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Proximity of Waste Disposals to Residential Neighborhoods and the Incidence for Malaria among under five children in Ikom, Cross River State, Nigeria

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Abstract

Epidemiological studies suggest that there may be an association between environmental exposure to waste dumpsites and malaria. The aim of this study was to investigate whether residential proximity to waste dumpsites result in increased rate of morbidity for malaria among the most vulnerable population groups such as children under the age of five. A total of 150 children between the ages of one and five years were sampled in a residential neighbourhood in Ikom, Ikom. Data were obtained from the parents of the subjects with the aid of a specially- designed and well-structured questionnaire, review of hospital records, and assessment of exposure and assessment of larval abundance. Results showed that among the subjects within the total sample of 150 subjects, there were 1670 reported cases of malaria among the subjects within 11months study period. Of this total, 1272 (76.1%) cases were treated in zone A (distance below 500 meters) and 398 (23.8%) in zone B (distance more than 500 meters). The Spearman correlation coefficient calculated between rate of morbidity and distance from dumpsite in zone A was r = 1.12 (p < 0.05) and was adjusted for other factors that may have contributed to the disease. The overall results showed that children living within a distance below 500 meters from the dumpsite (zone A) are 3.5 times more likely to suffer malaria than those living beyond 500meters' distance (zone B). A trend of lower incidence of malaria was therefore noted among children living in zone B. These results show that municipal waste dumpsites create pathological zones in which disease vectors proliferate and pose significant dangers within the residential neighbourhood.

Keywords: *Waste disposals, residential neighbourhoods, malaria, proximity, under-five children.*

Introduction

Most cities of the world are in a serious state of environmental crisis which threatens the quality of life of their inhabitants. They suffer from myriads of problems such as air and water pollution, urban crimes, traffic congestion, poor sanitation, water crisis, to name a few. One of the most serious problems is the increasing quantity of urban solid waste (Sahoo, 2006, Adapti *et al*, 2013). Increased population urbanization, industrialization and most especially, the increasing demand for consumer goods have encouraged massive importation of goods, which invariably has increased the per capita rate of waste generation in urban areas resulting in a serious strain on the environment (Ashtelli, 2012, Wood, 2006). Nigeria towns and cities also experience this trend. The problem of solid waste management in the country has become more and more complex due to high rate of population growth, urbanization and industrialization (Aguwamba, 2003). A study conducted in 1982 by a group of environmental specialists in 15 selected towns in Nigeria found that the volume of dumped waste ranged from about 2 x10^6 kg/year to as high as 56 x 10^6 kg/year in these areas. It was also found out that those areas within a radius of 0.5km of the city centres, accounted for about 40% of the uncleared volume of solid waste (Abumere, 1983). In recent times, it is estimated that each person in Nigeria generates about 0.85kg of waste per day

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(Cookey, 2004). In all, about 119 million tons of municipal and industrial waste are generated per day based on projections of the 2006 National Population estimates of 140 million (Ngwulaka *et al.*, 2009). The problem of how to manage these wastes is reaching critical proportion (Nkwocha and Ekeoma, 2009, Anurigwo, 1995, Adegoke, 1990). In response to this problem, and other emerging environmental challenges, the Federal Government of Nigeria enacted the National Policy on Environment (1989) and the National Environmental Sanitation policy (2006) as the key policy documents guiding environmental management and protection. The implementation of these policies is presently saddled with weak infrastructural base, coupled with poor institutional and inadequate managerial capacities to run towns and cities as political,social and economic entities (Nkwocha, Pat-Mbano and Nnaji, 2011).Nigeria still lacks an integrated approach to waste management which has resulted in uncertainties within the waste management sector, weak local accountability and poor strategic planning capabilities (Ayuba *et al.* 2013, Igoni *et al.* 2007). The continuous degradation of the environment, coupled with unsanitary disposal of various waste materials pose serious challenge to achieving the ecological sustainability in our development process. Moreso, it has continued to endanger the life of urban residents who are exposed to different diseases associated with unsanitary waste disposal practices (Okereke, 2012; Odocha, 1994).

Statement of the problem

The state of solid waste management in Cross River State in general and in Ikom in particular since in the early 1990s has been generally poor. Ever since the present democratic dispensation in 1999, local authorities and the government of Cross River State have made efforts to search for cost-effective and efficient methods of managing urban solid waste and keeping the streets clean. Efforts have been geared towards the provision of more trucks, equipment and recruitment of more personnel for the collection and disposal of the ever-increasing volume of municipal waste. The present administration went extra mile and contracted the waste collection services to private companies whose efforts have led to quantum improvements in the level of urban cleanliness. But unfortunately, waste dumps keep on proliferating especially in the outskirts of the city. The throw–away mentality continues to gain ground with residents, pedestrians, hawkers and most street users littering the environment with impurity. The most serious phenomenon is the emergence of large waste dumps in proximity to residential areas. Nkwocha and Emeribe (2008) identified more than 28 authorized and unauthorized waste dumpsites in Ikom to include those at Ogoja road, main market, border road, and Calabar Road. Most of these dumpsites are located at open lands and are poorly managed. These dumps constitute breeding grounds to disease vectors and may be associated with some of the diseases prevalent in the area. Few studies have attempted to investigate the waste-disease relationships especially in the town of Ikom. This study therefore tried to investigate whether the nearness of waste dumps to residential neighbourhoods in the town could lead to increased rate of morbidity for malaria. This study will certainly help, not only to collect information on this neglected area of waste management but will also help to improve understanding on waste-human relations in the area.

Main objective

The aim of this study is to investigate whether proximity of waste dumpsite to residential neighbourhoods may increase the incidence of malaria around Ikom waste dump sited along Ikom/Ogoja Road, Cross Rivers, Nigeria.

Materials and methods: sources of data

Primary sources

To obtain data for the research involved the use of different techniques which are as follows:

i. Quantitative analysis of solid waste
ii. Questionnaire Survey on parents of Exposed Children.
iii. Assessment of Exposure

iv. Assessment of Larval abundance at the dumpsite

i. Quantitative analysis of solid waste

An analysis of the amount of waste generated was conducted at Ikom District of the town. This analysis was conducted to determine the amount of waste generated per week by a population estimated at 39,324 living within the area. A sample of 150 households was used for the study and sample size determined by applying Yaro Tamane's Equation:

$$n = \frac{N}{1 + (Ne^2)}$$

Where n = Sample size
N = Population size
e^2 = level of error tolerance (e= 5% for confidence level of 95%)

The amount of waste generated was analysed together with the type of wastes and separation at source was also analysed to determine whether residents knew about waste separation. The amount of waste that was generated in a period of seven days was used to calculate the quantity generated daily.

During the survey, each family was provided with a polythene bag into which all waste generated on daily basis was emptied for a period of seven days, as recommended by Mwanza and Phiri (2013). After the seventh day, the amount of waste generated was noted by weighing the quantity generated by each family and the total volume divided by the number of family members. A sample of ten families from different residential groups was selected through simple random sampling (number of houses used) and mixed together to identify the type of wastes generated in the area.

Four research assistants were used during the period of the survey and each of them was assigned specific duties.

The five samples from each residential group in the area were emptied to a measuring wooden box of 500 litres after which the box was rocked back and front during the filling. The box is then weighed to find the density of the wastes. This was followed by sorting the waste items by hand placing them on sorting table. The smaller particles are mixed together and each of these items are weighed and values obtained converted into simple percentages.

ii. Survey on parents of exposed children

A well-structured questionnaire containing basic socio-economic characteristics of the children and their parents (age and sex of children, education and income status of parents, etc.) was carefully prepared. Other important variables on the housing conditions of the subjects such as presence of waste bins around homes, use of mosquito nets and insecticides were all included in the questionnaire. 200 copies of the questionnaire were then distributed to the subjects who were given a period of three days to fill them. 173 copies were later collected, but after serious examination of the responses from subjects, only 150 were adjudged fit for the study because the other 23 copies were not correctly filled.

Parents of the subject were also asked to indicate the number of times and the month of the year their children fell sick and were taken to the clinic, diseases they suffered from, names of clinics visited, and their hospital card number. Cases were retrospectively verified in the various clinics where the children were treated using their card numbers. Data on these variables were requested for the past months preceding our visit. For easy identification and compilation by the parents, all the requested variables were enlisted in a simple matrix format. These covariates were chosen based on previous literature identifying potential risk factors disease exposure (Tonne *et al*, 2007; Khitoliya, 2004.)

iii. Assessment of exposure to malaria infection

The study considered one important measure of exposure to malaria infection, namely: the distance between subjects from the dumpsite. Thus, in the study area, two cordon zones were carefully delineated. The first Zone designated as Zone A has the range of a distance between 100 and 500 meters from the

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dumpsite. While 100 of our subjects live in this zone. The remaining 50 subjects reside in the second zone designated as Zone B which was also in the same neighborhood but beyond 500 meters from the dumpsite. These two zones are separated from each other by Ikom and Ogoja Roads. Zone B may therefore be likened to as the "clean or control" zone.

iv. Assessment of larval abundance

In order to elucidate the breeding ecology of mosquitoes in Ikom, this study was carried out to assess the larval abundance in conventional mosquito breeding sites, evaluate the physico-chemical characteristics, and establish the relationship between such characteristics and larval abundance in the area.

Mosquito larval collection, processing, identification and analysis

Three kinds of conventional mosquito breeding habitats namely, containers from the dumpsites, drains, and domestic containers were selected for investigation. Four replicates of each larval habitat were randomly selected across the area, and mosquito larvae were sampled weekly from such habitats during the rainy season of 2010. Sampling was done between 0900hr and 1100hr, using a standard 300ml capacity dipper. Where this was not possible, especially with domestic containers, water from a number of breeding sites was pooled to make-up the required volume. Twenty dipper samples were taken randomly from each sampling site, and the mosquito larvae recovered were preserved immediately using 4% formaldehyde solution. The specimens were identified to genus level using aids provided.

Secondary sources

A lot of useful information and data were obtained from secondary sources for writing the project. These include those from text books, scientific journals, seminar proceedings, monographs, conference materials and maps. These were cited throughout the report especially in the literature review. Others include, hospital records of subjects that helped to indicate the number of times they suffered from malaria during the past 11 months. These records also indicated the symptoms experienced by subjects and results of their blood and urine specimens examined in the laboratory.

Collection and fixing of water sample for physico-chemical analysis

Water samples, for physico-chemical analysis, were collected concurrently with larvae from the three habitat types investigated, using 500ml capacity specimen bottles. The water was fixed immediately, using standard procedures, in preparation for laboratory analysis. However, water temperature and transparency were determined at the sites, during larval collection, using ordinary mercury thermometer and secchi disc, respectively.

Analyses of these samples were carried out at Entomology Laboratory, Department of Applied Biology, University of Calabar, Cross River State.

Results: quantity and types of waste generated

Quantity of waste generated

The result of the survey carried out in the area showed the following results (Table 1)

Table 1. Summary of the amount of waste generated

Variable	Sample
Number of Households	150
Population	39,324
Daily per capita waste generation	0.89kg
Estimated total amount generated per day	34.99 tons

The above tables show that the daily per capita waste generation is 0.89kg. This figure gives an estimated daily generation of 34.99 tons of waste and an estimated monthly quantity generated at 1049.7 tons in the area. This value may be far below expectations, as the study focused only on domestic wastes. Other wastes generated from hospitals, institutions (schools, offices etc.) were not included in the study.

Types of wastes generated

The types of wastes generated in the area are shown in Table 2 below

Table 2. Composition of wastes

Waste Composition	%
Putrescible waste	65
Plastic	20
Paper	7
Glass	3
Metal	4
Others	1
Total	**100**

Table 2 shows that 65% of household waste generated in the area are degradable wastes. These include food waste, leaves, garden wastes, sweepings etc. These wastes in constant biodegradation process form breeding grounds to different disease vectors when they are taken to the dump sites. Survey results also reveal that plastic materials occupied a major position in the domestic waste composition forming about 20% of the total waste generated. Although plastic materials are not easily biodegradable, its volumetric increase in the household waste is preoccupying as plastic waste recycling is still very low in the country. Other waste components include; paper (7%), glass or bottle (3%), metals (4%) and others including textiles, bones etc making only 1% of the total.

Composition of waste at ikom dumpsite

A sample of waste collected from Ikom and analyzed shows that the waste generated from domestic and commercial activities form the major component.

Commercial wastes have almost the same composition as domestic wastes including putrescible wastes (remnants, leaves etc.) metals, papers plastics, bottles and some wood, bones, textiles and miscellaneous inert materials (sand, ash). Most wastes deposited at the dumpsites are therefore of domestic and commercial origins.

The high percentage of biodegradable materials with high moisture content, makes it a favorable breeding ground for proliferation of micro-organisms and disease vectors such as rats, cockroaches, flies and mosquitoes.

Socio –economic characteristics of parents of exposed children

The descriptive information focused mainly on the socio-economic status of the parents (income, education) as well as some variables on the children (age, sex).

Age and sex of subjects

The average age of the children was 2.8 years. Based on the three age groupings 54 (36%) of the subjects were less than 1 years old, 50 (33.33%) between2 and 3 years old and 46 (30.67%) between 4 and 5 years old. There were 80 males (53.33%) and 70 females (46.67%) which shows almost equal representations in both sexes in the total sample. The highest number of children within the study age group per family was two while the least was one. All families surveyed have lived in their apartments for more than five years, indicating that the majority of the subjects have been exposed since birth.

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Income and educational level of parents

The average educational level of parents was the West African School Certificate, with an average monthly income level hovering between ₦ 15,000 and ₦ 20,000. This result show that most of the children are of poor parentage.

Housing conditions

The average household consists of 7 persons residing in a concrete dwelling of three rooms properly ventilated with sufficient doors and windows. Only 9 families of the subjects (6.9%) used Insecticide Treated Bed Nets (ITNs) while the greater majority made up of 121 families or 93.1% of the total sample did not. Also, while 102 families of the subjects (78.5%) did not apply insecticides within their homes only 28 families (21.5%) used it regularly to kill mosquitoes. All the families surveyed kept their waste bins outside their home as shown in Table 6, 7, 8 and 9.

Table 3. Age of children in years (n = 150)

Age of children (years)	No%
< 1	54(36.0)
2 – 3	50(33.33)
4 – 5	46(30.66)

Table 3 shows that 54 (36.0%) of the children were less than 1 year, 50 (33.33%) were between 2 and 3 years while 46 (30.66%) were between 4 and 5 years old.

Table 4. Income of parents

Income of parents	No%
15,000 – 20,000	90(69.2)
21,000 – 30,000	16(12.3)
31,000 – 35,000	14(10.76)
>35,000	10(7.69)

Table 4 reveals that 90 (69.2%) of the parents earn between ₦15,000 and ₦20,000, 16 (12.3%) earn between ₦21,000 and ₦30,000, 14 (10.76%) earn between ₦31,000 and ₦35,000 and only 10 (7.69%) earn above ₦35,000.

Table 5. Educational status of parents

Education status of father	No%
Higher Education	13(10.0)
Average Education	25(19.23)
Lower Education	92(70.76)

Education status of mother	No%
Higher Education	15(11.5)
Average Education	18(13.8)
Lower Education	97(74.6)

Table 5 reveals that 92 (70.76%) of the fathers of the subjects have lower education while 97 (74.6%) of the mothers also have lower education. Also, that only 13 (10.0%) of the fathers and 15 (11.5%) of the mothers had higher education and 25 (19.23%) of the fathers and 18 (13.8%) of the mothers had average education.

Table 6. Housing conditions

Housing Condition	No%
Well ventilated	121(93.1)
Poorly ventilated	9(6.9)

Table 6 reveals that 121 (93.1%) of the families live-in well-ventilated homes while only 9 (6.9%) live in poorly ventilated homes.

Table 7. Presence of waste bins in homes

Presence of waste bins	No%
Yes	130(100.0)
No	0(0.00)

Table 7 shows that all the homes (130) have waste bins for storage of wastes

Table 8. Use of mosquito nets (ITNS)

Use of mosquito nets	No%
Yes	9(6.9)
No	121(93.1)

Table 8 exposes the fact that only 9 (6.9%) of the families sleep under mosquito nets (ITNs) while 121 (93.1%) of them do not sleep under ITNS.

Table 9. Use of insecticides

Use of insecticides	No%
Yes	28(21.5)

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No	102(78.5)

Table 9 reveals that most of the families 102 (78.5%) of them do not use insecticides to kill mosquitoes in their homes while only 28 (21.5%) of them use insecticides to kill mosquitoes in their homes.

Exposure characteristics

Data used for the study spanned for a period of 11 months (October 2012 – July 2013) as most parents could no longer remember what happened beyond this period when filling the questionnaire. However, information obtained therefore revealed the prevalence of malaria among subjects in the two zones investigated. A trend of greater frequency was noted in Zone A in comparison with Zone B.

Table 10. Number of subjects treated for malaria in zones A and B (n=150)

Months	**Zone A (<200m)**		**Zone B (>500m) Control**		**Total**	**Cum.%**
	No. Treated (F)	%	No. Treated (F)	%		
Sept. 12	120	9.4	53	13.3	**173**	10.4
Oct. 12	140	11.0	47	11.8	**187**	11.2
Nov. 12	150	11.7	30	7.5	**180**	10.8
Dec. 12	100	7.9	12	3.0	**112**	6.7
Jan. 13	80	6.3	20	5.0	**100**	5.9
Feb. 13	88	6.9	30	7.5	**118**	7.0
Mar. 13	110	8.6	45	11.3	**155**	9.3
April 13	100	7.9	33	8.3	**133**	7.9
May 13	121	9.5	40	10.0	**161**	9.6
June 13	128	10.1	42	10.6	**170**	10.2
July 13	135	10.6	46	11.6	**181**	10.8
Total	**1272**	**76.1**	**398**	**23.8**	**1670**	**100.0**

Among the total sample of 150 subjects, there were 1670 reported cases of malaria among the subjects within 11 months' study period. Of this total, 1272 (76.1%) cases were treated in zone A (d < 500 meters) and 398 (23.8%) in zone B (d > 500 meters) as shown in Table 10. Medical notes from hospital records revealed that the infected subjects showed symptoms of the disease (high fever, body weakness, loss of appetite, etc.). Results of their blood analysis also indicated that each of the infected children had malaria parasite, though with different degrees of infection. While the highest incidence of malaria was recorded in the month of October 2012 with 187 cases (11.2%) the least incidence occurred in January 2013 with 100 cases (5.9%). The rate of malaria incidence decreased with age and was significantly higher among subjects living around the dumpsites. Also, the Ratio Rate (RR) was significantly high (6%) among subjects in Zone A than those in Zone B (0.76%). However, this ratio decreased with age in both zones. There was no significant difference in the rate of morbidity between the two sexes in the overall sample.

Table 11. Cases of malaria resulting from proximity of ikom waste dumpsites to residential neighborhood

Months	**Total No. of Children Treated for Malaria**	**%**	**Serious Cases**	**%**	**No of Deaths**	**%**	**Total Alive**	**%**
Sept.'12	173	10.4	13	2.9	2	0.4	171	10.2
Oct.' 12	187	11.2	9	1.9	1	0.2	186	11.1
Nov.' 12	180	10.8	11	2.5	2	0.4	178	10.6
Dec.' 12	112	6.7	5	1.1	2	0.4	110	6.6

Jan. ‘13	100	5.9	7	1.5	3	0.6	97	5.8
Feb.’13	118	7.0	18	3.9	5	1.1	113	6.8
Mar.’13	155	9.3	8	1.8	1	0.2	154	9.2
Apr.’13	133	7.9	11	2.5	0	0	133	7.9
May.’13	161	9.6	10	2.2	2	0.4	159	9.5
Jun.’13	170	10.2	3	0.7	0	0	170	10.2
Jul.’13	181	10.8	5	1.1	1	0.2	180	10.8
Total	**1670**	**100**	**100**	**5.9**	**19**	**1.1**	**1651**	**98.7**

Relationship between distance from dumpsite and morbidity for malaria

The rate of morbidity correlated positively with distance from dumpsite (0.83). The Spearman correlation coefficient calculated between rate of morbidity and distance from dumpsite in Zone A was 1.12 ($p<0.05$) and was adjusted for other factors that may have contributed to the disease. This negative correlation indicated that proximity to the dumpsite exposed children to the hazards of malaria infection. Similarly, the correlation coefficient of 0.14 in Zone B indicates that long distance from dumpsite lowers exposure to the disease. This also implies that the rate of morbidity decreased with increasing distance from the dumpsite with a strong evidence of a spatial trend ($p<0.0001$). Correlations during seasonal exposures (dry and wet season) were 0.77 and 0.52 and positive. Results also showed a strong association between distance from the dumpsite and malaria disease in the overall sample (OR=3.2, 95% C1.7-7.2). The association varied among the age groupings of the children and relative distance from the dumpsite. It was strongest for the children below 3 years of age (adjusted OR=3.3, 95%, Cl 1.19-8.1) than those above 4 years in Zone A (OR=2.5, 95%, Cl 1.3-6.7) and those in Zone B (OR=2.7, 95% Cl 1.38-5.7). Furthermore, the effect estimates for cumulative malaria infection increased the odds of the disease for children below 3 years of age 9.3% per inter quartile range (IQR). The overall result showed that children living within a distance below 500 meters from the dumpsite (Zone A) are 3.5 times more likely to suffer from malaria than those living beyond 500 meters’ distance (Zone B). A trend of lower incidence of malaria was therefore noted among children living in Zone B, which was the less exposed zone.

Assessment of larval abundance

Table 12. Mean mosquito larval abundance and distribution in breeding habitat in ikom

Species/Habitat	**Dump site containers**	**Drains**	**Domestic containers**
Aedes	1	1	2
Anopheles	10	6	4
Culex	1	2	2
Total	**12**	**9**	**8**

Table 12 shows the mean occurrence of mosquito types in the different breeding habitats in Ikom. The frequency of larval occurrence in the positive habitats occurred in the following order of decreasing abundance Dumpsite containers > Drains > Domestic containers. The distribution of mosquito types in the positive habitat varied considerably. Aedes occurred more frequently in domestic containers with equal presence in drains and dumpsites. Generally, the Anopheles individuals were the most frequently occurring mosquitoes. The mosquitoes preferred breeding in dump sites containers, with some presence in drains and least encountered in Domestic containers.

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Table 13. Physico-chemical properties of mosquito larval breeding habitats in Ikom

Parameters	Dumpsite	Drains	Domestic containers	Mean ± S.D
Temperature $^{\circ C}$	25.50^{oc}	25.90^{oc}	26.20^{oc}	25.9 ±4
Dissolved Solids (mg/l)	5.80^{a}	93.30^{b}	123.60^{c}	49.6 ± 7.04
Transparency	0.14^{c}	0.06^{b}	0.02^{a}	0.07 ± 0.22
Dissolved oxygen (mg/l)	26.5^{a}	30.20^{b}	38.10^{c}	31.6 ± 4.6
Nitrate (mg/l)	0.50^{a}	0.87^{b}	14.30^{c}	5 ± 2
Phosphate (mg/l)	0.19^{a}	0.21^{b}	0.24^{c}	0.21 ± 0.4
Sulphate (mg/l)	0.44^{c}	0.40^{a}	0.43^{b}	0.42 ± 0.5
Carbonate (mg/l)	0.51^{a}	0.81^{b}	0.99^{c}	0.77 ± 0.7
Conductivity (ps/cm)	228.60^{b}	245.9^{c}	129.70^{a}	201.4±11.6
Ph	8.26^{b}	8.44^{c}	8.22^{a}	8.30 ± 2.35

Table13 values followed by same superscript alphabets in a row are not significantly different, at p= 0.05 level of significance.

The mean physico-chemical characteristics of water in the three larval breeding habitats are shown in Table 13, Temperature, Phosphate, Sulphate, Carbonate and Transparency were not significantly different ($p > 0.05$) among the three larval habitat categories. However, the same cannot be said for the remaining physico-chemical parameters that varied significantly ($p< 0.05$) among habitats.

Total dissolved solids in dump sites and drains were significantly different ($p> 0.05$), and lower than recorded in domestic containers, with the latter having the highest amounts of Total dissolved solids (Table 13). The Dissolved Oxygen content of the breeding habitats ranged from 26.5mg/l in dump site to 38.10mg/l in Domestic containers. Dissolved Oxygen in Dump site was significantly lower than in drains ($p< 0.05$) which was in turn significantly lower than in Domestic containers ($p< 0.05$). On the other hand, Conductivity was least in domestic containers but highest in the drains, and it varied significantly ($P < 0.05$) among the breeding habitats. pH was more or less uniform.

Table 14. Correlation coefficients between mosquito larval abundance and physic-chemical properties of breeding habitat

Parameters	Aedes	Anopheles	Culex
Temperature^{o} C	0.6401	0.9588	0.7475
Dissolved Solids (mg/l)	0.3842	0.6269	0.5905
Transparency	0.7321	-0.1098	0.1875
Dissolved oxygen (mg/l)	0.9071	-0.2915	-0.0927
Nitrate (mg/l)	0.7828	-0.9014	-0.8626
Phosphate (mg/l)	0.2777	0.7084	0.4875
Sulphate (mg/l)	0.9276	-0.6192	-0.4134
Carbonate (mg/l)	-0.4831	0.9872	0.773
Conductivity (ps/cm)	0.2777	0.7085	0.4875

Table 14 shows the relationships between physico-chemical parameters and larval abundance. The correlation coefficients between physico-chemical properties and larval abundance were mostly high though, while some were negative. The weak correlation coefficients were mostly restricted to Aedes and Culex mosquitoes. The abundance of Anopheles mosquitoes correlated weakly only with Dissolved Oxygen.

Conclusion

This study is one of the evidences that support the argument that exposure to environmental pollutants such as waste dumps can compromise urban public health and the pathology of related diseases (Steve and Elijah, 2010). Several risk factors for malaria were not controlled (diet, use of net and insecticides, latent period, etc.) which may appear as important co-founders when their frequency in the sub-population are associated with exposures. Despite these limitations, we argue that if our results could show high rates of malaria incidence and morbidity among our subjects when our exposure assessment fraught with certain limitations, then it could be that the real relationship between malaria and proximity to waste dumps may likely be stronger. Nonetheless, the case study is a clear demonstration that accumulation of solid waste in proximity to residential areas constitutes a path way to many chronic diseases including malaria. There is a great need to further explore the waste-malaria paradigm in environmental health studies with the view to developing new strategies for intervention and prevention of this disease. Ultimately, the promotion of urban cleanliness and effective management of municipal wastes may be the most sensible strategies to Roll Back Malaria in Nigerian urban areas in the years ahead.

Recommendations

i. Dumpsites should be sited far away from residential homes (>500m) since municipal wastes create pathological zones, in which disease vectors proliferate and pose significant dangers to human health and the environment.
ii. There is the need to educate the public on proper waste generation and disposal practices, including sorting of waste and the use of correct dumpsites.
iii. There should be adequate information at dumpsites for users on where and how to deposit wastes.
iv. Government should establish regulations and by laws on waste disposal, including specifications on types of bins, and form in which wastes should be deposited at dumpsites.
v. Government should provide more funds towards the disposal of waste. Such funds should be used for the provision of necessary facilities such as equipment, vehicles and for the regular maintenance of the dumpsites.
vi. Dumpsites should be adequately constructed and maintained. Should be accessible to users and regular collection of wastes should be ensured to prevent dumpsites from overflowing and blocking roads.
vii. There is need for regular monitoring and surveillance of public dumpsites and even private premises especially in the high population density areas like Ikom by government sanitation officers.
viii. More sanitation workers and waste management contractors should be employed and adequately trained to cope with the ever-increasing waste disposal problems in the LGA, State and Country.
ix. Insecticides treated nets and other preventive measures for malaria should always be provided for all citizens especially those living close to dumpsites.

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