International Journal of Advanced Biotechnology and Research ISSN 0976-2612,
Vol 2, Issue 1, 2011, pp 159-167 http://www.bipublication.com

PROXIMITY OF MUNICIPAL WASTE DUMPSITES TO RESIDENTIAL NEIGHBOURHOODS AND RATE OF HOSPITALIZATION FOR MALARIA

Nkwocha, E. E[1], Egejuru, R. O[2], Pat-Mbano, E. C[3] and Njoku-Tony, R. F[1].
[1]Department of Environmental Technology, Federal University of Technology, Owerri.
[2]Department of Pathology, Federal Medical Center, Owerri, Nigeria
[3] Department of Urban and Regional Planning, Imo State University, Owerri

ABSTRACT

A number of studies have investigated the incidence of malaria all over the world but only very few have attempted to study the association between environmental exposure to waste dumpsites and the disease. The aim of this study was to test the hypothesis that residential proximity to waste dumpsites resulted in increased rate of hospitalization for malaria among the most vulnerable population groups such as children. A total of 160 children (n=160) between the ages of 1 and 5 years were sampled in a residential neighborhood in Owerri. The area was divided into zones A (0-500m from dumpsite) and B (>500m). Data were obtained from hospital records of the children validated by information from their parents with the aid of a specially designed and well-structured questionnaire. Results show that there was a significant increase in the incidence of malaria and rate of hospitalization among children. There was a strong association between distance from the waste dumpsite and malaria disease in the overall sample (OR=3.2, 95%, CI 7-7.2).The most affected group was those between the ages of 2 and 3 years living within a radius of less than 300 meters from the dump site (adjusted OR=3.3; 95%, CI 1.19-8.1). These results show that unauthorized waste dumpsites within residential neighborhoods create pathological zones in which disease vectors proliferate and pose significant dangers to the health of local populations and environment.

KEYWORDS: Distance, Dumpsite, Hospitalization, Malaria, Waste.

INTRODUCTION

The continued function and survival of any human society is dependent, to a large extent, on its adaptability and resilience to environmental events [1]. As globalization accelerates the rate and spatial scale of human–environment interaction, the distinction between natural and man-made disasters becomes blurred [2]. In Nigeria, solid waste management has remained one of the greatest environmental challenges of urban municipalities [3] gulping about 10 to 20 percent of their annual budgets [4, 5]. This is partly because their phenomenal population and spatial growth is not coupled with the provision of waste treatment and disposal facilities. Consequently, urban residents have dumped their waste indiscriminately at open spaces, undeveloped plots and by the road sides leading to environmental degradation [6]. There is great anxiety about environmental risks associated with poor waste management in the country. Increasingly, the public is becoming aware of potential hazards to health resulting from disposal of a wide range of wastes [7]. Some authorities argue that exposure to different sources of pollution can aggravate health problems especially among the most vulnerable groups [8, 9, 10]. Others specifically posit that waste dumps could provide conditions in which disease vectors could persist and reproduce [11, 12] although this depends on waste constituents, environmental conditions, age of the dumps and waste management practices [13, 14]. Among these vectors are mosquitoes that cause malaria. This disease is caused by the bite of an infected female Anopheles mosquito which transmits the Plasmodium

falciparum parasite into the human bloodstream; from there it travels to the liver, where it grows and multiplies from a period of 8 days to several months and even years [15].

A number of studies have investigated the incidence of malaria all over the world [16, 17, 18, 19, 20]. It is estimated that the annual death resulting from this disease is between 1.1 and 2.7 million people out of which over one million are children under the age of five in the Sub-Saharan Africa [21, 22, 23, 24]. Much attention was focused on pregnant women and children due to their high vulnerability and exposure to conditions that cause malaria, added to the increasing resistance of malaria parasite to modern drugs [25, 26, 27]. Malaria is holoendemic in Nigeria as high intensity transmission occurs all year round, with rates of transmission higher in the wet season than in the dry season, and with more victims in the southern than in the northern part [28]. There is limited evidence from the results of all these studies to suggest that the breeding and multiplication of mosquitoes on solid waste dumps can lead to increase in the incidence of malaria. This study examined the health effect of a waste dumpsite on the population living in proximity to it. It tries to establish whether the proximity of a residential area to a municipal waste dumpsite has a significant influence on the rate of hospitalization of children for malaria.

MATERIALS AND METHODS

The study area is located in the South-Western fringe of Owerri Municipal, in a relatively new and fast growing neighborhood called New Market Layout. This area was chosen for several reasons: Firstly, it is well delineated from other residential zones in Owerri Municipal by natural and man-made features. In fact, the area is bounded in the South, through South-West by a large undeveloped land that emptied into the Otamiri stream; in the East by Emmanuel College premises and the New Market site, all running parallel to a major transportation route (Douglas Road), and in the North by Royce Road. Its location is therefore distinct and interesting for such a study. Secondly, although some commercial activities are practiced along the streets and major roads bordering the area, the zone is mainly residential, with a very high population density of more than 600 persons per square kilometer [29]. The final reason is the willingness of residents to cooperate with anything that has to do with the dumpsite, because of its high nuisance value within the neighborhood.

However, as a result of lack of waste collection systems in the area, residents found it most convenient to dump their waste on an undeveloped piece of land located about 800 meters away from the nearby Otamiri stream, which in fact, serves as a source of water supply to many communities downstream (Nekede, Ihiagwa, Obinze). Refuse has been dumped on this site for more than 15 years, on a surface area approximately 6 hectares in size, 5 meters high and uncovered. Nearly 10 tons of wastes are dumped here each day. Waste components mainly include metals, (beverage cans, ferrous materials), used papers, rags, plastics and organic materials (food remnants, decaying leaves, fruits and vegetables, etc). All these materials provided a condusive environment for the anopheles mosquitoes to breed in large numbers. The area surrounding the dumpsite is highly urbanized and mainly used for mixed residential houses made up of bungalows and high-rises not exceeding two floors. The closest buildings are located at a distance of 105 meters from the dumpsite, which shows the integration of the latter within the neighborhood. The total population of the neighborhood is currently estimated at about 18,563 based on the projection of the National Population Census data of 2006. From this population, which fell within a Census Enumeration Zone (CEZ), a sample of 134 families having 188 children between the ages of 1 and 5 years were randomly selected using their House Enumeration Numbers. This age range of children was chosen as they constituted the most vulnerable groups

especially to malaria. The choice of families was validated through field visits which helped to remove over-aged children from our sample. A total of 160 subjects was finally selected for the study (n=160).

It is not easy to embark on epidemiological investigation on waste-health relationships within a population in an environment fraught with paucity of data. Data used for the study were therefore obtained through surrogate methods. 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. Parents of the subjects were also asked to indicate the number of times and month of the year their children fell sick and were admitted into the hospitals, diseases they suffered from, names of hospitals visited, and their hospital card numbers. Cases were retrospectively verified in the two hospitals where the children were treated using their card numbers (Federal Medical Center and General Hospital Umuguma both in Owerri). Data on these variables were requested for the past 15 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 for disease exposure [30, 31]. In addition, a simple demonstration was made to ascertain that the waste dumpsite was the breeding ground for Anopheline mosquitoes within the neighborhood. Six different pails containing water were exposed at various locations around residential buildings within the area; two at the dumpsite, two at a distance of 400m and the remaining two beyond 500m from the dumpsite towards the end of May 2010 to allow female anopheles mosquitoes to lay their eggs. The larvae from one of the pails at each of these locations were collected (4 different samples) between 0900hr and 1100hr late June 2010, using 300ml capacity dipper and were preserved in 4% formaldehyde solution. The identification of the genus level of the larvae was done using existing techniques **[32]**. The other three pails were properly covered with mosquito nets and the larvae inside them were allowed to mature into adult mosquitoes which were later killed by slight application of an insecticide. The dead samples were then collected and preserved dry on silica gel and latter sent for laboratory analysis. The morphological characteristics distinguishing Mosquito sexes and Anopheline types were done using existing techniques [33].

The study considered one important measure of exposure to malaria infection, namely; the distance between subjects from the waste 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 dumpsite. While 110 of our subjects live in this zone, the remaining 50 subjects reside in the second zone known 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 Royce and Nekede Roads. Zone B may therefore be likened to as the “clean or control” zone. Given the limited sample size, three age groupings of the children were made (<1 year, 2-3 years and 4-5 years). To neutralize the effect of variables such as housing conditions, income and education levels of parents, etc, a logistic model was used. The exposure measures among subjects and total sample population were done using logistic regression. Risk estimates were measured in the form of Odd-Ratios (ORs). The exposure measures for malaria and rate of hospitalization among subjects were equally carried out considering the influence of the seasons. Analyses on the special effects of residential distance from the dumpsite and the rate of hospitalization were also made using logistic regression model in which distance was sub-divided into 100, 200, 300, 400 and 500 meters and above and

included as categorical variables. Because of the sample size, the ORs were adjusted for potential confounders. Regression ANOVA and chi-square tests were used to compare major differences between the two zones. Coefficients were calculated using the Spearman rank order correlation test. Data was analyzed by SPSS for Window 11.0 (SPSS, Chicago, IL. USA)

RESULTS AND DISCUSSION

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). The average age of the children was 2.8 years. Based on the three age groupings, 54 (33.75%) of the subjects were less than 2 years old, 53 (33.13%) between 2 and 3 years, and 53 (33.13%) between 4 and 5 years old. There were 83 males (51%) and 77 females (49%) which shows almost equal representations of 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 the families surveyed have lived in their apartments for more than five years, indicating that the majority of the subjects have been exposed since birth. 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, indicating that most of the children are of poor parentage based on Nigerian standards. 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 (5%) used Insecticide Treated Bed Nets (ITNs), while the greater majority made up of 151 families or 95% of the total sample did not. Also, while132 families of the subjects (83%) did not apply insecticides within their homes only 28 families (17%) used it regularly to kill mosquitoes. All the families surveyed kept their waste bins outside their homes as shown in Table 1

Table 1: Descriptive characteristics of the Study population and exposure (n = 160)

Age of children (years)	**No%**
< 2	54 (33.75)
2-3	53 (33.13)
4-5	53 (33.13)
Income of parents (N)	**No%**
15,000-20,000	98 (61.25)
21,000 – 30,000	21 (13.12)
31,000 – 35,000	23 (14.38)
>35,000	18 (11.25)
Education status of father	**No/%**
Higher Education	23 (14.38)
Average Education	35 (21.87)
Lower Education	102 (63.75)
[[[	
[[	
[[[[	
Education status of mother	**No/%**
Higher Education	15 (9.36)
Average Education	18 (11.26)
Lower Education	127 (73.38)

Housing Conditions	No%
Well ventilated	151 (94.38)
Poorly ventilated	9 (5.62)

Presence of bins	No%
Yes	160 (100.0)
No	00 (0.00)

Use of mosquito treated nets	No%
Yes	9 (5.63)
No	151 (94.37)

Use of insecticides	No%
Yes	28 (17.5)
No	132 (82.5)

Data used for the study spanned for a period of 11 months (October 2009 to August 2010) as hospital records were difficult to obtain after one year and 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 as indicated in Table 2.

Table 2: Number of subjects treated for malaria in zones A and B (n =160)

	Zone A (d<500m)		Zone B (d>500m)			
Months	No Treated (F)	%	No treated (F)	%	Total	%
Oct. '09	57	12.6	6	1.3	63	13.9
Nov. '09	47	10.3	4	0.8	51	11.1
Dec.'09	40	8.8	5	1.1	45	9.9
Jan. '10	36	7.9	3	0.6	39	8.6
Feb. '10	23	5.0	3	0.6	26	5.7
Mar. '10	32	7.0	6	1.3	38	8.4
April '10	27	6.0	7	1.6	34	7.5
May '10	43	9.5	4	0.8	47	10.3
June '10	29	6.4	4	0.8	33	7.2
July '10	35	7.7	6	1.3	41	9.0
Aug. '10	30	6.6	5	1.1	35	7.7
	399	88.3	53	11.8	452	100.0

Source: Field Survey 2009/2010

Among the total sample of n=160, there were 452 reported cases of malaria among the subjects within the 11-month study period. Of this total, 399 cases (88.3%) were treated in Zone A (d < 500 meters) and 53 (11.8%) in Zone B (d>500 meters) as shown in Table 2. 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 analyses also indicated *P. falciparum* parasitaemia in each of the subjects, though with different degrees of infection. Also, each infected child spent a minimum of one day and a maximum of 9 days in the hospital. While

the highest incidence of malaria was recorded in the month of October 2009 with 63 cases (13.9%), the least incidence occurred in February 2010 with 26 cases (5.7%). About 100 serious cases of malaria were reported with a total hospitalization period of 1174 days showing an average of 2.7 days per subject as indicated in Table 3. Also, 27% of subjects in Zone A suffered double episodes, with the duration of the illness ranging between 3 to 5 days. Only 2% of subjects in Zone B suffered double episodes of the disease. Unfortunately, there were 19 (4.2%) reported cases of death resulting from malaria which occurred among children between the ages of 2 and 3 years old, all occurring in Zone A .

The rate of morbidity for malaria decreased with age and was significantly higher among subjects living around the dumpsite. Also, the rate of hospitalization recorded was highest among children between the ages of 2 and 3 years indicating that this group was the most vulnerable. In the same vein, the morbidity rate ratio (RR) for malaria 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 hospitalization between the two sexes in the overall sample.

The rate of hospitalization correlated positively with distance from dumpsite (0.83). The Spearman correlation coefficient calculated between rate of hospitalization 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 ($p<0.05$) in Zone B indicates that long distance from dumpsite lowers exposure to the disease. This also implies that the rate of hospitalization 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 seasons) were 0.77 and 0.52 and positive. Results also showed a strong association between distance from the dumpsite and incidence of malaria in the overall sample (OR=3.2, 95%, Cl.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%, CI 1.19-8.1) than those above 4 years in Zone A (OR=2.5, 95%, CI 1.3-6.7) and those in Zone B (OR=2.7, 95%, CI 1.38-5.7). Furthermore, the effect estimate for cumulative malaria infection increased the odds of the disease for children below 3 years of age by 9.3% per inter quartile range (IQR). The overall result showed that children living within a

Months	**Total No. of Children Treated for Malaria**	**%**	**Serious cases**	**%**	**No. of Deaths**	**%**	**Duration of Hospitalization (no of days)**	**%**	**Total Alive**	**%**
Oct. '09	63	13.9	13	2.9	2	0.4	182	15.5	61	13.5
Nov. '09	51	11.2	9	1.9	1	0.2	131	11.2	50	11.1
Dec.'09	45	9.9	11	2.5	2	0.4	126	10.7	43	9.5
Jan. '10	39	8.6	18	3.9	2	0.4	108	9.2	37	8.2
Feb. '10	26	5.7	7	1.5	3	0.6	61	5.2	23	5.1
Mar. '10	38	8.4	5	1.1	5	1.1	73	6.2	33	7.3
April '10	34	7.5	8	1.8	1	0.2	82	6.9	33	7.3
May '10	47	10.4	11	2.5	-	-	131	11.2	47	10.4
June '10	33	7.3	10	2.2	2	0.4	112	9.5	31	6.9
July '10	41	9.1	3	0.7	-	-	77	6.6	41	9.0
Aug. '10	35	7.7	5	1.1	1	0.2	91	7.8	34	7.5
TOTAL	452	100.0	100	22.1	19	4.2	1174	-	433	95.8

Table 3: Cases of Malaria Resulting from Proximity of New Market Residential Area To A Waste Dumpsite.

Source: Field Survey 2009/2010

distance of between 200 and 300 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. The result of the frequency of larval occurence from the three exposed pails varied considerably with distance from the dumpsite. Larval abundance in the three breeding replicates correlated with distance and varied significantly ($p<0.05$). Also, out of the 78 mosquitoes sampled at the three sites, 72 (92.3%) were collected at the dumpsite, 5 (6.4%) at a distance of 400m and the remaining 3 (3.8%) at a distance above 500m. Observation revealed that *Anopheles gambiae* and *Anopheles funestre* were the two predominant species constituting 85% and 15% respectively of the total sample which corresponds with other findings in the region [34]. The predominance of the former at the dumpsite, in particular, contributed significantly to the high prevalence of malaria within a perimeter of 400m from the dumpsite [35].

The results obtained from this study suggest that children are vulnerable to environmental diseases such as malaria. They also indicate that the level of vulnerability is a function of the level of exposure and distance to the source of the disease [36, 37]. It was observed that the peak period of malaria infection corresponded with months of climatic transition with low rainfalls, which encouraged the breeding of anopheles mosquitoes at the dumpsite [28]. This observation corroborates other findings that mosquitoes and the disease they carry are especially sensitive to temperature changes [39], and that warm temperatures accelerate the maturation of disease-vectors such as mosquitoes as they tend to concentrate in the same places which enhance the transmission of the parasite they carry [40]. It is known that if the plasmodium parasite is not properly killed in the human bloodstream, it might lead to the emergence of a strain that may be resistant to drugs and frequent hospitalization of the patient [41, 42]. If the drop in the rate of infection and hospitalization in June 2010 corresponded with months of high rainfall when these vectors lay their eggs in humified waste dumps, the low value of infection recorded in the month of February of the same year may be attributed to the chilling effect caused by the cold and dry Harmattan winds from the northern part of the country, when all the children are properly covered against cold, which consequently protected them from frequent mosquito bites. Other cogent reasons emerged to buttress our argument that proximity to the waste dump increased the incidence of malaria and high rate of hospitalization among children living in the study area and these include:

i. All the parents of the subjects indicated in the questionnaire that the incidence of malaria before the appearance of the waste dump in the area was minimal.
ii. The presence of the dumpsite and the accumulation of waste provided breeding ground for mosquitoes that vehicle this disease.
iii. The exposure route was only through mosquito bites among a population group that is highly vulnerable and less mobile.

While wastes are regularly collected in some neighborhoods within Owerri, usually occupied by prominent politicians and businessmen (Works Layout, Aladinma, Ikenegbu, etc.), other neighborhoods (such as the case in point) whose residents are mainly people of low income are the scene of dumpsites of different ages and sizes. Our results partly show that the growing health disparities that result from poverty and inadequate infrastructure and service provision in our urban areas raise serious concerns about environmental justice [43, 44]. The high rate of hospitalization due to malaria especially among the most vulnerable groups such as children, and other likely diseases arising from poor management of municipal solid waste should make this sector an obvious priority for the local municipality. This will help to reduce the number of mosquito breeding habitats and increase the time required for vectors to locate oviposition sites [34]. Our results constitute an eloquent testimony that children living in low income and poor neighborhoods are often at greater risk of

exposure to environment-based hazards than other groups [45, 46].

CONCLUSION

This study is one of the evidences that support the argument that exposure to environmental pollutants such as waste dumps, can contribute to compromise urban public health and the pathology of related diseases. Several risk factors for malaria were not controlled (diet, latent period, number of hours spent outside the zone, etc.) which may appear as important confounders 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 hospitalization among our subjects when our exposure assessment is fraught with some of these limitations, then it could be that the real relationships between rate of morbidity for 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 pathway of many chronic diseases including malaria. There is 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 sustainable strategies to "Roll Back Malaria" in Nigerian urban areas in the years ahead.

REFERENCES

[1] Young, O.R. and Berkout, F. (2006). The Globalization Systems: An Agenda for Scientific Research, GlobEnviron Change 16:304-316.

[2] Pezzoli, K. and Turkey R. (2007). The NIEHS Environmental Health Sciences Data Resource Portal: Placing Advance Technology in Service of Vulnerable Communities; *Environ Health Perspect*115, (4):564-571.

[3] Nkwocha, E E and Ekeoma, I. O. (2009) Street littering in Nigerian towns: Towards a framework for sustainable urban cleanliness. *Afri Research Rev* 3(5): 147-164.

[4] FEPA, (1999) Federal Environmental Protection Agency Report on the State of Nigerian Environment, Abuja, Fed. Govt. Press.

[5] FMH, (1989) Federal Ministry of Health Guidelines for Malaria Control in Africa. Lagos Nigeria.

[6] Houmsou, RS, Amuta, EU; Sar, T.T (2010). Impact of urbanization on parasitic infections in developing countries. *RIF* 1(1):38-41.

[7] Sheldon, T.A. and Smith D. (1995). Assessing the Health Effects of Disposal Sites: Issues in Risk Analysis and Some Bayesian Conclusions. Chap. 10. Waste Location and Environment. pp.158-186.

[8] Bhatia, S.C. (2009). Environmental pollution and control in chemical process industries. New Delhi. Khanna Pub p1273.

[9] Wang, S; Lengeler, C; Smith, TA; Vountson, P; Cisse, G; Tanner, M. (2006) Rapid urban malaria appraisal (RUMA) !!!: Epidemiology of urban malaria in the municipality of Youpougou (Abidjan*) Malar J* 7:e29.

[10] Goren, A. and Hellman, S. (2001). Impact of Vehicular Air Pollution on Health of Children in Tel Aviv: Isreal Environment Bulletin, Ministry of Environment Tel Aviv, Winter, 2001-5761, Vol. 24 No.1.

[11] Sogoba, N; Doumbia, S; Vounatsou, P; Baber, I; Keita, M et al. (2007). Monitoring of larval habitats and mosquito densities in the Sudan Savanna of Mali; Implications for malaria vector control. *American J Trop Med Hyg*. 77(1); 82-88.

[12] Weidong, GU, Regens, JL; Beier, JC; Novak, R.J. (2006). Source reduction of mosquito larval habitats has unexpected consequences on malaria transmission. *PNAS* 103(46):7560-17563.

[13] Swan, J.R.M., Crook, B.; Gilbert, J. (2002). Microbial Emissions from composting sites. In: Environmental and Health Impact of Solid Waste Management Activities (eds Hester R E and Harrison R M). Issues in Environmental Science and Technology, Vol.18:73-101 Cambridge, R.S. of Chemistry.

[14] Tony, G.O. (1978).The breeding site preference of mosquitoes in Ibadan, Nigeria. *Nigerian J. Entomol* 1 (3):71-75.

[15] Afolabi, B. (2006). "Why Malaria is more deadly in Nigeria". *Pharmanews* 28 (5) 1-6.

[16] Gerritsen, A A M; Kruger, P; Leoff, MFS; Grobusc; MP. (2008). Malaria incidence in Limpopo Province, South Africa 1998-2007. *Malar J* 7:e167.

[17] Ceesay, S.J; Casals-Pascal, C; Erskine, J; Anya, S.E; Duah, N.O et al. (2008). Changes in malaria indices between 1998 and 2007 in the Gambia: A retrospective analysis. *Lancet* 372 (9649); 1545-1554.

[18] Tiono, AB; Kabore, Y; Traore, A; Convelto, N; Pagnoni, F; Sirima, S B. (2007) mplementation of home-based management of malaria in children reduces the work load for peripheral health facilities in a rural district of Burkina Faso. *Malar J* 7:e201.

[19] Ayala, F.J.; Escalente, A.A; Rich, S.M. (1999) Evolution of plasmodium and the recent origin of the World Populations of *Plasmodium falciparum. Parasitologia* 41:55-68.

[20] Sturchler, D. (1989). How much malaria is there worldwide *Parasitology* Today 5:39-40.
[21] Moorthy, VS; Reed, Z; Smith, PG. (2007) Measurement of malaria vaccine efficacy in phase 111 trials: reports of a WHO consultation.*Vaccine* 25:5115-5123.
[22] Killeen, GF; Smith, TA; Ferguson HM; Mshinda, H; Abdulla, S et al. (2007) Preventing childhood malaria in Africa by protecting adults from mosquitoes with insecticides treated nets. *PLOS Med* 4(7):e229.
[23] Ikhisemoge, T. (2006). Health Encyclopedia: Diseases and Conditions; A Seminar on New Trends of Malaria Management in Nigeria, Pharmanews, Oct.
[24] Snow, R.W. (1997). Relation between severe malaria morbidity in children and level of *Plasmodium falciparum* transmission in Africa. *Lancet* 349:1650-1654.
[25] Jumbo Gta; Mbaawuaga Em; Anongu, Su; Egar, Dz; Peters EJ et al. (2001) The burden of malaria among under-five children. Findings from Maakurdi City, North Central Nigeria. *RIF* 1(3):140-144.
[26]Orasanya, OB; Honshen, M; Sofola, O.T. (2007). Utilization of insecticide treated net by under-five children in Nigeria: Assessing progress towards the Abuja targets. *Malar J* 2:e145.
[27] Hemingway, J. (1999). Insecticide Resistance in Malaria Vectors: A New Approach to an old subject. *Parasitologia* 41:515-518.
[28] Okogun, G.A.R. (2003). Ecology; Biology of Anopheles mosquitoes and prevalence transmission intensity of malaria in mid-West Nigeria. Doctoral Dessartation in Med. Parasitology. Imo State Uni, Owerri. p272
[29] Obioha, E; Lokesusi, F (2007) Population growth, economic activities and environmental degradation in Imo State, Nigeria. *Int Dev Manag Rev* 2(1); 26-39.
[30] Tonne, C., Melly, S., Muttleman, M., Coull, B. Goldbery, R. and Schwartz, J. (2007). A case control Analysis of Exposure to traffic and myocardial Infarction *Environ Health Perspect* 115(1): 53-57.
[31] Khitotiya, R.K. (2004). Environmental Pollutions: Management and Control Sustainable Development. New Delhi S. Chad and Company Ltd. Chap.4.
[32] Olayemi, IK, Omalu, ICJ; Famolete, OI; Shega, SP; Idris, B. (2010). Distribution of mosquito larvae in relation to physiochemical characteristics of breeding habitat in Minna, North Central Nigeria. *RIF* 1(1):49-53.
[33] Gilles, MT and Coetzee, M. (1987). A supplement to the Anophelinae of Africa South of the Sahara Afro-Tropical Region). Publication of the South African Institute of Medical Research 55:12-23.
[34] Oguoma, VM, Nwaorgu, OC. Mbanefo, EC, Ikeze, OO, Umeh JM et al. (2010).Species composition of Anopheles mosquito in three villages of Uratta Owerri North Local Government Area of Imo State of Nigeria *RIF* 1(4):192-196.
[35] Okwa, OO, Rasheed, A, Adeyemi, A, Omoyeni, M, Oni, I et al. (2007). Anopheles species abundances and vectoral competence in six areas of Lagos, Nigeria. *Journal of Coll and Animal Biology*. (2):19-23.
[36] Anderson, R.M. and May R.M. (1982). Coevolution of hosts and parasites. *Parasitology* 85:41-426.
[37] Fasan P.O. (1969). Malaria in school children of Lagos city and Lagos state. *West Africa J.* 18:176-180.
[38] Okogun, G.A.R. (2003). Ecology; Biology of Anopheles mosquitoes and prevalence transmission intensity of malaria in mid-West Nigeria. Doctoral Dissertation in Med. Parasitology. Imo State Uni, Owerri. p272
[39] Tibbett, J. (2007). Health Effects on Climate Change. *Environ Health Perspect1*15(40):197-203.
[40] Tibett, J. and Epsein, E. (2005). Climate Change Futures: Health, Ecological and Economic Dimensions, WHO Pub, New York.
[41] William, T.N. (2006) High Incidence of Malaria in Thalasemia Children *J. Nature* 383:522-525
[42] Mendis, K.N. and Carter R. (1995). Clinical Diseases and Pathogenesis in Malaria. *Parasitology Today* 11(5) 101-110.
[43] Thomas, G.E; Mitchell, F. and Williams, M. (eds) (2006) Examining the Health Disparities Research Plan of the National Institute of Health; Unfinished Business, Washington. D.C., NAP.
[44] Pellow, D. N; Brulle and R.J. (2005). Power, Justice and The Environment: A Critical Appraisal of the Environmental Justice Movement, Cambridge, MA; MIT Press.
[45] Olayemi, I. K. (2008).Influence of land-use on the fitness of *Anopheles gambiae*, the principal vector of malaria in Nigeria. *Online Journal of Health and Allied Sc.* 7(4): 3-8.
[46] Mabunde, S; Aponte, JJ; Tiago, A; Alonso, P. (2009). A country-wide malaria survey in Mozambique II; Malaria attributable proportion of fever and establishment of malaria case definition in children across different epidemiological settings. *Malar J* 8:e74.