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Spatial Analysis of Factors Responsible for Incidence of Water Borne Diseases in Ile-Ife, Nigeria

Olajuyigbe Ayo Emmanuel[1*], Alinaitwe Prossy[3], Adegboyega Suleiman Abdul-Azeez[2] and Salubi Eunice[3]

[1]*Department of Urban and Regional Planning, School of Environmental Technology, Federal University of Technology, Akure*
[2]*Department of GIS and Remote Sensing, School of Earth and Mineral Sciences, Federal University of Technology, Akure, Nigeria*
[3]*Department of Remote Sensing and GIS, Regional Centre for Training in Aerospace Surveys, Ile-Ife, Nigeria*

The high prevalence of cases of water borne diseases in most cities in Nigeria is alarming. In these cities, there is little documentation about the spatial variability of the incidence of the diseases. This study adopts GIS techniques to investigate the spatial variation of water borne diseases in Ile-Ife, Nigeria. Data for the study were acquired from IKONOS satellite imagery and topographical map from which essential features were extracted using digital image processing techniques of Erdas Imagine 9.1 version. Structured questionnaire was also used to elicit information on households' socio-economic characteristics. Water samples were collected and analyzed using standard microbial and chemical methods. The microbial count, pH and water hardness were interpolated using Krigging interpolation technique in ArcGIS 9.3. The secondary data utilized for the study include land use data and reported cases of water borne diseases from health facilities. Geocoding technique of ArcGIS 9.3 was employed to match the addresses of the patients with the cases of water borne diseases. The results showed that most reported cases of water borne diseases were due to environmental factors including poor environmental sanitation and topography. This implies that a continuous negligence and under estimation of the role of these factors in the spatial spread of the water borne diseases may increase the vulnerability and health risk of the people in the area. The study recommends frequent treatment of wells and boreholes, improved environmental sanitation and enhanced waste management strategies.

Keyword: GIS, water borne diseases, spatial variability, environmental sanitation, water samples, satellite imagery

Introduction

Waterborne diseases are very rampant especially in sub Saharan Africa due to lack of access to clean water and poor sanitation. In Nigeria, contaminations of drinking water with pathogens have also been reported in several towns (Bai et al., 2007). Waterborne outbreaks of enteric disease have occurred either when public drinking water supplies were not adequately treated after contamination with surface water or when surface waters contaminated with enteric pathogens have been used for recreational purpose (Johnson et al., 2003). Today only 58% of Nigerians have access to safe water (UNICEF & WHO, 2012). Thus, most households have to resort to drinking water from wells and streams especially in the rural and suburban communities. These water sources are largely untreated and might harbour waterborne and vector-borne diseases such as cholera, typhoid fever, diarrhoea, hepatitis and guinea worm (Rahman et al., 2001; Adekunle, 2004; Fenwick, 2006).

In developing countries, particularly in Nigeria, the two main water problems man contends with are the quantity and quality of water (Adeniyi, 2004 & Olajuyigbe, 2010). In view of its occurrence and distribution pattern, water is not easily available to man in the desirable amount and quality. This is a problem experienced in most cities and towns in the developing nations not to mention their rural settings. These factors have led to the growing rate of water borne diseases like typhoid fever and cholera experienced in this part of the world (Edwards, 1993).

Waterborne diseases are caused by pathogenic micro organisms which are directly transmitted when contaminated fresh water is consumed. Contaminated fresh water, used in the preparation of food, and be the source of food borne diseases through consumption of the same micro organisms. Many rivers, streams and wells worldwide are affected by faecal contamination leading to increased health risks to persons exposed to the water, degradation of recreational and drinking water quality (Simmons, 1994; Obiri-Danso et al., 2009). Pathogenic bacteria that may be associated with faecal contamination

*Corresponding author. Email: olajuyigbe03@yahoo.com

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include pathogenic strains of *Escherichia coli, Campylobacter, Salmonella species, Shigella species* and *Vibrio cholerae*. In addition to these organisms causing human diseases, resistance to antibiotics has made treatment of the diseases they cause more difficult (Lamikanra & Okeke, 1997; Okeke et al., 2007).

A report by Central Bank of Nigeria in 2003 showed that in 2004 fertility rate in Nigeria was 5.6% per annum. Furthermore, the report estimated that the Nigerian population has a natural rate of increase of 3.0%. By implication in 2025, Nigerian population should be about 231.6 million. This high natural rate of increase will affect family size and indirectly affect household utility factor in relation to water demand. This implies that a household demand for piped connection would increase as family size increases. In addition, there are evidences that waterborne diseases that had been eradicated in many parts of the world are still common in Nigeria (Ifabiyi, 2011). This is further established by the UNDP 2006 Human Development Index as reported by (Nzedkah, 2006) that ranked Nigeria 159th among 177 countries assessed for availability of safe water. The same report also indicted the country as a bedfellow in a club of 30 nations with the poorest quality of life worldwide.

Numerous cases of water borne disease have been documented in the country. For example, there are increasing evidences of fresh outbreak of cholera, diarrhoea, guinea worm and other waterborne diseases. A survey by the Federal Ministry of Health (FMOH) in 1989 showed outbreak of cholera in Katsina, Kaduna, Kano, Bornu, Plateau, Benue, Cross-river, Akwa-Ibom, Lagos and Delta States. Furthermore, in 1989, Nigeria recorded 1,059 cases of cholera with 60 deaths (5.7%); and within the same there were 65,588 cases of simple diarrhoea with 132 deaths (0.2%). Also within the same period, there were 2,911 cases of hepatitis with 21 deaths (0.7%), and typhoid and paratyphoid going to 4,280 cases with 49 deaths (1.1%) (William, 1991).

Studies have shown that the occurrence of waterborne diseases in cities of developing countries has been due to unsafe water, inadequate sanitation and poor hygiene among human population. For example, Oguntoke et al (2009) examines the relationship between the spatial patterns of waterborne disease and water quality in parts of Ibadan, Nigeria in which he concluded that provision of adequate portable water remains the most important tool for preventing water borne diseases in the city. This situation is not peculiar to only the big cities in Nigeria as the Vanguard newspapers on the 25th of August, 2011 reported that at least one person was confirmed dead and 20 hospitalized in different hospitals due to the devastating effect of water borne diseases in Ile-Ife, Nigeria. However, there is little documentation about water borne diseases in Ile-Ife which perhaps perpetuates the inadequate awareness of their occurrences and incidence factors let alone the spatial-temporal trend.

In view of the above, this study attempts to assess and map the incidence factors responsible for the spread of water borne diseases in Ile-Ife, Nigeria. Moreover, the study explores the spatial analytical tools of Geographic Information Systems (GIS) to capture the incidence factors in a bid to curtail the possible spatial spread of water borne diseases in the study area.

Materials and Methods

Research site

Ile-Ife houses two Local Government Areas (LGAs) namely, Ife Central and Ife East LGAs. Specifically, Ife Central LGA consists of 11 political wards while only 3 wards in Ife-East LGA fall within the city. It lies between latitudes 07^0 31'N and 07^0 34'N and longitudes 04^0 30'E and 04^0 34'E (Figure. 1). It is one of the largest urban centers in Osun state, Nigeria and probably the oldest town of the Yoruba people. The most acclaimed beautiful University in Africa, Obafemi Awolowo University is domiciled in this city. Hence, Ile-Ife is considered as highly urbanized but suffers a serious setback in the area of infrastructure development. The population of the area is about 167,254 persons consisting of 88,403 males and 78,801 females based on the 2006 census result (NPC, 2007).

The study area lies within the humid semi-hot equatorial zone. The climate is dominated by two major air masses; the warm and the dry tropical continental wind from the Sahara Desert and the hot, humid tropical maritime wind from the Atlantic zone (the south West Monsoon wind). The wet season starts from mid March to late October while the dry season runs from November to March. The city has mean annual rainfall of about 1400mm while the mean temperature ranges between 28^{0}C to 34^{0}C. Relative humidity is about 75.8% to 86% for dry and wet seasons respectively. With the prevailing climatic conditions coupled with the altitudinal location (286m above sea level), the study area is populated with non-forested wetlands that somewhat influence the quality of well water as well as vulnerability of the residents to water borne diseases.

The study area is underlain by metamorphic rocks of the basement complex, which outcrop over many parts. Rocks of the basement complex found here is schist, associated with quartzite ridges. The vegetation of the area falls under tropical rainforest belt characterized with multiple canopies and lianas. Farming practice on the floodplains of some major rivers in Ile-Ife is characterized by small holdings with cultivation of field crops such as maize, cocoyam and vegetables. Most floodplains in the study area are occupied by residential buildings. The built up area of this city is in fact growing quite fast towards the river channels and floodplains.

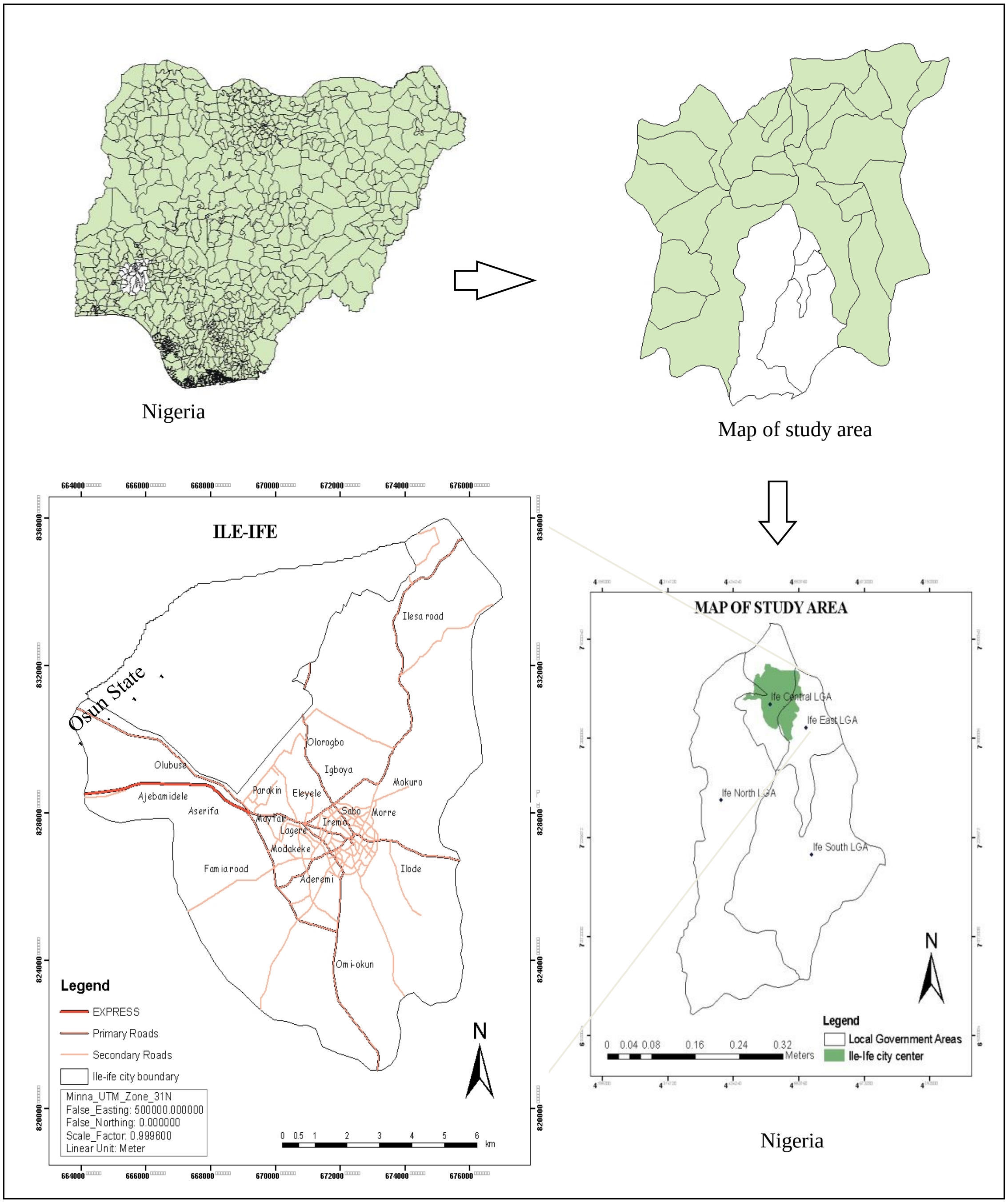


Figure 1. Location of the study area.

Database description

The application of GIS enables a system for establishing the relationship and interaction between the various spatial and aspatial factors responsible for the outbreak of water borne diseases. This section thus, explains the procedure for analyzing the various factors responsible for the incidence and spread of water borne diseases.

Both primary and secondary data were deployed to accomplish the purpose of this study. The primary data sources include 1966 topographical map on scale 1:50,000 acquired from the office of the Surveyor-General of the Federation, Abuja, Nigeria, administration of structured questionnaire, collection of water samples and IKONOS satellite imagery. In addition, Global Positioning System (GPS) was used to obtain the coordinates of hospitals, boreholes, wells, and waste disposal sites. The secondary data utilized for this study include administrative map of Ile-Ife acquired from the archive of Ife Central Local Government Area, land use map of Ile-Ife obtained from the repository of Regional Centre for Training in Aerospace Surveys (RECTAS), data on location and address of health care facilities obtained from the Osun state Ministry of Health and data on recorded cases of water borne diseases accessed and obtained on request from the selected health care centres within the study area.

Data processing, integration and analysis

Data collection was based on ten (10) wards in Ife Central LGA and three (3) out of eleven (11) wards in Ife East LGA due to the high population concentration in these areas. The topographical map was scanned loaded, imported and displayed using Erdas Imagine 9.1 software. The area of interest (aoi) was delineated as subset of the image. The subset images were georeferenced using the coordinates of Ground Control Points (GCP) generated during field survey (Table 1). The images were resampled using polynomial transformation technique to facilitate data integration. Data layers such as road network, topological features, place names, drainage networks, relief features and location of health facilities were created. These data were updated using data extracted from 2011 IKONOS image. Also, data extracted from the administration of structured questionnaire were integrated to the database.

Essentially, structured questionnaire was used to elicit information on bio data of residents, living conditions, income, health history, sources and access to potable water, other socio-economic conditions of the people as well as the incidence of water borne diseases in Ile-Ife. With assumption of an average of 7 people per household (Fasakin, 2000), the city has 23,893 households. About 2.5% of the total number of households was selected for the survey. This translates to a total of 600 questionnaires. This sample size is considered adequate in view of the homogenous nature of the population. The questionnaires were subsequently administered randomly to residents in the selected wards using stratified random sampling technique.

Table 1. Coordinates of ground control points.

S/N	Location	UTM (X)	UTM (Y)
1	Lagere	7.486638	4.549417
2	OAU campus Gate	7.497028	4.522278
3	Modakeke Junction	7.476944	4.540027
4	Moore Junction	7.496111	4.568611
5	Enuwa Square	7.484833	4.563056
6	Ondo Road Junction	7.460917	4.558722
7	Road 7 Junction	7.499389	4.552944
8	NTA Station	7.500889	4.590361
9	Mayfair	7.490638	4.533527
10	Sabo	7.491194	4.557083
11	OAU Pedestrian Bridge	7.495028	4.521806
12	Eleyele Junction	7.487742	4.547883
13	Okerewe	7.483889	4.560722
14	Aderemi Road	7.479778	4.556333

The digitized road networks were classified into expressway, primary, secondary and other roads based on the width and the usage of the roads. The roads and streets were adequately named and served as basic dataset for matching street address of cases of water borne diseases gathered from the hospitals to the patients' residential addresses using Geocoding technique in ArcGIS 9.3. Also from the preliminary field survey, the land use types observed were digitized from the already classified high resolution imagery using on-screen digitization and hence, land use data layers which include residential, commercial, administrative, agricultural, recreational, religious and industrial were generated. Built up areas were mapped out based on the level of compactness. It is remarkable to point out that incidence of slum occurrence was observed at the periphery of the study area where uncoordinated low density development had sprung up.

The thematic layers such as roads and water courses were represented as polyline feature, land use as polygons, health care centres and waste dumpsites as point features. These spatial features were linked to their corresponding attributes in the GIS environment.

Water sampling and analysis

Water samples were collected from 24 hand dug wells and boreholes to complement information gathered through the administration of questionnaires in the study area. The samples were collected as 1 litre grab samples in sterile bottles and preserved in refrigerator until the time of analysis. The total viable microbial count and other required laboratory analysis were performed using standard microbial and chemical methods. Microbial analysis comprised media preparation, inoculation and incubation of the collected water samples to obtain microbial growth count and followed by chemical analysis that explored the pH and Total hardness of the water samples. The microbial count, pH and water hardness were interpolated using Krigging interpolation technique in ArcGIS 9.3. The results of the data analysis were presented in form of tables, bar graphs and maps.

Results and Discussion

Figure 2 shows the different land use patterns in the study area. Most of the outskirts are farmlands but the middle part is entirely residential areas. The buildings as observed in the high resolution satellite imagery were digitized out and it can be seen from the Map (Figure 2) that Ile-Ife has a radial centric form of settlement with much congestion at the central part of the city. Dispersed form of settlement can also be observed towards the boundary. This indicates that the city is gradually expanding into the agricultural zones. Ile-Ife is dominantly residential.

Accordingly, the spatial distribution of health care facilities followed the residential/commercial land use pattern. However, a high concentration of the health care facilities was observed in the city centre where built-ups are relatively compact, suggesting high population concentration (Figure 3).

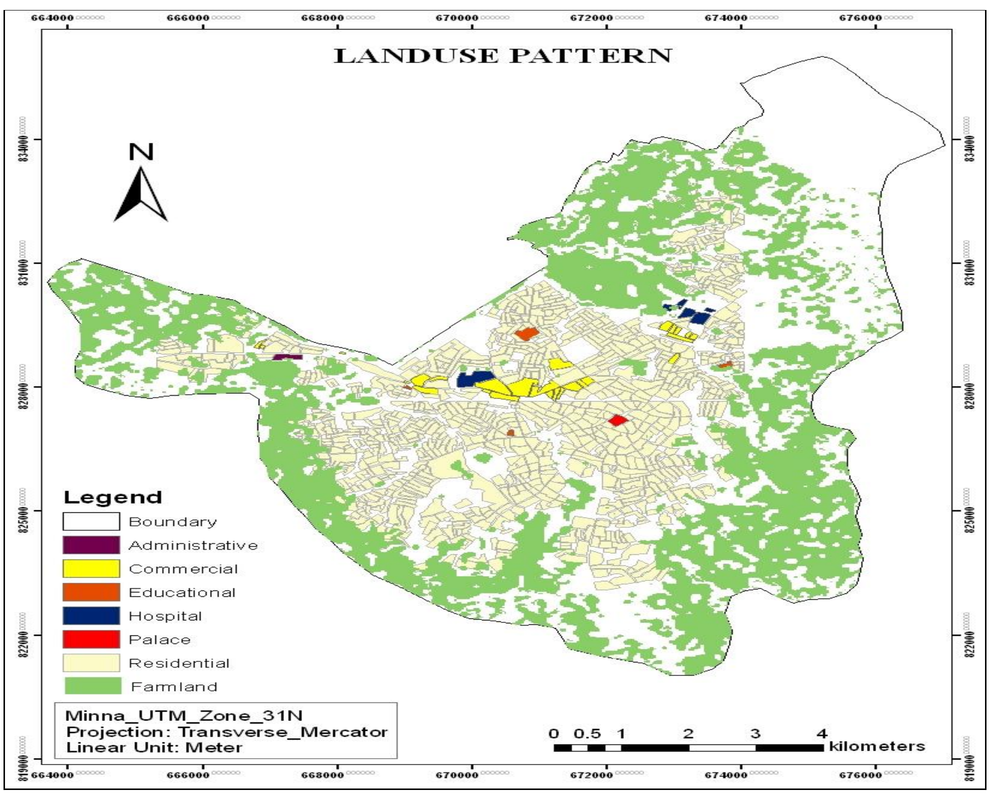


Figure 2. Land use map of the study area.

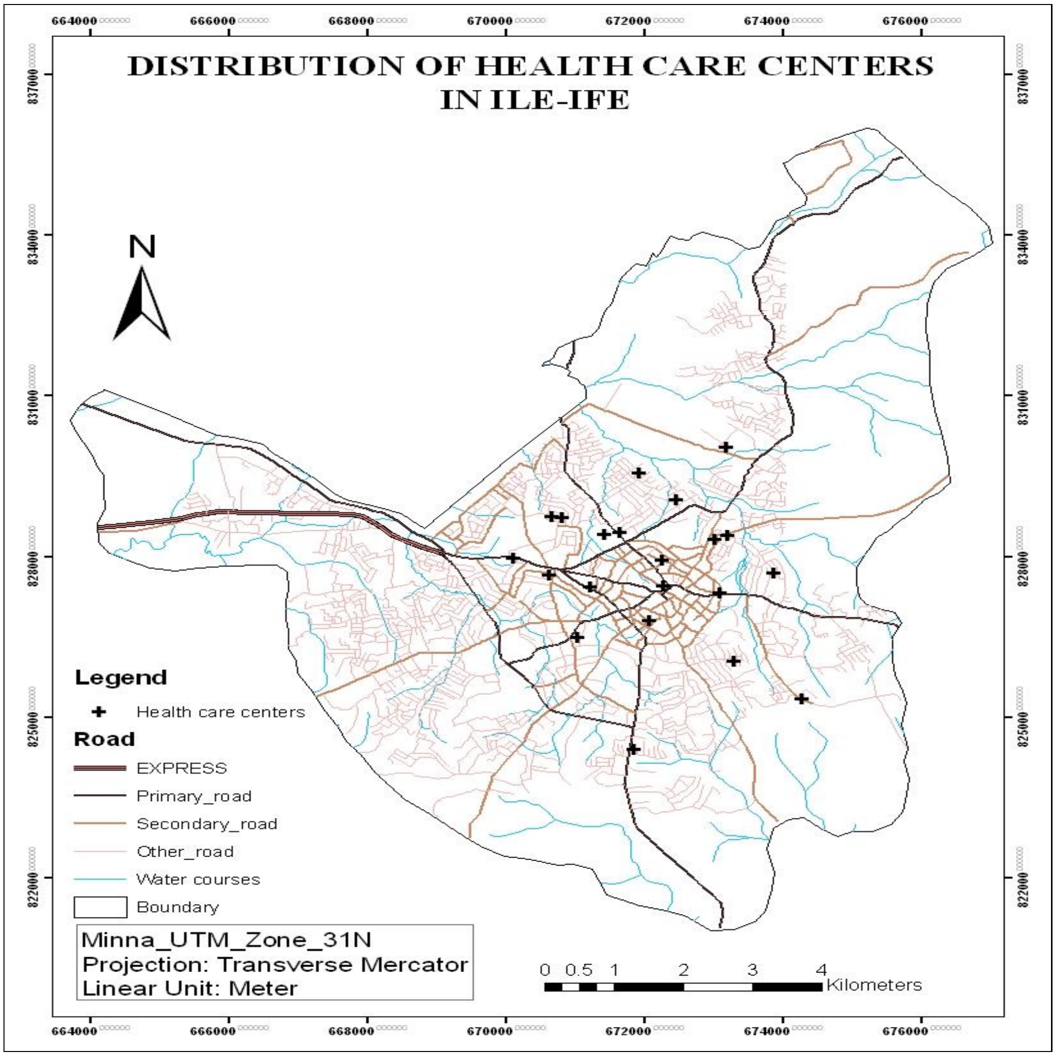


Figure 3. Distribution of health care centres in Ile-Ife.

There are 22 health care facilities in Ile-Ife. Their specific locations are depicted in Figure. 3. They include: Ife East LGA Health Care Centre, Omitoto; Ife East LGA Primary Health Care (PHC), Odo Iwara Ilode; Ife East PHC, Moore; Ife East LGA PHC, Olugbodo; Maternity Block PHC; Ifelodun Health Centre, Ondo Road; Osun State Hospital; Oke-Ogbo Comprehensive Health Centre (CHC); Modakeke State Hospital; Enuwa PHC, Oduduwa Street; Akarabata PHC; Eleyele/Parakin PHC; Seventh Day Adventist Hospital, Lagere Road; Igboya Health Facility; Aderemi PHC; Fajuyi PHC; Ile Canan PHC; Ilare Ward 4 Health Facility Centre, Olu-Nife, Sabo; O.A.U Teaching Hospital; Iredapo Health Centre and Gbalefefe Health Centre. The cases of reported water borne diseases between 2008 and 2011 gathered from these health care facilities were spatially geocoded. This involved matching the cases with the appropriate addresses of the patients through a spatial geo-information technique known as geo-coding. Based on these addresses, water borne disease incidence maps were consequently prepared for each of the health facilities. The various maps were subsequently coalesced to generate a map indicating the total water borne disease incidence for Ile-Ife (Figure. 10). In an attempt to elicit incidence factors, cases of water borne diseases reported in 6 health facilities were fully discussed in this study. This process culminated to the identification and discussion of the incidence factors of water borne diseases for Ile-Ife. It is apposite to emphasize that the 6 health facilities that were chosen for identification of incidence factors were randomly selected. The number of the facilities chosen was considered adequate because of the homogeneous nature of the study area especially with respect to physical and socio-economic traits.

It is evident from Figure 4 that the cases of water borne diseases collected from Ifelodun PHC between 2008 and 2011 were concentrated along Ondo Road

Bye-pass that runs through Modakeke and the peripheral areas of Ile-Ife. The areas along this road including all infrastructures were gravely affected by the aged-long communal Ife-Modakeke crisis of 1997-2000. Following the conclusion of the civil strife, resettlement took place along this road. The only available sources of water for the residents are wells that more often than not are uncovered. These water points are highly susceptible to contamination, thus the high concentration of water borne diseases in the area.

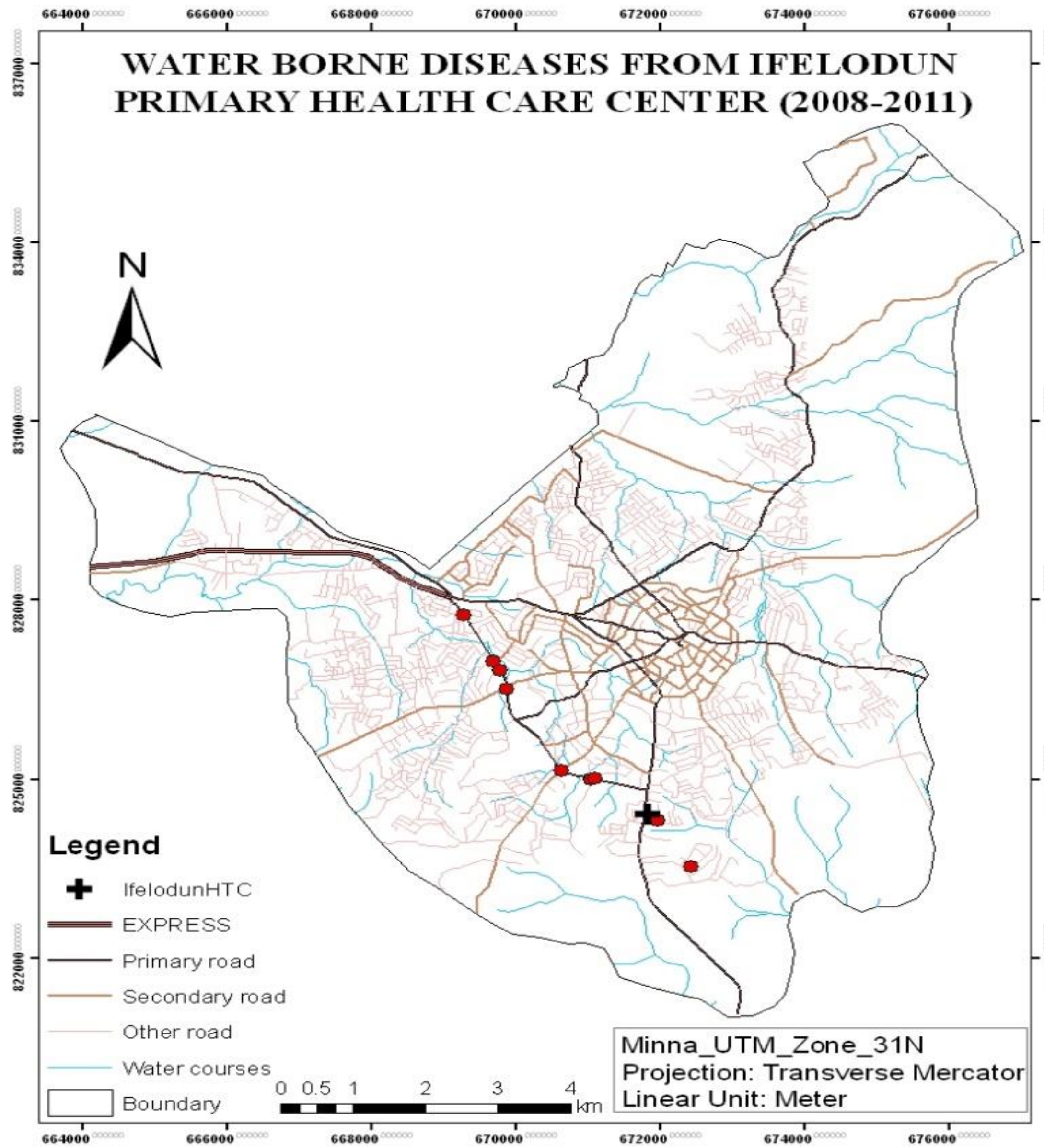


Figure 4. Cases of water borne diseases from Ifelodun PHC (2008-2011).

Igboya Primary Health centre is located along Road 7 in Igboya area. Figure. 5 shows the spatial incidences of waterborne diseases from 2008-2011 as collected from that Health Centre. It was clearly observed that most patients who receive treatment from the health center are residents of the area. The area lies in the low topography where incessant urban flooding has been recorded in recent times. Both low topography and flooding have great potentials at affecting the quality of surface and groundwater systems. Thus, the physical location of Igboya has a serious implication on the well water that constitutes the major source of domestic water for the inhabitants.

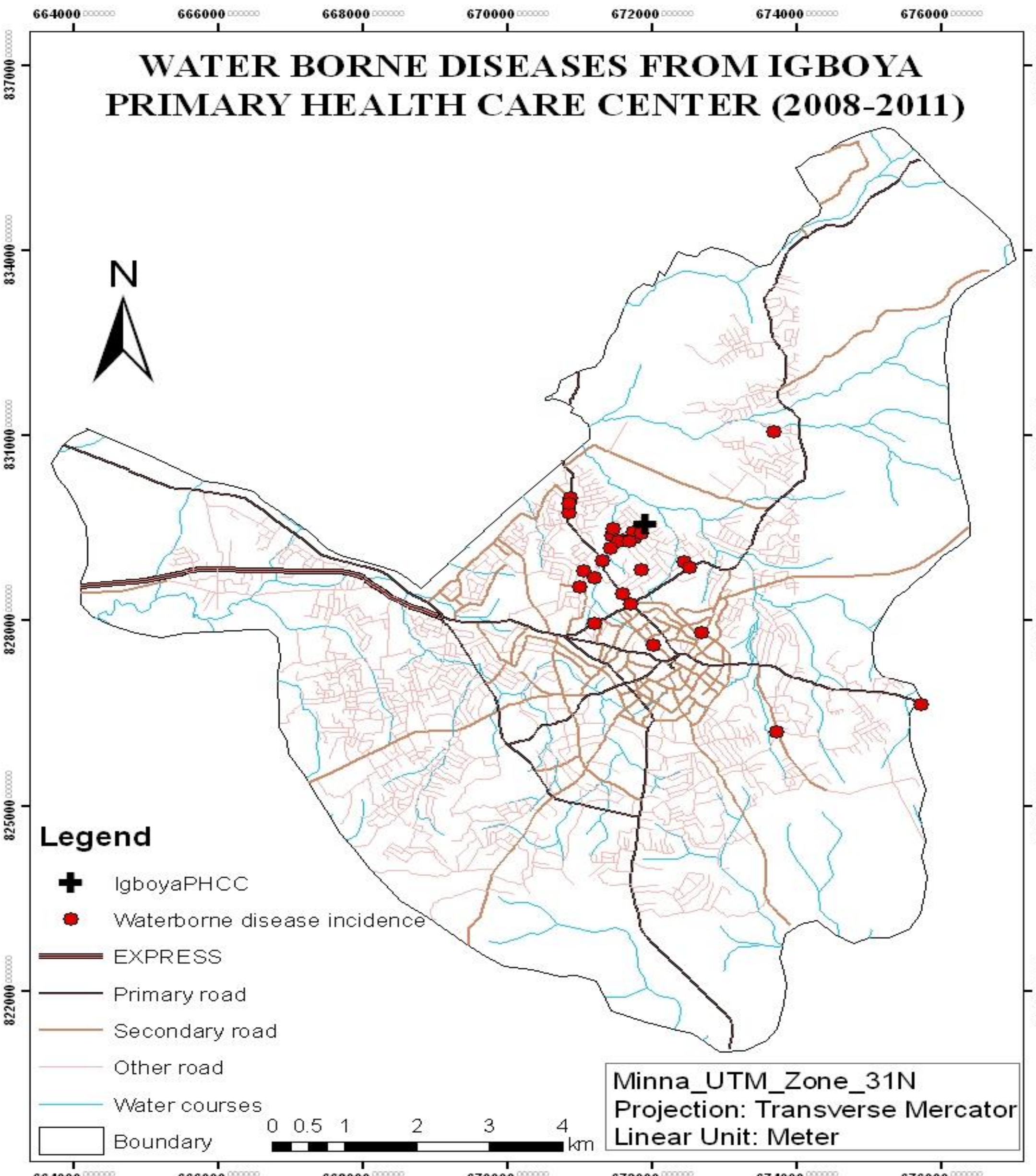


Figure 5. Cases of water borne diseases from Igboya PHC (2008-2011).

It is also obvious from Figure. 6 that cases of water borne diseases treated at Olugbodo PHC between 2008 and 2011 were found within the city centre where dilapidated old buildings were concentrated and indiscriminate waste disposal of both solid and liquid were noticed. Thus, there is high tendency for the wells around the area to be susceptible to contamination. Since these residents do not have access to piped borne water, they could be considered as highly vulnerable to water borne diseases as they rely on wells for their domestic water need.

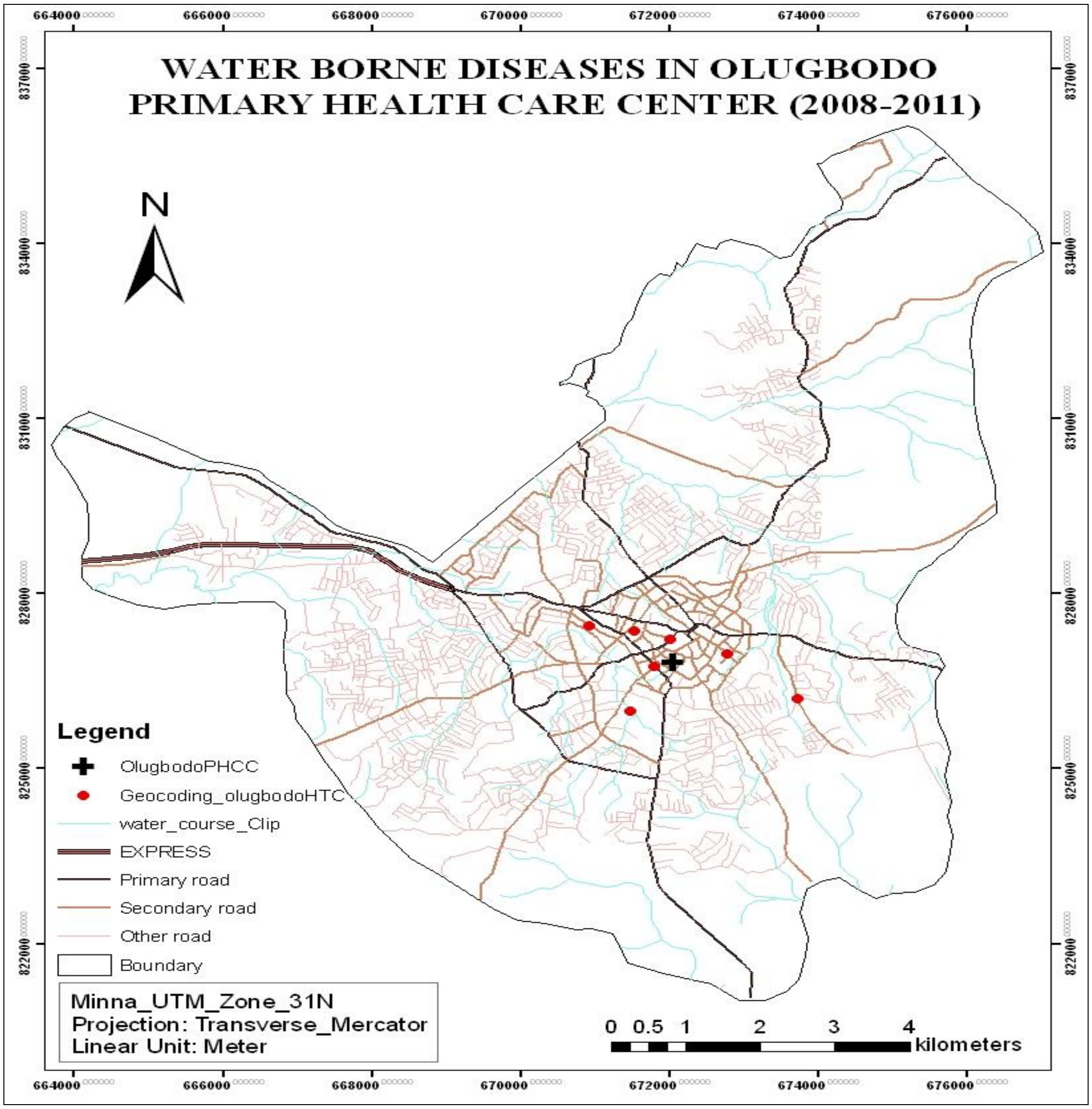


Figure 6. Cases of water borne diseases from Olugbodo PHC (2008-2011).

In Figure 7, the spatial distribution of reported cases of water borne diseases at Ile Canani PHC along Ilara Road, in Ile-Ife showed that the patients were found along the roads within the city centre where majority of the residents used open-pit toilets as observed during field survey. Also, the area was noticed to be very close to Oduogbe market where large wastes were generated and improperly disposed in the nearby stream. No doubt, this mode of wastes disposal could have compromised the quality of well water in the area.

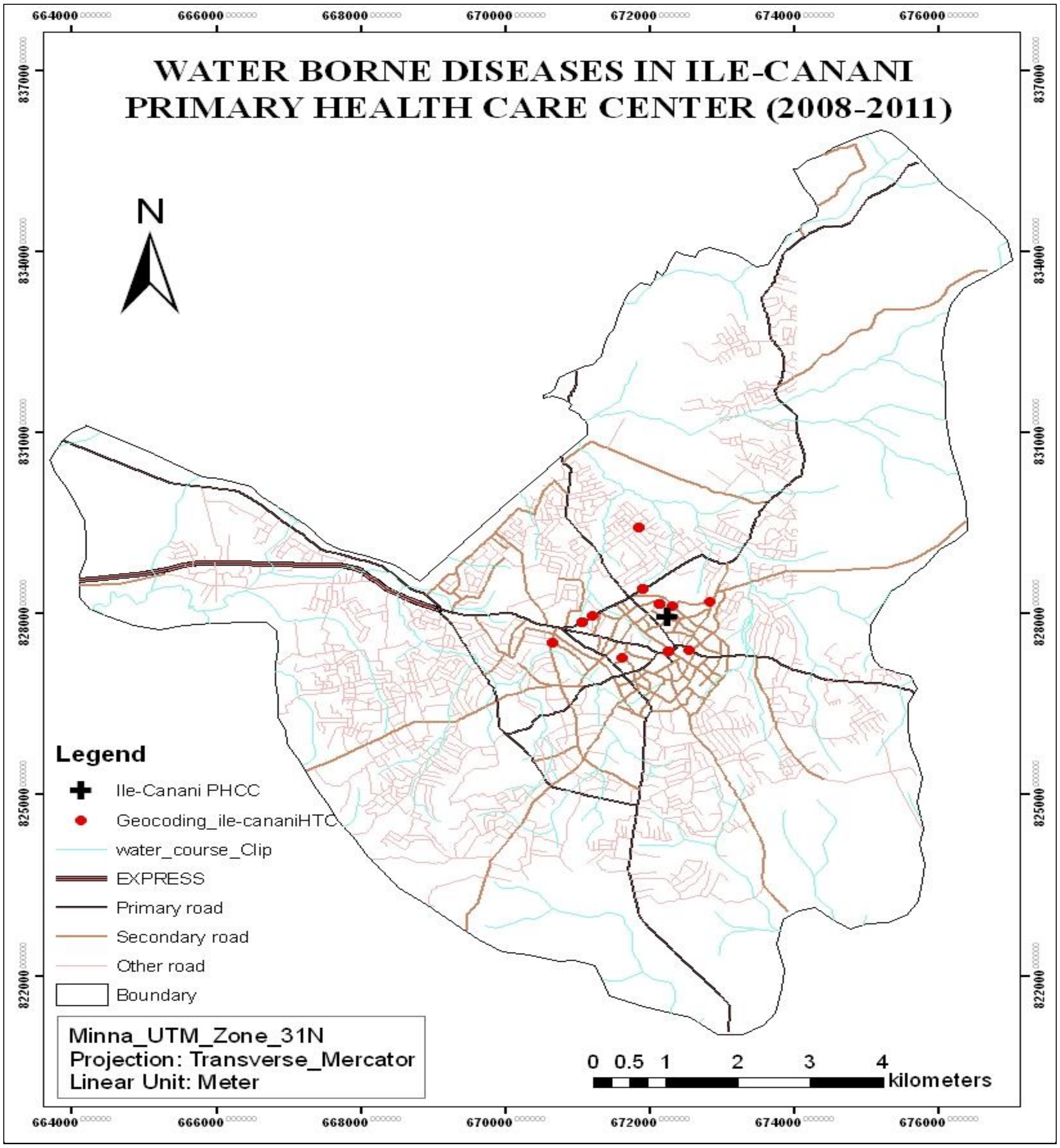


Figure 7. Cases of water borne diseases from Ile-Canani PHC (2008-2011).

Figure 8 further showed geocoding of the cases of water borne diseases in Ife East General Hospital. The addresses of the patients revealed that most of the patients resided in the areas around the swamps.

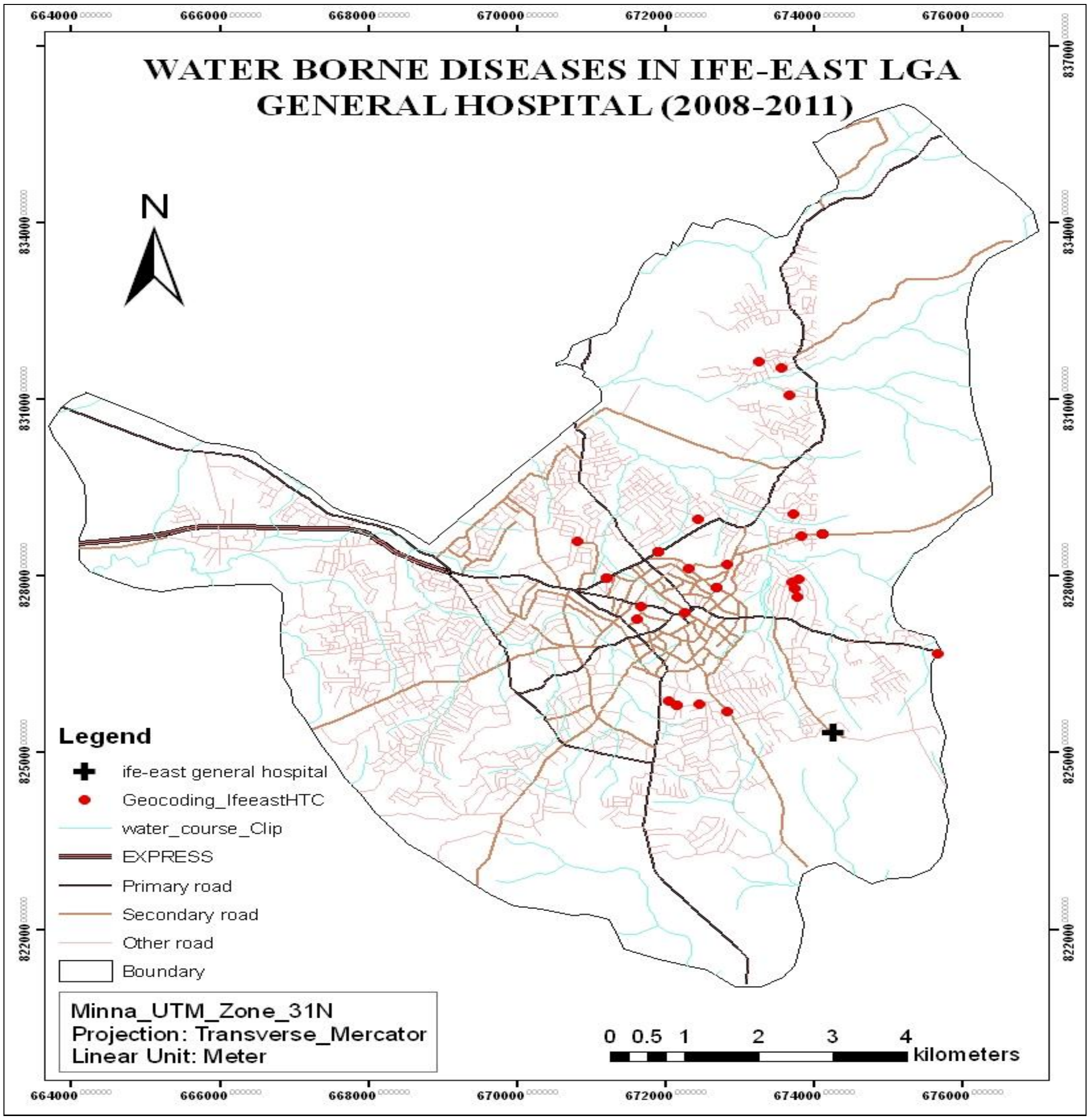


Figure 8. Cases of water borne diseases from Ife East General Hospital (2008-2011).

Whilst in Figure 9, cases of water borne diseases, particularly in Seventh Day Adventist Hospital (SDA) depicted both in and out patients. Though most of the in-patients were observed to have come from outside Il-Ife to receive treatment but the out-patient department showed that most out-patients were residents of Ile-Ife.

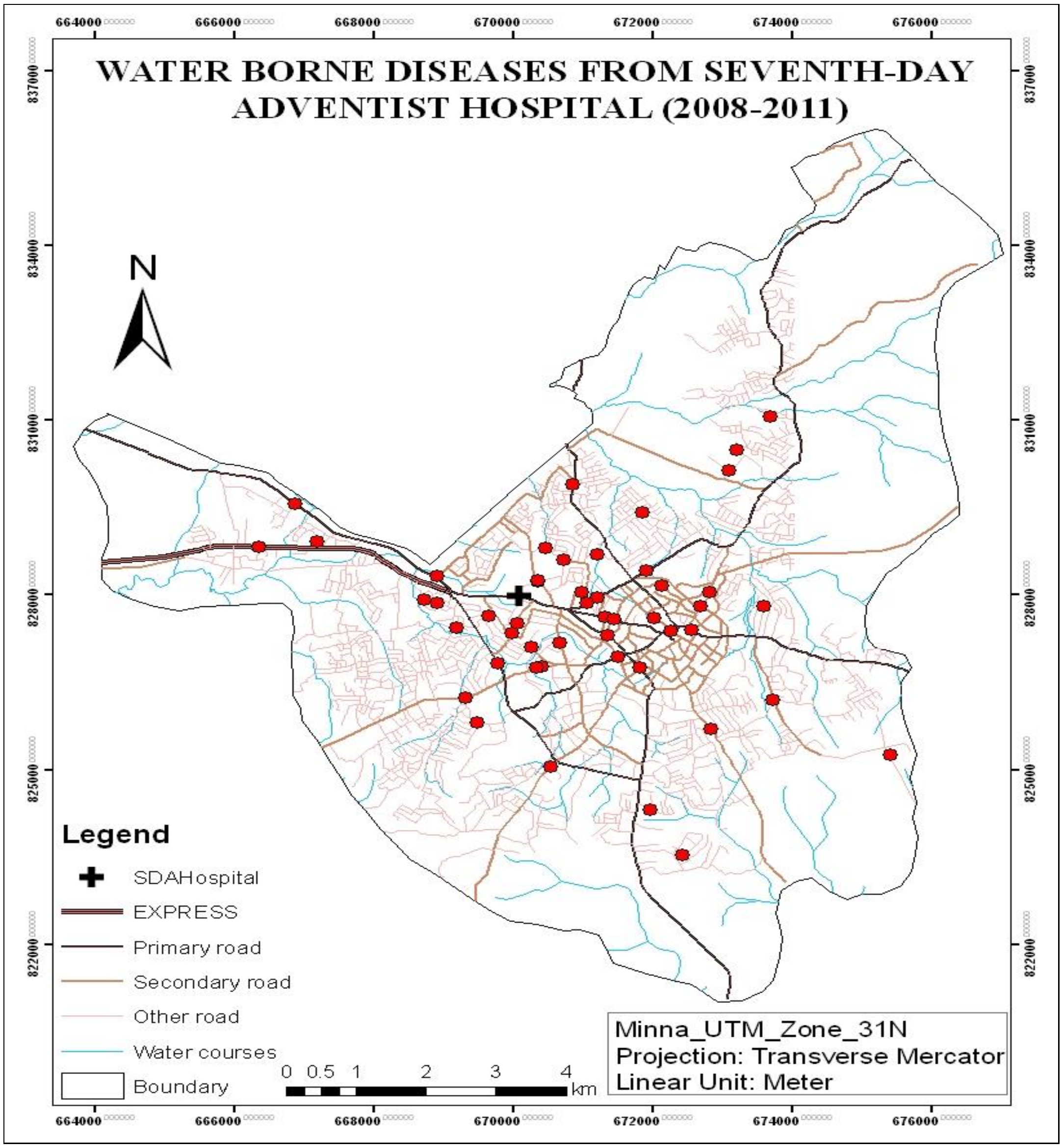
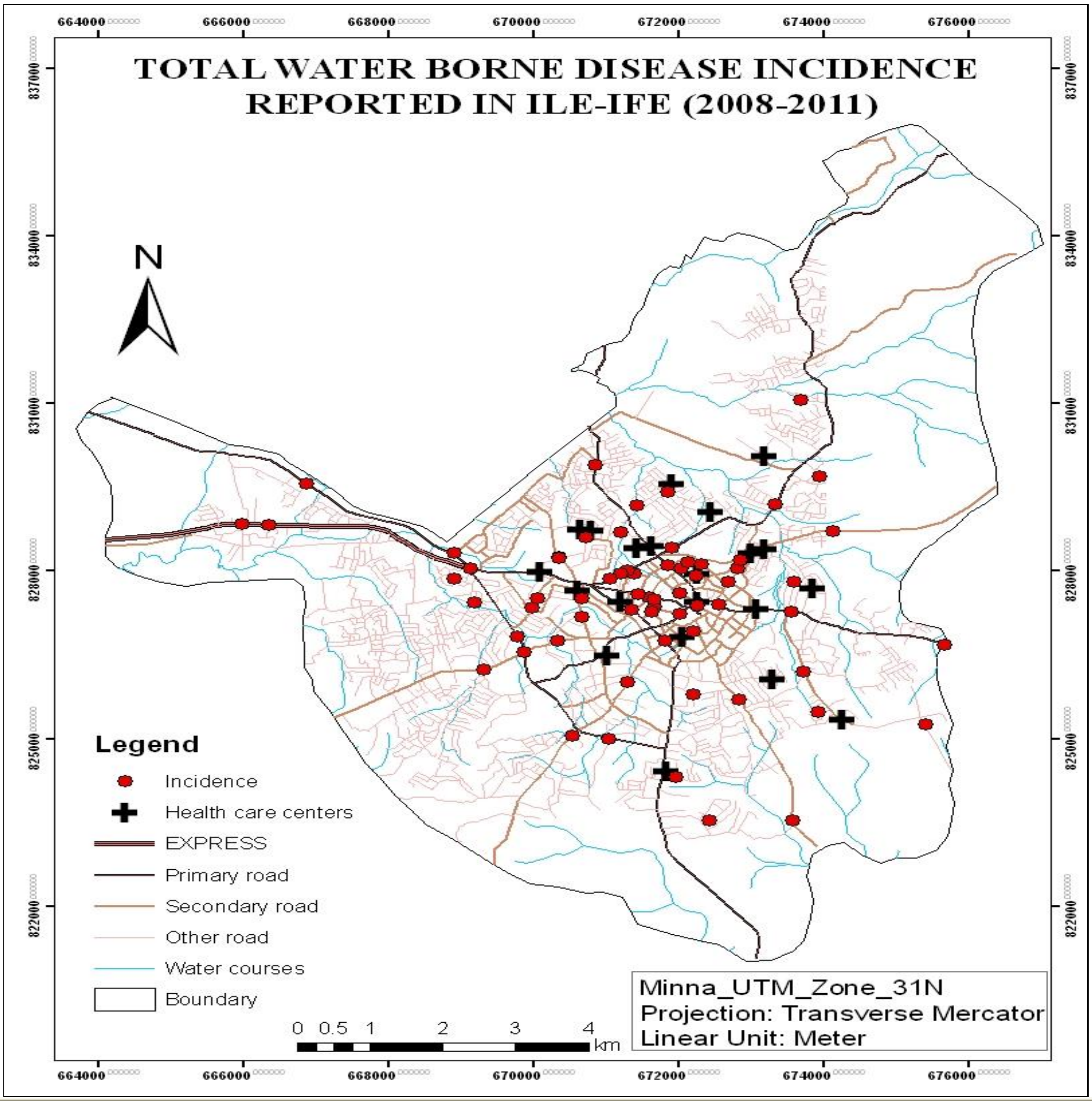


Figure 9. Cases of water borne diseases from Seventh Day Adventist Hospital (2008-2011).

Figure 10 shows the general incidences of water borne diseases in Ile-Ife as recorded from all the health facilities in the city. It is obvious from the Figure. that the incidences of water borne diseases were mostly concentrated in Modakeke and Sabo areas. During the field survey it was clearly observed that the living conditions in these areas were hygienically poor. Residents rely on open wells for their domestic water need while faecal wastes are largely disposed through pit latrines which more often than not are near the water sources (wells). Again, there are no well designated dumpsites as most refuse are put along the road. Water contamination from such practices must have been reflected in the high cases of water borne diseases that are recorded in these areas. It was however observed that the cases of water borne diseases decrease progressively away from the city centre. For example, it was observed during field investigation that pit latrines were more prevalent in the city core. Specifically, in the study area, faecal waste through septic tank decreases away from urban periphery to the city core. Earlier studies have confirmed that socio-economic factors such as income, level of education, occupation, awareness on health issues among others could be instrumental to the observed pattern (Olajuyigbe, 2010).



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A			25, ADYELABOWO, STREET, IFE	12/10/2010	25, ADYELABOWO, STREET, IFE	F	52yrs	Typhoid	
A		0 TOWN PLANNING RD	Town planning road	Wednesday,	SON,Town planning Road	M	24yrs	Typhoid	
A		0 TOWN PLANNING RD	Town planning road	Tuesday, Jan	SON,Town planning Road	M	22yrs	Typhoid	
A		0 TOWN PLANNING RD	Town planning road	Wednesday,	SON,Town planning Road	F	23yrs	Dysentry	
A		0 EDE RD	Ede road	Thursday, Ja	O.A.U,Ede Road	M	60yrs	Typhoid	
A		0 ONDO BYE PASS	Ondo bye pass	10/Febuary/2	Ondo Road,Ife	F	57yrs	Typhoid	
A			Ayebowa Village	Tuesday, Feb	Ayebowa Village	F	4mths	Dysentry	
A			Oduduwa street,Ife	Tuesday, Mar	Oduduwa street,Ife	F	30yrs	Dysentry	

Figure 10. Composite map of waterborne diseases from all the health facilities in Ile-Ife from 2008 -2011.

A further breakdown of the data also indicated a high prevalence of typhoid in the city. Other significant water borne diseases recorded include diarrhoreal and dysentery. However, only few cases of cholera were recorded (Figure 11).

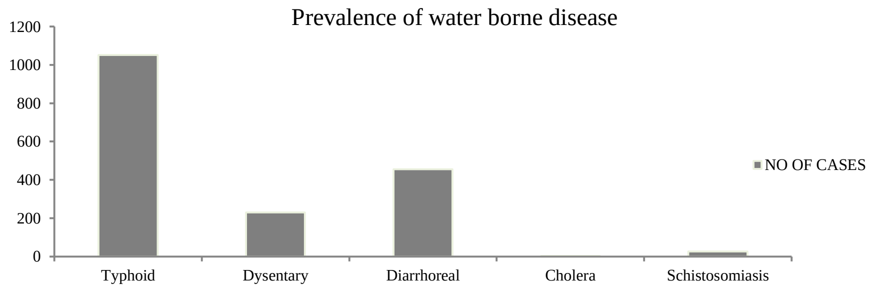

Figure 11. Prevalence of water borne diseases in Ile-Ife.

Further analysis of water samples revealed other factors that promote incidence of water borne diseases in the study area as presented in Figure 12 and Table 2. As shown in Figure 12 the water samples were collected from Modakeke Ward 1, Modakeke Ward 2, Iremo 1, Iremo 4, Ilare 2, Moore Ward and Ilode Ward 2. From the results of the laboratory analysis, factors such as Hardness of water, pH of water and microbial growth were found to have been responsible for high prevalence of water borne diseases in Ile-Ife.

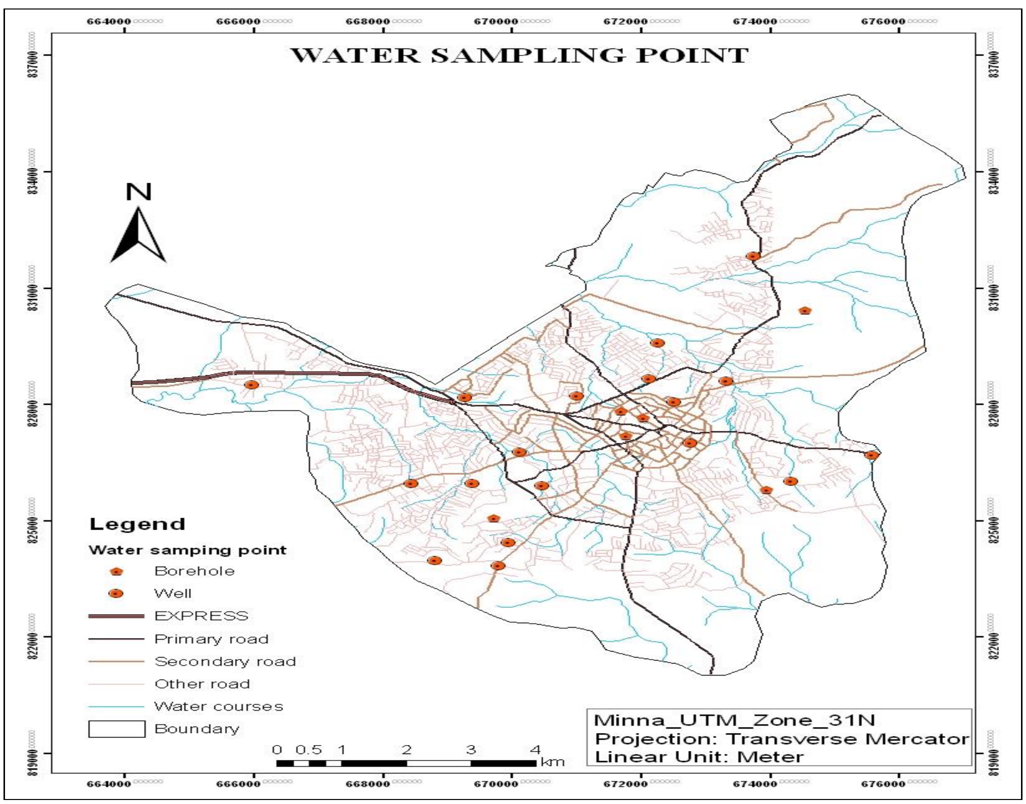

Figure 12. Water sample points in the study area.

Table 2 showed that the total number of water samples analyzed were 24, comprising 18 wells and 6 boreholes. From the table, microbial count analysis revealed that from 18 wells analyzed, 12 well samples showed microbial growth. Conversely, all the 6 borehole samples analyzed showed microbial growth, as revealed in colonies 6 and 8. Coliform forming unit in colonies 6 and 8 as shown in the table, 5 well samples showed microbial growth and 13 well samples showed no microbial growth, while only 2 borehole samples showed microbial growth and 6 borehole samples had no microbial growth. The spatial pattern of the microbial count is also depicted on Figure 13.

Table 2. Table of descriptive analysis of water samples.

		N	Mean	Std. Deviation	Std. Error	95% confidence interval for mean Lower Bound	Upper Bound	Min.	Max.
pH	Well	18	5.8267	.43062	.10150	5.6125	6.0408	4.99	6.89
	Borehole	6	6.2417	.16510	.06740	6.0684	6.4149	5.92	6.38
	Total	24	5.9304	.42034	.08580	5.7529	6.1079	4.99	6.89
Total hardness	Well	18	88.00	83.500	19.681	46.48	129.52	4	296
	Borehole	6	252.00	155.208	63.364	89.12	414.88	96	452
	Total	24	129.00	125.110	25.538	76.17	181.83	4	452
No of colonies in colony 6	Well	12	8.67	6.329	1.827	4.65	12.69	2	24
	Borehole	6	5.17	2.994	1.222	2.02	8.31	2	9
	Total	18	7.50	5.607	1.322	4.71	10.29	2	24
No of colonies in colony 8	Well	12	86666666.67	6.329E7	1.827E7	46451928.17	1.27E8	20000000	240000000
	Borehole	6	51666666.67	2.994E7	1.222E7	20241953.53	83091379.80	20000000	90000000
	Total	18	75000000.00	5.607E7	1.322E7	47115835.50	1.03E8	20000000	240000000
Coliform forming unit in colony 6	Well	5	3.60	1.517	.678	1.72	5.48	2	6
	Borehole	2	1.00	.000	.000	1.00	1.00	1	1
	Total	7	2.86	1.773	.670	1.22	4.50	1	6
Coliform forming unit in colony 8	Well	5	3.60E9	1.517E9	6.782E8	1.72E9	5.48E9	2000000000	6000000000
	Borehole	2	1.00E9	.000	.000	1.00E9	1.00E9	1000000000	1000000000
	Total	7	2.86E9	1.773E9	6.701E8	1.22E9	4.50E9	1000000000	6000000000

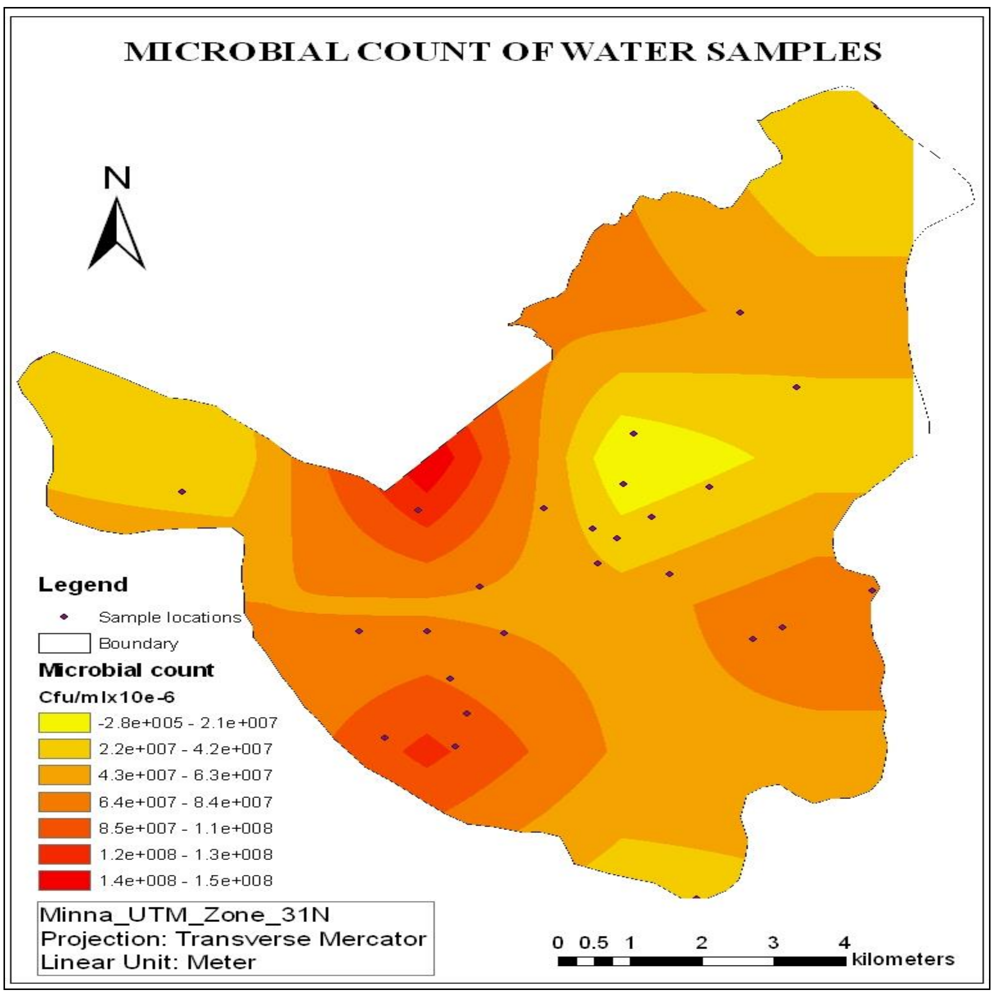

Figure 13. Microbial count of water samples in Ile-Ife.

In table 3, the pH of well water sampled in the study area varied from 4.99 to 6.89 while the pH of borehole water samples also varied between 5.92 and 6.38. Water hardness of the wells sampled ranged between 4mg/L and 296 mg/L while that of the borehole varied from 96mg/L to 452mg/L. These results suggest that most of the wells and boreholes sampled were to a varying extent contaminated and hence, drinking water from these sources can aggravate the prevalence of the water borne diseases (Figures 14 and 15).

Table 3. Table showing the Laboratory results of different wells and boreholes sampled.

Well	Water samples		Borehole	Water samples	
	pH	Total Hardness (mg/L)		pH	Total Hardness (mg/L)
W1	5.78	40	B1	6.29	408
W2	5.38	12	B2	6.33	136
W3	5.56	4	B3	6.30	452
W4	4.99	16	B4	6.38	296
W5	6.89	296	B5	6.23	124
W6	6.27	240	B6	5.92	96
W7	5.96	152			
W8	5.39	56			
W9	6.20	80			
W10	6.37	176			
W11	5.73	52			
W12	5.75	44			
W13	5.48	20			
W14	6.00	156			
W15	5.71	92			
W16	5.82	24			
W17	5.92	84			
W18	5.68	40			

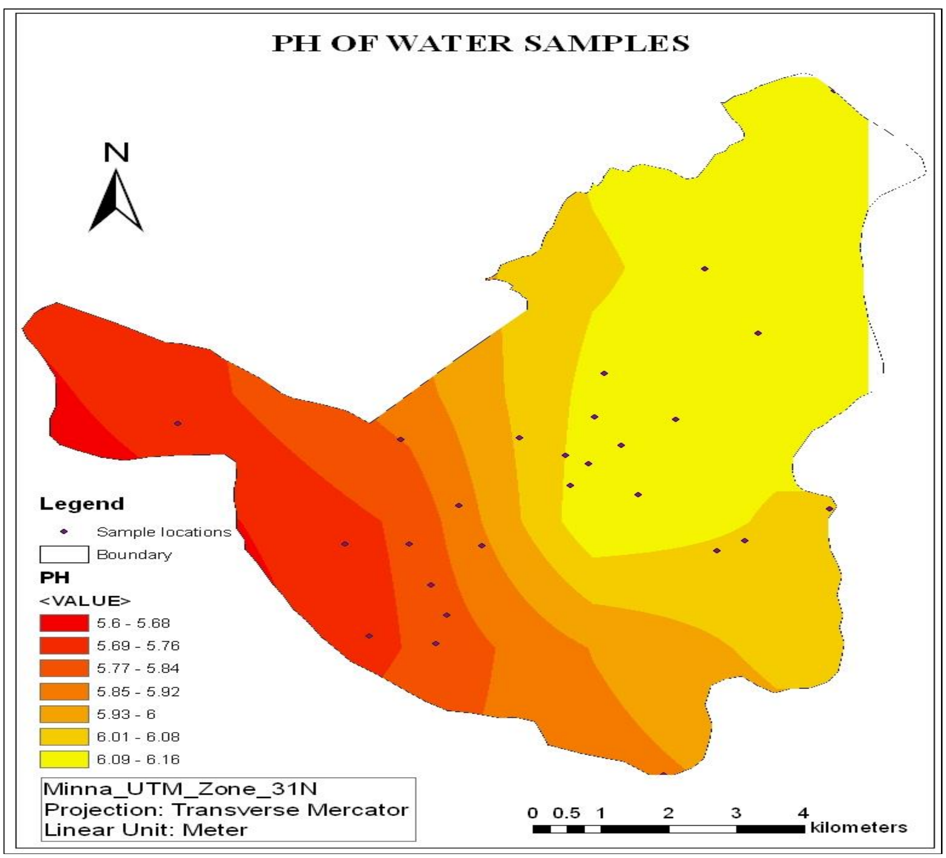

Figure 14. pH of Water Samples in Ile-Ife

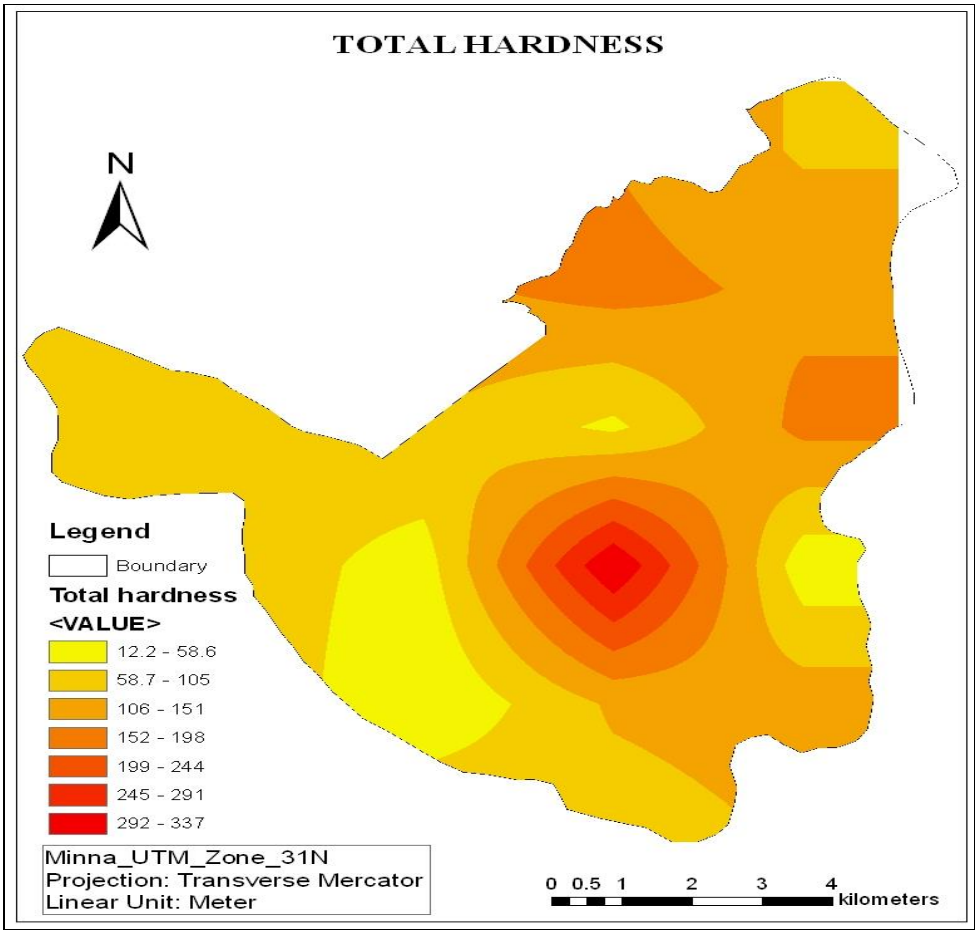

Figure 15. Water Hardness in Ile-Ife.

Conclusions

This study investigated the factors responsible for the prevalence of water borne diseases in Ile-Ife, Nigeria. It was observed that most of the reported cases of water borne diseases were due to environmental factors such as poor environmental sanitation, indiscriminate waste disposal, effect of age-long communal crisis, low topography and swamps that led to high microbial growth, water hardness and high pH of the well and borehole water in the study area. The long term desire of water supply system in the city should be to ensure that every household is connected to the piped water system since this is usually the only system that is considered as safe (Franceys, 1993; Sullivan et al, 2003; Cairncross & Valdmanis, 2006). However, at the interim, it is canvassed that appropriate government agencies should encourage frequent treatment of all existing wells and boreholes in the city. In addition, to the development of a sustainable waste management for the city, it is further suggested that the environmental sanitation officers of the LGAs should embark on public enlightenment campaigns on the health implications of indiscriminate waste disposal and poor environmental sanitation.

No doubt, there are clear evidences of collapsing infrastructure in most developing countries. Thus, most city dwellers in these countries are susceptible to high incidence of water borne diseases. Therefore, broader examination of the variables used in this study, on a regional scale using GIS and remote sensing techniques may provide much needed framework for making comparison and enhancing possibility of providing appropriate measures to tackle the problem of water borne diseases that are becoming endemic in the developing countries.

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