Health Impacts of Domestic Wastewater Disposal on Bida Town, Niger State, Nigeria: A GIS Aplication

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Abstract- 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 into the environment. This study employed GIS (Geographic Information System) techniques at the data collection, analysis and presentation stages to investigate the health impacts of domestic wastewater disposal in the study area. The research discovered that about eighty six percent (86%) of the sampled households have negative health impacts on land surfaces, waterbodies and human beings in the study area. There are significant average negative impacts of domestic wastewater disposal on all the eight Areas and two regions of the study area. The authors recommend; formal and informal education, new and efficient Government Agency, new legislation, and a GIS inventory database for domestic wastewater disposal for the study area.

I. INTRODUCTION

Wastewater is the flow of used water from a community. The characteristics of 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, and similar facilities. The industrial wastewater varies in a given area depending on the types of industries available there. In many countries of the world storm sewers and the sanitary wastewater sewers are combined. This makes the quantity of storm water that combines with domestic wastewater very high (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)

We cannot allow wastewater to be disposed in a manner dangerous to human health and lesser life forms or damaging to the natural environment. Our planet has the remarkable ability to heal itself, but there is a limit to what it can do and we must make it our goal to always stay within safe bounds. That limit is not always clear to scientists, and we must always take the safe approach to avoid it (Pollutionissue, 2010).

Geographic Information System (GIS) is a configuration of computer hardware and software specifically designed to effectively capture, store, update, manipulate, analyse and display all forms of spatially referenced information. GIS makes it possible to map, model, query and analyse large quantities of data all together in a single database within the shortest time frame. It allows analysts to collate and analyse information more readily than is possible with traditional techniques. GIS is very useful in a wide range of situations such as environmental resource management, emergency planning etc. GIS is a decision making tool which has the ability to compartmentalise information in layers and then combines it with other layers of information for utility in subsequent analysis (Ayeni and Ifechukwu, 2003; Igbokwe, Ono and Ogunobo, 2003; Keftin, 2005 and Ejiobih, 2009a).

Sahu (2013) reported that GIS was successfully used to analyse domestic wastewater for determining its major pollutants. This study employed GIS techniques at the data collection, analysis and presentation stages.

II. Aim

The aim of the study is to evaluate the health impacts of domestic wastewater disposal on land surface, human and waterbodies in the study area using the application of GIS.

III. Objectives

(i) To investigate the sources of health impacts of domestic wastewater disposal on land surfaces, human and waterbodies in the study area.
(ii) To ascertain the items effected by health impacts of domestic wastewater disposal in the study area.
(iii) To study the level of negative health impacts on land surface, human and waterbodies in the study area.

IV. Research Questions

(i) Are there significant sources of health impacts of domestic wastewater disposal on land surfaces, human and waterbodies in the study area?
(ii) The percentages of items effected by health impacts of domestic wastewater disposals are they significant?
(iii) Are there pronounced negative health impacts of domestic wastewater on land surface, human and waterbodies in the study area?

V. The Study Area

The study area as shown in Figure 1.0 is subdivided naturally into eight homogenous areas, and two regions by road networks. Areas 1, 2, 3 and 4 are in the Core region while Areas 5, 6, 7 and 8 are in the Outer region of the study area.

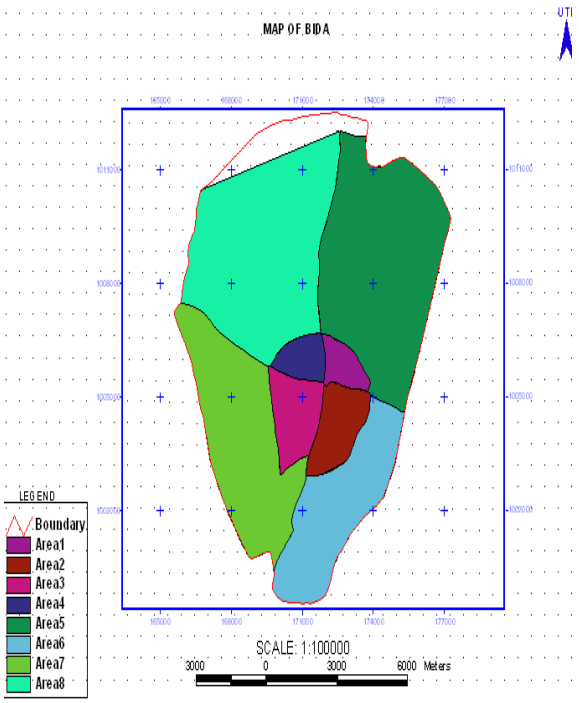

Figure 1.0: Map of Bida Town (the study area) highlighting the eight Areas

Adapted from: Yinang; (2010)

VI. Sample Size and Procedure

The sample size was based on SURCON (2003) rules and regulations on large scale survey activities in Nigeria for boundary demarcations. The rule stipulates a maximum interval of 400meters between points. Thus a total of two hundred and forty (240) households were sampled.

Global Position System (GPS) receiver was used to obtain the geospatial data for the 240 households. Structured questionnaire was administered on the 240 households for their attribute data. Interview, photographs

and on the spot observations were used to obtain additional attribute data for the study. Figure 2.0 indicates the locations of the sampled households.

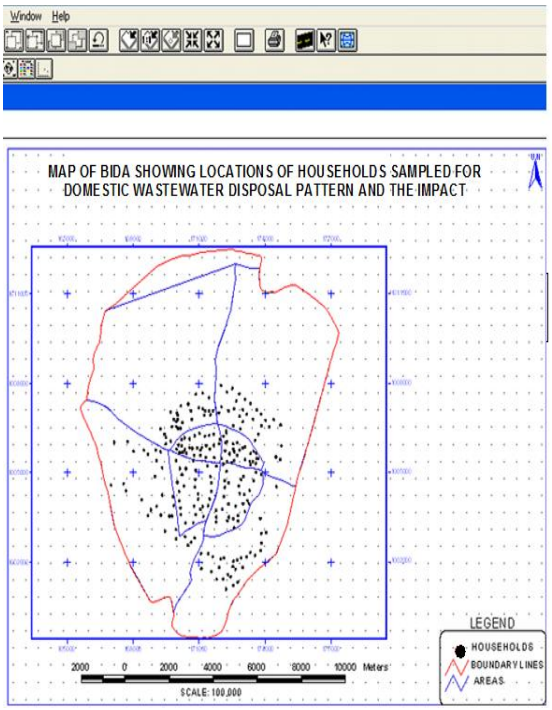

Figure 2.0: Map of the Study Area for the Sampled 240 Households

Source: Author's Field Survey; December, 2011

Database Design and Presentations

The four segments of database design and creation were covered. They include; view of reality, conceptual design model, logical design model and physical design model. GIS query results on tables and maps were used to present results of Areas with highest and least sources, effected items and negative health impacts respectively. Statistical tables and Bar charts were also used to present the results.

Sources of Health Impacts of Domestic Wastewater Disposal on Land Surfaces, Human and Waterbodies in the Study Area

Table 1.0 and Figure 3.0 show the sources of health impacts of domestic wastewater disposal in the study area. Figure 4.0 and Table 2.0 indicate the location of the Area with the highest sources of health impacts of domestic wastewater. Figure 5.0 and Table 3.0 highlight the location of the Area with the least health impacts of domestic wastewater disposals in the study area.

Table 1.0: Sources of Health Impact of Domestic Wastewater Disposal in Percentages (%)

Areas	Biological Properties of Domestic Wastewater (BC)	Physicochemical Properties of Domestic Wastewater (PCC)	Poor Locations of Wells/Boreholes (PLWB)	Not Applicable (NA1)	Households with Source of Impact (HWSI)
A1	93	93	83	7	93
A2	63	63	53	37	63
A3	43	43	43	57	43
A4	70	70	73	27	73
A5	40	40	63	37	63
A6	27	27	57	43	57
A7	17	17	83	17	83
A8	67	67	73	27	73

Sources: Author's Field Survey; December 2011

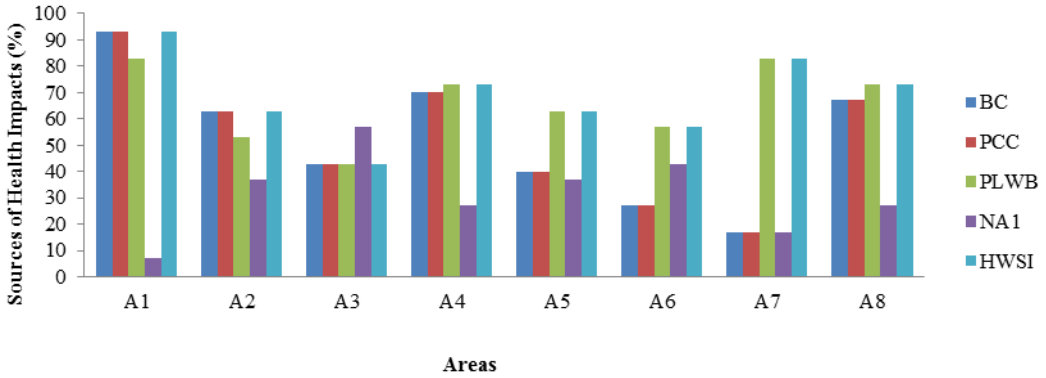

Figure 3.0: Sources of Health Impacts of Domestic Wastewater Disposal

Sources: Author's Field Survey; December 2011

Note: A1-A8 – represents the Eight Area; BC - Biological Properties of Domestic Wastewater; PCC - Physicochemical Properties of Domestic Wastewater; PLWB - Poor Locations of Wells/Boreholes; NA1 - Not Applicable; HWSI - Households with Source of Impact

Table 2.0: GIS Query Result for Area with Highest Sources of Heath Impact of Domestic Wastewater Disposal on Land Surface, Water bodies and Human in Yellow (%)

SID	BC	PCC	PLWB	NA1	HWSI	SIR
A1	93	93	83	7	93	HIGHEST
A2	63	63	53	37	63	4TH
A3	43	43	43	57	43	LEAST
A4	70	70	73	27	73	3RD
A5	40	40	63	37	63	4TH
A6	27	27	57	43	57	5TH
A7	17	17	83	17	83	2ND
A8	67	67	73	27	73	3RD

Source: Authors' Survey: 2015

Note: SID – Identification for the Areas; BC - Biological Properties of Domestic Wastewater; PCC - Physicochemical Properties of Domestic Wastewater; PLWB - Poor Locations of Wells/Boreholes; NA1 - Not Applicable; HWSI - Households with Source of Impact; SIR – Sources of Impacts Remarks

Table 3.0: GIS Query Result for Area with Least Sources of Heath Impact of Domestic Wastewater Disposal on Land Surface, Water bodies and Human in Yellow (%)

SID	BC	PCC	PLWB	NA1	HWSI	SIR
A1	93	93	83	7	93	HIGHEST
A2	63	63	53	37	63	4TH
A3	43	43	43	57	43	LEAST
A4	70	70	73	27	73	3RD
A5	40	40	63	37	63	4TH
A6	27	27	57	43	57	5TH
A7	17	17	83	17	83	2ND
A8	67	67	73	27	73	3RD

Source: Authors' Survey: 2015

Note: SID – Identification for the Areas; BC - Biological Properties of Domestic Wastewater; PCC - Physicochemical Properties of Domestic Wastewater; PLWB - Poor Locations of Wells/Boreholes; NA1 - Not Applicable; HWSI - Households with Source of Impact; SIR – Sources of Impacts Remarks

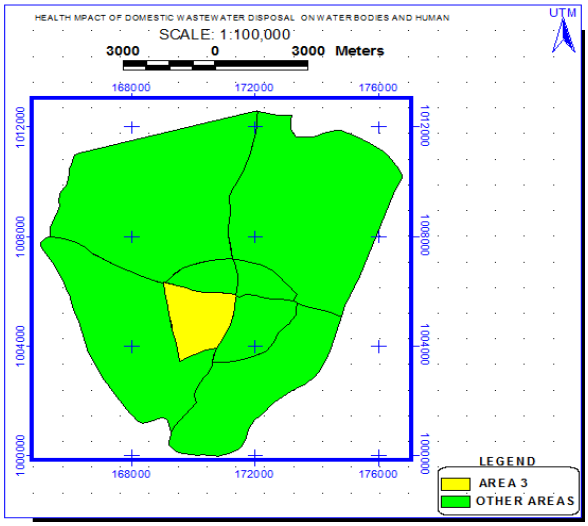

Figure 5.0: GIS Query Result for Area with Least Sources of Heath Impact of Domestic Wastewater Disposal on Land Surface, Water bodies and Human in Yellow

Source: Authors' Survey: 2015

(i) Sources of Health Impacts

The health impact sources considered include; biological properties and physicochemical properties of domestic wastewater and poor locations of well/boreholes. The households having the variables and those not having were also considered in all the eight Areas. There are significant sources of health impacts of domestic wastewater. There is average of about fifty three percent of biological and physicochemical properties sources of health impacts of domestic wastewater disposal in the study area. There is also average of sixty six percent poor location of pit latrines/boreholes as sources of health impacts of domestic wastewater. These average are very significant and need to be controlled. The households that are producing sources of health impacts are more than those not producing. The expectation is zero percent tolerant of production of sources of health impacts for all the households.

(ii) GIS Query Results on Sources of Health Impacts of Domestic Wastewater

Table 2.0 and Figure 4.0 highlight Area 1 as the place with highest sources of health impacts of domestic wastewater disposal in the study area. Table 2.0 outlines the percentages of the variables in yellow colour. Figure 5.0 shows with yellow colour the location of Area 3 as the place with least sources of health impacts of domestic wastewater in the study area. The variables are indicated in Table 3.0.

The GIS query results are very useful for decision making. The Area that needs most attention is Area 1 while Area 3 needs the least.

Items Effected by Health Impacts of Domestic Wastewater Disposal in the Study Area

The items effected by health impacts of domestic wastewater disposal in the study area are outlined in Table 4.0 and Figure 6.0, Table 5.0 and Figure 7.0 indicate the Area with highest percentages of items effected by health impacts of domestic wastewater. Table 6.0 and Figure 8.0 show the location with the least percentages of items effected by the health impacts in the study area.

Table 4.0: Effected Items by Health Impact of Domestic Wastewater Disposal in Percentages (%)

Area	Land Surface (LS)	Wells/Boreholes (WB)	Human (H)	Not Applicable (NA2)	Households with sources of Heath Impact (HWA)
A1	93	83	93	7	93
A2	67	53	67	33	67
A3	43	43	43	57	43
A4	73	73	73	27	73
A5	40	63	63	37	63
A6	27	57	57	27	57
A7	17	83	83	17	83
A8	67	73	73	27	73

Sources: Author's Field Survey; December 2011

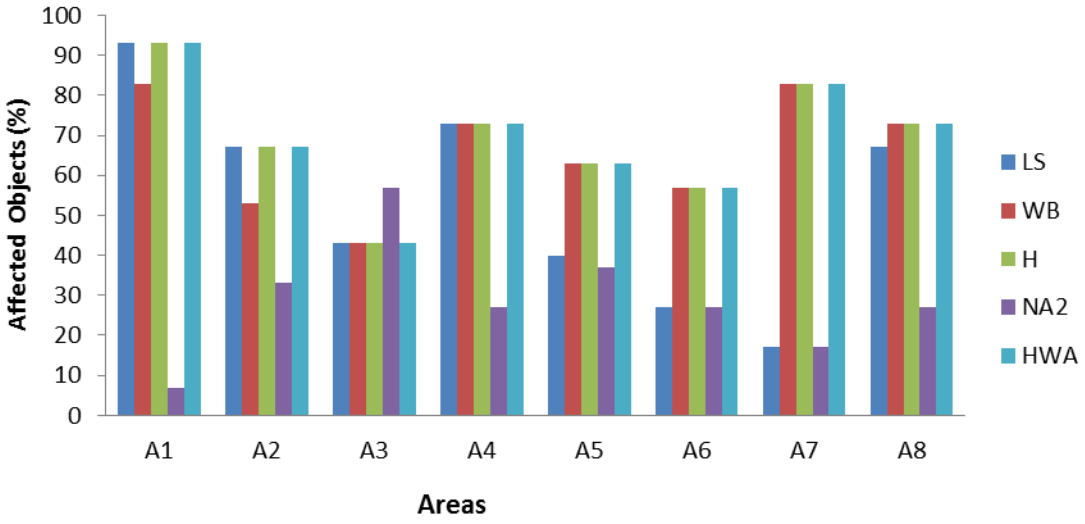

Figure 6.0: Effected Land Surfaces, Water Bodies and Human by Domestic Wastewater Disposal in the Study Area

Sources: Author's Field Survey; December 2011

Note: A1-A8- Represent the eight Areas; LS - Land Surface; WB - Wells/Boreholes; H – Human; NA2 - Not Applicable; HWA - Households with sources of Heath Impact

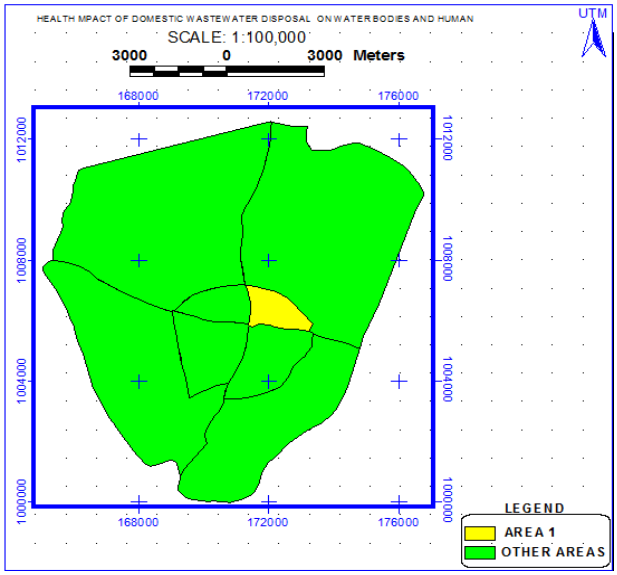

Figure 4.0: GIS Query Result for Area with Highest Sources of Heath Impact of Domestic Wastewater Disposal on Land Surface, Water bodies and Human in Yellow

Source: Authors' Survey: 2015

Table 5.0: GIS Query Result for Area with Highest Land Surfaces, Water Bodies and Human Effected By Health Implications of Domestic Wastewater Disposal in Yellow (%)

AAID	LS	WB	H	NA2	HWA	AAR
A1	93	83	93	7	93	HIGHEST
A2	63	53	63	37	63	4TH
A3	43	43	43	57	43	LEAST
A4	70	73	73	27	73	3RD
A5	40	63	63	37	63	4TH
A6	27	57	57	27	57	5TH
A7	17	83	83	17	83	2ND
A8	67	73	73	27	73	3RD

Source: Authors' Survey: 2015
Note: A1-A8- Represent the eight Areas; LS - Land Surface; WB - Wells/Boreholes;
H – Human; NA2 - Not Applicable; HWA - Households with sources of Heath Impact; AAR – Remarks for Effected Areas

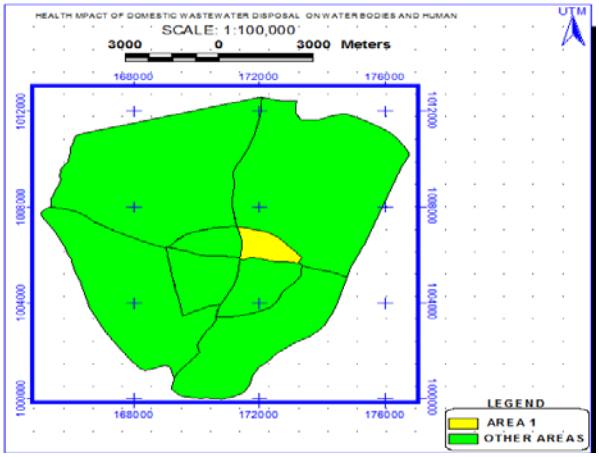

Figure 7.0: GIS Query Result for Area with Highest Sources of Heath Impact of Domestic Wastewater Disposal on Land Surface, Water bodies and Human in Yellow

Source: Authors' Survey: 2015

Table 6.0: GIS Query Result for Area with Least Land Surfaces, Water Bodies and Human Effected By Health Implications of Domestic Wastewater Disposal in Yellow (%)

AAID	LS	WB	H	NA2	HWA	AAR
A1	93	83	93	7	93	HIGHEST
A2	63	53	63	37	63	4TH
A3	43	43	43	57	43	LEAST
A4	70	73	73	27	73	3RD
A5	40	63	63	37	63	4TH
A6	27	57	57	27	57	5TH
A7	17	83	83	17	83	2ND
A8	67	73	73	27	73	3RD

Source: Authors' Survey: 2015
Note: A1-A8- Represent the eight Areas; LS - Land Surface; WB - Wells/Boreholes;

H – Human; NA2 - Not Applicable; HWA - Households with sources of Heath Impact; AAR – Remarks for Effected Areas

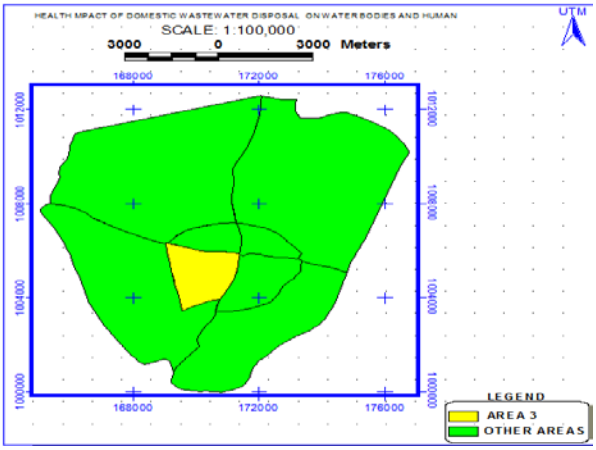

Figure 8.0: GIS Query Result for Area with Least Land Surfaces, Water Bodies and Human Effected by Health Implications of Domestic Wastewater Disposal in Yellow
Source: Authors' Survey: 2015

(i) Items Effected by Health Impacts

The factors considered in order to ascertain the items effected include; Land surfaces, well/boreholes and human exposed to health impacts. The percentages of households with effected items and those without were also considered. The study reveals that there are significant percentages of land surfaces, wells/boreholes and human beings effected by health impacts of domestic wastewater disposals in the study area. There are higher percentages of the sampled households with effected land surfaces, wells/boreholes and human than those without effected items.

(ii) GIS Query Results on Items Effected by Health Impacts

GIS query result on Figure 7.0 shows with yellow colour Area 1 as the location with highest percentages of land surfaces, wells/boreholes and human exposed or effected by health impacts of domestic wastewater. Table 5.0 outlines the percentages of the variables in yellow colour.

Area 3 is highlighted by GIS query as the location with the least percentages of land surfaces, wells/boreholes and human exposed to health impacts of domestic wastewater disposal in study area on Figure 8.0. The variables are highlighted in yellow in Table 6.0.

Negative Health Impacts of Domestic Wastewater Disposal on the Study Area

The levels of negative health impacts are shown in Table 7.0 and Figure 9.0. Table 8.0 and Figure 10.0 elucidate the location with highest negative health impacts. Table 9.0 and Figure 11.0 describe the location with least negative health impacts of domestic wastewater disposal in the study area.

Table 8.0: Negative Health Impacts of Domestic Wastewater Disposal on Land Surfaces, Water Bodies and Human in Percentages

Area	**Bacteria (BAC)**	**Malaria (MAL)**	**Other Sickness (OS)**	**Wells/Boreholes (WBD) Exposed to Pollution**	**Not Applicable (NA3)**	**Households with Negative impact (HWN)**
A1	93	97	0	83	3	97
A2	67	90	0	53	10	90
A3	43	57	7	43	36	64
A4	70	80	10	73	10	90
A5	40	87	3	63	10	90
A6	27	73	0	57	27	73
A7	17	93	0	83	7	93
A8	67	93	0	73	7	93

Sources: Author's Field Survey; December 2011

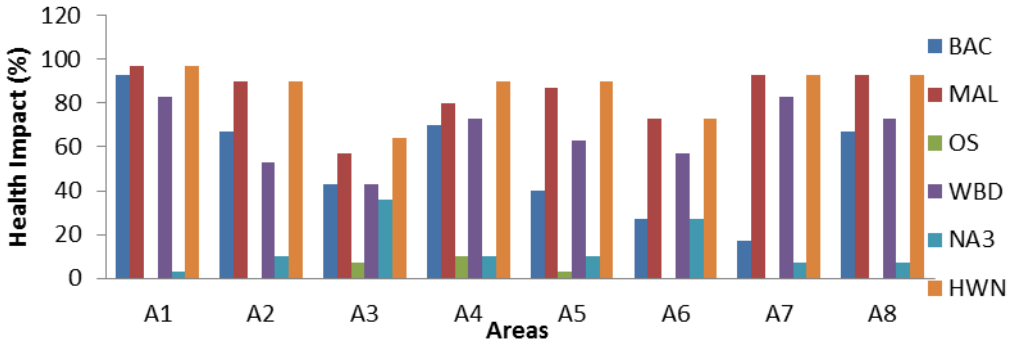

Figure 10.0: Negative Health Impacts of Domestic Wastewater Disposal on Land Surface, Water Bodies and Human

Sources: Author's Field Survey; December 2011

Note: A_1-A_8 - represents Eight Areas; BAC – Bacteria; MAL – Malaria; OS - Other Sickness; WBD - Wells/Boreholes; NA3 - Not Applicable; HWN - Households with Negative impact.

Table 9.0: GIS Query Result for Area with Highest Adverse Health Impacts of Domestic Wastewater Disposal on Land Surface, Waterbodies and Human (%)

IID	BAC	MAL	OS	IWBD	NA3	HWN	NIR
A1	93	97	0	83	3	97	HIGHEST
A2	63	90	0	53	10	90	3RD
A3	43	57	7	43	36	64	LEAST
A4	70	80	10	73	10	90	3RD
A5	40	87	3	63	10	90	3RD
A6	27	73	0	57	27	73	4TH
A7	17	93	0	83	7	93	2ND
A8	67	93	0	73	7	93	2ND

Source: Authors' Survey: 2015
Note: IID - represents Eight Areas; BAC – Bacteria; MAL – Malaria; OS - Other Sickness; WBD - Wells/Boreholes; NA3 - Not Applicable; HWN - Households with Negative impact; NIR – Remarks for Adverse Areas

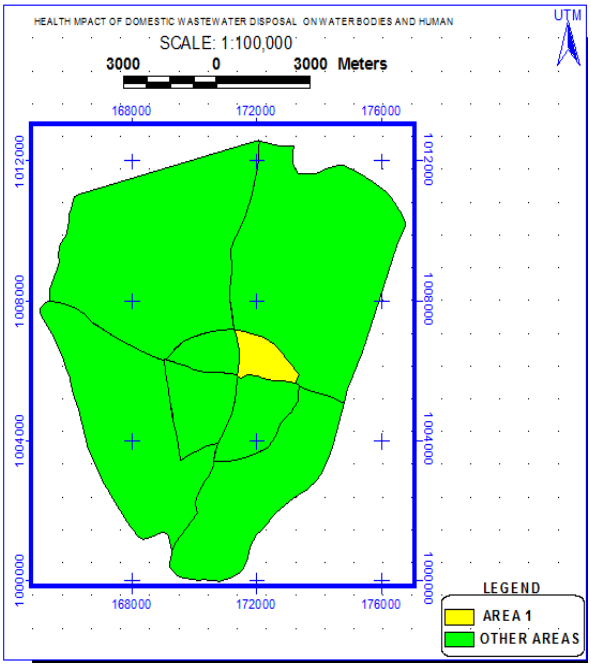

Figure 11.0: GIS Query Result for Area with Highest Adverse Health Impacts of Domestic Wastewater Disposal on Land Surface, Waterbodies and Human

Source: Authors' Survey: 2015

Table 10.0: GIS Query Result for Area with Least Adverse Health Impacts of Domestic Wastewater Disposal on Land Surface, Waterbodies and Human (%)

IID	BAC	MAL	OS	IWBD	NA3	HWN	NIR
A1	93	97	0	83	3	97	HIGHEST
A2	63	90	0	53	10	90	3RD
A3	43	57	7	43	36	64	LEAST
A4	70	80	10	73	10	90	3RD
A5	40	87	3	63	10	90	3RD
A6	27	73	0	57	27	73	4TH
A7	17	93	0	83	7	93	2ND
A8	67	93	0	73	7	93	2ND

Source: Authors' Survey: 2015

Note: IID - represents Eight Areas; BAC – Bacteria; MAL – Malaria; OS - Other Sickness; WBD - Wells/Boreholes; NA3 - Not Applicable; HWN - Households with Negative impact; NIR – Remarks for Adverse Areas

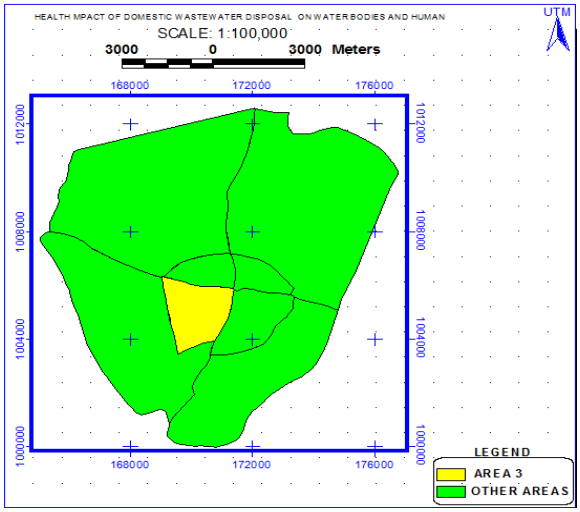

Figure 12.0: GIS Query Result for Area with Least Adverse Health Impacts of Domestic Wastewater Disposal on Land Surface, Waterbodies and Human.

Source: Authors' Survey: 2015

(i) Negative Health Impacts

The variables used to evaluate the negative health impacts of Domestic wastewater on the effected items are; presence of bacteria, human effected by malaria and other sickness, and wells/boreholes exposed to pollution. The households with negative health impacts and those without were also examined. The sampled populations reveal that there are significant negative health impacts of domestic wastewater disposal in the study area as outlined in Table 8.0 and Figure 10.0. More than eighty percent of the sampled populations have malaria incidences. Sixty six percent of the wells/boreholes are exposed to pollution from pit latrines/soakaways. There are more households exposed to negative health impacts than those not exposed. These findings are in agreement with those of other authors that discharge of untreated and wastewater into the environment is dangerous to the environment and public health (Odueme, 2009 and Cefns, 2013).

(ii) GIS Query Results on the Negative Health Impacts

GIS query results on Table 4.9 and Figure 11.0 indicate that Area 1 has the highest negative health impacts of bacteria, malaria, other sickness and wells/boreholes pollutions in the study area. Table 10.0 and Figure 12.0 are GIS query results showing Area 3 as the location with the least negative health impacts of domestic wastewater in the study area. The GIS query results are in agreement with other authors that GIS makes it possible to map, model, query and analyse large quantities of spatial data (Ayeni and Ifechukwu, 2003 and Keftin, 2005).

The Average Negative Health Impacts of Domestic Wastewater Disposals on the Study Area

The average negative health impacts for the eight areas are highlighted on Table 11.0 and Figure 13.0. Table 12.0 and Figure 14.0 indicate the average negative health impacts for the two regions.

Table 11.0: Average Negative Health Impact of Domestic Wastewater Disposal on the Eight Areas in Percentages

Area (A)	**A_1**	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**A_8**
Average Negative Impact	68	53	38	58	48	39	48	58

Source: Author's Field Survey; December 2011

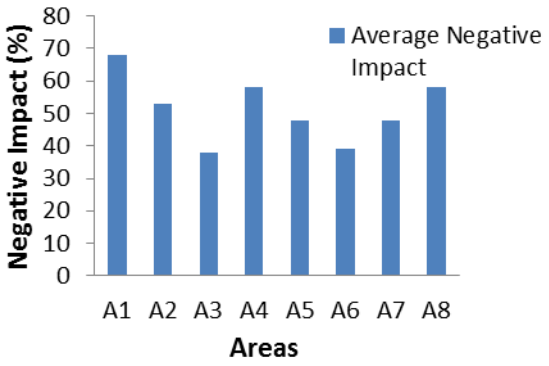

Figure 13.0: Average Negative Health Impact of Domestic Wastewater on the Eight Areas
Source: Author's Field Survey; December 2011
Note: A_1-A_8 – Represents Eight Areas

Table 12.0: Negative Health Impact of Domestic Wastewater Disposal on Two Regions in Percentages

Region	**Core**	**Outer**
Average Negative impacts	54	51

Source: Author's Field Survey; December 2011

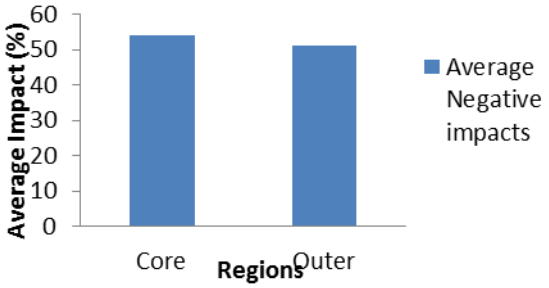

Figure 14.0: Average Negative Health Impact of Domestic Wastewater on Two Regions in Percentage
Source: Author's Field Survey; December 2011

(i) The Average Negative Health Impacts for the Eight Areas

Table 11.0 and Figure 13.0 the average negative health impacts for the eight Areas. The average is from the values of land pollution, malaria, other sickness and wells/boreholes pollutions variables as shown on Table 8.0. All the eight Areas have significantly high percentages of average negative health impacts. Area 1 has the highest with sixty eight percent average for the four sampled variables. Area 3 has thirty eight percent which is the least. Other Areas 2, 4, 5, 6, 7 and 8 have 53%, 58%, 48%, 39% 48% and 58% averages respectively of the four sampled variables. This shows that the public health and the environment of the Areas are greatly exposed to health hazards.

(ii) The Average Negative Health Impacts for the Two Regions

Table 12.0 and Figure 14.0 attest that there are high significant percentages of average negative health impacts of domestic wastewater in the two regions. The Core region has average negative health impacts of fifty four percent (54%). Cefns (2013) reports that wastewater from both residential (domestic) and non-residential sources unless properly treated can harm public health and the environment. This study affirms this report that domestic wastewater without any treatment are freely without concern discharge into the environments in the study area and are dangerous to public health and the environment.

Discussion on Health Impacts of Domestic Wastewater on the Study Area

The study reveals that there are significant sources of health impacts of domestic wastewater disposal on land surfaces in the study area. It also ascertains that there are significant percentages of items, land surfaces, wells/boreholes and human exposed to adverse health impacts of domestic wastewater disposal in the study area. The research further asserts that there are significant percentages of negative health impacts associated with domestic wastewater disposals in the study area. Laboratory test conducted on twenty four samples of domestic wastewater disposal on land surfaces indicates that the physical, chemical and biological properties both in dry and rainy seasons are outside World Health Organisation (WHO) standards and are dangerous to the environment and public health. The findings are in affirmation to the assertion of Pollutionissue (2010) that health problems and diseases have often been caused by discharging untreated or inadequately treated wastewater into the environment.

GIS technique employed in the study makes it easy to analyse the results to determine locations with highest or least incidences. The results are show in map and tabular formats to enable policy makers to take decision on how best to control or manage the domestic wastewater disposal in the study area.

VII. Conclusion

It is pertinent to note that in this century the residents of the study area discharge untreated domestic wastewater without restrains into the environment. The study affirms existing research assertions from other parts of the world that discharging of untreated or inadequately treated domestic wastewater in the environment is dangerous to the environment and public health.
GIS query was successfully used to dictate the locations of places with highest and least disposal incidences of negative health impacts of domestic wastewater disposal.

VIII. Recommendation

With reference to the findings, discussion and conclusions in this paper, the authors recommend the following.
There is an urgent need for formal and informal education of the residents of the study area on domestic wastewater disposal. This would create awareness on the dangers associated with discharging of untreated or inadequately treated domestic wastewater into the environment.

There should be an efficient Government Agency directly charged with the control, and management of wastewater disposal in the study area.

To promote efficiency, it is expedient to have legislation directly focusing on wastewater disposal facilities, treatment and management.

GIS inventory for domestic wastewater disposal for all residents of the study area is necessary in order to monitor the levels of compliance to expected standards.

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