Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol 2, No.10, 2012

Physico-chemical Assessment of Mosquito Breeding Sites from Selected Mining Communities at the Obuasi Municipality in Ghana.

Tiimub, B. M[1]., Adu, B. K[1]., and Obiri-Danso, K[2].

1. Tiimub, Benjamin Makimilua (Corresponding Author).

Tele: +233 244501055 E-mail: benmakimit@yahoo.com

University of Education, Winneba, College of'Agriculture, Faculty of Science and Environment, Department of Environmental Health and Sanitation, P. O. Box 40 Asante Mampong, Ghana.

1. Adu, Benjamin Kwasi

Tel. + 233 247675027/0207062398 E-mail: adubenjamin72@ yahoo. com

2. Kwasi Obiri-Danso

Tele + 233 244995831/20-816-8426 E-mail: obirid@yahoo.com

Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology- Kumasi, Ghana.

The research is financed by Lecturers own Research Grants provided by the Government of Ghana and augmented with minimum cost of laboratory analysis by AngloGold Ashanti Gold Mines Limited.

Abstract

A survey was conducted in the Obuasi Municipality in Ghana to assess the impact of some physic-chemicals in waters of mosquito breeding sites from 15 randomly selected communities. The water samples, collected fortnightly for eight months, were analyzed using spectrophotometry and other standard laboratory protocols at the AngloGold Ashanti Environmental Quality Assurance Laboratory for temperature, total suspended solids, total dissolved solids, dissolved oxygen, electrical conductivity and pH. The physico-chemical parameters which ranged from 17.03 ± 0.18^{0}C - 24.06 ± 0.18^{0}C (temperature), 17.03 ± 4.04mg/L - 96.67 ± 4.04mg/L (TSS), 1.09±3.23mg/L - 35.67±3.23mg/L (TDS), 3.97 ± 0.13mg/L - 7.43 ± 0.13mg/L (DO), 17.00 ± 1.30µScm^{-3} - 83.00 ± 1.30 µScm^{-3} (EC) and 7.77 ± 0.0 - 10.70 ± 0.01 (pH) were much lower relative to the EPA Maximum Permissible Limits. It is apparent that under rising temperature conditions of climate change, the mosquito's habitat may be highly favoured for adaptation and prolific breeding in the tropics and this further creates the opportunity for research partners to get actively involved in finding integrated control measures to counteract the life cycle of the pest.

Keywords: Anglogold Ashanti, Obuasi Municipality, Physio-chemical Analysis, Mosquito Breeding Waters

1.0 Introduction

Mosquitoes exploit almost all types of lentic aquatic environments. Anopheles mosquito has been found to use fresh water habitats for breeding. Larvae of anopheles mosquitoes in clear water of suitable pH, temperature and nutrient conditions have been found to thrive in aquatic bodies such as fresh composition (Russel, 1999). However, high water or salt marshes, mangrove swamps, rice fields, current and flooding have been reported to lead to grassy ditches, the edges of streams and rivers and anopheles species larval deaths due to reduction in small, temporary rain pools (CDC*.,* 2007).

Diagnostic and scientific research has shown that many mosquito species prefer habitats without oxygen tension causing physical harm to the larvae with vegetation whilst some breed in open, sunlight pools (Okogun, 2005). Water of a near neutral pH of 6.8 – 7.2 is preferable for breeding of many species of mosquitoes whereas few species breed in tree holes or the leaf axils of some found to be most optimal for the weakening of the egg shells plants (CDC, 2004). Anopheline species are known to be for the first instar larvae stage to emerge, although large numbers are ground pools breeders (Okogun *et al.,* 2003). Various chemical properties of the larval habitat observed in gutters, peri domestic runoff and domestic are related to vegetation and a wide range of heavy metal, nutrients and physicochemical characteristics of the water, ranging from pH, optimum temperature, total suspended solids, total dissolved solids, electrical conductivity etc. have been found to affect larval development and survival (Mutero *et al.,* 2004).

According to Okogun *et al.,* 2003, mosquito eggs are white in color when first deposited but darken within 12 to 24 hours. Most species' eggs appear similar when seen by the naked eye, with the exception of the *Anopheles spp*., whose eggs have, floats attached to each side. When viewed with magnification, eggs of different species can be seen to vary from canoe-shaped to elongate or elongate-oval in shape. Some species lay eggs simply, and others glue them together to form rafts. The incubation period (elapsed time between oviposition and readiness to hatch) is dependent on environmental and genetic factors and varies considerably among different species (Gilvear & Bradley, 2000).

Permanent water and standing water species deposit their eggs directly on the water surface, and these may hatch in one to four days depending on temperature (Brandy and Holum, 1996)**.** In addition, many floodwater and container-breeding species deposit their eggs on moist soil or other wet substrates. These eggs may hatch within a few days after being flooded, or the fully developed larvae may remain within the eggs for up to a year or more depending on immersion conditions. These quiescent eggs accumulate over time due to continued oviposition by blood-fed females. When temporarily flooded, they hatch, along with more recently deposited eggs. Populations can attain large numbers quickly this way.

According to CDC, 2004, larvae (wigglers or wrigglers) of all mosquitoes live in the water. Near the last abdominal segment in most species is a siphon or air tube that serves as a respiratory apparatus when the larva suspends vertically below the water surface.

Larvae of Anopheles, however, breathe through a cluster of small abdominal plates, which causes them to lie flat close to the underside of the water surface when not diving. Larvae of some species are predaceous (e.g. *Toxorhynchites rutilis* and *Psorophora ciliate*) and prey on other invertebrates, including mosquito larvae. Most larvae are filter feeders, ingesting anything smaller than about 10 microns by vibrating their mouth brushes and sweeping in particulate matter and small organisms from the surrounding water (CDC, 2004).

This study examined under field and laboratory conditions some of the physicochemical characteristics of the breeding sites for the development and fecundity in Anopheline and Culicine mosquitoes. Prodigious numbers of mosquitoes can hatch simultaneously under the proper conditions. In rapidly developing broods, survival of the immature stages can be quite high, but estimates for many species indicates that immature survival is normally less than 5%. But 5% of millions represents a sizable number. Irrespective of population densities, if they transmit disease or preferentially feed on humans, which many species do, they become appropriate targets for control activities (Okogun *et al.,* 2003).

1.1 Problem Statement and Justification for the Study

The people of Obuasi Municipality have been complaining of malaria issues over the past decades due to the poor sanitary effects on the environment that is surrounded by many water bodies, and mining as a result of shallow excavations have been a source of breeding sites for mosquitoes as vectors which develop the parasite for malaria transmission. Due to the release of certain trace metals and nutrients into the water, breeding of the various mosquitoes such as the *Anopheline* and the *Culicines* can produce numbers that are densely populated posing so much chronic malaria fatigue on the people in endemic communities (Bradley & Kutz, 2006). Despite the fact that a number of integrated approaches involving indoor residual spraying control measures experiments within dwelling places of household, schools and markets in addition to larvaeciding on the surface waters to control the various mosquito species have been seriously implemented by the AngloGold Malaria Centre in Ghana just as in Kenya and other tropical countries, previous studies conducted revealed that, all the control strategies could not yet avail a lasting solution to the problem (CDC, 2004). Trying to use the integrated approach by adopting a research principle to investigate what goes on in terms of adaptability of the mosquitoes at their breeding sites to varying physicochemical conditions could therefore, help determine appropriate malaria control strategies through sound environmental management principles (Bradley & Kutz, 2006).

The rationale was to relate the physicochemical characteristics of the breeding habitats with the behavior of mosquito species of public health significance. By so doing, it might be possible to predict whether the population of mosquitoes has the potential to further rise due to unpredicted changes that could be associated with the changing climatic conditions such as heavy rainfall and unexpected flooding, urbanization, mass consumption and mass waste generation and consequential pollution of the environment in the Obuasi Municipality and its adjoining peri-urban communities. Additionally, creation of slums and improper disposal of waste water from various channels may directly or indirectly constitute mosquito breeding sites. These amongst other factors, are apparent reasons why it was absolutely necessary to conduct a research to assess the water quality in relation to the species of mosquito larval development by purposively sampling point sources of fresh and stagnant waters in Ghana using the Obuasi Municipality as a case for the study. Suitability of the mosquito breeding sites and the level of water quality in terms of its heavy metal and nutrients the physico-chemical characteristics could determine the type of mosquito larval development in a particular water body (Brandy and Holum, 1996).

1.2 Research Objective

The general objective was to assess the physico-chemical characteristics of water from various mosquito breeding sites within the Obuasi Municipality and other adjoining pri-urban communities.

1.2.1 The Specific Objectives were to:

1. Survey stagnant water bodies for mosquito larvae at breeding sites.
2. Collect water samples from located breeding sites to the laboratory for analysis.
3. Determine physico-chemical quality of the water samples in which the mosquitoes breed.

1.3. Methodology

This work was done under surveillance on experimental bases. Here, some preliminary field survey and selection of the sampling points was done using the Obuasi Municipal Profile for identification of various communities. This surveillance for stagnant water bodies for mosquito larvae was done within the sampling duration of eight months within fifteen sampling communities.

1.3.1 Methods of Analyses for Physicochemical Parameters in Water

Moreover, water samples were collected from located breeding sites to the laboratory for analysis using standard. However, a thermometer was used for measuring temperature on the field. The pH and conductivity of the mosquito breeding waters was determined directly on the field using Yokagawa pH 72 pH/ORP Meter and DO meter was used for measuring dissolved oxygen of water, direct on the field.

1.3.2 Total Dissolved Solids (TDS) Dried at $180^0C \pm 2^0C$ and Total Suspended Solids (TSS) Dried at $103\text{-}105^0C$.

Total Dissolved solids and total suspended solids were analyzed by means of the same filtration apparatus and process: The water sample was stirred with magnetic stirrer and a measured volume was pipette onto a glass- fiber filter with applied vacuum. It was then washed with three successive 10-ml volumes of reagent – grade water, allowing complete draining between washing and the suction was continued for about 3 minutes after filtration was complete. The total filtrate (with washings) was transferred to weigh evaporating dish and evaporated to dryness on a steam bath. Where filtrate volume exceeded dish capacity successive portions were added to the same dish after evaporation. It was dried for at least 1 H in an oven at $180\ ^0C \pm 2^0C$ and 103-105˚C for TDs and TSS respectively, cooled in desiccators to balance temperature and weighed. The cycle of drying, cooling, desiccating and weighing was repeated until a constant weight was obtained or until weight change was less than 4% of previous weight or 0.5 mg, whichever was less with the caution that duplicate determination agreed within 5% of their averages.

Calculation: Milligram total dissolved solids/ L = (A-B) ×1000 / Sample volume, mL, and

Mg total suspended solid = (A-B) ×1000× /sample volume, mL, where: A=weight of filter + dried residue, mg and B=weight of filter, mg. For precision, the standard deviation was 5.2 mg/lL(coefficient of variation 33%) at 15mg/L, 24mg/L (10%) at 242 mg/L, and 13mg/L; (0.76) at 1707mg/L in studies by two analysis of four sets at 10 determinations each. . Single – laboratory duplicates analyses of 50 samples of the water were made with a standard deviation difference of 2.8 mg/l. Multivariate analysis was conducted on all physicochemical data using Statistical Package for Social Scientists (SPSS) Version 18.0 at $P < 0.05$ level of significance.

1.4 Results

Some Physical and Chemical Characteristics of Mosquito Breeding Waters

Table 1 Mean concentration of physico-chemical parameters (Mg/L and µS/cm) from fifteen communities mosquito breeding water sampling sites as (homogeneous subsets).

Community	Temp.	TSS	TDS	DO	EC	pH
1.Gausu	20.47±0.18	1.87±4.04	1.09±3.23	5.67±0.13	36.67±1.30	8.52±0.01
2.Bedieso	20.47±0.18	1.57±4.04	2.32±3.23	80±0.13	35.00±1.30	10.70±0.01
3.Mensakrom	19.37±0.18	3.87±4.04	4.54±3.23	5.00±0.13	78.67±1.30	8.67±0.01
4.Kunka new town	20.00±0.18	2.27±4.04	2.14±3.23	6.30±0.13	46.33±1.30	8.60±0.01
5.Nyameso	20.50±0.18	1.20±4.04	9.57±3.23	7.03±0.13	23.67±1.30	8.05±0.01
6.Sanso	20.00±0.18	2.97±4.04	3.16±3.23	7.17±0.13	78.67±1.30	8.02±0.01
7.Nhyiraeso	19.87±0.18	86.67±4.04	1.45±3.23	7.43±0.13	17.00±1.30	9.95±0.01
8.Bediem	19.67±0.18	1.27±4.04	6.16±3.23	5.23±0.13	27.67±1.30	8.06±0.01
9.Bongobiri	20.17±0.18	2.57±4.04	7.42±3.23	4.57±0.13	52.67±1.30	8.02±0.01
10 North Nyamebekyere	20.47±0.18	1.33±4.04	7.40±3.23	5.93±0.13	28.00±1.30	9.71±0.01
11.Binsere	17.03±0.18	2.30±4.04	4.88±3.23	4.87±0.13	45.67±1.30	8.10±0.01
12.Abompe Extension	24.06±0.18	4.07±4.04	3.20±3.23	7.00±0.13	83.00±1.30	9.55±0.01
13.Nyameso: control B	19.13±0.18	96.67±4.04	26.00±3.23	3.97±0.13	20.00±1.30	7.87±0.01
14.Akaporiso	20.67±0.18	1.34±4.04	7.98±3.23	5.00±0.13	22.67±1.30	8.04±0.01
15.Akaporiso control A	18.67±0.18	1.10±4.04	35.67±3.23	4.60±0.13	19.00±1.30	7.77±0.01
EPA MPL	< 3°C	1000mg/L	50mg/L	50mg/L	1500 µS/cm	6 – 9

*The mean difference is significant at the 0.05 level.

From table 1 above, the temperature of water from various mosquito breeding sites varied between 17.03 ± 0.18^{0}C and 24.06 ± 0.18^{0}C. The lowest value was recorded at Binsere and the highest at Abompe Extension. However, there was a definite pattern in the rest of the data ranges which varied slightly even though the mean temperature difference between the highest and lowest data points was up to 7.03 ^{0}C. The entire temperature records from all the fifteen sites were above the EPA Maximum Permissible Limit (MPL) of <3^{o}C for fresh aquatic ecosystems.

A site-by-site multivariate comparison of means for temperature between the Akaporiso control site A and the rest of the sites revealed significant differences (i.e. P<0.000 and P<0.006) between it and the rest of the sites with exception to the other control site B at Nyameso where the difference was not significant (P>0.381). A similar comparison between control site B at Nyameso and the rest of the sites for temperature revealed much significant differences between them (P<0.000, P<0.002 and P<0.016), except the control site B, Mensakrom, Bediem and Akaporiso control site A where the differences were not significant (P≥0.988, P≥0.201 and P≥0.381) respectively when compared with the Akaporiso control site A.

The mean Total Suspended Solids (TSS) concentration in the mosquito breeding waters ranged from 17.03 ± 4.04mg/L - 96.67 ± 4.04mg/L. The lowest value was recorded at Akaporiso control site A and the highest at Nyameso control site B. The next highest value of 86.67 ± 4.04mg/L was recorded at Nhyiraeso and the rest of the water sites data points were below 5mg/L for TSS. When compared with the EPA MPL of 1000mg/L for TSS, all the values recorded from the fifteen sites were below it.

A site-by-site multivariate comparison of means for Total Suspended Solids (TSS) revealed that there was much significant difference (i.e. P<0.000), between the Akaporiso control site A and the rest of the sites. A similar comparison between control site B at Nyameso and the rest of the sites for TSS further revealed much significant differences between them (P<0.000). However, the difference in TSS level of water between the two control sites namely; Akaporiso and Nyameso was not significant (P>0.211)

In addition, the mean Total Dissolved Solids (TDS) concentration of the water varied between 1.09±3.23mg/L and 35.67±3.23mg/L from the various sites. The lowest value was obtained from Gausu and the highest at Nyameso control site B. The rest of the data points from the remaining sites were generally below 10mg/L for TDS and were further generally lower when compared with the EPA MPL of 50mg/L for TDS in fresh surface waters.

A site-by-site multivariate comparison of means for Total Dissolved Solids (TDS) between the Akaporiso control site A and the rest of the sites revealed some significant differences between it and the rest of the sites (i.e. P<0.001 and P<0.017). But the differences between the control site A at Akaporiso and the Control site B at Nyameso where were not significant (P>0.483 and P>0.116) respectively. A similar comparison between the control site B at Nyameso and the rest of the sites for TDS revealed much significant differences between them (P<0.000). However, between the control site B and Nhyiraeso the differences in TDS concentrations were not significant (P>0.483 and P>0.116) respectively.

The Dissolved Oxygen (DO) content of the mosquito breeding water sources in the fifteen communities ranged from 3.97 ± 0.13mg/L - 7.43 ± 0.13mg/L. The lowest value was recorded at the Nyameso Control site B and the highest at Nhyiraeso and all the mean values recorded from the various mosquito breeding waters were far below the EPA MPL of 50mg/L.

A site-by-site multivariate comparison of means for Dissolved Oxygen (DO) between the Akaporiso control site A and the rest of the sites revealed some statistically significant differences between them (P<0.000 and P<0.002) respectively, except between the Akaporiso control site A and Nyameso, Mensakrom, Bongobiri, Binsere, and Akaporiso sampling site where the differences were not significant (P>0.154, P>1.000, P>0.720 and P>0.154) respectively. Similarly, a comparison between the control site B at Nyameso and the rest of the sites for DO revealed much significant differences between them (P<0.000, P<0.002 and P<0.004) respectively.

The Electrical Conductivity (EC) of all the fifteen mosquito breeding water sites varied between 17.00 ± 1.30 µS/cm and 83.00 ± 1.30 µS/cm. The lowest value was recorded at Nhyiraeso and the highest at Abompe Extension. The mean values at all the sites were generally below the EPA MPL of 150mg/L for EC.

A site-by-site multivariate comparison of means for Electrical Conductivity (EC) between the Akaporiso control site A and the rest of the sites revealed significant differences between them (i.e. P<0.000 and P<0.050) respectively, except between the Akaporiso control site A and Nhyiraeso, Nyameso control site B and Akaporiso sampling sites where the differences were not significant (P>0.950, P>1.000 and P>0.252) respectively. Further comparison between the control site B at Nyameso and the rest of the sites for EC revealed much significant differences between them (P<0.000). However, between the Nyameso Control site B and the Nyameso, Nhyiraeso and Akaporiso sampling sites the differences were not significant (P>0.252, P>0.551and P>0.720) respectively.

The pH levels of all the mosquito water breeding sites further varied between 7.77 ± 0.01 and10.70 ± 0.01. The lowest value was recorded at the Akaporiso Control site whilst the highest at the Bedieso water source. The pH of water from the sites entire sites were generally below the EPA MPL range of 6-9 except for Nhyiraeso, North Nyamebekyere and Abompe Extension which recorded the values (i.e. 9.95 ± 0.01, 9.71 ± 0.01 and 9.55 ± 0.01) that were slightly above it. Additionally, a site-by-site multivariate comparison of means for pH between the Akaporiso control site A and the rest of the sites revealed significant differences between them (i.e. P<0.000). Similarly, the difference between the control site B at Nyameso and the rest of the sites for pH were much significant

(P<0.000).

1.5 Discussion

The results shown above did not reveal any significant pattern of attendant pollution or contamination of the fresh waters that probably served as the direct breeding grounds of the various mosquito species. The levels of physico-chemical parameters in the mosquito breeding waters which were found to be ranging from 17.03 ± 0.18^{0}C - 24.06 ± 0.18^{0}C , 17.03 ± 4.04mg/L - 96.67 ± 4.04mg/L, 1.09±3.23mg/L -35.67±3.23mg/L, 3.97 ± 0.13mg/L - 7.43 ± 0.13mg/L, 17.00 ± 1.30 - 83.00 ± 1.30 and 7.77 ± 0.0 - 10.70 ± 0.01 for Temperature, TSS, TDS, DO, EC and pH respectively were relatively much lower when compared to their corresponding EPA Maximum Permissible Limits of < 3^{0}C , 1000mg/L, 50mg/L, 50mg/L, 1500mg/L and 6–9 for waters that are likely to be polluted. The mean differences between all the physico-chemical parameters were generally statistically significant at approximately P<0.000 – P < 0.005 between the two control sites and the rest of the ordinary sampling sites even though between the two control sites there were no significant differences.

According to the Centre for Disease Control in2004, larvae (wigglers or wrigglers) of all mosquitoes live in the water. Near the last abdominal segment in most species is a siphon or air tube that serves as a respiratory apparatus when the larva suspends vertically below the water surface.

Scientific study of the biology of the mosquito however, reveals that the larvae of *Anopheles* breathe through a cluster of small abdominal plates, which causes them to lie flat close to the underside of the water surface when not diving (Curtis, 1996). The larvae of some species are predaceous (e.g. *Toxorhynchites rutilis* and *Psorophora ciliate*) and prey on other invertebrates, including mosquito larvae (CDC, 2004).

Additionally, most larvae are filter feeders under suitable temperatures and pH, good transparency and optimum oxygen diffusion (CDC, 2007); ingesting anything smaller than about 10 microns by vibrating their mouth brushes and sweeping in particulate matter and small organisms from the surrounding water (Sanford, 2005). This further implies that the higher the, DO requirement of a water the more unfavourable or unsuitable it is probably to the filter feeding mosquitoes species which require fresher, transparent and more oxygenated waters to complete its life cycle as previously pointed by (Curtis in 1996). Additionally, a low DO requirement of an aquatic habitat is an indirect reflection of lower concentrations of TSS and TDS which in its respective higher concentrations could reduce transparency and increase oxygen deficiency (Webb & Walling, 1992). However, the DO requirement of the mosquito breeding grounds were generally less than 10mg/L at all the sites studied, except, for the Bedieso site where its level at 80±0.13mg/L was far and above the EPA Maximum Permissible limit of 50mg/L. This trend reveals that the waters were generally favorable grounds for prolific breeding of the mosquitoes.

Gilvear and Bradley in 2000 further observed that some processes alter the dissolved oxygen content; oxygen drops during respiration and decomposition; it however, rises with photosynthetic activity. A pH that is too high is undesirable because free ammonia increases with rising pH. According to Pelizza, *et al* in 2007, pH of 7 is neutral , and water of a near neutral pH of 6.8 -7.2 is preferable for breeding of many species of mosquitoes whereas few species breed in tree holes or the leaf axils of some found to be most optimal for the weakening of the egg shells. If pH readings are outside this range, mosquito eggs, larvae and pupae growth is reduced (CDC 2007, Curtis, 1996). At values below 4.5 or above 10, mortalities occur. However, the pH of all the water sites were favourable for mosquito breeding except the Bediako site where the level (10.70±0.01) was above the EPA recommended range and mosquito larval mortality could set in.

Sanford, in 2005 added that pond water temperature affects both spawning and growth of larvae and pupae. The mean temperatures of the water sites studied, which ranged between 17.03 ± 0.18^{0}C - 24.06 ± 0.18^{0}C conformed to the range of 16 -32^{0}C specified by Bradley & Kutz at the US EPA in 2006 as the best for the breeding of most mosquito species in the tropics.

Conclusion

The fact that by standard comparison, this study further recorded much lower physico-chemical conditions than the EPA Maximum Permissible Limits for waters that are likely to be contaminated confirms that the waters were suitable for mosquito habitation. It could even meet the requirements of the filter feeding mosquito species and support their survival and breeding to a greater extent. Consequently, it was not surprising that during the sampling, colonies of various mosquito larvae were found to be growing on the surface waters which were closely monitored for its quality. The physico-chemical concentrations in the water were generally within the EPA Maximum Permissible limits and the phenomenon is most likely to favour prolific breeding pattern and natural adaptation of the various mosquito species which have interesting and much varying developmental characteristics under tropical conditions.

Recommendations

It is strongly recommended that, international and multilateral organization such as the Global Malaria Fund and Global Environmental Facility should release grants to the AngloGlold Malaria Centre to scale up its strategic malaria control programmes to benefit more communities outside the Obuasi Municipality and partner with institutions of higher academia for dissemination of knowledge towards appropriate malaria control and preventive health education promotion in Ghana.

Acknowledgement

The authors are so grateful to the Authoritists of the AngloGold Malaria Centre and the Environmental Monitoring Department of the Mines for supporting the work through the provision of laboratory facilities, transport and other logistics to collect and analyze the data**.**

References

Bradley, P. & Kutz, F.W. (eds) (2006). *Proceedings of the Workshop on Stormwater Management and Mosquito Control*. U.S Environmental Protection Agency, Office of Research and Development. EPA /903/R-06/004.

Brandy. E. & Holum J. R(1996). CHEMISTRY, the sudy of matter and its changes, 2nd Ed. John Wiley & so. New York .Pp 588.

Centre for Disease Control and Prevention (2007*). Infectious disease information: Mosquito-Borne Diseases*. Retrieved July 14, 2009 from http://www.cdc.gov/ncidod/diseases/list_mosquitoborne.hmt

Centre for Disease Control and Prevention (2004). Life stages of Anopheles mosquitoes. MMWR 52:989 – 997

Curtis, C. F. (1996). *An overview of mosquito biology, behavior and importance. Ciba Found Symp. 3-7.*

Gilvear, D. J, and Bradley, C. (2000). *Hydrological monitoring and surveillance for wetland conservation and management*; a UK perspective. Phy Chem. Earth Pt B 25:571-588

Mutero CM, Nga'ang'a PN , Wekoyela P , Githure j , Konradsen F (2004). Ammoniumsulphate fertilizer increases mosquitoes in rate field .Acta Trop. 89:187-192.

Okogun GRA, (2005). Life table Analysis of Anopheles malaria vectors: generational mortality as tool in mosquito vector abundance and control studies. J. vector Borne Dis. 42:45-53.

Okogun GRA , Bethran EB, Anthony N, Okere Jude C , Anegbe C. (2003). Epidemiological Implications of preferences of Breeding sites of Mosquito species in Midwestern Nigeria Ann. Agric, Environ. Med.10:217- 222.

Pelizza SA, Lopez Lastra CC, Becne JJ , Bisara V , Garcia JJ (2007) . Effects of temperature , pH and salinity on the infection of Leptolegria capmany Seymour (peronosporomycetes) in mosquito larvae . J. invertebrate pathol . 96(2): 133- 137.

Russel, R. C. (1999). Constructed wetlands and mosquitoes: health hazards and management options-an Australian perspective. *Ecological Engineering*. 12, 107-124

Sanford, M. R, (2005). Effects of Inorganic Nitrogen Enrichment on Mosquitoes (Diptera: Culicidae) and associated aquatic Community in a Constructed Treatment Wetland. Journal of Medical Entomology. 42, 766-776.

Webb. B.W. and Walling D.E.(1992) . Water Quality.II. Chemical Characteristics.In The Rivers Handbook, Volume 1. (P.Calow and G.E. Pets, Ed.), Blackwell scientific Publication Oxford , UK Pp 73-100