GIS APLICATION IN DOMESTIC WASTEWATER DISPOSAL OF TOILET DISPOSAL FACILITIES IN BIDA, NIGER STATE, NIGERIA

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ABSTRACT

Discharge of untreated or inadequately treated wastewater into the environment is a serious source of health problems and environmental pollutions globally including Nigeria. This study applied GIS technique to evaluate the toilet facilities for domestic wastewater disposals and the associated impacts on public health and the environment in Bida, Niger State. Two hundred and forty households were sampled in the study area. Global Position System (GPS) receiver was used to obtain the geospatial data (3-D coordinates) of the sampled households. Structured questionnaires were administered to obtain the attribute data for the households. GIS database was created for the sampled households. The results of the study shows that about fifty percent (50%) of the sampled population make use of non-standard toilet facilities for domestic wastewater disposals. Sixty six percent (66%) of the pit latrines and soakaways are located within thirty meters (30m) to wells/boreholes thereby exposing the users of such wells/boreholes to health problems. GIS query was used to indicate the locations with the highest and least non-standard toilet facilities for domestic wastewater disposals. It is recommended that GIS should be used to prepare a comprehensive database of domestic wastewater disposal facilities for the study area, formal and informal education, legislation, enforcement, adequate monitoring and management as solution to the high level of non-standard toilet disposal facilities and the associated adverse consequence.

INTRODUCTION

Effective environmental planning, monitoring and management generally require quality, detailed and easily accessible data on related subjects about the environment. A technology that allows users and providers to view, understand, question, interpret and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes reports and charts is very vital (Velăzquez, 2009).

Thus in this research Geographic Informatics System (GIS) is used to ensure effective environmental planning, monitoring and management for toilet disposal facilities in the study area. Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises of liquid waste discharged by domestic residences, commercial properties, industries, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. Wastewater is the flow of used water from a community. The characteristics of the wastewater discharges will vary from location to location depending upon population and industrial sector served, land use, groundwater levels, and degree of separation between storm water and sanitary wastes. Domestic wastewater includes typical liquid wastes from the kitchen, bathroom, and laundry, as well as any other wastes that people may accidentally or intentionally pour down the drain. Sanitary wastewater consists of domestic wastewater as well as water discharged from commercial, institutional,

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and similar facilities (Environmental Canada, 2010).

In many parts of the world, including United States of America, health problems and diseases have often been caused by discharging untreated or inadequately treated wastewater. These wastewater discharges have resulted in the spreading of diseases, and destruction of aquatic life. They have serious impact on all living creatures, and can negatively affect the use of water for drinking, household needs, recreation, fishing, transportation and commerce (Pollutionissue, 2010). In the study area, the location of many toilet disposal facilities to drinking water sources affirm the assertion that discharge of wastewater can have serious adverse impacts on drinking water.

Aim

The aim of the research is to use the techniques of GIS to study the level of toilet disposal facilities in order to establish its consequences on the inhabitants of the study area. This will be achieved with the following objectives:

(i) To investigate standards of toilet disposal facilities used by households in the study area.

(ii) To ascertain the adverse consequences of toilet disposal facilities in the study area.

(iii) To evaluate the level of Government influences on toilet disposal facilities.

The Study Area

The study area, Bida Town, is located in the low basin formed by valleys of rivers Niger and Kaduna in the North Central zone of Nigeria. It is South–West of Minna, the capital of Niger State. The study area is naturally subdivided into eight homogenous Areas, four zones and two regions by road networks as in figure 1.0 below.

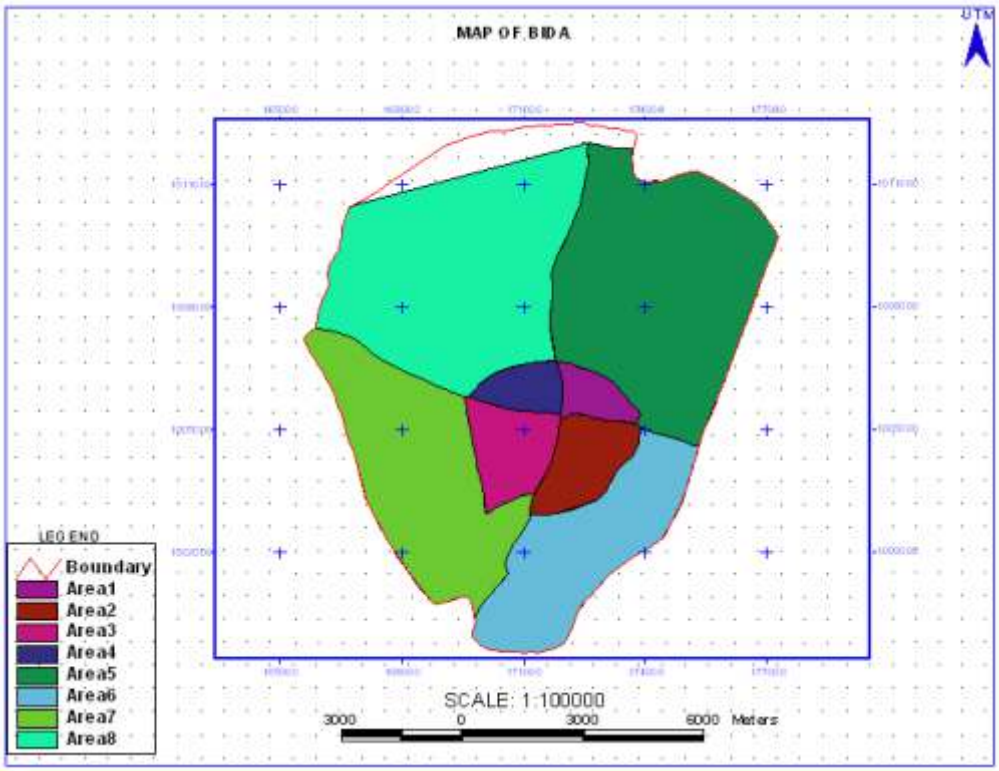


Figure 1.0: Map of Bida Town (the study area) highlighting the eight Areas
Adapted from: Yinang; (2010)

Sample Size and Procedures

The sample size for households was based on SURCON (2003) guidelines for large scale survey activities in Nigeria. The guideline specified that maximum interval between any two consecutive points along a straight should not be more than 400mters. Based on this guideline two hundred and forty households were sampled. This was made up of thirty households for each Area and one hundred and twenty households for each region (Core and Outer regions respectively).

The sampling procedure involved the use of handheld Global Position System (GPS) receivers to obtain the geospatial data (3-D coordinates) of the households according to their Areas. Structured questionnaire were administered on all the households for necessary attribute data on toilet disposal facilities in the study area. Interviews and other direct observational assessments were made to obtain other attribute data on toilet disposal facilities in the study area. Table 1.0 and Figure 2.0 respectively show the sample sizes.

Table 1.0: Domestic Wastewater Sample size for Households

Zones	Areas/Region	Sectors	Length of sector (km)	Intervals (m)	Total samples for sectors	Total sample for Areas	Total sample for Zones
Zone 1 (NE)	Area 1 (Core)	Upper Middle Lower	1.24 “ “	124 “ “	10 10 10	30	
Zone 1 (NE)	Area 5 (Outer)	Upper Middle Lower	3.81 “ “	381 “ “	10 10 10	30	60
Zone 2 (SE)	Area 2 (Core)	Upper Middle Lower	2.23 “ “	223 “ “	10 10 10	30	
Zone 2 (SE)	Area 6 (Outer)	Upper Middle Lower	3.03 “ “	303 “ “	10 10 10	30	60
Zone 3 (SW)	Area 3 (Core)	Upper Middle Lower	2.28 “ “	228 “ “	10 10 10	30	
Zone 3 (SW)	Area 7 (Outer)	Upper Middle Lower	3.03 “ “	303 “ “	10 10 10	30	60
Zone 4 (SW)	Area 4 (Core)	Upper Middle Lower	2.60 “ “	260 “ “	10 10 10	30	
Zone 4 (SW)	Area 8 (Core)	Upper Middle Lower	2.60 “ “	260 “ “	10 10 10	30	60
Total	4		8	24	240	240	240

Source: Author's Field Survey; December, 2011

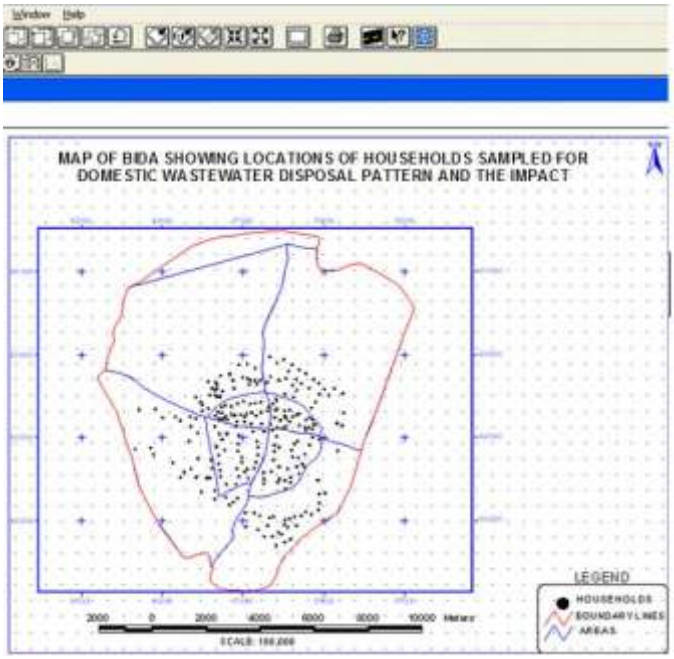


Figure 2.0: Map of the Study Area for the Sampled 240 Households
Source: Authors' Field Survey; December, 2011

Data Processing and Presentations

Data processing and presentation carried out include; data storage, database design and creation, and presentation. Note Pad, AutoCad and ArcView 3.2a software were used for the data processing and presentations. The database design covered four segments; view of reality, conceptual design, logical design and physical design models. The GIS query for the Areas with highest and lowest poor toilet facilities in the study area was administered.

Toilet Facilities for Domestic Wastewater Disposal in the Study Area

Table 2.0 and Figure 3.0 show the results of toilet facilities in the study area in percentages for the eight Areas. Table 2.0 is an extract from the GIS database created on domestic wastewater disposal facilities for the sampled population

Table 2.0: Toilet Disposal Facilities for the Sampled Households in Percentages

Areas	Bush/Open Places (TBO)	Septic Tanks (TST)	Pit Latrine (TPIT)	Total Toilet (TT)	Total Poor Toilet(TPT)
A1	7	17	76	100	83
A2	3	39	58	100	61
A3	4	31	65	100	69
A4	4	17	79	100	83
A5	11	57	32	100	43
A6	5	86	9	100	14
A7	0	86	14	100	14
A8	3	70	27	100	30

Source: Author's Field Survey; December 2011

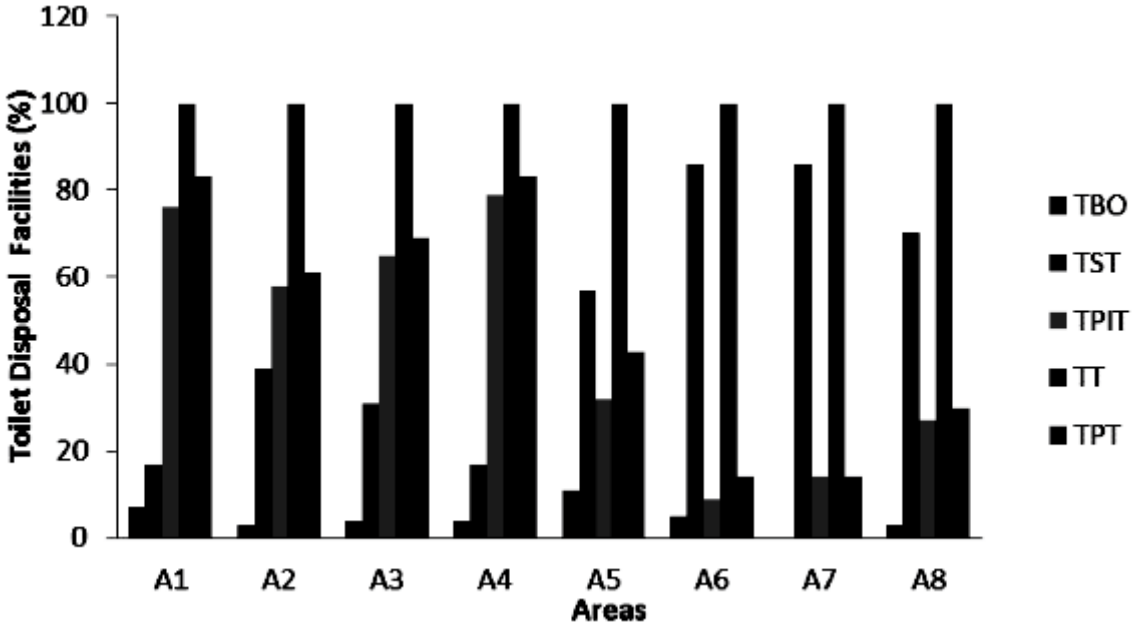


Figure 3.0: Toilet Disposal Facilities in the Study Area
Source: Author's Field Survey; December 2011

Note:
TBO – Bush/Open places; TST – Septic tank; TPit – Pit Latrine; TPT – Total Poor Toilet;

The toilet facilities used in the study area for disposal are; the bush/open spaces, septic tank system and pit latrine facilities. The septic tank is universally accepted as standard facility for disposal while the bush/open spaces and pit toilet facilities are not.

(I) Bush/open Spaces Facilities

All the Areas 1-8 except Area 7 had incidences of households using bush/open space facilities as their major facilities for toilet disposal. Area 5 has the highest occurrence with 11 percent of the sampled population using bush/open spaces facilities as indicated in Table 2.0 and Figure 3.0 Area 1 ranked second with 7 percent of sampled population using bush/open spaces facilities. The study also found out that sometimes with or without the knowledge of their parents children from households that use other facilities make use of the bush/open spaces for their toilet disposal. Although, the percentages are low for all the Areas but the health hazards associated with this practice is grievous. Houseflies can spread disease from the toilet disposals in bush/open spaces to the entire study area. Zero tolerance for the use of bush/open spaces should be allowed considering the consequences.

(ii) Septic Tank Facilities

The Outer Areas (5 to 8) have greater percentages of the sampled populations using the septic tank facilities. Areas 6 and 7 have highest percentages (86%) of sampled population using the septic tank facilities. Areas 1 and 4 had the least percentage (17%) of the sampled population using septic tank facilities. The implication of the variance in the use of the septic tank facilities is that Areas with lower percentages of the facilities would contribute higher adverse consequences to the study area. This is so because they would use other non-standard methods which cause environmental degradation and health hazards.

(iii) Pit Latrine Facilities

Greater percentage of the sampled population within Area 1 to 4 employed pit latrine facilities their toilet disposals. Area 4

has highest percentage (79%) of the sampled population using the pit latrine facilities. There is no Area from the sampled population that does not use pit latrine facilities for as a means of toilet disposal facility. The study reveals that bad odour and flies are associated with pit latrine facilities. Also it is obvious that both female and male users of this facilities expose their private parts (organs) to the usual vapour from the pit. The hygienic condition of the pit latrine facilities make it undesirable for human usage.

GIS Query Results

Table 3.0 and Figure 4.0 indicate the location with highest poor (non-standard) toilet disposal facilities in the study area. Table 4.0 and Figure 5.0 highlight the Areas with least poor (non-standard) toilet disposal facilities.

Table 3.0: GIS Query Result for Areas with Highest Poor Toilet Facilities in Yellow (%)

TID	TBO	TST	TPIT	TT	TPT	PTR
A1	7	17	76	100	83	HIGHEST
A2	3	39	58	100	61	3RD
A3	4	31	65	100	69	2ND
A4	4	17	79	100	83	HIGHEST
A5	11	57	32	100	43	4TH
A6	5	86	9	100	14	LEAST
A7	0	86	14	100	14	LEAST
A8	3	70	27	100	30	5TH

Source: Authors' Survey: 2015

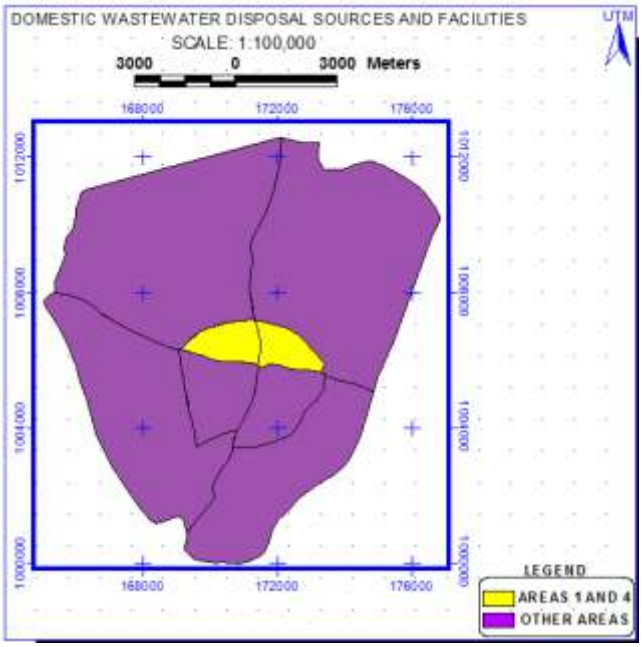


Figure 4.0: GIS Query Result for Areas with Highest Poor Toilet Facilities in Yellow
Source: Authors' Survey: 2015

Table 4.0: GIS Query Result for Areas with Least Poor Toilet Facilities in Yellow (%)

TID	TBO	TST	TPIT	TT	TPT	PTR
A1	7	17	76	100	83	HIGHEST
A2	3	39	58	100	61	3RD
A3	4	31	65	100	69	2ND
A4	4	17	79	100	83	HIGHEST
A5	11	57	32	100	43	4TH
A6	5	86	9	100	14	LEAST
A7	0	86	14	100	14	LEAST
A8	3	70	27	100	30	5TH

Source: Authors' Survey: 2015
Note: TID – Toilet Identification numbers for Areas 1-8;
TBO – Bush/Open places; TST – Septic tank; TPit – Pit Latrine;
TT – Total for toilet; TPT – Total Poor toilet facilities; PTR – poor toilet remarks

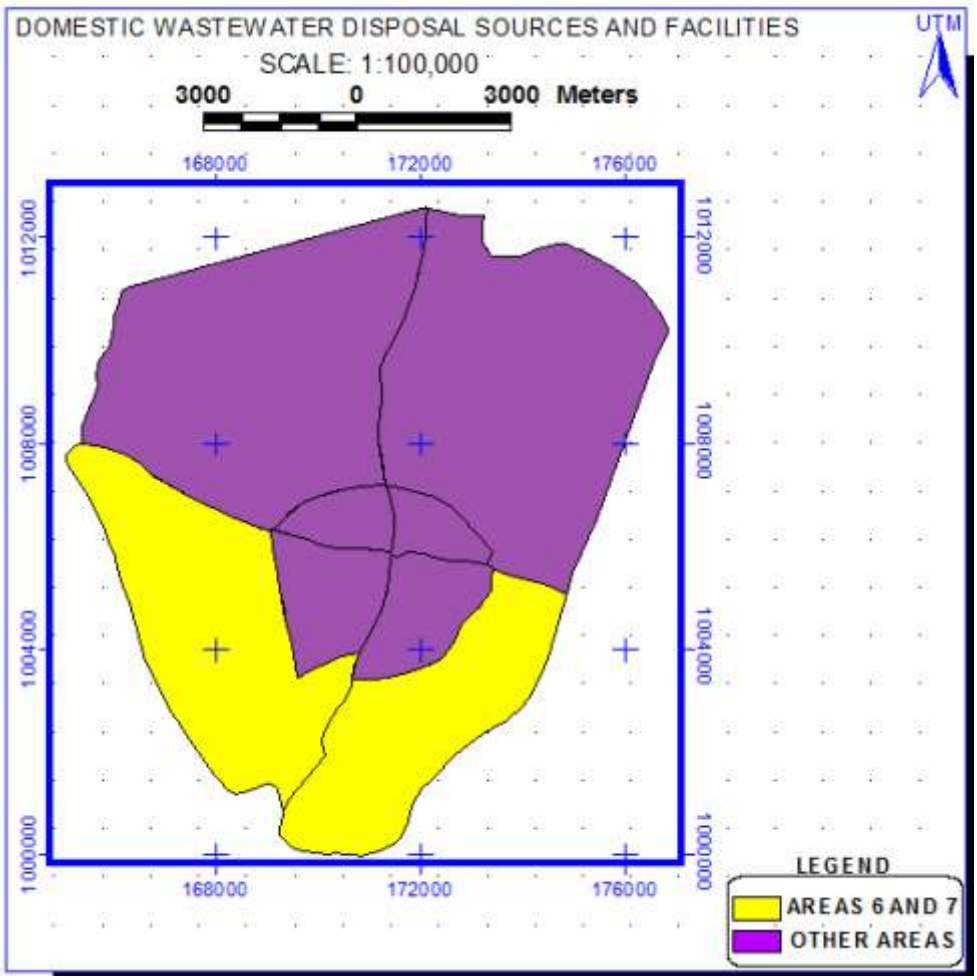


Figure 5.0: GIS Query Result for Areas with Least Poor Toilet Facilities in Yellow
Source: Authors' Survey: 2015

(i)Location with Highest Poor Toilet Facilities

Figure 4.0 highlights in yellow colour the locations of Areas 1 and 4 with the highest overall percentages (83%) of poor toilet facilities. Table 3.0 indicates in yellow colour the variables in percentages that made them the Areas with the highest poor toilet facilities. The combination of the figure and table query results are very useful for policy and decision makers for adequate information and guidance in taking actions or decisions in environmental management. This is in agreement with Ibe and Amusa (2011) in the use of GIS query to find locations with highest incidences of environmental problem in a town.

(ii) Location with Least Poor Toilet Facilities

Figure 5.0 and Table 4.0 indicate in yellow colour Areas 6 and 7 with the lowest percentages (14%) of the sampled populations using poor toilet facilities for their disposals. Figure 5.0 shows their locations on the map of the study area while Table 4.0 shows the variables and their percentages. Ndukwe *et-al* (2003) employed GIS query to locate areas with environment needs. The query results show that to enforce the use of standard toilet facilities in residential buildings in the study area less attention should be given to Areas 6 and 7 than Areas 1 and 4.

Discussion on Average Poor Toilet Disposal Facilities in the Study Area

Table 5.0 and Figure 6.0, and Table 6.0 and Figure 7.0 below give a summary of the levels of poor toilet disposal facilities in the eight Areas of the study area and

Table 5.0: Level of Poor Toilet Facilities in Percentage

Area (A)	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8
TPT	83	61	69	83	43	14	14	30

Sources: Author's Field Survey; December 2011
Note: TPT – Total Poor toilet facilities for each area;

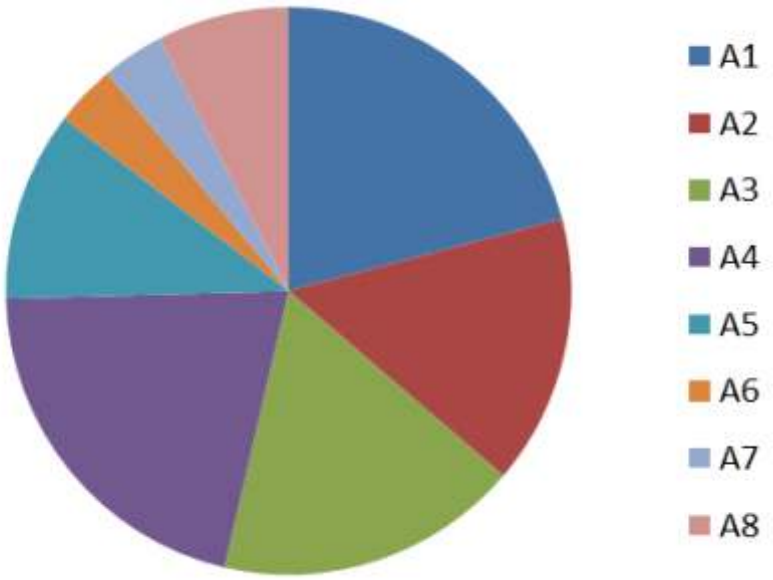


Figure 6.0: Levels of Poor Toilet Facilities in Percentages for the Eight Areas (1-8) Sources: Author's Field Survey; December 2011
Note: A_1-A_8 are the eight Areas

Table 6.0: Level of Poor Toilet Facilities in Percentages for the two Regions

Region	Core		Outer	
	Frequency	Percentage (%)	Frequency	Percentage (%)
APT	89	74	30	25

Sources: Author's Field Survey; December 2011
Note: APT – Average Poor toilet facilities for Regions

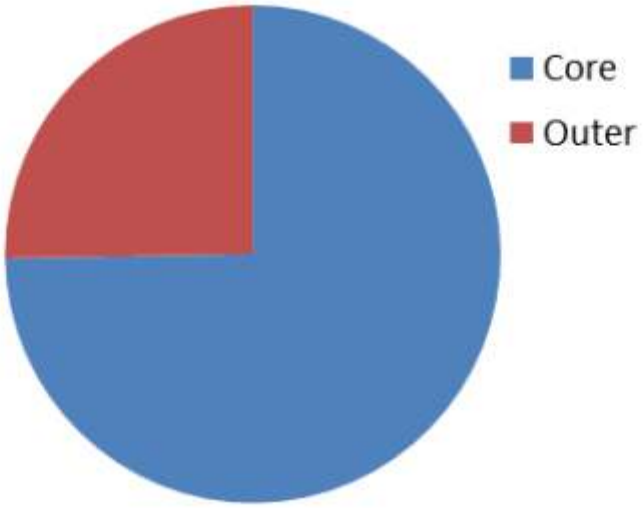


Figure 7.0: Level of Poor Toilet Facilities in Percentage for the two Regions
Sources: Author's Field Survey; December 2011

(i) Average Domestic Wastewater Toilet Disposals Facilities in the Eight Areas

Table 5.0 and Figure 6.0 above show that significantly there are poor domestic wastewater toilet disposals facilities in all the eight Areas of the study area. The variables used to evaluate the toilet disposal facilities are; Bush/open places, septic tanks and pit latrines toilet facilities. The use of bush/open spaces pit latrines are considered non-standard or poor toilet disposal facilities. The septic tank toilet disposal facilities are generally accepted standard disposal facilities. The study reveals that Area 1 has eighty three percent (83%) of the sampled using poor domestic wastewater toilet disposal facilities. Areas 2, 3 and 4 have 61%, 69% and 83% respectively of poor toilet disposal facilities. These percentages are very high and significantly of concern when compared with the expected or acceptable percentage of zero (0%). Areas 5, 6, 7 and 8 have 43%, 14%, 14%, and 30% of the sampled populations using poor toilet facilities for domestic wastewater disposals. Suleiman (2004) reports that in many countries of the world there are poor industrial and domestic wastewater disposals and the associated environmental problems. The levels of poor toilet disposal facilities in all the eight Areas of the study areas affirm this report. It also shows that the government agencies responsible for approving and monitoring the standards of toilet disposal facilities in the study area have much work to do.

(ii) Average Domestic Wastewater Toilet Disposals Facilities for the Two Regions

The study from Table 6.0 reveals that out of the one hundred and twenty households sampled in the Core region, eighty nine of them representing seventy four percent (74%) make use of poor toilet disposal facilities. This is significantly below standard in this century and should be discouraged vehemently. The Outer region of the study area has thirty households representing twenty five percent (25%) using poor toilet disposal facilities. Figure 7.0 is a pie chart showing the respective percentages for the Core and Outer regions. For households using standard methods the study reveal that children from different homes often use open spaces, solid waste dump sites or nearby gutters. These poor disposals on bushes and open spaces with aids of rain run-offs usually end up in streams and rivers thereby pollute them greatly. The pit latrines are sited so close to wells and or borehole in most cases below the minimum limit of thirty meters (30m). Thus most of the wells in the study area need standard laboratory tests to confirm their suitability for drinking and house use. The World Bank (1995) in Akan *et al*, (2010) asserts that in Nigeria available reports indicate gross contamination of most major-river bodies across the nation are caused by discharge of industrial effluents, sewage and agricultural waste among others. This finding from this study affirms the World Bank and Akan *et al*, assertion. The situation should not be left on like this.

Health Implications of Poor Toilet Disposal Facilities on Well/Boreholes in the Study Area

Table 7.0 and Figure 8.0 below illustrate the health implications of poor toilet disposal facilities in the study area:

Table 7.0: Negative health Impacts of Poor Toilet Disposal Facilities in Percentages

Area (A)	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8
Negative Impacts	83	53	43	73	63	57	83	73

Sources: Author's Field Survey; December 2011

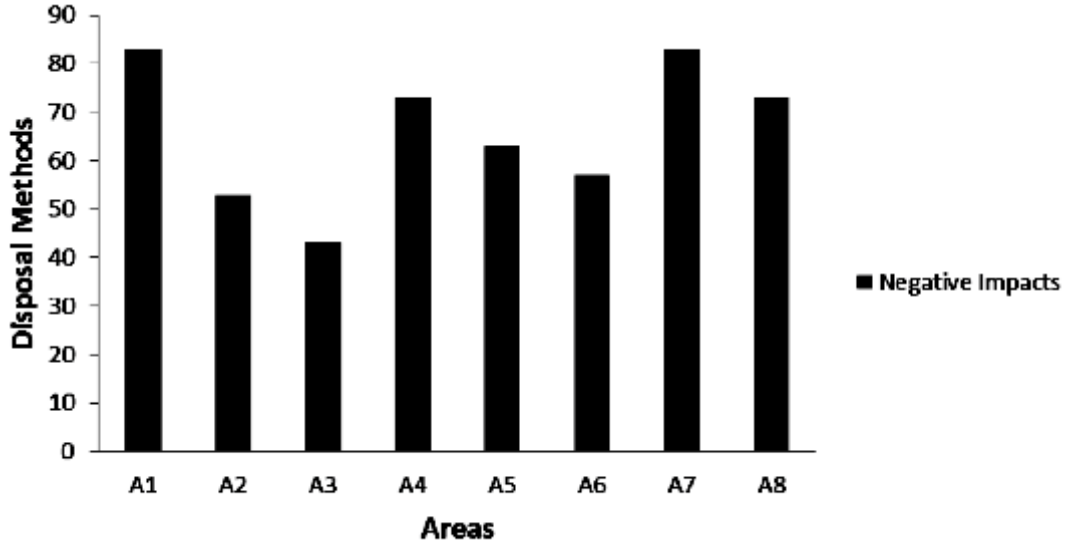


Figure 8.0: Negative health Impacts of Poor Toilet Disposal Facilities in Percentages. Sources: Author's Field Survey; December 2011

The international standard minimum safe distance between wells/boreholes and a soakaways/pit latrine is thirty meters (30m). Any well/borehole located below this minimum is considered polluted or exposed to pollution. High significant percentages of wells/boreholes located in the study area are found to be polluted by this standard. Areas 1 and 7 have highest percentages of wells/boreholes pollution negative health impacts of domestic wastewater disposals. Area 3 has the least percent (43%) of its sampled populations with wells/boreholes pollution negative impacts of domestic wastewater disposals. Other Areas 2, 4, 5, 6 and 8 have 53%, 73%, 63%, 57% and 73% respectively of well/boreholes pollution negative health impacts of domestic wastewater disposals. Ayeni and Ademeno (2003) rejected boreholes sites less than thirty metres from pollution points to avoid infiltration and pollution of the boreholes. The use of many wells and boreholes in the study area is dangerous especially where standard laboratory analysis have not been conducted and no treatment applied to the well/boreholes water.

The Influence of Government on Poor Toilet Disposal Facilities in the Study Area

Table 8.0 below is a database on government influences based on result of the sampled population. The Federal Government influence on domestic wastewater disposal facilities was ranked 0% for all the households in all the Areas both Core and Outer Areas. The Table also showed 0% influence for the State and Local Government respectively. The prevailing reality in the study area affirms the 0% influences of the three tiers of government generally on domestic wastewater disposal facilities and particularly on toilet disposal facilities.

Table 8.0: Database of Government Influence on Domestic Wastewater Disposal Facilities in the Study Area in Percentages (%)

ID	FG(Y)	FG(N)	TOTAL(FG)	SG(Y)	SG(N)	TOTAL(SG)	LG(Y)	LG(N)	TOTAL(LG)
2	0	100	100	0	100	100	0	100	100
6	0	100	100	0	100	100	0	100	100
1	0	100	100	0	100	100	0	100	100
5	0	100	100	0	100	100	0	100	100
4	0	100	100	0	100	100	0	100	100
3	0	100	100	0	100	100	0	100	100
7	0	100	100	0	100	100	0	100	100
8	0	100	100	0	100	100	0	100	100

Sources: Author's Field Survey; 2011

Note:

FG(Y) = Federal Government has noticeable positive influence on the domestic wastewater facilities/disposal methods

FG (N) = Federal Government has no noticeable positive influence on domestic wastewater facilities/disposal method.

SG(Y) = State Government has noticeable influence

SG (N) = State Government has no noticeable influence

LG(Y) = Local Government has noticeable influence

LG (N) = Local Government has no noticeable influence

Conclusion

The adverse health and environmental consequences of poor disposal of domestic wastewater from the toilet are great. In the study area good percentage of the sampled populations make use of poor (non-standard) toilet disposal facilities. Government, Non-Governmental Organisation and the residents of the study area must collaborate to overcome the adverse consequences and the use of non-standard disposal facilities.

Recommendations

With the foregoing results and discussions, the following recommendations are made:

(i) There should be GIS inventory Survey for Domestic Wastewater Disposal facilities in general and toilet disposal facilities in particular under the collaboration of the State and Local Government Authorities in the study area.

(ii) There should also be a GIS inventory study on the consequences or impacts of poor domestic wastewater disposal facilities in the study area.

(iii) The Government, Non-Government organisations (NGOs) and Community Base Organisation (CBOs) in the study area should embark on formal and non-formal Education to sensitize the residents of the study area on the adverse impacts of poor domestic wastewater disposal toilet facilities.

(iv) There should be legislation solely on domestic wastewater disposal to address the issues of facilities, treatment before disposals, enforcement, fines, etc.

(v) Well and Boreholes should not be located within 30metres from pit latrines and soakaway. Those that are within the minimum interval should be subjected to standard laboratory test.

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