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Research Article
Spatial Patterns of the Fecal Contaminations Index in Yenagoa Metropolis, Bayelsa State, Nigeria

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Abstract
Background and Objective: The several health challenges of humans in most communities are traceable to the state of the community environmental unhealthiness. The several environmental health issues and disease profiles among local settlement in Yenagoa metropolis has become so worrisome. This study was undertaken to map, identify and analyze the distribution of faecal contamination index within the metropolitan Yenagoa. **Materials and Methods:** Ten Communities, Amarata, Biogbolo, Ekeki, Kpansia, Okaka, Okutukutu, Onopa, Swali, Yenezue-Epie and Yenezue-Gene were randomly selected. The coordinates of each of the communities and the faecal contamination sites were recorded using the map and location Application on an Android phone. In each site, three faecal contamination indexes, open site, waste dump site and leaking septic tanks were physically identified and mapped. The faecal contamination index was counted in a map grid and the frequency was calculated. **Results:** From the result, forty-one standpoints in twenty-six sites of the 10 communities had one of the three sources of faecal contamination. Dumpsites (56.1%) were more predominant than open sites (17.1%) and leak septic sites (19.5%), respectively. The spatial analysis by count cell method was calculated using Variance- Mean Ratio (VMR). The VMR was calculated to be 1.70. **Conclusion:** This showed that the distribution pattern of the faecal contamination index was even, regular and uniform. This is an indication that the disease pattern associated with faecal contamination may spread uniformly across the living homes in the study communities.

Key words: Spatial patterns, faecal contaminations, disease burden, Yenagoa, distribution pattern

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The several health challenges of humans in the most community are traceable to the state of the community environmental unhealthiness[1]. Environmental unhealthiness is the product of poor sanitation practices and the source of faecal disposal. Reports showed that several incidences of diarrhoea[2,3], helminths infection[4] and gastro- enteric diseases[5] had their sources from the pattern of faecal contamination in the environment. These diseases have been responsible for over 499,000 deaths in children under 5-years of age[6]. The close link between the pattern of the spread of diseases and the source of faecal contamination in a community has become a sensitive index that describes a community health status[7]. World Health Organization[8] Toilet facilities are far the most important indices that define the livelihood of a community-household disease pattern in the most rural and urban settlements. In most developing countries, the type, method, adequacy of toilet facilities affects the community sanitation status[9]. Sanitation, according to Tsinda *et al.*[10], is a de ne system that promotes proper disposal of human and animal waste to improve and protect the public and environmental health. The study by Mihrete *et al.*[11] have shown that poor sanitation has caused over 280,000 diarrheal related deaths annually across the globe. In Nigeria alone, over 38% of children below 5 years suffer from poor sanitation related illnesses[12]. Yenagoa metropolis is a fast-growing urban Centre. Environmental health issues and increasing disease profile among the citizenry in the local settlement has become so worrisome. Over the past 2 decades, researchers have developed automated tools for the efficient storage, analysis and presentation of geographic data[13]. These rapidly evolving technologies now known as Geographic Information System (GIS) has been used recently across different fields of scientific study[14] to provide the means of storing, analyzing, sharing and visualizing real-time spatial data in an easy to understand manner[15]. Geographic Information System has been used in the surveillance, epidemiology and monitoring of disease intervention[16]. Mapping disease cases in geographic space, allows the governments to easily identify the triggers and spread of disease across geographic regions and thus optimize quick intervention plans and effective monitoring. The basic pre-requisite needed to improve the household, community health care quality and sanitation practices is to identify the spatial pattern of the sources of faecal contamination and define their role in community disease burden[17] and present them in an easy to understand the map. There is a paucity of this information in Yenagoa Metropolis of Bayelsa State. This study was therefore designed to map, identify and analyze the clusters of faecal contamination sites within the metropolitan Yenagoa. The result of this report shall provide vital information to the Government and health planner on the need to improve community-based environmental health practices and suggest the provision of affordable toilet facilities to communities across the areas.

MATERIALS AND METHODS

Study area: Yenagoa metropolis (4°53'N and 5°17'E) is the capital city of Bayelsa State and also the headquarter of Yenagoa municipal. The study was undertaken from August, 2019 to November, 2020. The study communities are within the Epie water ways[18].

Study design and sampling techniques: The study design and the sampling techniques have been described in Amawulu *et al.*[18]. The study adopted a cross-sectional survey of the streets, waterways and households with leaking septic tanks across the Yenagoa metropolis in Bayelsa State.

The first stage of the survey involves the identification and mapping of communities in the Yenagoa metropolis and her streets. A field survey was carried out to randomly select 10 communities within the metropolis. A minimum of two streets per community was selected. The Communities selected are Amarata, Biogbolo, Ekeki, Kpansia, Okaka, Okutukutu, Onopa, Swali, Yenagoa, Yenezue-Epie, Yenezue-Gene. The coordinates of each of the communities were recorded using the map and location Application on an Android phone (Techno A701) in Table 1. In each location, three faecal contamination indexes were physically identified and mapped. These are; open sites, waste dump sites and leaking septic tanks. The coordinates were the contamination indices were identified was also taken.

Map overlay: The overlay of the map was done at the Geography Department of the University of Port Harcourt Administrative map of Bayelsa State showing the Yenagoa Local Government Area at the scale of 1:500000 was obtained from the Surveyor General's office, Bayelsa State Ministry of Land and Housing. The map was scanned into my document for further computer use. The map was georeferenced and digitized using Arc View GIS software (version 3.2a, ESRI, CA, USA) according to the pattern in Martin *et al.*[19] and Ekpo *et al.*[20]. The location of each site was linked to the number of types of sources of faecal

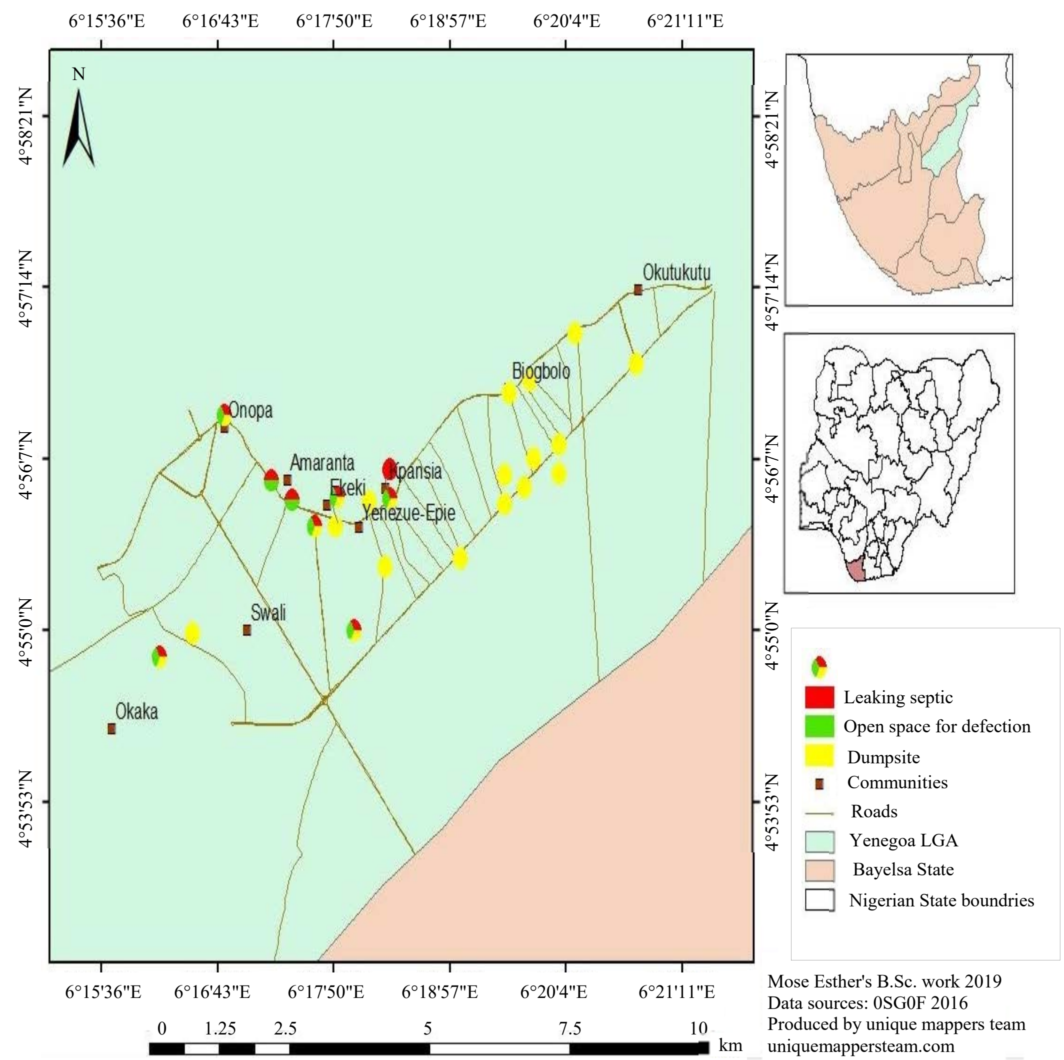

Fig. 1: Spatial pattern of faecal contamination in Yenagoa metropolis

contamination using site-specific identifiers or identification 1D numbers. The degree of clustered was calculated using the cell count method while the Variance to Mean Ratio (VMR) was calculated to determine the index of dispersion.

Method of data analysis: Data entry was done using Microsoft excel and analysis was done using the SPSS software version 20. Descriptive statistics were calculated for the frequency of the sources of faecal contamination using simple percentages Relationship between variables was calculated using ANOVA at the confidence level of p = 0.05. The cell count method was adopted to compare the distribution pattern of the sources of faecal contamination across the communities. Forty-two cells (2 inches apart) were drawn from the distribution map. Sixteen cells fall within the sampled areas. The numbers of the different faecal contamination index in each cell was counted. The mean (x) and variance (δ^2) of the frequency were calculated from the map grid of the field data in Fig. 1. A Variance Mean Ratio (VMR) was calculated[21]. The result of the VMR was used to justify the distribution pattern:

$$\text{Mean }(x) = \frac{\sum fx}{\sum f} \tag{1}$$

$$\text{Variance }(\delta^2) = \frac{\sum f_o}{\sum f}(x\text{-}x)^2 \tag{2}$$

$$\text{VMR} = \frac{\delta^2}{x^-} \tag{3}$$

Decision, If

MVR = 1 : Distribution is random
MVR<1 : Distribution is near cluster than random
MVR>1 : Distribution is regular, even or uniform

RESULTS

Twenty-six sites in 10 communities were mapped. Three faecal contamination indexes were identified. The sources of faecal contamination in the increasing order of frequency were; open site (17.1%), leaking septic (19.5%) and dumpsite (56.1%), respectively. Differences in the frequency of faecal contamination index across the communities were significant($p< 0.05$) in Table 1. The spatial distribution of the faecal contamination index showed that the four sites had the concentration of all three of the faecal contamination index. One site had a concentration of leaking septic and open defecation sites. The majority of the communities had the waste dumpsite as an index of faecal contamination. Forty-two location standpoints of faecal contamination index were counted. Out of the 42 grids, the contamination index was observed in 16 cells as shown in column 1 of Table 2. The frequency of each of the contamination indexes was recorded as in column 2. The summation of frequency gives 16. The summation of the product of the number of cells and frequency was 211. This value divided by the number of cells gives a mean value of 8.12. The square deviation in column 3 was calculated. The summation of the product of square deviation and frequency in column 4 gives a variance of 359.51. Dividing this value by frequency gives a value of its variance as 13.83. Dividing the variance by the mean value gives a Variance-Mean Ratio (VMR). The VMR analysis of the faecal contamination index across the study communities was 1.71 by count cell method. From the analyses, the distribution pattern of the various faecal contamination index was even, regular and uniform:

Table 1: Number of sites and classification of sources of faecal contamination index in Yenagoa metropolis during August, 2019 to November, 2020

		Number of sources of faecal contamination counted			
Location	Number of sites	Open site	Waste dump	Leaking septic	All sources
Amarata	3	2	2	2	6
Biogbolo	5	0	5	0	5
Ekeki	3	3	3	3	9
Kpansia	3	0	2	1	3
Okaka	2	0	2	0	2
Okutukutu	2	0	2	0	2
Yenezue epie	2	2	2	2	6
Yenezue gene	2	0	2	0	2
Onopa	2	0	2	0	2
Swali	2	1	2	1	4
Total	26	07 (17.1%)	23 (56.1%)	08 (19.5%)	41

Table 2: Variance-mean ratio of faecal contamination index calculated from the map grid during August, 2019 to November, 2020

Number of cells (x)	Frequency (f_o)	$f_o x$	$(x-\bar{x})^2$	$f_o (x-\bar{x})^2$
1	0	0	50.69	0.00
2	0	0	37.45	0.00
3	2	6	26.21	157.29
4	1	4	16.97	16.97
5	0	0	9.73	0.00
6	7	42	4.49	31.46
7	4	28	1.25	5.02
8	3	24	0.01	0.04
9	0	0	0.77	0.00
10	2	20	3.53	7.07
11	3	33	8.29	24.88
12	0	0	15.05	0.00
13	2	26	23.81	47.63
14	2	28	34.57	69.15
15	0	0	47.33	0.00
16	0	0	62.09	0.00
Total	26	211		359.51

$$\text{Mean}\ (x) = \frac{\sum fx}{\sum f} = 8.12$$

$$\text{Variance}\ (\delta^2) = \frac{\sum f_o}{\sum f}(x\text{-}x)^2 = 13.83$$

$$^*\text{VMR} = 1.71$$

Decision: Spatial pattern was even, regular and uniform.

DISCUSSION

The three predominant faecal contamination index in Yenagoa metropolis was the open site, leaking septic and dumpsite. A similar observation has been reported by Amawulu *et al.*[18] in the same environment. More dumpsite was recorded in the study locations. This observation is consistent with, Joab *et al.*[22]. The frequency of these faecal contamination indexes across communities in the Yenagoa metropolis in this present study is an indication that the community health practices in the study location are poor. The poor community health status may highlight the poor sanitation practices in the locality. This result aligns with Mihrete *et al.*[11] and Ezeh *et al.*[12] who also affirmed that where community sanitation is poor, there is the tendency of the inhabitants showing high burdens of various kinds of diseases. The differences in the frequency of the faecal contamination index across the communities were significant. The difference is an indication that the level of sanitation and disease burden differs from community to community. However, while similar studies by Amawulu *et al.*[18] have attributed the differences in the frequency of the faecal contamination index to the differences in the level of health education, Olajumoke and Kayode[15] had a contrary view and attributed the differences to the different attitude and adherence of community members to issues of health habits.

The spatial distribution of the faecal contamination index was 1.71. This is an indication that the distribution pattern of the faecal contamination index was even, regular and uniform. Several studies Taiwo *et al.*[4] and Palaniyandi *et al.*[14], have reported spatial distribution of infectious diseases, only a few have reported the spatial pattern of disease index in a spatial map[23]. The implication of this observed faecal contamination index in this present study is that the index is likely going to be distributed uniformly across the local settlement. This may cause faecal related pollution along with the waterways, roads side and neighbourhoods thereby posing serious health challenges to the residents within the locations. This observation is consistent with the previous reports[24,25] who both reported that the proximity of waste dump disperse within the human settlement was responsible for the incidence of malaria and *V. cholera* in a rural community. However, Olajuyigbe *et al.*[17] made a contrarily view that when faecal contamination is clustered and aggregated, it may propagate a disease from its origin and spread to proximal communities earlier than the communities which are farther apart.

CONCLUSION

The three predominant faecal contamination indexes in the study locations were waste dump sites, leaking septic and open defecation site. The distribution pattern of these faecal contamination indexes was even, regular and uniform. This showed the tendency of disease agents spreading uniformly across the living homes in the study communities nearer to each other.

SIGNIFICANCE STATEMENT

This study discovered the three major faecal contamination indexes in the Yenagoa metropolis which are uniformly distributed across the locality. These indices may be sources of many health-related issues. The study is of paramount importance to the Government, Health planners and communities, as it has uncovered critical areas of community health indices and presented the result in an easy to understand the map, which many researchers were not able to explore. This may be a milestone for other researchers to develop.

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