GIS Study on Ecological Impacts of Domestic Wastewater Disposal on Bida Town, Niger State, Nigeria

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Abstract- Wastewater from industrial and domestic operations are disposed into surface water in most urban Nigerian cities culminating into water management problems. This study used GIS (Geographic Information System) to investigate the level of ecological impacts of domestic wastewater disposal on Bida Town. From the findings about fifty three percent (53.4%) of the sampled households have sources of ecological impacts and parts of their land surfaces negatively effected by domestic wastewater disposals. The Core region of the study area has sixty percent (60%) average negative ecological impacts and the Outer region thirty four percent (34%) average. The authors recommend; formal and non-formal education on domestic wastewater disposal, new edict on standard domestic wastewater disposal facilities and creation of GIS database for ecological impacts of domestic wastewater disposal for the study area.

I. INTRODUCTION

According to Okwuidegbe (2009), Pollutionissue (2010) and Wikipedia (2011) waste including wastewater have adverse environmental, health, social and economic impacts. Thus it is necessary to research on how to reduce or eliminate these impacts.

Samalia, Marcus and Momale (2011) emphasise that in most urban Nigerian cities, wastewater from industrial and domestic operations are disposed into surface water, receiving bodies culminating into water management problems. Cefns (2013) reports that wastewater from both residential (domestic) and non-residential sources unless properly treated, can harm public health and the environment. Eating of vegetables and beef from cattle grazing fields freshly irrigated with raw domestic or non-domestic wastewater, or drinking from raw wastewater canals or ponds are harmful to humans (FAO, 2013).

Although in Nigeria the application of Geographic Information System (GIS) in wastewater management is obviously scarce, Water world (2013) states that the use of GIS in municipal water and wastewater business is growing. According to Nielsen (2011), GIS Database of North Carolina Municipal wasteland has been prepared for municipal wastewater treatment, land application for pricing and quantity impact to humans. This study therefore is one of the growing applications of GIS in the study of impact of domestic wastewater disposal in the communities.

According to Velăzquez (2009), GIS integrates hardware, software and data for capturing, managing, analysing and displaying all forms of geographically referenced information. It allows us 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. It helps to answer questions and solve problems by looking at the data in a way that is quickly understood and easily shared.

II. AIM

The aim of the study was to investigate the ecological impacts of domestic wastewater disposal on the study area using Geographic Information System.

III. OBJECTIVES

(i) To ascertain the sources of ecological impacts of domestic wastewater disposal in the study area.
(ii) To evaluate the items effected by ecological impacts of domestic wastewater in the study area.
(iii) To study the negative ecological impacts of domestic wastewater existing in the study area.

IV. RESEARCH QUESTION

(i) Are there significant sources of ecological impacts of domestic wastewater in the study area?
(ii) The effected items by ecological impacts of domestic wastewater in the study area are they pronounced?
(iii) Are the negative ecological impacts of domestic wastewater disposal significant 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.

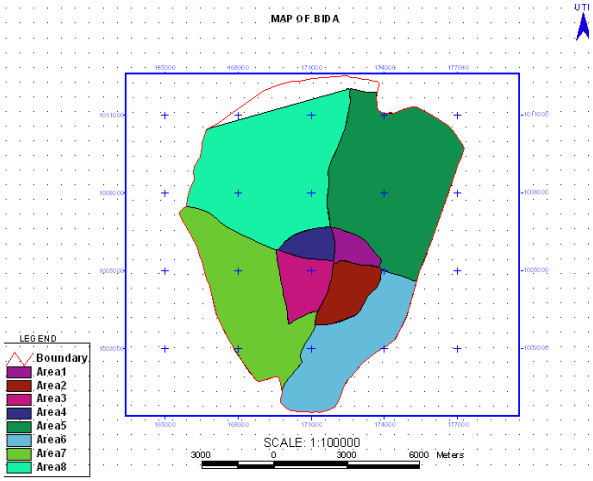

Figure 1.0: Map of Bida Town (the study area) highlighting the eight Areas

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 Positioning 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.

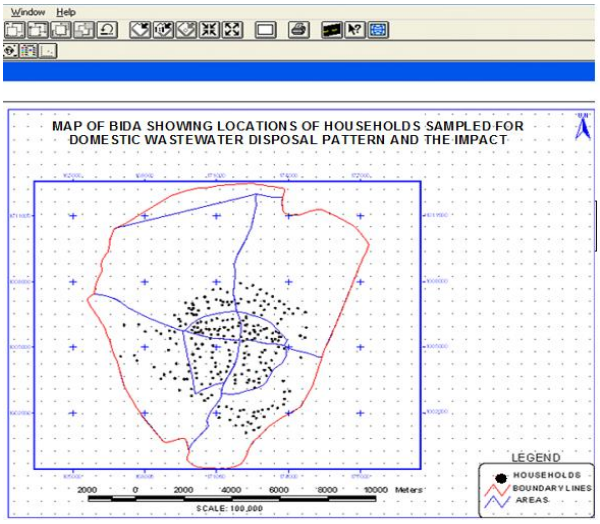

Figure 2.0: Map of the Study Area for the Sampled 240 Households

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 ecological impacts respectively. Statistical tables and Bar charts were also used to present the results.

Sources of Ecological Impacts of Domestic Wastewater Disposal on Land Surfaces in the Study Area

Table 1.0 and Figure 3.0 highlight the sources of ecological impacts on land surfaces in the study area. Table 2.0 and Figure 4.0 outline the location with highest sources of ecological impacts. Table 3.0 and Figure 5.0 show the location of the Area with least sources of ecological impacts of domestic wastewater disposal on land surfaces in the study area.

Table 1.0: Sources of Ecological Impacts of Domestic Wastewater Disposal on Land Surfaces and Human in Percentages (%)

Areas	Free Flowing Domestic Wastewater (FFD)	Pools of Domestic Wastewater (PD)	Not Applicable (NA1)	(Households with Sources of Impact HWSI)
A1	90	50	10	90
A2	63	30	33	67
A3	43	30	57	43
A4	70	20	27	73
A5	40	20	60	40
A6	27	3	73	27
A7	17	0	83	17
A8	70	33	30	70

Sources: Author's Field Survey; December 2011

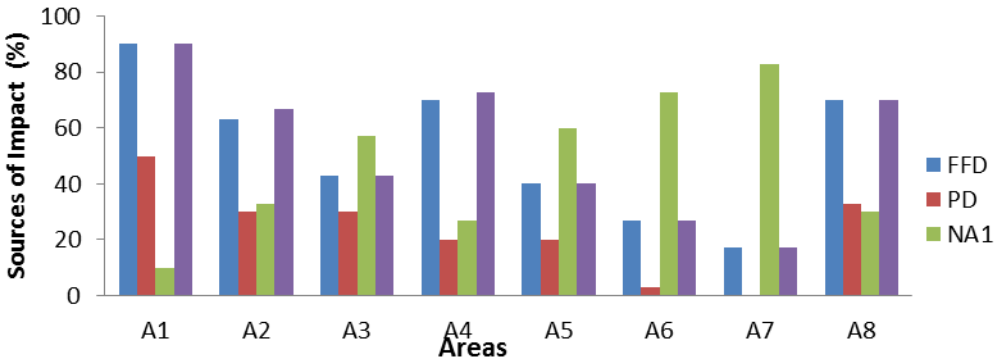

Figure 3.0: Sources of Domestic Wastewater Impact on Land Surface in the Study Area
Sources: Author's Field Survey; December 2011

Note: A_1-A_8 – Represents Eight Areas; FFD - Free Flowing Domestic Wastewater;
PD - Pools of Domestic Wastewater; NA1 - Not Applicable; HWSI - Households with Sources of Impact

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

SID	FFD	PD	NAI	HWSI	SIR
A1	90	50	10	90	HIGHEST
A2	63	30	33	67	4TH
A3	43	30	57	43	5TH
A4	70	20	27	73	3RD
A5	40	20	60	40	6TH
A6	27	3	73	27	7TH
A7	17	0	83	17	LEAST
A8	70	33	30	70	2ND

Source: Authors' Survey: 2015

Note: SID – Identification for the Areas; FFD - Free Flowing Domestic Wastewater;
PD - Pools of Domestic Wastewater; NA1 - Not Applicable; HWSI - Households with Sources of Impact; SIR - Remarks for sources of impacts

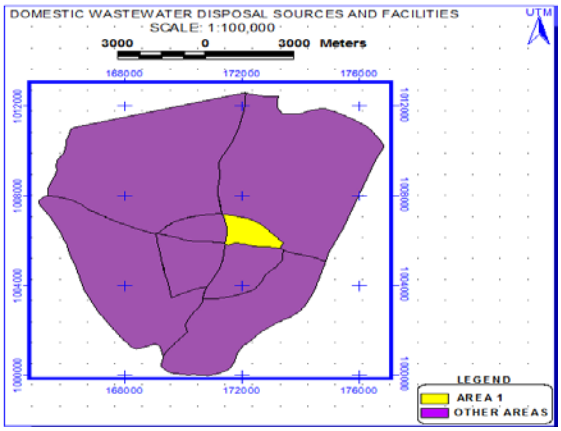

Figure 4.0: GIS Query Result for Area with Highest Sources of Impact of Domestic Wastewater Disposal on Land Surface in Yellow

Source: Authors' Survey: 2015

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

SID	FFD	PD	NAI	HWSI	SIR
A1	90	50	10	90	HIGHEST
A2	63	30	33	67	4TH
A3	43	30	57	43	5TH
A4	70	20	27	73	3RD
A5	40	20	60	40	6TH
A6	27	3	73	27	7TH
A7	17	0	83	17	LEAST
A8	70	33	30	70	2ND

Source: Authors' Survey: 2015

Note: SID – Identification for the Areas; FFD - Free Flowing Domestic Wastewater;
PD - Pools of Domestic Wastewater; NA1 - Not Applicable; HWSI - Households with Sources of Impact; SIR - Remarks for sources of impacts

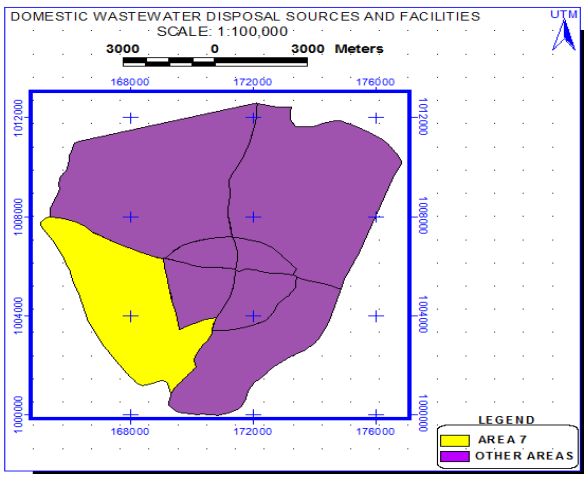

Figure 5.0: GIS Query Result for Area with Least Sources of Impact of Domestic Wastewater Disposal on Land Surface in Yellow

Source: Authors' Survey: 2015

(i) Sources of Ecological Impacts

The variables used are; free flowing domestic wastewater disposals on land surfaces, pools of domestic wastewater disposal on land surfaces, Not applicable and Households with sources of impacts. The study reveals that there are significant free flowing and pools of domestic wastewater disposals on land surface of the study area. The significant percentages of the sampled households from all eight Areas have free flowing and or pools. There was no Area with one

hundred percent not applicable (none sources) for sources of ecological impacts. All the eight Areas have sources of ecological impacts.

(ii) GIS Query Results on Sources of Ecological Impacts

Figure 4.0 indicates with yellow colour Area 1 as the location with highest number of sampled households having sources of domestic wastewater disposals on land surface. Table 2.0 shows the values of the variables that made Area 1 the highest source of ecological impacts. Area one has ninety percent of sampled population with free flowing domestic wastewater on land surfaces and fifty percent with pools on land surfaces

Figure 5.0 and Table 3.0 highlight that Area 7 is the location with the least percentage of sampled population having sources of ecological impacts.

Parts of Land Surfaces Effected by Ecological Impacts of Domestic Wastewater Disposal

The Table 4.0 and Figure 6.0 illustrate the parts of land surfaces effected by ecological impacts of domestic wastewater disposal. Table 5.0 and Figure 7.0 outlines the area with highest percentages of parts of land surfaces effected by ecological impacts. Table 6.0 and Figure 8.0 indicate the location of the Area with the least parts of land surfaces effected by ecological impacts of domestic wastewater disposals.

Table 4.0: Part of Land Surface Effected by Domestic Wastewater

Area	Streets/Walkways (SWW)	Open Spaces (OSC)	Nearby Bush (NB)	Not Applicable (NA2)	Households with Effects (HWA)
A1	43	13	60	10	90
A2	53	20	7	33	67
A3	40	23	13	57	43
A4	57	27	13	27	73
A5	20	17	13	60	40
A6	3	3	20	73	27
A7	13	0	3	83	17
A8	60	7	7	30	70

Source: Author's Field Survey; December 2011

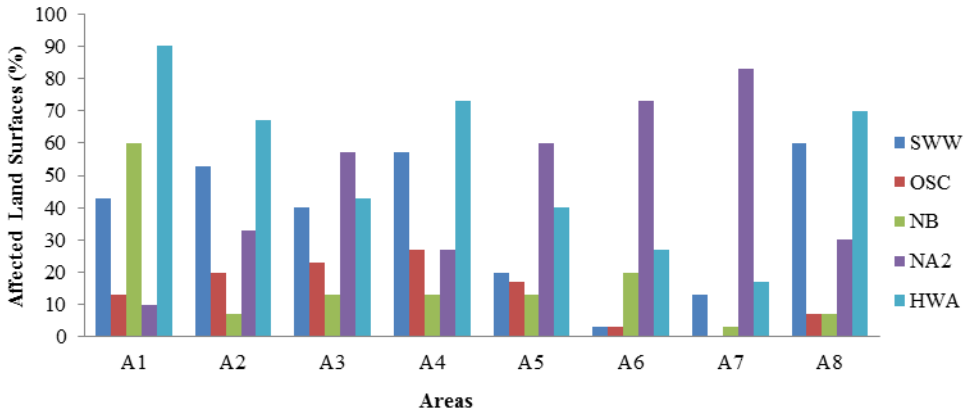

Figure 6.0: Part of Land Surface Effected by Domestic Wastewater

Sources: Author's Field Survey; December 2011

Note: SWW - Streets/Walkways; OSC - Open Spaces; NB - Nearby Bush; NA2 – Not Applicable; HWA - Households with Effects

Table 6.0: GIS Query Result for Area with Highest Effected Land Surfaces by Domestic Wastewater Disposal in Yellow (%)

AAID	SWW	OSC	NB	NA2	HWA	AAR
A1	43	13	60	10	90	HIGHEST
A2	53	20	7	33	67	4TH
A3	40	23	13	57	43	5TH
A4	57	27	13	27	73	2ND
A5	20	17	13	60	40	6TH
A6	3	3	20	73	27	7TH
A7	13	0	3	83	17	LEAST
A8	60	7	7	30	70	3RD

Source: Authors' Survey: 2015

Note: AAID - Identification for the Areas; SWW - Streets/Walkways; OSC - Open Spaces; NB - Nearby Bush; NA2 – Not Applicable; HWA - Households with Effects; AAR – Remarks for Effected Land Surfaces

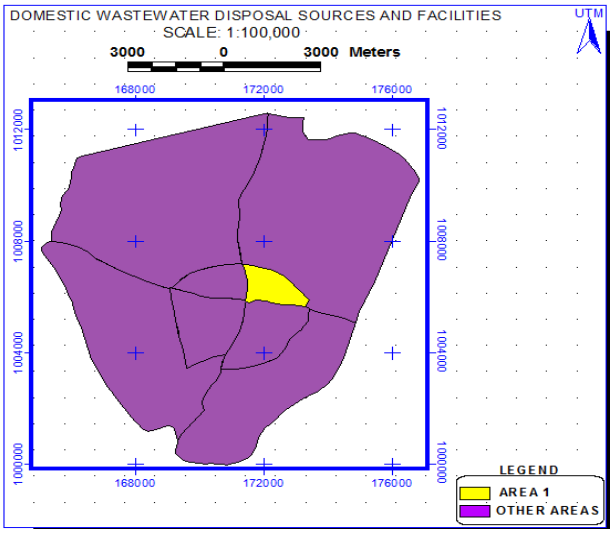

Figure 7.0: GIS Query Result for Area with Highest Effected Land Surfaces by Domestic Wastewater Disposal in Yellow

Source: Authors' Survey: 2015

Table 6.0: GIS Query Result for Area with Least Effected Land Surfaces by Domestic Wastewater Disposal in Yellow (%)

AAID	SWW	OSC	NB	NA2	HWA	AAR
A1	43	13	60	10	90	HIGHEST
A2	53	20	7	33	67	4TH
A3	40	23	13	57	43	5TH
A4	57	27	13	27	73	2ND
A5	20	17	13	60	40	6TH
A6	3	3	20	73	27	7TH
A7	13	0	3	83	17	LEAST
A8	60	7	7	30	70	3RD

Source: Authors' Survey: 2015

Note: AAID - Identification for the Areas; SWW - Streets/Walkways; OSC - Open Spaces; NB - Nearby Bush; NA2 – Not Applicable; HWA - Households with Effects; AAR – Remarks for Effected Land Surfaces

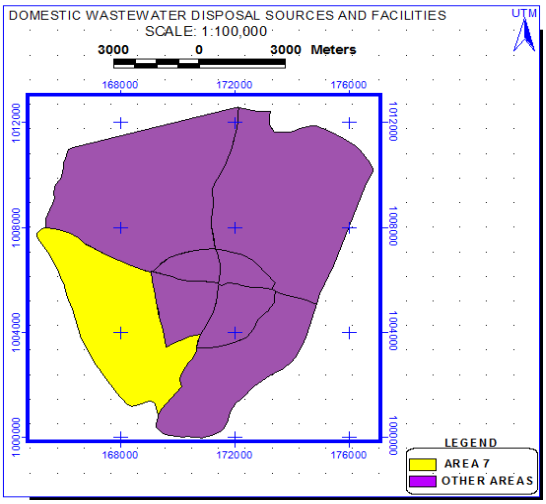

Figure 8.0: GIS Query Result for Area with Highest Effected Land Surfaces by Domestic Wastewater Disposal in Yellow

Source: Authors' Survey: 2015

(i) Parts of Land Surfaces Effected by Ecological Impacts

Table 4.0 and Figure 6.0 indicate that the parts of land surfaces effected are street/walkways, open spaces/compounds and nearby bushes. The study show that there are significant percentages of parts of land surfaces effected in all the eight Areas. Street/walkways are mostly effected followed by nearby bushes and the open spaces/compounds. There are more households with effected parts of land surfaces than those without (not applicable).

(ii) GIS Query Results on Parts of Land Surfaces Effected by Ecological Impacts

Table 6.0 and Figure 8.0 elucidate that Area 7 has the least percentages of effected land surfaces by ecological impacts.

Table 7.0 and Figure 9.0 show the negative ecological impacts on land surfaces in the study area. Table 8.0 and Figure 10.0 highlight the area with highest negative ecological impacts. Table 9.0 and Figure 11.0 indicate Area with least negative ecological impacts of domestic wastewater disposal.

Negative Ecological Impacts of Domestic Wastewater Disposal on Land Surfaces in the Study Area.

Figure 7.0 indicates with yellow colour Area 1 as the location with highest percentage of parts of land surface effected by ecological impacts of domestic wastewater disposals. Table 5.0 highlights the percentages of the variable of parts of land surfaces effected in Area 1. Forty three percent of the sampled streets/walkways, thirteen percent of open spaces/compounds and sixty percent of nearby bushes are effected in Area 1. Ninety percent of the sampled households have at least an aspect of their land surfaces effected by ecological impacts.

Table 9.0: Negative Impacts of Domestic wastewater on Land Surface in Percentages

Areas	Poor Aesthetics (PAE)	Grey/muddy colour (GMC)	Bad Odour (BO)	Shit Erosion (SE)	Flies/ Mosquitoes (FM)	Not Applicable (NA3)	Households with Negative Impact (HWN1)
A1	90	90	90	37	90	10	90
A2	67	67	67	10	67	33	67
A3	43	43	43	23	43	57	43
A4	73	73	73	23	73	27	73
A5	40	40	40	7	40	60	40
A6	27	27	27	3	27	73	27
A7	17	17	17	10	17	83	17
A8	70	70	70	37	70	30	70

Sources: Author's Field Survey; December 2011

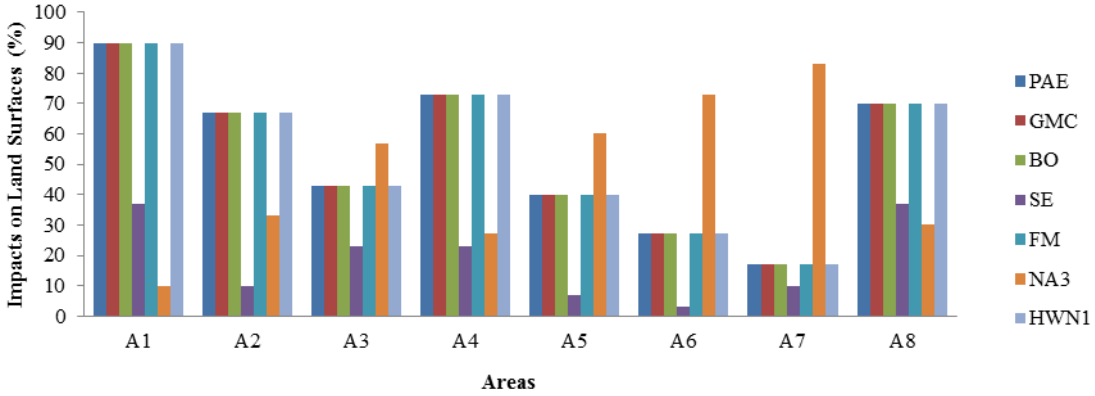

Figure 10.0: Ecological Impacts of Domestic Wastewater Disposal on Land Surface

Sources: Author's Field Survey; December, 2011

Note: PAE - Poor Aesthetics; GMC - Grey/muddy colour; BO - Bad Odour; SE - Sheet Erosion; FM - Flies/Mosquitoes; NA3 - Not Applicable; HWN1 - Households with Negative Impact

Table 9.0: GIS Query Result for Area with Highest Adverse Ecological Impacts of Domestic Wastewater Disposal on Land Surface in Yellow (%)

IID	PAE	GMC	BO	SE	FM	NA3	HWN	NIR
A1	90	90	90	37	90	10	90	HIGHEST
A2	67	67	67	10	67	33	67	4TH
A3	43	43	43	23	43	57	43	5TH
A4	73	73	73	23	73	27	73	2ND
A5	40	40	40	7	40	60	40	6TH
A6	27	27	27	3	27	73	27	7TH
A7	17	17	17	10	17	83	17	LEAST
A8	70	70	70	37	70	30	70	3RD

Table 10.0: GIS Query Result for Area with Least Adverse Ecological Impacts of Domestic Wastewater Disposal on Land Surface in Yellow (%)

IID	PAE	GMC	BO	SE	FM	NA3	HWN	NIR
A1	90	90	90	37	90	10	90	HIGHEST
A2	67	67	67	10	67	33	67	4TH
A3	43	43	43	23	43	57	43	5TH
A4	73	73	73	23	73	27	73	2ND
A5	40	40	40	7	40	60	40	6TH
A6	27	27	27	3	27	73	27	7TH
A7	17	17	17	10	17	83	17	LEAST
A8	70	70	70	37	70	30	70	3RD

Source: Authors' Survey: 2015

Note: IID - Identification for the Areas ; PAE - Poor Aesthetics; GMC - Grey/muddy colour; BO - Bad Odour; SE - Sheet Erosion; FM - Flies/Mosquitoes; NA3 - Not Applicable; HWN1 - Households with Negative Impact; NIR – Negative impact remarks

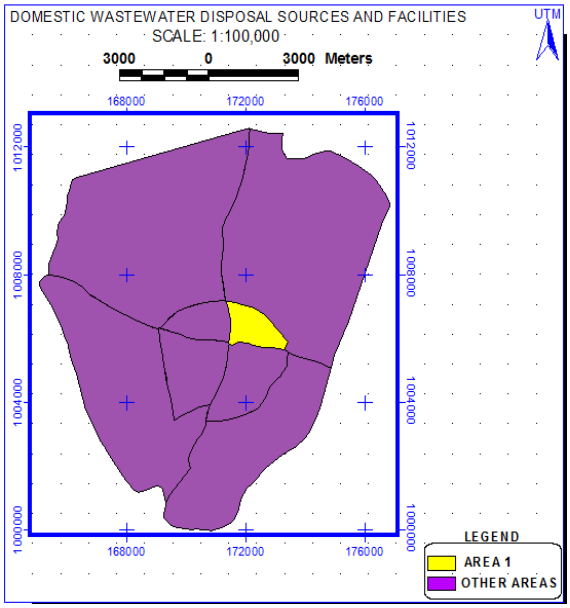

Figure 11.0: GIS Query Result for Area with Highest Adverse Ecological Impacts of Domestic Wastewater Disposal on Land Surface in Yellow

Source: Authors' Survey: 2015
Source: Authors' Survey: 2015
Note: IID - Identification for the Areas ; PAE - Poor Aesthetics; GMC - Grey/muddy colour; BO - Bad Odour; SE - Shit Erosion; FM - Flies/Mosquitoes; NA3 - Not Applicable; HWN1 - Households with Negative Impact; NIR – Negative impact remarks

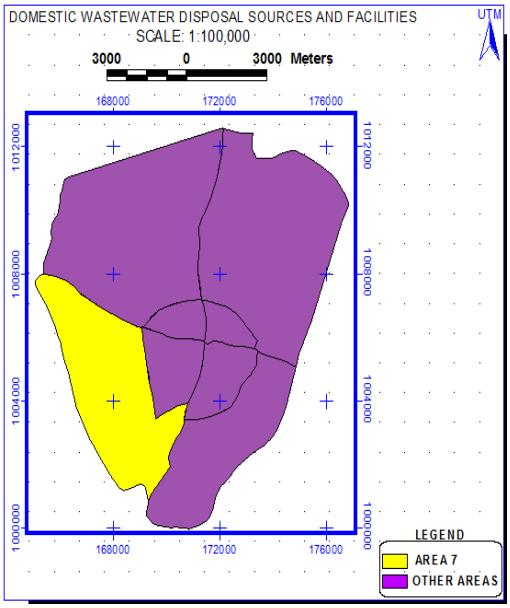

Figure 12.0: GIS Query Result for Area with Least Adverse Ecological Impacts of Domestic Wastewater Disposal on Land Surface in Yellow

Source: Authors' Survey: 2015

(i) The Negative Ecological Impacts

Table 8.0 and Figure 10.0 that the negative ecological impacts of domestic wastewater disposals on land surfaces include; poor aesthetic, grey/muddy colour, bad odour, shit erosion and flies/mosquitoes. There was no Area without a negative ecological impact variables. All the variable have high significant percentages of negative ecological values except shit erosion. The households with negative ecological impacts are more than those without.

(ii) GIS Query Results on Negative Ecological Impacts

The GIS query results show that Area 1 has the highest incidences of negative impacts. Area 7 from the query results is the location with least negative ecological impacts of domestic wastewater on land surfaces of the study area.

Average Negative Ecological Impacts of Domestic Wastewater Disposals on land Surfaces

Table 11.0 and Figure 13.0 show the average negative ecological impacts for the eight Areas. Tables 12.0 and Figure 14.0 highlight the average negative ecological impacts for the two regions.

Table 11.0: Average Negative Ecological 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	79	56	43	63	33	22	16	63

Source: Author's Field Survey; December 2011

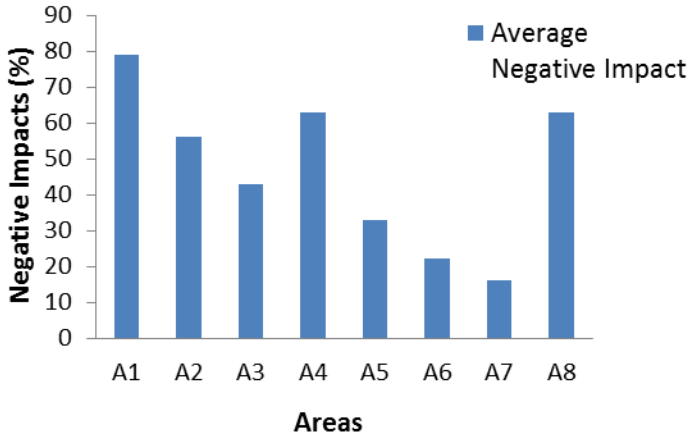

Figure 13.0: Average Ecological Impacts of Domestic Wastewater Disposal on Areas

Source: Author's Field Survey; December 2011

Note: A_1-A_8 – Represents Eight Areas

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

Region	Core	Outer
Average Negative impacts	60	34

Source: Author's Field Survey; December 2011

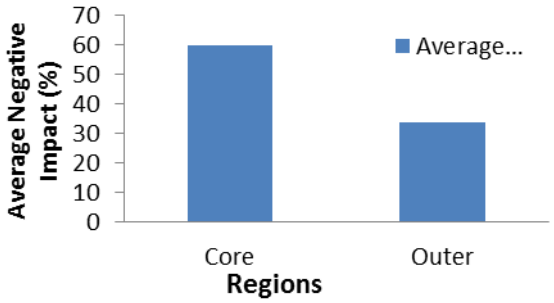

Figure 14.0: Average Ecological Impact of Domestic Wastewater Disposal on Two Regions in Percentage

S

ource: Author's Field Survey; December 2011

(i) Average negative ecological for eight Areas

The average negative ecological impacts are from the mean of poor aesthetics, bad/muddy, colours, bad odours and shit erosion values. The highest negative average is for Area 1 with seventy nine percent (79%) average. The second highest average negative ecological impact is sixty three percent for Areas 4 and 8 respectively. The least is sixteen percent for Area 7. The others are; Area 2,

56%; Area 3, 43%, Area 5, 33% and Area 6, 22%. All the Areas have significant average negative ecological impacts. The acceptable should be zero because of the public health that could be effected by any disease from a household with negative ecological impact.

(ii) Average Negative Ecological Impacts for the Two Regions

The average negative ecological impacts for the region are significantly higher. The Core region from Table 12.0 and Figure 14.0 has an average of sixty percent (60%) negative ecological impacts of domestic wastewater disposals on land surfaces. This is very high and should be discouraged. The Outer region has an average of thirty four percent (34%) negative ecological impacts on land surfaces. These results are in agreement with previous assertions by other authors already referred to in this paper that discharge of untreated domestic wastewater on the environment is dangerous to public health and pollute the environment. This study reveals that the land surfaces are significantly polluted.

Discussion on Ecological Impacts of Domestic Wastewater Disposal on Land Surfaces

The foregoing results attest that there are significant; sources of ecological impacts, parts of land surfaces effected by ecological impacts on land surfaces of the study area. This shows that there are strong relationships between sources of ecological impacts, the parts of land surfaces effected and the negative ecological impacts. Area 1 indicated as highest source of ecological impacts by GIS query results, also has the highest parts of land surfaces effected and highest negative ecological impacts on land surfaces. Thus, to ameliorate or eliminate ecological impacts of domestic wastewater on land surfaces the focus must be on eliminating or controlling the sources of ecological impacts. Area 1 highlighted by GIS query to have highest source should be the priority Area to solve the problem of sources of ecological impacts.

The implications of the high significant negative ecological impacts are; land degradation, pollution and high risk of adverse effects on public health. These findings are in agreement with the assertions of many authors that discharging untreated domestic wastewater to the environment, pollutes the environment, waterbodies and pose danger to public health (Pollution Issue, 2010; Environmental Canada, 2013 and FAO, 2013).

CONCLUSIONS

The study indicates that there are high levels of sources of ecological impacts of domestic wastewater on land surfaces. That there are significant parts of land surface effected by ecological impacts of domestic wastewater in the study area. Also the levels of negative ecological impacts of domestic wastewater disposal are high for all the eight Areas and the two regions of the study area. GIS was used at data collection, processing, analysis and presentation stages in this research.

RECOMMENDATION

The authors with reference to the foregoing; results, discussions and conclusions recommend that;

- Government Agencies, Non-Governmental Organisations and Community Organisations should embark on formal and non-formal education in order to enlighten the residents of the study area on the need to stop the sources of ecological impacts.
- Also, there should be edicts from both the State and Local Government Authorities on the need to adopt standard disposal facilities in the eight Areas so as to reduce the quantity of free flowing and pools of domestic wastewater disposals on land surface of the study area.
- There should be GIS database created for ecological impacts in the study area by the State Government for monitoring and effective management.

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