risks; Waste Management; Jahi District; Geospatial Analysis

## 1. Introduction

Waste management is a critical issue in developing countries, especially within the African continent. The rapid increase in solid waste generation due to anthropogenic activities has led to improper disposal practices, adversely affecting human health and the environment [1]. Municipal solid waste (MSW) includes everyday items like packaging, furniture, electronics, and food waste from homes, schools, hospitals, and businesses [2]. Despite urbanization, economic growth, and rising living standards contributing to increased waste production, waste management practices remain inefficient [3, 4]. Only a fraction of 50% to 70% of the generated waste is collected and generally serves a part of the urban areas, particularly the high-income areas [5]. The low-income and peri-urban areas are not served [6], with significant portions of the waste improperly disposed of in open spaces [7], abandoned pits, river channels, and roadsides [8]. This mismanagement poses severe health risks and environmental hazards.

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### 1.1. Statement of the Problem

Jahi District, a rapidly developing area, faces significant solid waste disposal challenges. Population growth and urban expansion have led to increased waste generation and the emergence of numerous illegal dumpsites. These dumpsites near residential areas, road sides (Figure 6), and streams provide breeding grounds for disease vectors and contribute to environmental degradation. The absence of a central waste collection point or transfer station exacerbates the problem, especially in low-income areas like Kado-Kuchi and Jahi 2. Local waste collectors often resort to illegal dumping, posing serious health risks to residents. If unaddressed, this issue could lead to outbreaks of communicable diseases and other health conditions.

### 1.2. Justification

Improper waste disposal practices in Jahi District, such as reckless dumping along roadsides and near streams, expose residents to environmental degradation and health risks, including flooding, drainage obstruction, and the spread of infectious diseases like cholera, diarrhea, and typhoid fever. This research aims to provide a suitable transfer station site, thereby reducing the health risks associated with nearby waste dumps and aiding authorities in managing waste effectively. Achieving this will contribute towards the Sustainable Development Goal (SDG11) for sustainable cities and communities.

### 1.3. Study Area

The study focused on Jahi District, a developing area in Phase 2 of Abuja's cadastral zones within the Abuja Municipal Council (AMAC) of the Federal Capital Territory (FCT), Nigeria [9]. Geographically, Jahi lies between latitudes 9°7'0"N and 9°4'30"N and longitudes 7°25'30"E and 7°27'30"E, bordered by Katampe, Mabushi, Kado, and Gwarimpa (Figure 1). The district is predominantly residential with some commercial spaces, characterized by a tropical wet and dry climate, with a rainy season from April to October and a dry season from November to March. The local economy includes civil servants, artisans, and traders, with the major tribes being Gbagyi and Hausa, alongside Igbo, Yoruba, and Fulani communities.

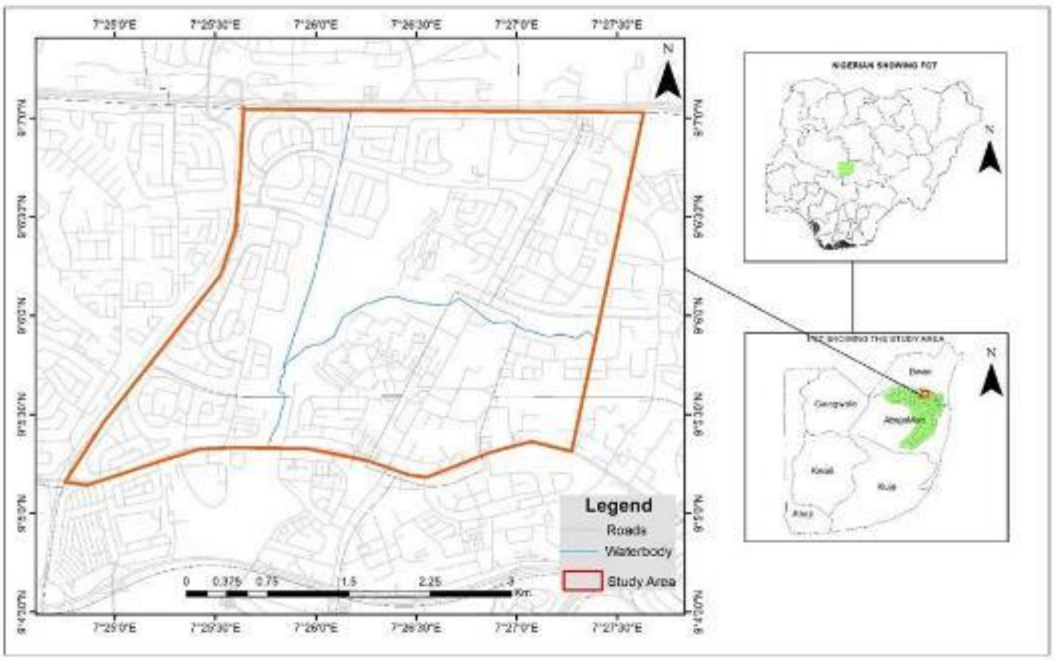


**Figure 1** Study Area Map

### 1.4. Objectives

This study objectives included

- identify the location and distribution of dumpsites in Jahi District;
- delineate areas with high potential health risks; and
- determine a suitable site for a waste transfer station.

### 1.5. Hypothesis

The study hypothesized that improper waste disposal practices in Jahi District significantly contributes to health risks for residents. This hypothesis was developed based on observations of numerous illegal dumpsites, inadequate waste management infrastructure, and the resulting health and environmental issues. Addressing these issues is crucial for improving public health, and environmental quality, and achieving sustainable urban development.

## 2. Materials and Methods

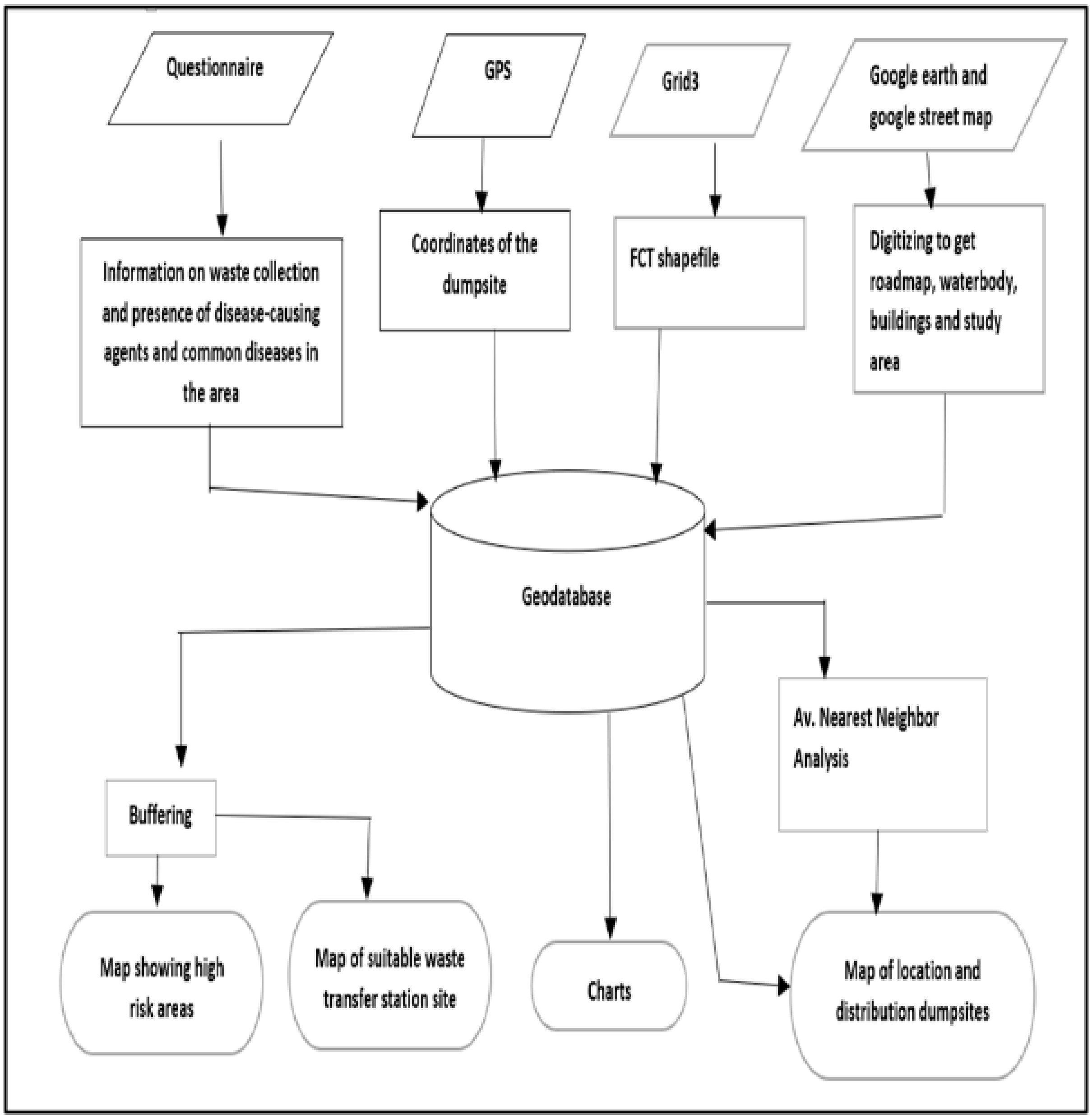


**Figure 2** Methodology Workflow adopted in the Study

### 2.1. Data Types and Sources

The methodology followed a systematic approach (Figure 2) to achieve the overall aim of the research. Both primary and secondary data were employed in this research. The primary data was gathered through field surveys and measurements, questionnaires, and Global Positioning Systems (GPS). A preliminary reconnaissance survey was conducted to familiarize with the study area and to identify the existing dumpsites. The questionnaires provided insights into waste collection and disposal methods, as well as the presence of agents posing potential health risks and the incidence of diseases (Table 1). Data was collected from residents within the study area by administering 60 questionnaires. A simple random sampling technique was employed to ensure that each individual had an equal probability of being selected. The information gathered encompassed waste disposal practices, the presence of disease-causing agents, and the types of diseases affecting the community. GPS was employed to obtain the coordinates of the dumpsites and ground control points necessary for georeferencing the study area map (Table 2).

Secondary data encompassed high-resolution Geo-Eye imagery from 2021, sourced from Google Earth and Google Street Map, which were instrumental in delineating the study area. Additional secondary data sources included the GEO-Referenced Infrastructure and Demographic Data for Development Nigeria (GRID3 Nigeria), from which the Nigeria Administrative shapefile and the Federal Capital Territory (FCT) shapefile were obtained, alongside data from the internet and published journals.

The software utilized in this research included Microsoft Office Suite and ArcGIS version 10.5. Microsoft Word was employed for word processing, while Microsoft Excel was used to generate charts and tables from the questionnaire data. Field data were stored in Excel and subsequently imported into ArcGIS. ArcGIS facilitated georeferencing, spatial analysis, digitization, and map creation.

### 2.2. Data Preparation and Analysis

The FCT boundary shapefile was extracted from the Nigeria Administrative shapefile, and the FCT Cadastral zone map was clipped from the FCT boundary shapefile. The Geo-Eye image was georeferenced and overlaid on the clipped FCT shapefile. Digitization of the study area, road network, and water body was performed using on-screen digitization.

The geographic locations of dumpsites and dumpsters were recorded using handheld GPS. This data was subsequently saved in Excel and imported into ArcGIS for analysis.

**Table 1** Data Types and Sources

| Data List | Data Type | Data | Data Source |
|---|---|---|---|
| GPS Points | Primary | Dumpsite coordinates | Field Survey |
| Questionnaire | Primary | Response from the residents | Field Survey |
| Camera | Primary | Dumpsite and dumpster images | Field Survey |
| Geo-Eye | Secondary | Satellite Imagery | Google Earth |
| Google Street Map | Secondary | Internet | Google |
| Shapefiles | Secondary | Nigeria Admin and FCT Cadastral zones shapefile | GRID3 Nigeria |

**Table 2** GPS Coordinates of the dumpsite in the study area.

| Name | Longitude | Latitude |
|---|---|---|
| Big dumpsite by Next shop DPT1 | 7.438157 | 9.091724 |
| Small dumpsite by Next shop DPT2 | 7.437971 | 9.090850 |
| Big dumpsite opposite Jahi Road DPT3 | 7.443908 | 9.095085 |
| Big Dumpsite by Gishiri Road | 7.453316 | 9.099896 |
| Small dumpsite within Kado Kuchi | 7.435171 | 9.093090 |
| Dumpsite by the stream along Jahi Road | 7.445584 | 9.102930 |
| Marbel Estate Dumpster | 7.433669 | 9.109081 |
| Estate 2 Dumpster | 7.433668 | 9.110963 |

The data presented in (Table 2) was individually saved in Excel and subsequently imported into ArcGIS utilizing the tools menu bar and coordinate extension. The coordinates of the dumpsites and dumpsters were overlaid onto the study area shapefile, which included layers for water bodies, settlements, and the road network, to accurately depict the spatial distribution and locations of the dumpsites (Figure 4) and dumpsters (Figure 11).

### 2.3. Spatial Analysis

Average Nearest Neighbor (ANN) Analysis was conducted using the spatial statistic tool to determine if the distribution of dumpsites exhibited any discernible patterns. ANN analysis measures the distance between each feature centroid and its nearest neighbor's centroid location. It then averages all these nearest neighbor distances. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed is considered clustered. If the average distance is greater than a hypothetical random distribution, the features are considered dispersed. The ANN ratio is calculated as the observed average distance divided by the expected average distance, based on a hypothetical random distribution (Figure 3).

The Average Nearest Neighbor ratio is given as:

$$ANN = \frac{\bar{D}_O}{\bar{D}_E} \qquad (1)$$

where $\bar{D}_O$ is the observed mean distance between each feature and its nearest neighbor:

$$\bar{D}_O = \frac{\sum_{i=1}^{n} d_i}{n} \qquad (2)$$

and $\bar{D}_E$ is the expected mean distance for the features given in a random pattern:

$$\bar{D}_E = \frac{0.5}{\sqrt{n/A}} \qquad (3)$$

In the above equations, $d_i$ equals the distance between feature $i$ and it's nearest neighboring feature, $n$ corresponds to the total number of features, and $A$ is the area of a minimum enclosing rectangle around all features, or it's a user-specified Area value.

The average nearest neighbor z-score for the statistic is calculated as:

$$z = \frac{\bar{D}_O - \bar{D}_E}{SE} \qquad (4)$$

where:

$$SE = \frac{0.26136}{\sqrt{n^2/A}} \qquad (5)$$

**Figure 3** Equations for calculating Average Nearest Neighbour (ANN)

Questionnaire analysis was carried out using Microsoft Excel. Charts were used to represent the result of the analysis. Buffer analysis was performed using the proximity tool to identify areas surrounding the dumpsites. Buffers of 30m, 50m, and 70m were created around dumpsites based on field observations of odor and smoke. The analysis aimed to determine acceptable distances between refuse dumps and residential areas.

Proposed waste transfer station sites were evaluated using the Manitoba transfer station siting criteria standard [10], considering social issues, environmental factors, site economics, and regulatory requirements. In conformance with setback requirements, minimum distances between the transfer station site and specific features were assessed based on Waste Management Facilities Regulation 37/2016 [10].

## 3. Results and Discussion

Jahi District, despite being a relatively small area, contains numerous dumpsites, which pose significant health risks to its residents. (Figure 4) illustrates the distribution of these waste sites, categorized into two groups: small and large. The smaller dumpsites typically measure between 2 meters to 3 meters in length, while the larger ones range from 8 meters to 15 meters. Without regular removal and proper waste management infrastructure, the smaller dumpsites are likely to expand, and the larger ones will grow even further. As these dumpsites increase in size, they become increasingly challenging to manage, heightening the risk of disease exposure for residents. Notably, the three major dumpsites in the area are situated along roadways, and if not addressed, they may obstruct traffic. The accumulation of waste in the neighborhood is not only visually unappealing but also detracts from the area's aesthetic value, as depicted in (Figures 5 and 6).

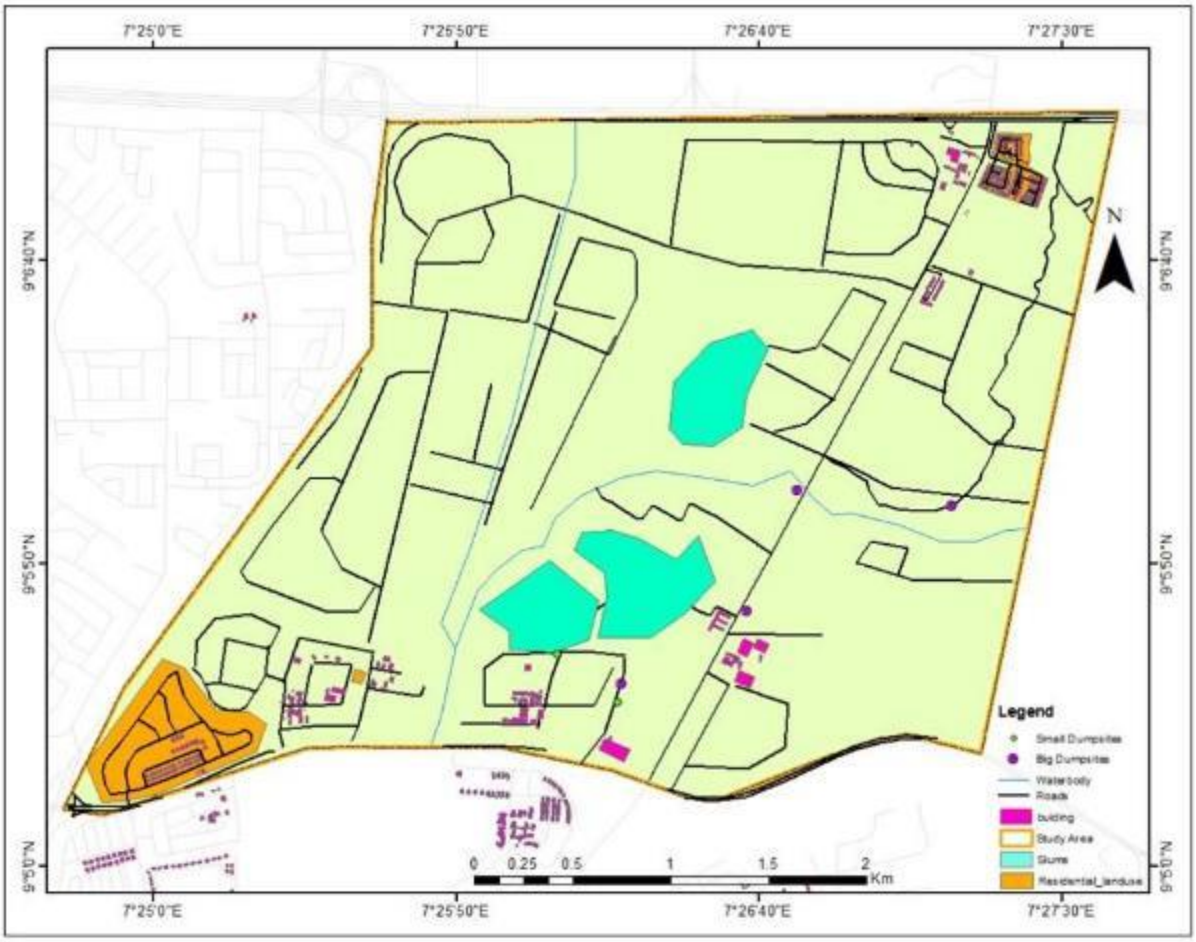


**Figure 4** Location and Distribution of Dumpsites in the Study Area.

**Figure 5** Dumpsites Close to Buildings

**Source:** Author's field work

**Figure 6** Dumpsite along the Roadside

**Source:** Author's field work

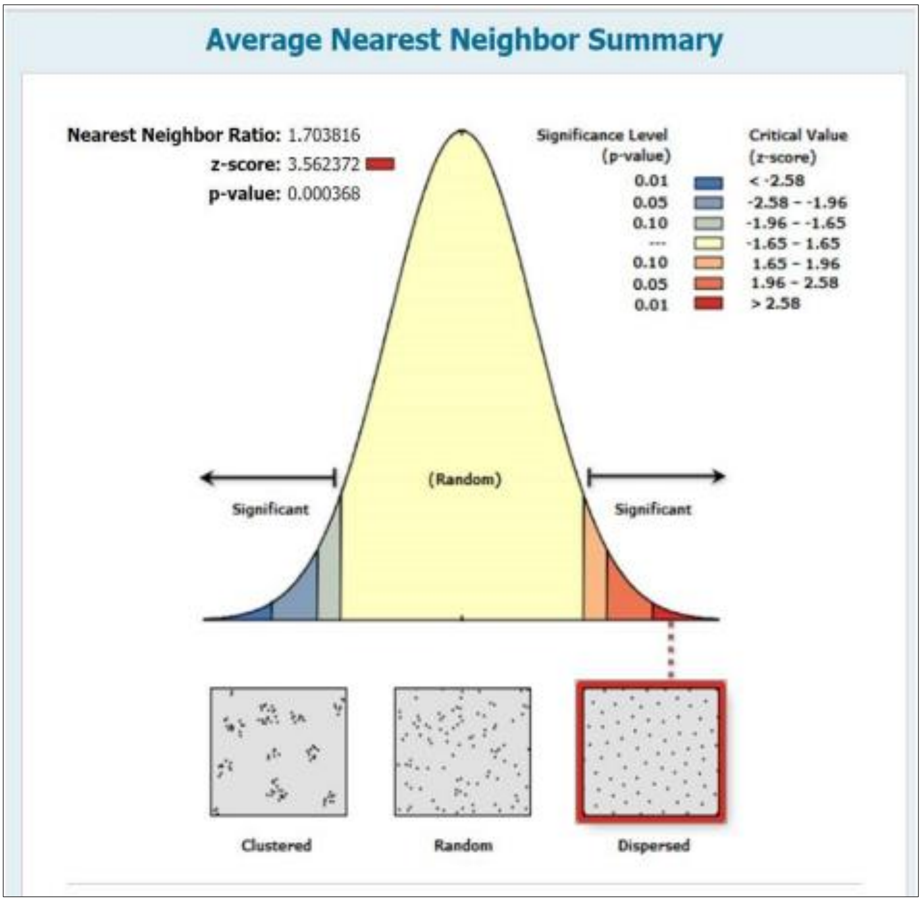


**Figure 7** Distribution Pattern of Dumpsites in the Study Area

The Average Nearest Neighbor (ANN) analysis was employed to ascertain whether a discernible pattern exists in the distribution of dumpsites within the study area. This method evaluates if the data under scrutiny formed a clustered, dispersed, or random pattern throughout the study region.

The findings from the ANN analysis, along with the dumpsite location map, indicates that the dumpsites exhibit a dispersed distribution pattern (Figure 7). This dispersal can be attributed to the absence of centralized collection points equipped with large bins in low-income areas, which lack both bins and accessible roads. Consequently, residents’ resort to indiscriminate waste dumping, leading to the proliferation of numerous dumpsites in the area.

Field measurements were conducted to determine the distances of the dumpsites from buildings at intervals of 30 meters, 50 meters, and 70 meters (Figure 8) using GPS and measuring tapes. Based on these field observations, the proximity analysis tool was utilized to perform buffering at the specified distances. The analysis revealed that buildings are situated close to the dumpsites, with some structures located less than 30 meters away, thereby exposing residents to significant health risks.

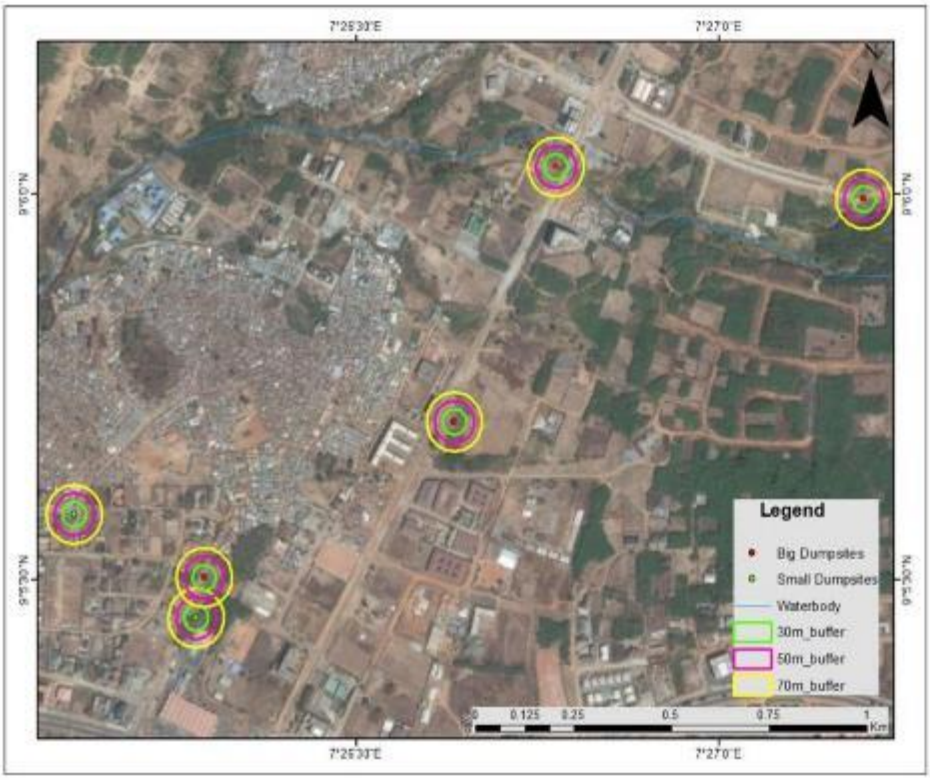


**Figure 8** Proximity Analysis Buffering at 30m, 50m, and 70m respectively

**Table 3** Proximity to Dumpsite and Level of Health Risk

| Location | Level of risk |
|---|---|
| People living within 70meters range | Low risk |
| People living within 50meters range | Medium risk |
| People living within 30meters range | High risk |

Field observations revealed that refuse at the dumpsites is often incinerated, and within 30-metre buffer zone, repulsive odors and smoke from the burning waste can be detected, posing significant health risks to residents within this radius. Pollutants from the burning refuse are released primarily into the air at ground level, making them easily inhalable. This is in line with the results from previous researchers [11, 12, 13, 14, 15].

The refuse in the study area is frequently burnt using tires, generating dense black smoke that lingers in the air for extended periods. During the harmattan season, the windy conditions cause the smoke to spread over greater distances, increasing the number of people at risk. During this time, smoke can be perceived up to 50 meters away, placing these areas at medium risk. The smoke from burning tires contains toxic pollutants harmful to human health.

Field observations and questionnaire responses indicated that stagnant water at the dumpsites serve as breeding ground for vector larvae. Within a 30-meter radius, residents reported infestations of flies, mosquitoes, cockroaches, rats, and mice, all of which are known vectors that harbor pathogens and transmit diseases. Consequently, residents in this area are highly exposed to vector-borne diseases, making it a high-risk zone. At a distance of 50 meters from the waste dumps, fewer disease vectors were observed, with the least number at 70 meters (Table 3).

The dumpsites in parts of Jahi 2 are in close proximity to water sources, leading to water pollution. Contaminated water is known to harbor bacteria that cause cholera, dysentery, typhoid, hepatitis A, and polio.

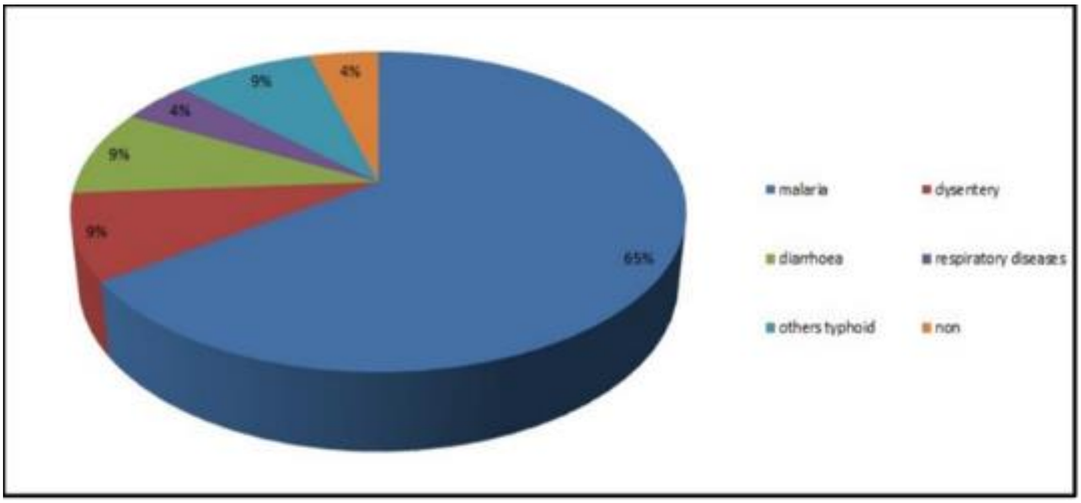


**Figure 9** Common diseases affecting households in the study area.

Analysis of the questionnaires revealed that residents reported infestations of flies, mosquitoes, cockroaches, rats, and mice, which are known vectors that harbor pathogens and transmit diseases. 72% of respondents confirmed the presence of these vectors. This response predominantly came from residents living within 30 meters of the dumpsite, with a smaller proportion from those living within 50 meters. Only 22% of respondents at 50 meters reported vector presence, and none at 70 meters. This analysis indicates a high prevalence of vectors in the area.

Malaria, transmitted by mosquitoes, is the most prevalent disease (65%). Other common diseases include dysentery (9%), diarrhea (9%), and typhoid (9%). Flies that come into contact with feces and subsequently contaminate food are responsible for spreading dysentery and diarrhea (Figure 9). Respiratory diseases (4%) were the least common among the reported ailments.

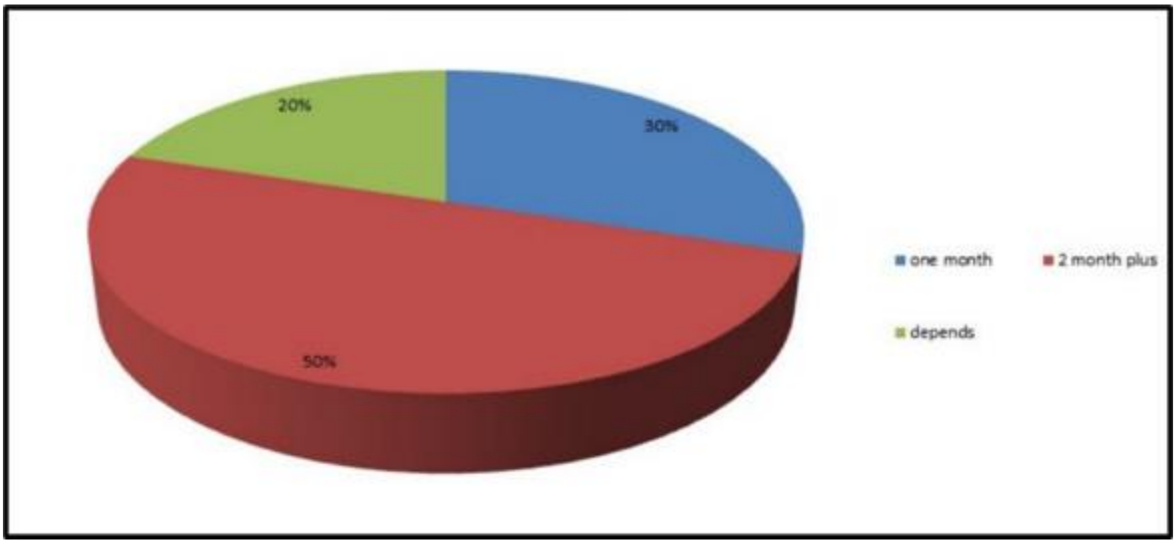


**Figure 10** Pie Chart showing the Rate of Infection from the Common Diseases

(Figure 10) illustrates the infection rates from common diseases. Approximately 50% of respondents reported contracting one of the diseases every two months, 30% experienced infections monthly, and 20% indicated that the frequency of infection varied based on individual immunity.

An essential element of effective waste management is the proper on-site storage and efficient disposal of waste. The study area, being predominantly residential, is unsuitable for the establishment of a landfill. In high-income areas, dumpsters are provided for waste disposal, and these areas are well-connected by accessible roads, facilitating efficient waste collection. Conversely, the Abuja Environmental Protection Board (AEPB) trucks are unable to service the slums in the study area due to the dense clustering of houses and the inaccessibility of roads.

To address the issue of indiscriminate dumping in Jahi District, the study proposed the establishment of a waste transfer station. This station would serve as an organized, temporary dump site from which waste trucks can regularly evacuate waste. It would also offer a convenient disposal option for cart pushers and community members. Based on the preferences of residents and the Manitoba siting criteria, a suitable location for the waste transfer station was selected (Figure 12).

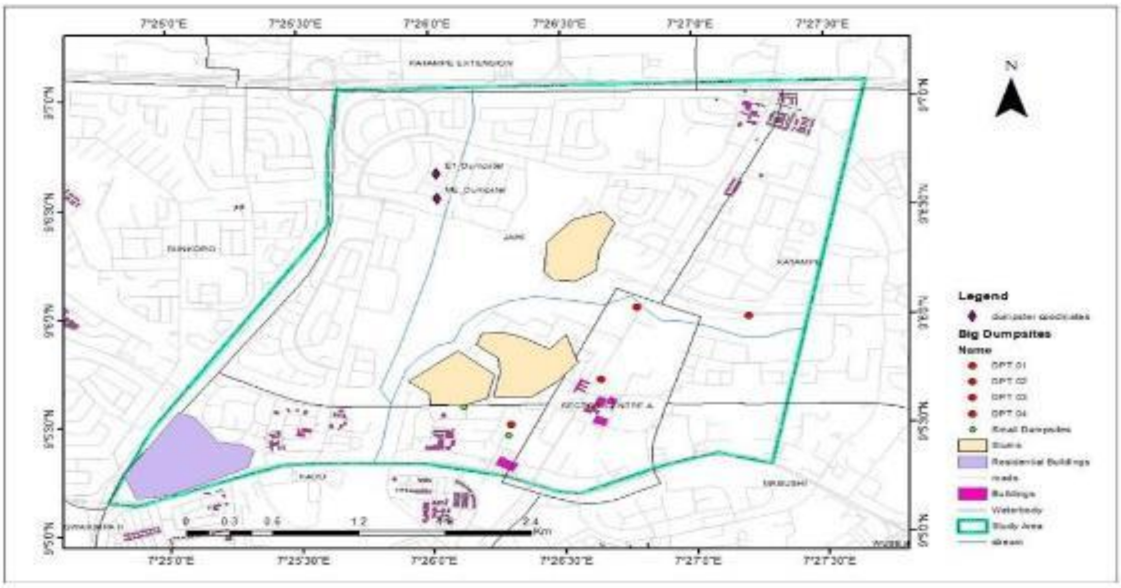


**Figure 11** Dumpster Locations in the Study Area.

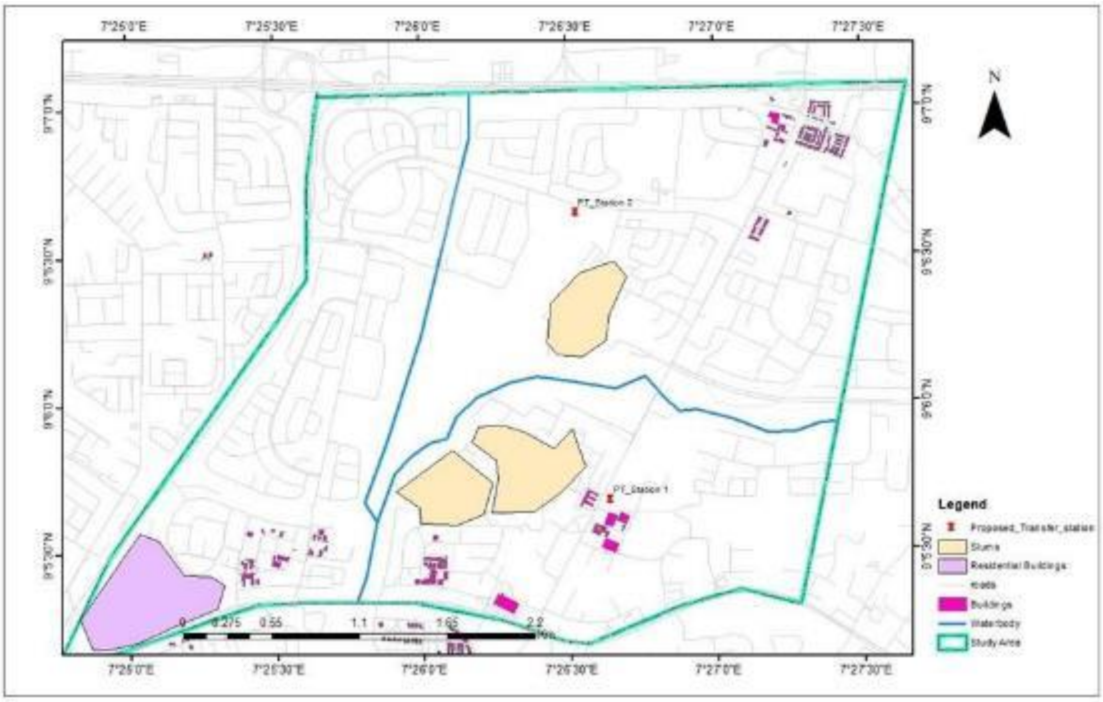


**Figure 12** Proposed Suitable Waste Transfer Site

## 4. Conclusion

This study has investigated the health risks associated with waste disposal practices in Jahi District, FCT. The findings indicate that the rapid population growth in Jahi has resulted in increased waste generation and the proliferation of numerous dumpsites. The study successfully identified the locations of these dumpsites. By employing geospatial techniques, particularly the buffer proximity tool, the research demonstrated the high-risk health areas. It further illustrated that Geographic Information Systems (GIS) can significantly contribute to environmental preservation by guiding management planners on minimizing the adverse impacts of improper waste disposal through the strategic siting of waste transfer stations. The study utilized the Manitoba criteria for siting waste transfer stations, which involve establishing a buffer zone between the stations, settlements, and water bodies. Based on the results, several suitable areas for waste transfer stations were identified. The research revealed that dumpsites are situated in close proximity to buildings and water bodies, posing severe health risks to the residents of Jahi District and leading to pollution and the spread of vector-borne diseases. The location of dumpsites near residential areas contradicts sustainable development practices and impedes progress towards achieving Sustainable Development Goals (SDGs 3 and 11). The study established a significant correlation between the spread of diseases and proximity to dumpsites. Consequently, the research proposed a suitable site for a transfer station to mitigate indiscriminate waste dumping practices and reduce the associated health risks.

### 4.1. Recommendations

The application of GIS and satellite remote sensing has proven effective in waste management planning, identifying the location and distribution of solid waste dumps, and monitoring solid waste dumps/landfills. These technologies are invaluable tools for government use in waste management. To address the issues and health threats posed by dumpsites, the following measures should be implemented:

- A standard transfer station should be constructed by either the government or the private sector, and existing dumpsites should be cleared.
- Public participation is crucial when planning and siting a waste facility. Forming a committee that includes community members can integrate public input into the waste management facility siting and development process.
- The government should enhance and enforce existing waste management policies.

- Awareness campaigns should be conducted to educate the community about the importance of maintaining a clean environment and the principles of waste reduction, reuse, and recycling. This can be facilitated by incorporating educational centers or interpretive trails in the transfer station to educate community members on waste prevention strategies.

## Compliance with ethical standards

### *Acknowledgments*

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### *Disclosure of conflict of interest*

All authors declare no conflict of interest.

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