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Proliferation of household waste irregular dumpsites in Niger Delta region (Nigeria): unsustainable public health monitoring and future restitution

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Abstract

Inadequate collection and improper disposal of municipal waste have a direct negative impact on cities. Disease occurrence in Obio-Akpor (Port Harcourt metropolis, Nigeria) was suspected and linked to the proliferation of dumpsites and proximity to residential households. Evidence showed frequent incidence of diseases outbreak coupled with the topographic coastal nature and the morphological propelling dynamics of sediments transport in the area assisting the situation. The main objective of this study was to assess how the spatial distribution of irregular dumpsites is linked to the disease occurrence (cholera, diarrhoea and malaria) in the community. The data used for the study was obtained through questionnaires administrated at the hospitals, use of GPS for locating disease incidences and waste dumps, interviews and observations. Point pattern analysis using the G-function and the K-function was employed in analyzing the spatial distribution of dumpsites and disease incidences. Correlation tests were performed to test for the relationship between disease incidences and presence of dumpsites. The results showed that there was a significant relationship ($p < 0.05$) between disease incidences and presence of dumpsites. It was also observed that diseases could occur in areas where dumpsites were not present as cholera and diarrhoea are contagious but malaria is not, though it spreads. The study will be beneficial to governmental agencies, waste managers, institutions, environmentalists, health, social workers and future researchers.

Keywords: Cholera, Clustering, Diarrhoea, GPS data, Irregular dumpsites, Malaria, Monitoring, Restitution

Introduction

Irregular dumpsites serve as a receptor of heterogonous materials. Unsanitary landfilling or open dumping is common in developing countries [1–7] and known as the major threat to groundwater and other environmental resources [8, 9]. Inefficient management of municipal waste produced; especially in Nigeria is increasing nuisance, environmental burdens and schematically linking disposal problems to public health concerns. Almost 95% of the municipal solid waste generated goes straight into a poorly managed hole called dumpsite, which decomposes and underflows to the land resources through infiltration from the precipitation processes in a very unsatisfactory manner thereby subjecting ground and surface water, environmental and public health to possible risks [10, 11]. Since January 2009, Austria has given a red card to landfilling of waste materials and only allows pre-treated waste with very low organic matter to be legally landfilled through legislative actions. Since 2008, such an act defines waste management as a sustainable practice [12]. Inappropriate waste disposal can be very harmful [13]; it presents media for disease spreading and creates an overall negative impact on the environment because the released toxic heavy metals contaminate the

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soil [10], produce greenhouse gas [6], volatile organic compounds [14], and pollute water bodies [15, 16].

Dumpsites in the Niger Delta are alternatively used as landfilling because it is a cheap method for waste disposal and no treatment goes on there. The leachate produced at these landfills causes contamination by organic, inorganic and microbial pollutants [13, 14]. Locations where such indiscriminate dumping takes place become vulnerable to diseases since they become a harbor for mosquitoes and flies breeding, emission of methane gas, unpleasant odors, and serve as an invitation for all sorts of animals – domestic and wild which can, in turn, serve as vectors transmitting diseases through food-chain to humans and environs. The objective of the study was to assess how the spatial distribution of the dumpsites is linked to the disease occurrence of malaria and acute enteric infections such as diarrhoea and cholera in the Obio-Akpor area of the Niger Delta. Holistic examinations of the risks posed by dumpsites and landfills were researched to determine the pollutants' migration. Adelopo et al. [16] reported heavy metal contents of landfills, Kumarathilaka et al. [14] focused on the volatile organic compounds, while Aboyeji and Eigbokhan [15] applied geospatial methods and GIS to represent the pollutants' spatial characteristics. Adamcova et al. [17] studied types of the waste (hazardous content and percentage of organic matter) present at the sites and their physicochemical reactions, but the diseases' occurrence and their clustering have not been established in the area. However, Yeukai and Kharlamova [18] have looked at the spatial distribution of some diseases in relation to the dumpsites.

Figure 1 represents the study area. For the dry season, the daily relative humidity is 56%, and for the rainy season, it is 96% while the average annual rainfall in the Niger Delta is 2500 mm. Two identifiable patterns of rainfall occur, the longer one from April to October and the relatively shorter one from November to March. However, Uko and Tamunobereton-Ari [20] in their variability of climatic parameters of Port Harcourt cited the meteorological data of Port Harcourt airport, which provided an average 31.1–33.1 °C of maximum temperature (during the dry season, November–February). Okpara et al. [19] have conducted a study of the heavy metal pollution from the dumpsite's leachate, soil and water. Due to the topography, sediment and solid waste transport enhances the propelling of debris [21]. People living in riverine areas frequently experience all kinds of illnesses and report mosquito's bite that leads to malaria. Water pollution and poor environmental sanitation encourage the incidence of cholera, dysentery, and diarrhoea.

Materials and methods

Hospital survey and random sampling

We employed two-stage sampling techniques to select a representative sample. For the residential areas, hospital survey was conducted at five different hospitals within the communities living near the dumpsites to ascertain the level of disease cases diagnosed or treated in the area in recent time (10 months); and their reports were processed and analyzed. The selection of clusters (enumeration areas) was performed based on the households per person. According to Deaton [22], a sample size of 10% is adequate to draw statistical inferences. Therefore, 159 clusters were randomly selected from the study area. Six qualitative questionnaires were administered in selected hospitals in the community to seek information from the health experts (doctors, laboratory technicians, and matrons). From their file record, we configured our data to ascertain disease incidence and cases reported/treated. We also formed our objective based on the respondent's information and opinion expressed in the questionnaire delivered for the study. Based on the unstructured interviews' response, field surveys were conducted to observe and record the locations of irregular dumpsites and disease incidence using the Garmin GPS receiver for spatial distribution. The cases as represented in the clusters are residential areas or households within the surrounding dumpsite environment.

This study was carried out at Obio-Akpor local government area (LGA), created in 1989, located in the Niger Delta, Rivers State, southern Nigeria. The area is 260 km^2 with densely residential area of 2498 persons per km^2. Based on the last census conducted in Nigeria in 2006, the projected population growth was estimated at 2000 per annum in Obio-Akpor LGA. Hence, as of 2016, we have about 649,600 officially reported, which means the additional population will amount to 8000 by 2020 [23]. A study by Ogwueleka [24] showed that more than 25 Mt of solid waste was generated in Nigeria annually with the average rate of generation ranging from 0.44 kg cap^{-1} d^{-1} in rural areas to 0.66 kg cap^{-1} d^{-1} in urban areas. On average, as reported by Okpara et al. [19], a total of 63.9 kt are being generated monthly in Rivers state of which Obio-Akpor is one of the main contributing figures. However, Rivers State where the present study was undertaken is home to the country's wealth. It is the oil-producing state and Port Harcourt is the capital city that has witnessed a high influx of migrants as a result of its rapid urbanization. The major urban center and their waste generation rate were estimated at 0.45, 0.98 and 1.16 kg cap^{-1} d^{-1} for Emougha, Obio-Akpor and Port Harcourt, respectively according to Babatunde et al. [25].

Population projection assumes the same rate of growth for all LGAs within a state according to the National Population Commission of Nigeria (https://www.nationalpopulation.gov.ng/) and National Bureau of Statistics (https://nigerianstat.gov.ng/); hence, there is a possibility of high error rates. We chose Eliozu Rumuokoro

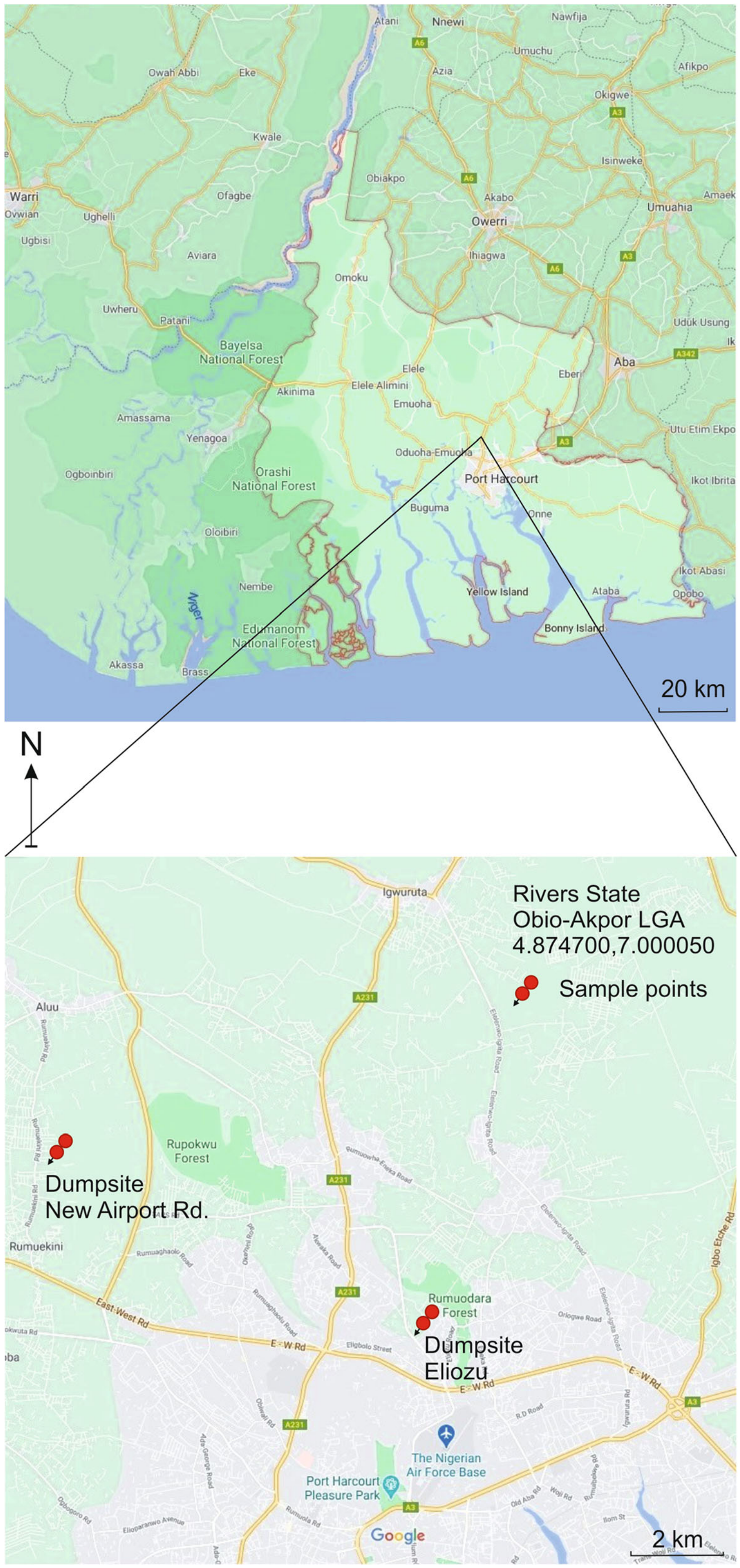

Fig. 1 The location of dumpsites in Obio-Akpor in the Niger Delta [19]

and Obiri Ikwere Rumuagholu communities for this study because they were located around dumpsites, in riverine areas with high disease incidence and low level of waste collection, and characterized by the presence of irregular dumpsites.

Analysis of the data used

We performed exploratory data analysis to view the pattern of the data generally. Data on the disease occurrence and distance of household's cases reported at the selected hospitals from the nearest dumpsite were tested for normality using the Kolmogorov-Smirnov test at 95% significance level. Correlations were used to test whether there is a significant relationship between disease occurrence and presence of selected dumpsites. Confirmatory data analysis involved the use of the K-function, which was used to further analyze the data and to reveal the patterns of progression. Calculation of distances between dumpsites and reported cases with disease incidence was done in SPSS (Statistical Package for the Social Sciences) using the following Pythagoras formula: $D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$, where D is the distance between disease cases reported and dumpsites, and $(x;\ y)$ are the location coordinates of reported-households cases and dumpsites.

Point pattern analysis; G-function and K-function

Arc-Mag 10.3 was used to generate point maps for dumpsites and disease incidence. The G-function was used as an exploratory data analysis technique to determine the inter-event distribution of diseases. The K-function was used to determine the significance and scale of clusters that were explored using the G-function. The G-function and the K-function were used to determine if the occurrence of diseases and the presence of dumpsites show any clustering or regularity as opposed to being randomly distributed.

Results and discussion

Our findings showed that solid waste generated in Obio-Akpor LGA is influenced by a number of factors. These factors include the services rendered by the municipal government such as the provision of waste bins, irregular collection, transport, residence approach to wastes and disposal practices employed. The waste management plans and policies represent an inefficient waste management system. All wastes are disposed at dumpsites without any protection of the environment and population. Waste disposal by incineration and burning was common for the purpose of the waste volume reduction but had health implications. In our study, we looked at three possible diseases that could affect human beings through this source. Diarrhoea, cholera and malaria were conspicuous from other diseases. Prerequisite knowledge of the effects of poor waste management on human health was accessed through a qualitative interview conducted in the hospitals within the study area. Without periodic health surveillance to detect early signs of diseases, monitoring of disease clustering is difficult. Therefore, this study offers help to reveal the impact of the unregulated dumpsites' disease occurrence and their locations. It shows how clustering is going on in the area. The results in Fig. 2 suggest that waste dumping on the roadside or undesignated sites is visible due to irregular collection of waste by the management agency.

The spatial distributions have established the type of disease spreading across the residential areas from the dumpsites. Three health centres in the New Airport Road area reported disease frequently treated as malaria, diarrhoea and cholera. Previous studies conducted in the same area also revealed presence of heavy metal concentration found in leachate from dumpsites, soil and water [19].

K-function was used as confirmatory data analysis to evaluate the evidence of our assumptions in this study by challenging the data input. In this case, we conducted the test to ascertain the relationship between the presence of irregular dumpsites and disease occurrence and to determine whether there was evidence of disease occurrence in relation to the dumpsites in Eliozu Rumuokoro and Obiri Ikwere Rumuagholu communities of Obio-Akpor LGA. The results are displayed in Fig. 3.

The result disclosed that households, residential or industries closer to dumpsites have a high risk of getting diseases than those that are further away from the source. We observed that the dispersed distance had not reached the expected straight line as shown in the confidence envelope. However, clustering of diseases at 300 m is an assertion that there is high disease incidence at short distances from the nearest dumpsite. The confidence envelope review graph showed that. From 1800 to 4000 m, there is evidence of regularity, which further ascertains a decrease in the disease incidence. An observed behavior from the results suggests that diseases are also occurring in clusters; hence the clustering of diseases after 3000 m from the nearest dumpsite. All these are associated with unsanitary dumpsites multiplication and inadequate waste collection in the area.

In Fig. 4, general observation showed significant level, the p-values indicating lower or higher clusters in the random sample, while the z-score representing critical value. With p-values < 0.05 and z-score > 2.50 there is less than 1% likelihood that this high-clustered pattern could be the result of random chance.

However, the simulation envelopes were used to show the significance of the clusters at the 95% significance level. If the observed phenomenon K(d) lies above the

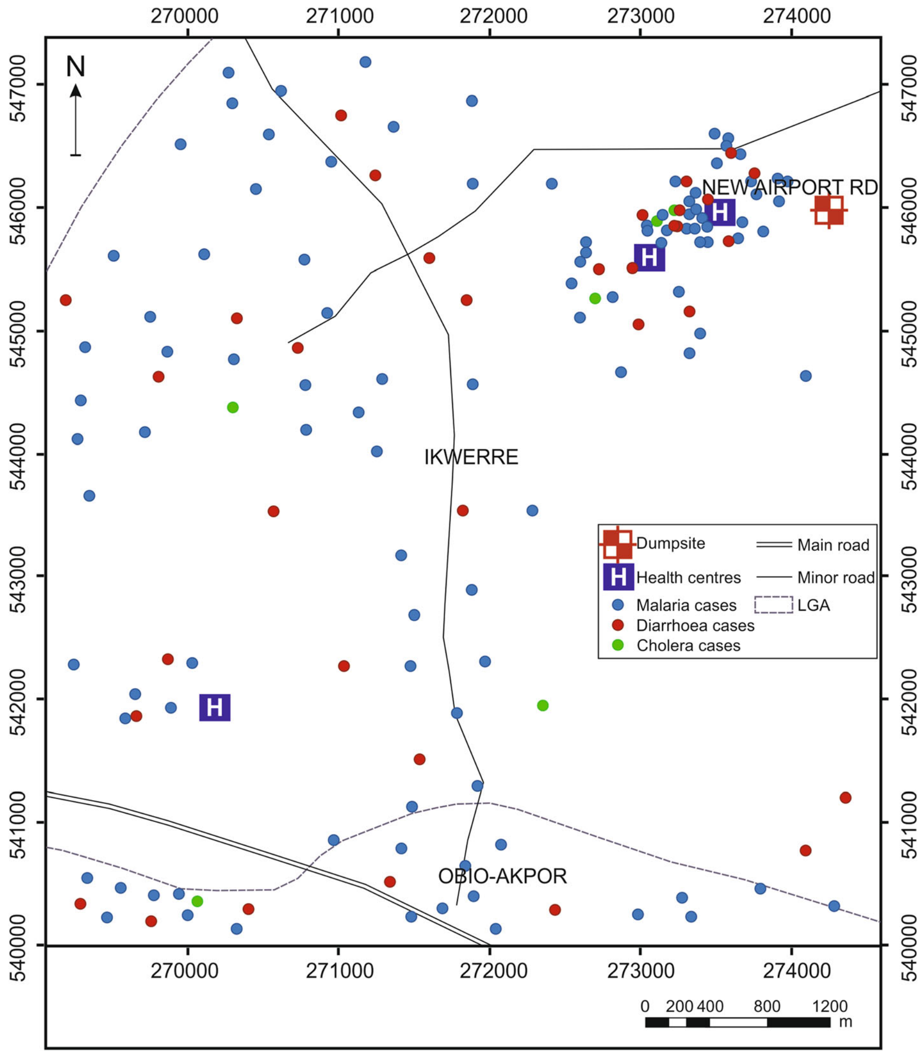

Fig. 2 The disease occurrence and spatial location of the New Airport Road dumpsites and undesignated dumps

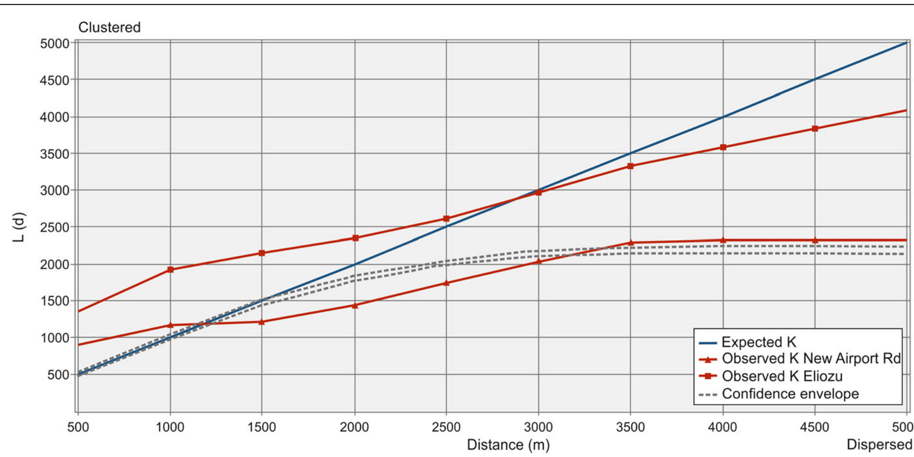

Fig. 3 The K-function (L(d)) showing the relationship between the presence of irregular dumpsites and disease dispersed distance in New Airport Road and Eliozu

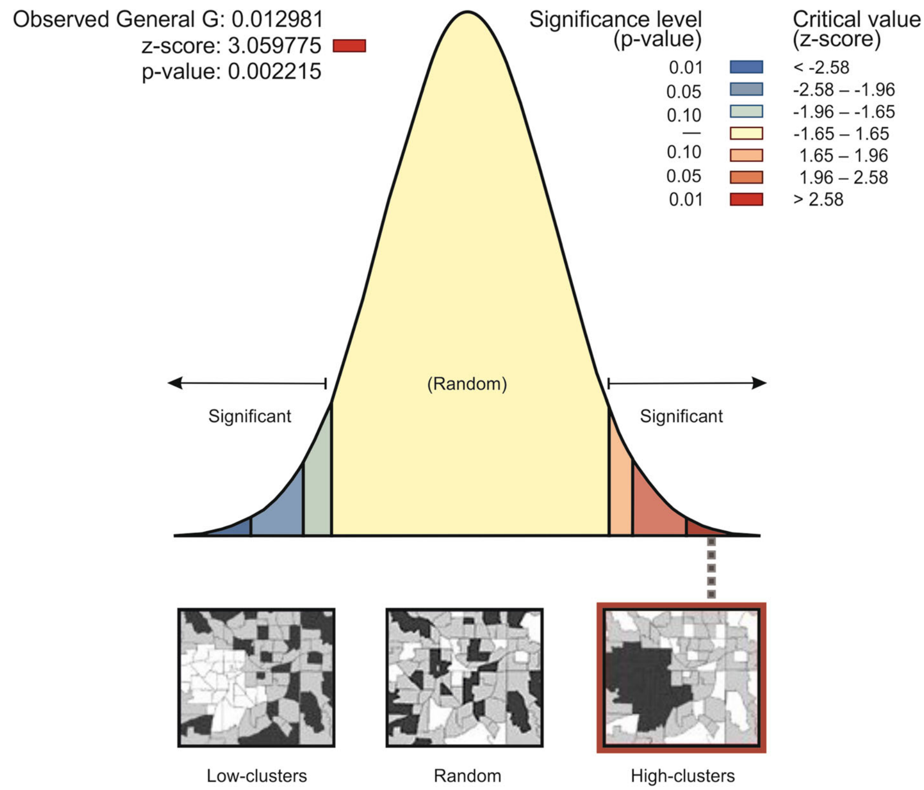

Fig. 4 High-low clustering report, General G Summary

upper envelope, the clustering will be significant, if K(d) lies below the upper envelope, the clustering will not be statistically significant.

We observe from Fig. 5a for the New Airport Road that there is statistically significant clustering of diseases at 250, 350, and 400 m because K(d) lies below the upper envelope. The clustering continues significantly at 700 to 800 m because K(d) is above the upper envelope. While in Fig. 5b clustering of diseases is statistically significant at 1100 m and continues in 240 m away in Eliozu. This could be because of the terrain and Eliozu's older dumpsites. It further suggests that there is a significant number of diseases occurring at a short distance from the dumpsite as compared to the number of diseases occurring in the cluster at 800 and 2400 m.

We used colour differences in Fig. 6 to differentiate diseases clustering spots and to separate them.

In the study area, two general, two private and one health centre (community) hospitals provided confidential data on the reported cases for their patients living close to the major dumpsites. By percentage calculations, we tabled the diseases, and results showed that among all other cases, cholera reported cases were minimal while malaria and diarrhoea had a higher share. Frequent reports of mosquito bites, which lead to malaria, by residents could be confirmed in Table 1, which showed the highest occurrence and spread from 60 to 95%. This is followed by diarrhoea 5 to 30%.

The impact of monitoring irregular dumpsites

The Niger Delta region has more factors playing the key roles in supporting disease spread: the pattern of settlement, availability of wetland, and nature of the terrain. Rural settlements lack essential amenities like good infrastructures, drainage systems, and accessibility of potable water. Hence, the region is a prone area and deserves better access to solid waste collection and disposal options [25, 26]. Monitoring, therefore, is important due to the lack of access to controlled waste treatment and disposal facility, which is very conspicuous. A larger settlement is found in the interior scale of the communities and they are generally facing a fragile ecosystem, delicate ecological sustenance and some containable disease spread. Most people in Eliozu Rumuokoro and Obiri Ikwere Rumuagholu communities live around dumpsites and riverine areas as seen in Fig. 2. Dumpsite impact monitoring will positively influence both environmental and ecologically sensitive areas. To effectively understand its impact, it is important to understand the dimensions and dynamics of anthological consequences on agriculture [27]. Moreover, a conscious effort is required to understand the present condition of

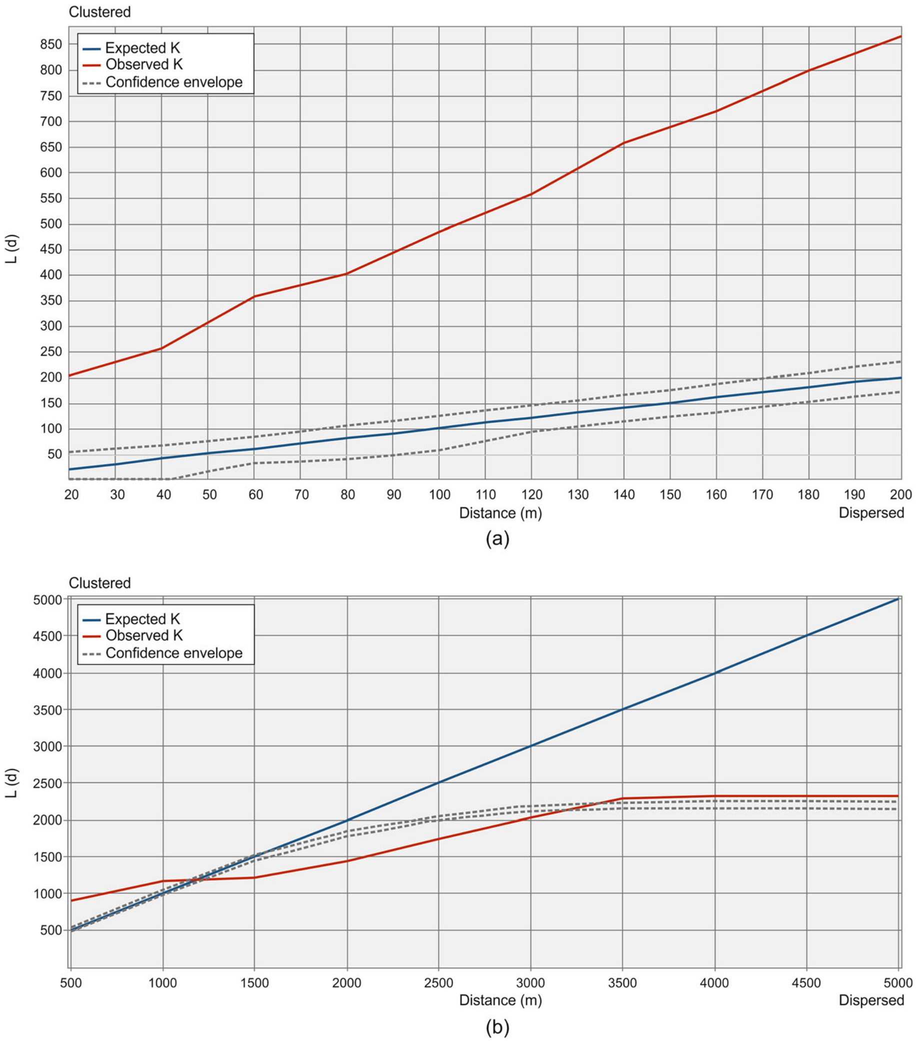

Fig. 5 The K-function (L(d)) with simulation envelopes showing the significance of clustering

dumpsite monitoring and the extent of ecological degradation, which affects both public health and natural ecosystems. However, in Table 1, the situation has not only provided rethinking strategies at the top management levels but has created a compromise requiring superabundant measures embracing all humankind.

Improve management approach for restitution

Strategic planning is important as it helps to know the actual extent of the ecological and public health disaster. In the Niger Delta region, ecological degradation has remained uncertain, uncounted and undocumented. On the national level, according to the reports on Premium Times (October 9, 2019) and Channels TV (December 31, 2019), Nigerian health capital budget was NGN 57 billion (approx. USD 149 million) with recurrent of NGN 315.6 billion (approx. USD 823 million), while in 2020, the capital estimate is NGN 109.91 billion (approx. USD 287 million) and recurrent placed at 359.33 billion (USD 937 million). For Nigeria in 2019, Ebuka Onyeji stated the following disease cases suspected, confirmed and deaths caused: Lassa fever – 167 deaths and 810 confirmed cases; cholera – 71 deaths and 595 confirmed cases; yellow fever – 47 deaths, 11 confirmed and 3410 suspected cases [28]. Budget proposal of the same year revealed that health was on the 11th position and was offered just NGN 46 billion (approx. USD 120 million), by a factor of six less than works and housing that was on the first position and engulfed NGN 262 billion (approx. USD 683 million). This means that excluding malaria, diarrhoea, dysentery, maternal mortality, etc., Nigeria had 287 deaths caused by these three

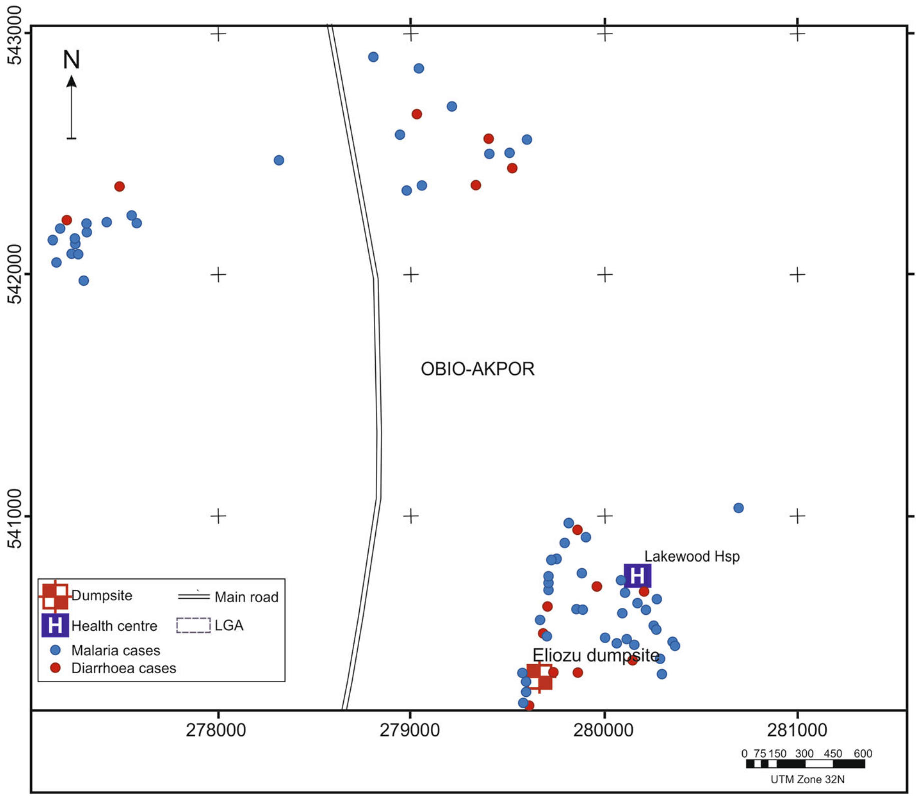

Fig. 6 Occurrence of the diseases in relation to dumpsites in New Airport Road and Eliozu

preventable diseases in 2019; and these diseases can be linked to the basic sanitary hygiene as well as poor hospital facilities. Figure 7 displays steps that can be employed in the planning process to tackle these problems.

Oil pollution led to the degradation and destruction of 10% of mangroves in Nigeria while there is no estimate to prove the contribution of pollution from dumpsites to the situation in the settlement areas. More so, there is total neglect on reports of the effects of heavy metal pollutants (eco-toxicants) in leachate and their transport pattern onto the plants, soil and water. Hence, the mangrove belt of the Niger Delta is "caught in the middle" between heavy metal pollution from leachates, brought by downstream flow from wetland area, and oil, spilt offshore and brought by the wave and tidal action to the mangrove estuarine ecosystem. Predominately, a typical eco-zone in the Niger delta has a floristic composition of vegetation such as *Alstonia boonei, Cleistopholis patens, Mitragyna* among others. More so, delta's eco-zone is rich in its floral biodiversity with over 219 plants species, which represent 66 families. The floral life forms are dominated by trees with 42%, followed by herbs 32.0%, shrubs 16.4%, and climbers/lianas 9.6% [29] but there is an on-going unaddressed threat to the Niger delta biodiversity.

Conclusions

This study established the fact that there is a correlation between the disease occurrence and irregular dumpsites in Obio-Akpor communities and additional actions must be taken to ascertain the

Table 1 The disease reported cases at different hospitals in Obio-Akpor LGA

Disease	Disease occurrence, % of cases reported				
	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Hospital 5
Malaria	60	70	80	90	95
Diarrhoea	30	30	20	10	5
Cholera	10	0	0	0	0

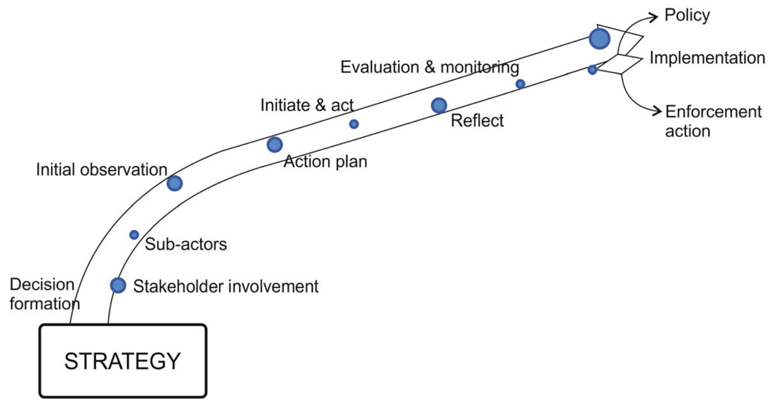

Fig. 7 Waste management planning strategy

effects of dumpsites proximity to residential apartments for public health promotion. As shown from clustering, diseases such as cholera and diarrhoea, with an exception of malaria, can occur in areas where dumpsites are not present because they are highly contagious. Therefore, appropriate siting of landfills, dumpsites or burrow pits is very significant and ones in charge must take cognisance of coastal proximity as well as other ecological importance into consideration. Total closure of dumpsites remains the best option for sustainable practice.

In conclusion, dumps are aiding acute infectious disease to spread, and malaria mosquitoes breeding spreads at every dumpsite as it has the highest percentage occurrence. Diarrhoea and cholera were found clustering around the dumpsites in the residential areas. From the interviewers' responds, unreported cases of diseases in question are more than reported cases. Observation also shows that residents often do not approach hospitals but choose local diagnosis of self-medication. Opinions of the health professionals and some documented cases used in the field studies revealed the occurrence of diseases (cholera, malaria and diarrhoea) spatially distributing from the Obio-Akpor LGA dumpsites' surroundings.

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Authors' contributions
Donatus A. Okpara provided the statistics, processed the data and fulfilled the analysis, wrote the draft. Marianna Kharlamova provided software, processed the data and performed the analysis, wrote the draft. Vladimir Grachev performed the analysis supervision, draft writing supervision, final manuscript writing. All authors read and approved the final manuscript.

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Availability of data and materials
All data generated or analyzed during this study are available upon request.

Competing interests
The authors declare they have no competing interests.

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