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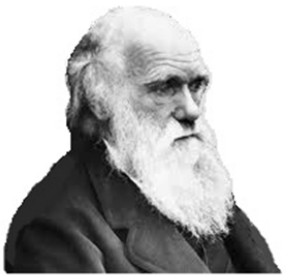

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Assessing the Potential Health Effect of Solid Waste Dump Site Located Close to Residential Areas in Jalingo, Taraba State, Using Geospatial Techniques

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ABSTRACT

The study examined the application of Remote Sensing and Geographic Information Systems in estimating the potential health effects of solid waste dump sites, located close to the residences within Jalingo town, in mapping out the existing dumpsites, in carrying out proximity analysis, and in assessing the impact of these dump sites on residences within the study area. Both, primary and secondary data were used to achieve the objectives of the study. The primary data were the geographical coordinates of all the dumpsites from the selected five wards in the study area. This was obtained using hand-held GPS. The secondary data applied included administrative boundary maps (Ancillary data) and recorded cases of malaria incidence from health facilities located in the area. Data were analyzed in ArcGIS 10.3 environment to display the X and Y coordinates and to obtain the spatial distribution of the dumpsites on a composites map. Geo-processing using ring buffering was carried out to form a proximity analysis of the dumpsites. Assessment of the impact of the dumpsites on the health of dwellers within the study area was achieved from a proximity analysis that compared location with the recorded cases of malaria. The findings of the study revealed that the proximity analysis of a 500 m and 1000 m standard demonstrated that residences within 7.857 km^2 and 31.439 km^2 of each dumpsite, respectively, are in danger of dumpsite related disease. This is because out of the total built-up area of 61.479 km^2 in the study area, most of the dumpsites located within 31.439 km^2 of the built-up area do not conform to the NESREA standard criteria of siting a dumpsite. The assessment of the cases of malaria incidence recorded and the numbers of dumpsites revealed that the dumpsites location close to residence had more cases of malaria incidence, thus it is believed that the dumpsites contribute to the breeding the female anopheles mosquito that transmit malaria to humans. The study recommends the dumpsite location suitability analysis be performed in Jalingo and that to avoid endemic Malaria, the appropriate authorities close down dumpsites close to residences.

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***Keyword*:** Solid Waste, Potential Health Effect, RS/GIS Approach, Jalingo, Nigeria

1. INTRODUCTION

Potential Health Effect which in other word can be referred to as health hazard has been defined as a danger to health resulting from exposure to environmental pollutants, such as asbestos or ionizing radiation, or to a life-style choice, such as cigarette smoking or chemical abuse. (Farlex Free Dictionary, 2017). Health hazard is also defined as a potential danger to a person's health. (Oxford Living Dictionary, 2017).

Waste can be defined as something which the owner no longer wants at a given time and that it is perceived to be of no market value. Municipal Solid Waste is defined as waste that are generated from residential, commercial, industrial, institutional, construction and demolition process and municipal services (Rachel *et al.*, 2009). Waste Dump Site has been defined as refuse dumps situated either on land or on water where waste materials, such as solid, liquids, semisolids and gaseous are deposited (Abdul, 2010). Residence is defined as a house or place where someone lives (Macmillan School Dictionary, 2004).

A GIS (Geographic Information System) is a decision support system that can facilitate and contribute to the improvement of human health risk assessment. It can be used to accurately characterize the known points of contamination, predict further areas of concentration that have not yet been measured and also generate predictions of elevated risk based on these predicted concentrations (Reese, 2004). Assessing the potential health effect of solid waste dump site close to the residential areas is the identification of the likely effects of dumpsites on residential dwellers.

Indiscriminate dumping of solid waste has become a common practice in most of our cities today. This practice of indiscriminate and improper dumping of Municipal Solid Waste (MSW) is on the increase in major cities of Nigeria today. This can be associated with rapid growth in population, deterioration in public standard of living, poor governance and low level of public awareness on environmental management and outcome of this is the dumping of solid waste in any available open space (Rachel *et al.*, 2009). Locating Solid Waste Dump Sites close to Residential areas can pose a serious health hazard to the community. It was confirmed that waste piled up by roadside, rivers, drainages and many open spaces in the cities thus poses threat to public health and the environment (Cheeseman *et al.*, 2007).

According to Aderoju *et al*. (2014), they stated that the standard criteria for the selection and location of a dumpsite base on the National Environmental Standards and Regulations Enforcement Agency (NESREA), is that built up areas dumpsites should be placed on at least 1000 m away from all settlements. Watercourse dumpsites should be placed on at least 1000 m away from water courses to avoid hazardous emission from waste. Roads dumpsites should be placed on at 2000 m away from an existing road so as to reduce transportation expenses, While elevation dumpsites should be placed on slopes with less than 9% inclination.

Citing and Monitoring of waste dump site is a major environmental factor that should be put into consideration by any society. This is because a number of health problems, such as malaria, typhoid, cholera, and dysentery are usually associated with open dumpsites which have led to the deteriorating health condition of many societies (Ezeah, *et al*., 2009).

In Jalingo city, a research was carried out by Abd'razack *et al.*, (2013) on "An Appraisal of Solid Waste Generation and Management in Jalingo City, Nigeria" and in their findings, they ascertained that the volume of waste generated in year 2000 rose from 2,017.35 tonnes monthly to about 2,159.01 tonnes monthly in year 2008. These, they associated to the tremendous growth in the population of the city. The goal of any human health evaluation process is to provide a framework for developing the risk information necessary to assist in the decision making processes at sites (Reese, 2004).

Abd'razack *et al.*, (2013) identified about 6 legal dump collection points and 92 illegal dump sites in Jalingo city, as people dump their waste to any available space and stream channels. Waste dumped into drainages can block the free flow of runoff water and this practice can result in flooding, and communities in such areas could be adversely affected, some waste are being dumped on the road side, thereby reducing the width of the road and aesthetic of the city. This could pose a serious health hazard to those residing close to dumpsites, and hence, the need to take precaution.

The above studies, carried out on solid waste within Jalingo City, focus on Solid Waste Management and Generation and very little or no study was carried out on the spatial distribution of solid waste dumpsites and proximity analysis of the solid waste dumpsite. This research, therefore, covers mapping of existing dumpsites within the study area and a proximity analysis of the solid waste dumpsites using Geographic Information System (GIS) to ascertain conformity with the standard criteria for citing dumpsites base on the National Environmental Standards and Regulations Enforcement Agency (NESREA), and assessment of the potential health effect of locating solid waste dumpsites close to residential areas within the study area.

This study is on assessing the potential health effect of solid waste dump site located close to residence within Jalingo town using Remote Sensing and GIS to map out the existing dumpsite, carry out proximity analysis and assess the impact of these dump sites on residence within the study area. This approach will help to identify the possible health risk associated with the location of this dump sites close to human habitations. The basic aim of this study is to assess the potential health effect of solid waste dumpsites within Jalingo Metropolis.

The specific objectives of this research work are:

(1) To map out the existing solid waste dump sites within the study area.
(2) To determine the proximity between the existing dumpsites and residential areas within the study area.
(3) To assess the potential effects of these dumpsites on health of individuals.

2. MATERIALS AND METHODS

2. 1. Study Area

Jalingo lies between latitude 08° 43′N and 09° 07′N of the Equator and longitude 10° 50′E and 11° 25′E of the Greenwich meridian, covering an approximate land mass of 59,400 square kilometers (**Fig. 1**). The study area is bounded by three local governments, Lau to the North, Yorro to the East, and Ardo-Kola to the South (Bureau for Land and Survey, 2017).

Jalingo LGA has Tropical Continental type of climate characterised by well-marked wet and dry season. The wet season usually begins around April and ends in October. The dry seasons begin in November and end in March. The dry season is characterized by the prevalence of the northeast trade winds, popularly known as the harmattan wind which is usually dry and

dusty. Jalingo has a mean rainfall of about 1,200 mm and annual mean temperature of about 29 °C. Relative humidity ranges between 60 – 70 per cent during the wet season to about 35 – 45 per cent in the dry season (Oruonye, 2014).

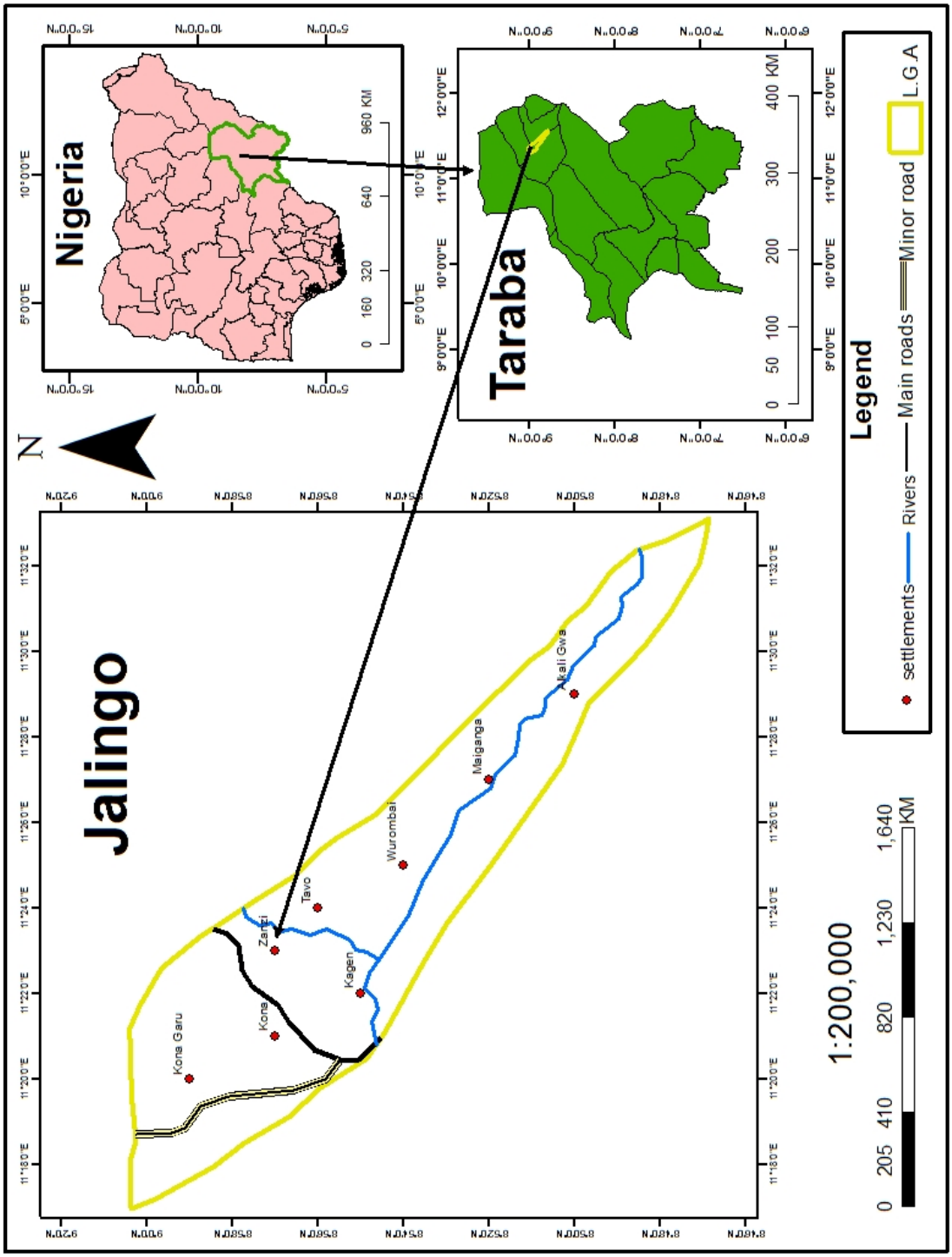

Fig. 1. Study Area: Map of Jalingo Local Government Area

The relief of Jalingo LGA consists of an undulating plain interspersed with mountain ranges. Between Kwaji-Mika to the east and Kona to the west, stretching to Kassa-Gongon to the south exists this compact mass of rock outcrops. According to Oruonye and Abba (2011), the mountain ranges run from Kona area through the border between Jalingo and Lau LGAs down to Yorro and Ardo Kola LGAs in a circular form to Gongon area.

The area is drained by two rivers and their tributaries (Fig. 1). These rivers are river Lamurde and river Sibre. The tributaries include river Mayogwoi, Pantinapu, Mikira, Gana, Zuwa, Sozina, Voti, Zampa, Bovo, Hweiya (River Lamurde), and Fan Petel, Yasa, Soyi (River Sibre). Other rivers are river Ngolkombi, Ladde, Fan Manga, Gongon, Vorabe, Kassa Kuru (Oruonye, 2014).

Jalingo is located within the northern guinea savanna zone characterized by grasses interspersed with tall trees and shrubs. Some of the trees include locust bean, sheabutter, eucalyptus, baobab and silk cotton tree (Oruonye, 2014).

Geologically, Jalingo Local Government Area (LGA) consists of sandstones of the Yolde formations which mark the transition from marine to continental sedimentation. In some areas there is an alternating sequence of shales, mudstones with minor sandstones. Jalingo LGA is located in the undifferentiated basement complex rock system. The outcrop of this rock could be seen in the heart of Jalingo town popularly referred to as the Jalingo hill. Quartz, mica and feldspar crystals (in fairly equal proportion) are some of the constituent minerals that make up this rock. This rock is overlaid by sandy-loam soil characterized by hydromorphic and ferruginous soils derived from the parent materials (Oruonye, 2014).

The population of Jalingo, as released by the National Population Commission (NPC, 2006), was 140,318 people with a projected growth rate of 3.2% annually (National Bureau of Statistic, 2016).

Agriculture is the dominant economic activity practiced by the vast majority of the people in the area, especially those settling along river lamurde. Along the river plain, dry season farming is being practiced on annual basis. During the wet season, the plain is used for the cultivation of food crops, such as maize, rice, and guinea corn. Thus, the plain has been put into intensive use yearly. In addition to the cultivation of crops, the plain is being used as a grazing land since fresh grasses and harvested crop materials are available (T.A.D.P., 2006).

2. 2. Methods

The primary data include the geographical coordinates of all the dumpsites in the study area using hand-held GPS while the secondary data used include administrative boundary maps (Ancillary data), and recorded cases of malaria incidences from health centres within the study area. The methods adopted for data collection were: Field survey was conducted using hand-held GPS (GARMIN 1040) to obtain Geographic Coordinate of dumpsites located within the study area.

Secondly, high resolution Image (Google) of the study area was used to extract and produce the Composite Map. Thirdly, data on malaria incidences was sourced from the Primary Healthcare Centre, Jalingo, and finally digital camera was used for capturing Pictorial Representation of some of the dumpsites within the study area. Data were analysed in ArcGIS 10.3 in Windows OS environment. **Figure 2** shows methodological flow diagram for the study.

Methodological Flow Diagram

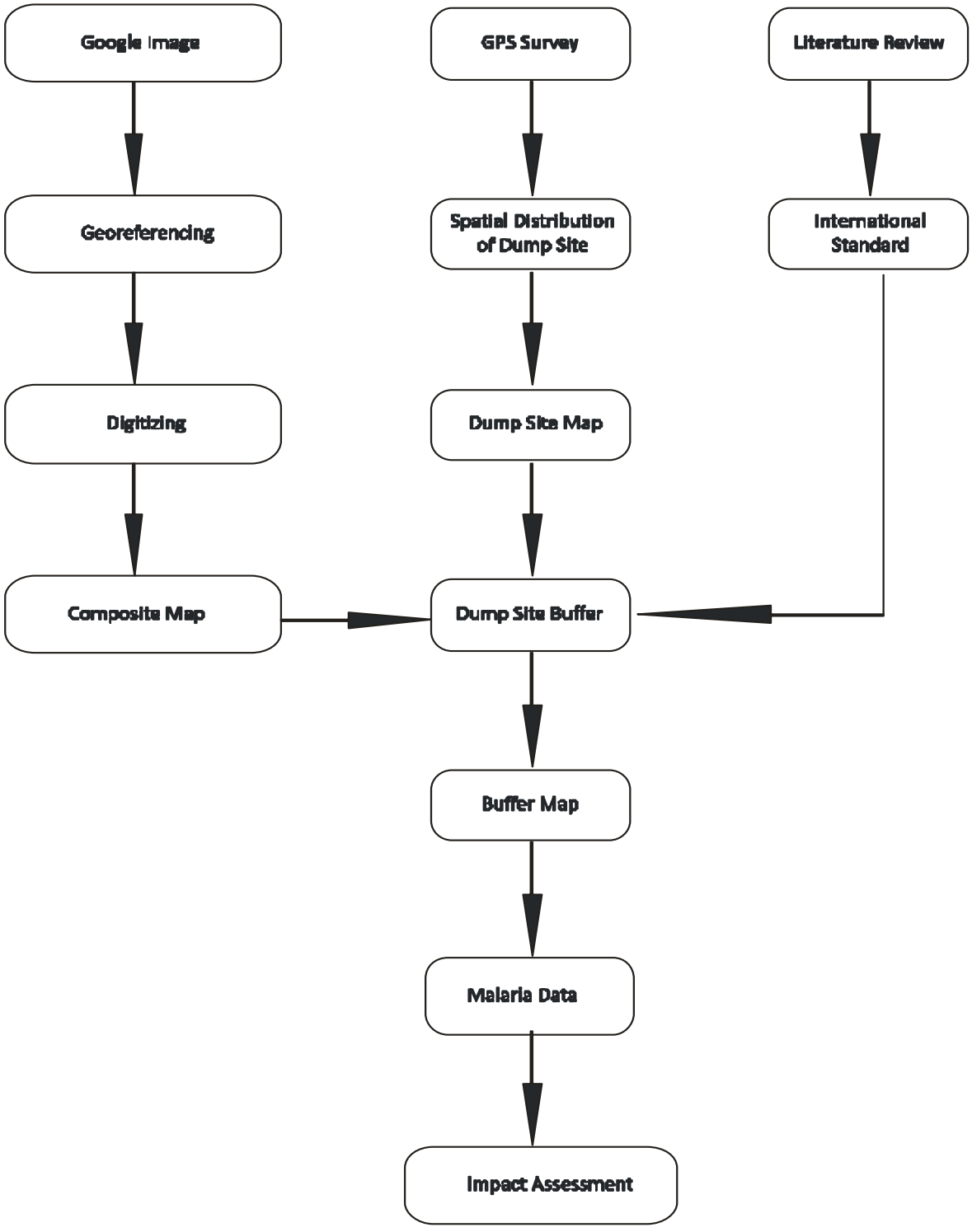

Fig. 2. Flow Chart

4. RESULTS AND DISCUSSION

4. 1. Mapping of Solid Waste Dumpsites within the Study Area

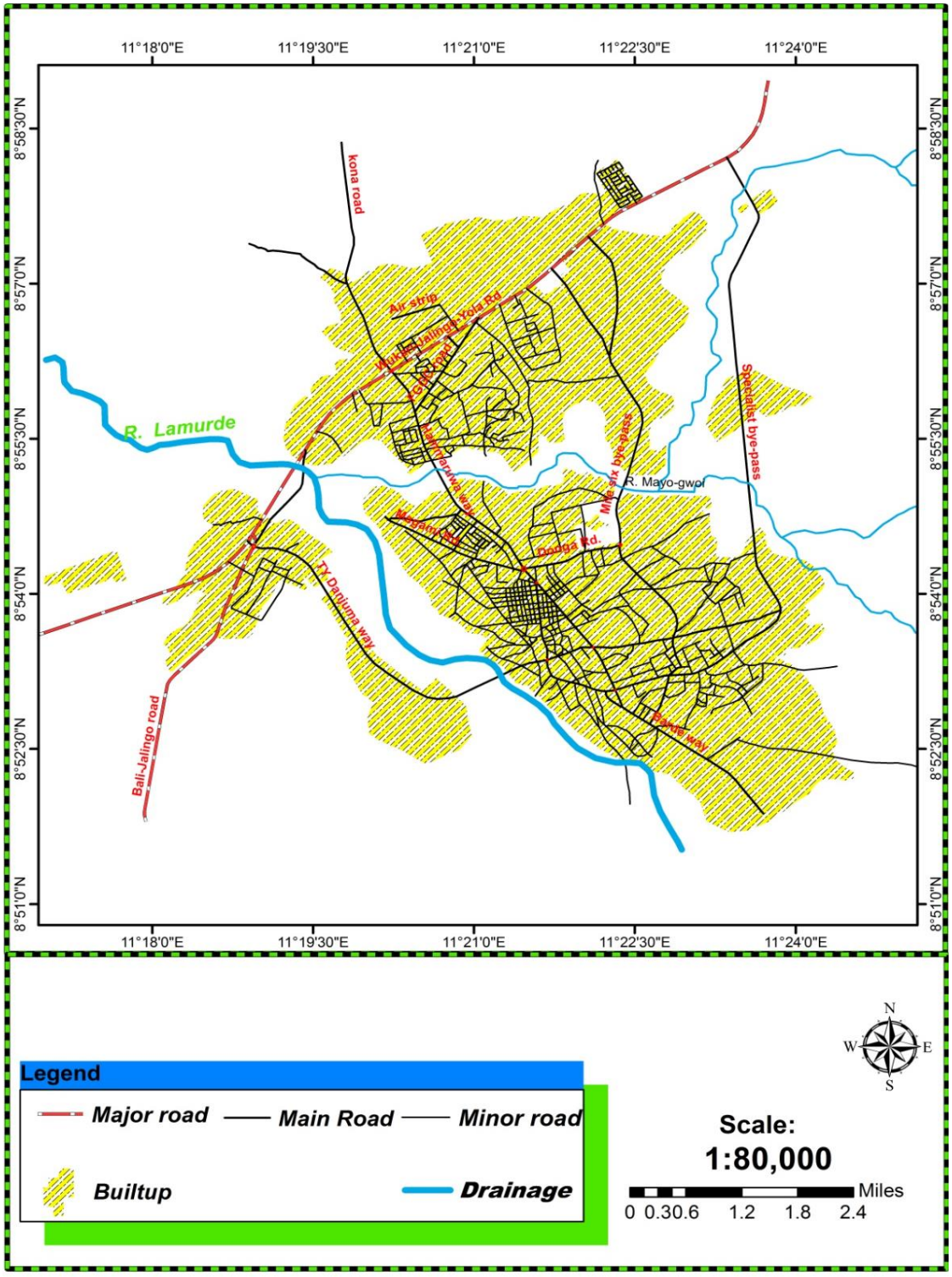

Figure 3. Composite map of the study area

Figure 3 shows the digitized composite map of the study area. The digitized map shows the existing road network, built-up area, drainages, while **Figure 4** shows the spatial distribution of solid waste dumpsite selected within the study area. It can be deduced from the map that the study area has 21 dumpsites which are spatially distributed with the highest number recorded in Kona ward with 8 dumpsites, followed by Barade Ward and Sarkin Dawaki ward with 4 ones each, Sintali has 3, while Majidadi has 2 dumpsites.

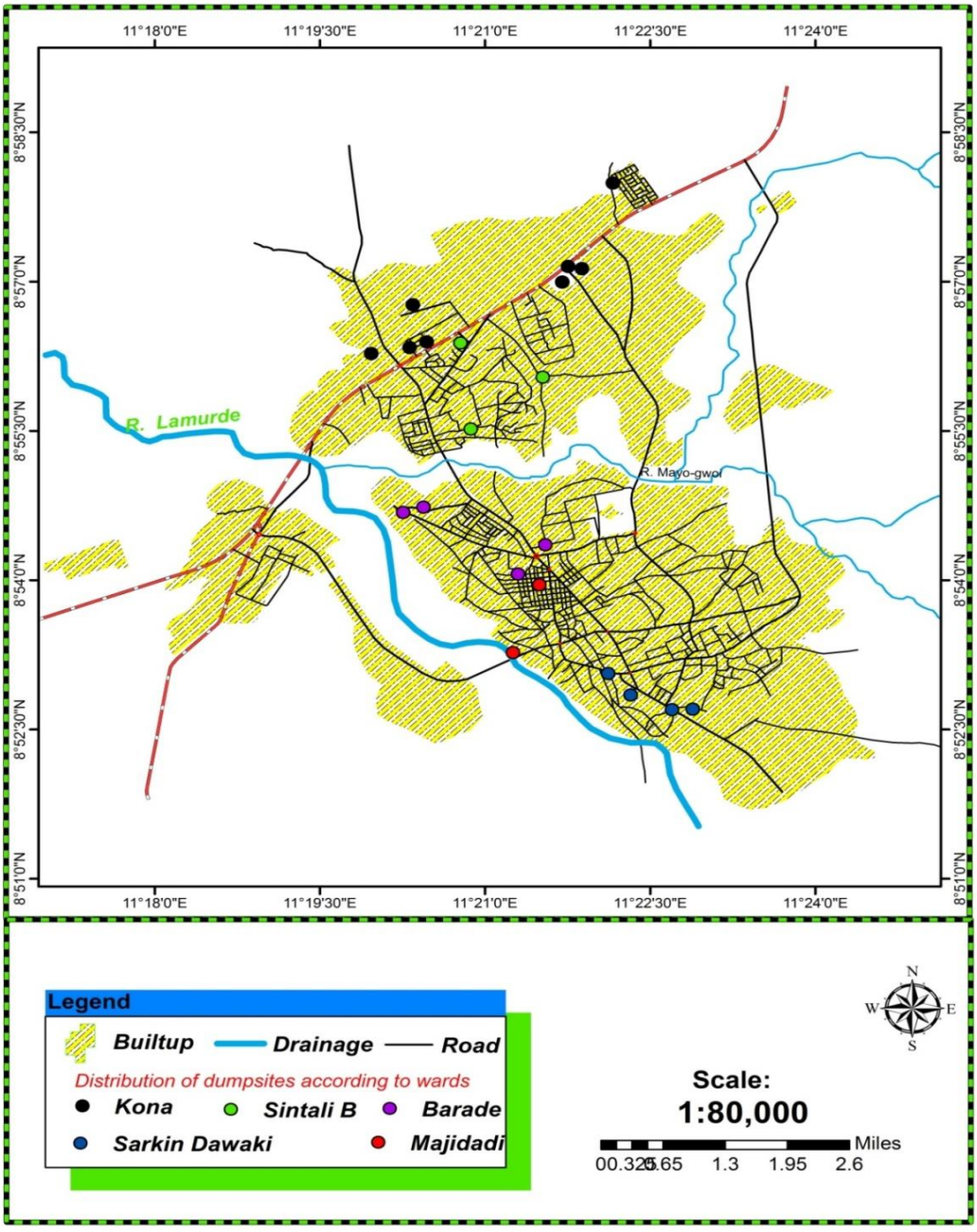

Figure 4. Spatial distributions of dumpsites in Barade ward, Kona Ward, Majidadi Ward, Sarkin Dawaki Ward and Sintali B Ward, respectively, located within the study area (Jalingo).

The site survey revealed that all the dumpsites identified in the study area considered are illegal dumpsites, this is because most of the solid wastes were dumped on virtually any available open space, either by the road side, drainages, or even within the vicinity of individual environments (**Table 1**). This is conformed to the research of Abd'razack *et al*. (2013) whose findings show that only 6 legal dump collection points and about 92 illegal dump sites were in Jalingo city, as people dump their wastes to any available space and stream channels they feel like.

Table 1. Geographical Coordinates of the Dumpsites in the study area.

WARD	LOCATION OF DUMPSITE	X	Y
Barade ward	New Magami Quarters	8.91133	11.33763
Barade ward	Behind Tukur P/Sch	8.901	11.355
Barade ward	Anguwan Saurara	8.91536	11.36206
Barade ward	Rigiyan Waluwel	8.93987	11.34118
Kona ward	Mile six	8.91541	11.36326
Kona ward	Mile six	8.9524	11.36228
Kona ward	Kona road	8.93793	11.3328
Kona ward	Behind main park	8.93895	11.33861
Kona ward	FGGC	8.93971	11.34631
Kona ward	Air Strip	8.9461	11.3391
Kona ward	Abuja phase two	8.943	11.358
Kona ward	Teknobat back gate	8.966	11.369
Majidadi	Behind Jalingo main market	8.87893	11.38125
Majidadi	Behind Jalingo main market	8.8783	11.37834
Sarkin Dawaki ward	Karofi	8.88785	11.35424
Sarkin Dawaki ward	Behind Police HQ	8.88075	11.37205
Sarkin Dawaki ward	Kasuwan Yelwa	8.88435	11.36866
Sarkin Dawaki ward	Kasuwan Yelwa	8.92531	11.34787
Sintali B	Behind Govt. Scie Sec. Sch	8.90591	11.35915
Sintali B	NTA Road	8.87791	11.38088
Sintali B	Anguwan NTA	8.91219	11.3407

Source: Field Survey, 2017

4. 2. Proximity Analysis between Dumpsite and Built-Up Areas

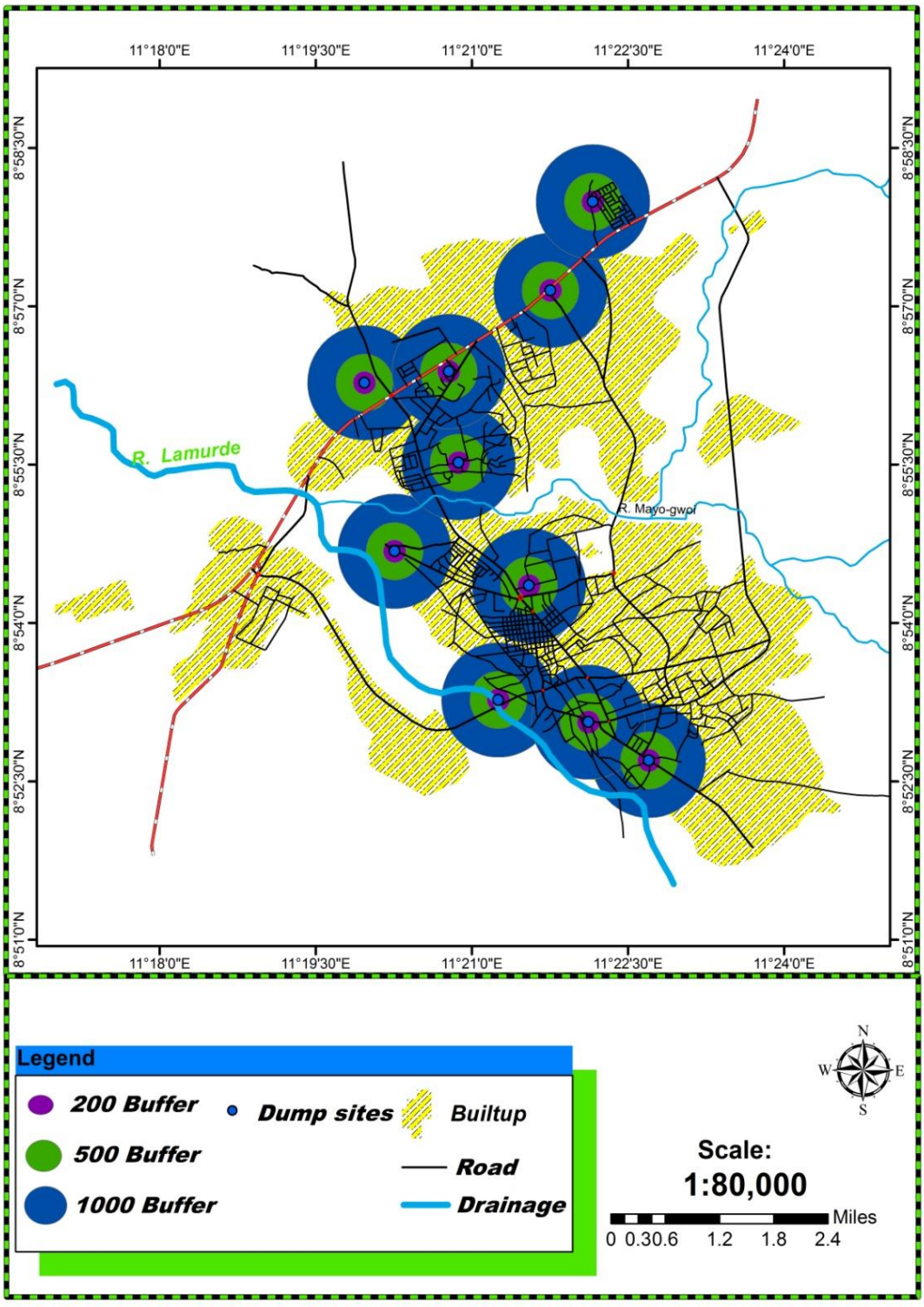

Figure 5. 200-m buffer, 500-m buffer, and 1000-m buffer analysis on dumpsites away from built-up areas, roads, and drainages within the study area.

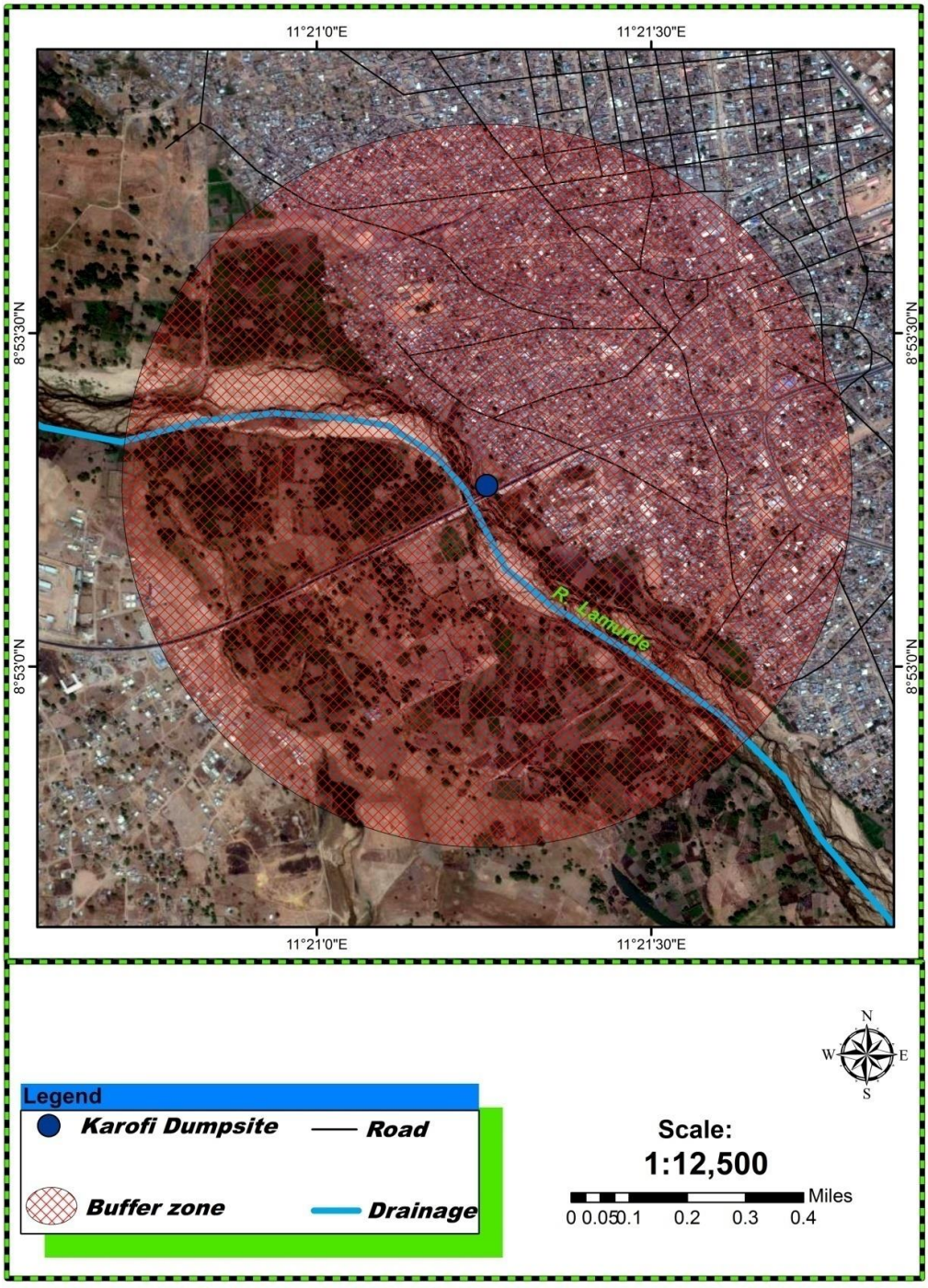

Figure 6. 1000-m buffer map of a dumpsite located at the bank of a major drainage, as well as built up areas located in Karofi, ward.

Figure 5 shows the proximity analysis map of dumpsites in the study area. It can be deduced from the map that, ring buffering of 200 m, 500 m, and 1000 m was achieved. It can

also be further deduced that, built-up area within the study area covered a landmass of 61.479 km^2 with various road networks crisscrossing the study area and so also drainages. Out of the 61.479 km^2 of the built-up area, in proximity of 200 m, 1.257 km^2 of the built-up area are in danger of dumpsite health related diseases. Furthermore, at proximity analysis of 500-m and 1000-m standards, 7.857 km^2 and 31.439 km^2, respectively, are in danger (**Table 2**). This means that in a holistic view of the study area, out of the total built-up area of 61.479 km^2 in the study area, virtually all the dumpsites located within 31.439 km^2 of the built-up area do not conform to the NESREA standard criteria of citing a dumpsite, which means, the study area is highly exposed to the dumpsite related diseases.

Figure 6 is a buffer of 1000 m of one of the dumpsite in Korofi, Sarkin Dawaki Ward of the study area on a high resolution image which clearly shows the extent of the built-up areas in danger of dumpsite related diseases (**Table 3**). This is because most of the dwellers within that area depend on the river as their major source of water for both, domestic and other commercial activities, the location of that dumpsite at the bank of the river poses a serious hazards on the health of dwellers in that area.

Table 2. Square Kilometers at 1000, 500, and 200 Meter Buffer

S/N	Buffer	Square kilometer in Danger of Dumpsite Related Diseases
1	1000 meter buffer	31.439 km^2
2	500 meter buffer	7.857 km^2
3	200 meter buffer	1.257 km^2

Source: Field Survey 2017

4. 3. Assessment of the negative effect of location of dumpsite close to built-up areas

Based on the result of the proximity analysis, in Figure 5 above, all of the dumpsites are not in conformity with the NESREA standard criteria of location of dumpsites at 1000 meters away from settlements, 1000 meters away from river channels and 2000 meters away from roads. The implication of this is that, the residence located close to these dumpsites are at risk of disease, such as malaria, dysentery, cholera, and eye irritation which have been associated to residents living close to waste dumpsites (Oyedele and Oyedele, 2017; Sindama *et al.*, 2017; Suleman *et al.*, 2015; Addo *et al.*, 2015; Thitame *et al.*, 2015; Foday *et al.*, 2013; Selin, 2013; Ogunrinola and Adepegba 2012). This was compared with the recorded cases of malaria obtained from the health care centres within the study area (**Table 4**). From the malaria data obtained from 2012 to 2016 (Table 3), Kona ward with the highest number of dumpsites recorded the highest cases of malaria of 21,148, followed by Sarkin Dawaki ward with a total number of 21,130 cases of malaria recorded, Sintali B recorded a total number of 18,335 cases of malaria, Barade ward recorded a total number of 17,023 cases of malaria, while Majidi ward recorded 12,626 cases of malaria. Based on this findings, it is obvious that the solid waste dumpsites located close to human habitation contributes to the breeding of mosquitoes, the ward with the highest number of dumpsites recorded the highest cases of malaria, due to the

possibility of its ability to breed the female anopheles mosquito that transmit malaria. In an interview with a Health Personnel with the Primary Health Care Development Agency, (Mr. Zakari Chindo), he confirmed that locating dumpsite close to the human habitation has a negative effect on human health. According to him, diseases such as malaria from breeds of mosquitoes and eye irritation from smokes emitting from burning of solid wastes, are also associated with open solid waste dumpsite. This result is in conformity with the findings of a pilot study of the Dandora Waste Dump conducted in Kenya in 2007 (UNEP, 2007), the study, as tentative as it was, showed that, there is a strong link between waste generation and human health. In an extensive tests carried out on the soil and water around the refuse dumpsites in comparison with samples from other sites, as well as medical tests carried out on humans living around the dumpsite shows evidence of infections, such as malaria, typhoid, and eye irritation from water, land, and air pollution (UNEP, 2007; Muthee, 2014).

Table 3. Showing Recorded Cases of Malaria in Jalingo Metropolis

S/N	MONTH/YEAR	Barade	Kona	Majidadi	Sarkin Dawaki	Sintali B
1.	JAN – DEC 2012	2883	3314	2064	3736	2833
2.	JAN – DEC 2013	2464	3430	2588	3276	2984
3.	JAN – DEC 2014	1890	2404	1784	2188	2107
4.	JAN – DEC 2015	4724	5826	2094	5719	4984
5.	JAN – DEC 2016	5062	6174	4096	6211	5427
	Total	**17,023**	**21,148**	**12,626**	**21,130**	**18,335**

Source: Primary Health Care Centre, Jalingo in collaboration with Family Health International (FHI).

Table 4. Comparison Between the Recorded Cases of Malaria and Number of Dumpsite Within Jalingo Metropolis

S/N	Ward	No. of dump site	2012 – 2016 malaria cases recorded
1.	Barade ward	4	**17,023**
2.	Kona ward	8	**21,148**
3.	Majidadi ward	2	**12,626**
4.	Sarkin Dawaki ward	4	**21,130**
5.	Sintali B ward	3	**18,335**

Source: Field Survey 2017 and Primary Health Care Centre, Jalingo.

5. CONCLUSIONS

The focal point of this research was to derive an insight into the high risk potential of dumpsite locations in Jalingo city. The result, however, points to the fact that solid waste dumpsites within Jalingo city are located at will, without consideration of its proximity to human habitation and its negative effect on human health, as such the need to observe standard location of dumpsite for a healthy environment is of paramount importance.

Based on the findings of the study, the spatial distribution of dumpsite in the five selected wards as area of the study showed that wastes are indiscriminately dumped at any available open space by the residence, with little or no attention being paid to its health implications which might be attributed to ignorance or the possibility of being left without an option.

The proximity analysis indicates that most of the dumpsites are located outside the NESREA's standard criteria of locating a dump site, at proximity analysis of 500-m and 1000-m standard, out of the total built-up area of 61.479km^2 in the study area; virtually all the dumpsites located within 7.857km^2 and 31.439km^2, respectively, are not in conformity, thereby exposing the study area to the dumpsite related diseases. Moreover, based on the records on malaria cases from the health care centers located within the selected five wards, it is obvious that, dwellers residing close to a dumpsite are at risk of other related disease, such as typhoid, cholera, dysentery, and eye irritation. Therefore this habit has now put about 31% out of the total land area covered of 61% at risk of dump site related diseases.

In order to adopt the standard criteria for location of dumpsites by the National Environmental Standard Regulation Enforcement Agency (NESREA), the findings therefore suggest that a site suitability analysis of dumpsite in Jalingo city should be undertaken as a matter of urgency.

Recommendation

GIS in our today's world has solved and is still solving many problems encountered by man and his environment. Therefore, GIS technology should be wholly embraced in the management of our dear environment due to its ability to accurately characterize known points of contamination, predict further areas of concentration that have not yet been measured, and also generate predictions of elevated risk based on these predicted concentrations. With the scope of the study limited to assessing the health effect of dumpsite location close to human habitation in the study area, the need for people's view on dumpsite and site suitable analysis in Jalingo is hereby recommended for a further research. This will bring about the required knowledge to the citizenries on dumpsite and related diseases, thereby keeping into NESREA standard criteria of location of dumpsite to save the citizens from health-related problems associated with dump site.

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