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PHYSICO-CHEMICAL ATTRIBUTES OF MALARIA VECTORS BREEDING SITES IN EKORI, YAKURR LGA, CROSS RIVER STATE, NIGERIA

EFFIOM, O. E.[1], ALARIBE, A. A. A .[2], USEH, M. F. [2]

[1]*Department of Biological Sciences, Veritas University, Abuja, Nigeria.*
[2]*Department of Medical Microbiology/Parasitology, University of Calabar, Calabar, Nigeria.*
e-mail: effiomo@veritas.edu.ng

ABSTRACT: This research aimed to investigate the physico-chemical parameters of various mosquito-breeding sites in Ekori, Cross River State, Nigeria. Knowledge of physico-chemical factors that influence mosquito breeding could be useful in mosquito population control. Larvae of mosquitoes were collected fortnightly from 28 breeding sites, and identified into anophelines and culicines. Similarly, water samples were collected from the same breeding sites and analyzed for physico-chemical parameters such as carbonate, bicarbonate, chlorine, dissolved oxygen, carbondioxide, pH, conductivity, etc. Water depth and temperatures were measured together with the survey of the physical surroundings, nature and conditions of the sites. The monthly rainfall of the study area was measured. The values of these parameters for the different mosquito habitats showed variation between the dry and the rainy seasons. Variable abundance of mosquito larvae and two species of malaria vectors in the respective habitats were also observed. These findings could be attributed to the corresponding variability observed in the values of physico-chemical parameters of the habitats. High populations of anopheline larvae were found in the breeding sites that had warm temperature (28-30^{0}C), clean shallow waters, high concentration of HCO_3^-, CO_3^{2-}, DO, low concentrations of $NO_{3,}^-$ low numbers of larvivorous organisms as well as the presence of water lettuce vegetation either within or around the habitats. Correlation analysis of the relation between physico-chemical parameters and mosquito larval abundance showed significance (P < 0.05). The results of this study suggest that physico-chemical parameters of mosquito breeding sites can be manipulated to check mosquito larval abundance for effective malaria control.

INTRODUCTION

The link between malaria and water has from time immemorial been an unbreakable one, especially as the life cycle of mosquito is entirely water-dependent, and mosquitoes are getting easily adapted to various water conditions in propagating themselves. The diverse water quality used by various *Anopheles* mosquitoes to breed and propagate themselves may be temporary (or transient), permanent, natural or man-made (Bourne, 2003; MAC 2003; NJMCA 2003). A good number of ecological factors influence the choice of site for breeding or oviposition as well as abundance of different species of anophelines. One very important ingredient for successful production of aquatic life forms is a proper balance of physical, chemical and biological parameters of water in ponds, lakes and reservoirs (Mustapha and Omotosho, 2005). Also, the interaction of both the physical and chemical properties of water influences the composition, distribution and abundance of aquatic organisms. The presence or absence of chemical elements in water body might be a limiting factor in the aquatic life productivity of such water body could determine the types of organism that may be available. Besides, it may indicate ecologically unstable ecosystem which can have positive or negative impact on the population of aquatic diversity (Pasche, 1980; Williams 1990; Sidneit *et al.*, 1992; Despommier *et al.*, 2000). Mustapha and Omotosho (2005), in their assessment of the physico-chemical properties of Moro Lake in Kwara State, Nigeria, reported how human agricultural activities sufficiently altered the physico-chemical characteristics of a natural fresh water body and also the natural dynamics which adversely affect other parameters such as aesthetics of the water, species distribution and diversity, their production capacity, and even disruption of the ecosystem balance in the water

Previous studies have revealed direct correlation between the availability of water and the frequency in which mosquito breeds and feeds on humans (Despommier *et al.*, 2000). This invariably implies that environmental factors directly and indirectly influence malaria transmission through their impact on the vectors. In other words, every physical and chemical environmental change in the mosquito habitat, be it natural or man-made, will re-orient the ecological landscape in which these vectors breed (Despommier and Chen 2003). The environmental factors that are said to impact on the malaria vectors and thus influence malaria transmission are changes in temperature, humidity, altitude, human population density, deforestation, farming, spread of irrigation project, and physico-chemical parameters (such as dissolved oxygen, carbon dioxide, carbonates, bicarbonates, nitrates, sodium chloride, chlorine, turbidity, conductivity, water depth, pH, etc.).

This study investigates the physico-chemical properties of the breeding and oviposition sites of malaria vectors in Ekori, Yakurr Local Government Area of Cross River State, Nigeria and their influence on the mosquito larval abundance.

MATERIALS AND METHODS

Study Area

The study site is located in Ekori, a sub-urban settlement centrally located in Yakurr Local Government Area of Cross River State, Nigeria. It is situated between latitude 4^o 27’ and 6^o 56’ North and longitude 7^o 51’ and 9^o 29’ East in the globe, and is about 135 km from Calabar, the State capital. It is one of the largest native communities in Cross River State, with a homogenous population of over 350,000 people. The community is surrounded by tropical rain forests with pockets of swamps and undeveloped plots of land overgrown with weeds and bushes within the town, all of which provide convenient hideouts and breeding sites for mosquitoes, the vectors of malaria, yellow fever, filariasis, etc. The six months study was undertaken between the months of February and July in 2010.

Parasitological Field Survey

During the field survey, mosquito larvae were collected fortnightly (early and late month) from deep streams. Also two batches (28 each batch) of water samples were collected in February and July, respectively, from various breeding sites for physico-chemical analyses. Both temperature and depth of the water were also measured on site. The water samples were analyzed in the Oceanography Departmental Laboratory of the University of Calabar, Calabar. The amount of monthly rainfall in the area was measured. Statistical analyses were carried out to determine the relationship between physico-chemical properties and the larval population.

Collection of Larvae and Pupae of Mosquitoes

The dipper tool method described by WHO (1992a) and WHO (1992b) was used to collect larvae and pupae of mosquitoes in deep wells and streams. The improvised dipper tool was gently lowered into the water at an angle of 45^o, such that only one side is below the water surface, and was used to cautiously skim along the water of the breeding sites, after which it was lifted up making sure that the water in it with the larvae and pupae did not pour out. With the aid of a dropper, they were sucked into the preservative. The skimming was repeated after the disturbed water had settled down and the larvae and pupae came up to the surface again. Collections from well were carried out still with a dipper tool whose handle had been extended by tying a long stick to it. In water bodies covered with floating vegetation, the vegetation or debris were first cleared with the dipper tool before collecting the larvae and pupae as described above.

Mosquito Larvae Identification

Morphometric identification methods of Gilles and Meillon (1968), Ribeiro and Ramos (2003) were used to identify the larvae. The anophelines showed the absence of breeding tube (siphon) at the last abdominal segment, possession of median tergal plates with a pair of palmate or "float" hairs on the 1^{st} - 8^{th} abdominal segment and only a pair of the thorax, and the presence of laterally placed tufts of spines called pecten on the 8^{th} abdominal segment.

The larvae of the two identified *Anopheles* species were distinguished from each other by the possession of three types of anopheline larval hairs, namely the shoulder, mesopleural and palmate hairs. There were sutural hair and absence of pigmentation on the clypeus (of *Anopheles gambiae*). While *Anopheles funestus* possessed four types of anopheline larval hairs, the shoulder, mesopleural, palmate and sutural hairs, and two distinct transverse bands of dark colour on the clypeus.

Determination of Physico-chemical Parameters of Water Samples from the Breeding Sites

Twenty eight (i.e., 2 sets of 14) water samples collected from mosquito breeding sites in the study area and labeled appropriately were analyzed for dissolved oxygen, carbon dioxide, temperature, pH, conductivity, turbidity, depth and metals using Dissolved Oxygen Kit, Mercury Thermometer, pH meter, Conductivity meter, sacki disc, and Atomic Absorption Spectrophotometer (for metals) respectively.

Measurement of Rainfall

Fourteen improvised rain gauges were constructed from measuring cylinders (plastic), funnel (plastic), mosquito net and black paper (Ramlingam *et al*., 1977). The net played the role of filter while the black paper was used to check evaporation of the water already in the cylinder.
In each village, the set-up was strategically placed undisturbed place where rain water can collect in it. A supervisor living around the place was appointed to monitor it. Readings were taken on the last day of every month for six months.

Statistical Analyses

The various data gathered during the study were subjected to statistical analysis using T-test to compare seasonal variations as well as equality of means, and Pearson correlation to compare physico-chemical parameters with larval population.

RESULTS

Mosquito larvae (7,247) were collected from the 28 breeding sites during the 6-months study. Of this, 652 (9.0%) were anophelines while the rest 6,595 (91.0%) were culicine larvae. Of the 652 anopheline larvae, 167 (25.61%) were identified as *An. funestus* and the other 485 (74.39%) were *An. gambiae* sensu strict .

Fig 1a: The different breeding sites, their physical conditions, the types and numbers of mosquito larvae caught per month during dry season.

LOCATION OF SITE AND ITS CODE	SAMPLE CODE	TYPE OF BREEDING SITTE	PHYSICAL APPEARANCE OF THE BREEDING SITE	DRY SEASON																	
				SUB-FAMILIES AND NUMBERS																	
				FEBRUARY						MARCH						APRIL					
				EARLY			LATE			EARLY			LATE			EARLY			LATE		
				An	Cu	Ae	An	Cu	Ae	An	Cu	Ae	An	Cu	Ae	An	Cu	Ae	An	Cu	Ae
LEKPANKOM	1	Pond	Dirty and exposed	0	8	13	0	4	8	0									0	4	5
(LE)	2	Pond	Dirty with vegetation cover	0	5	11	0	5	14	0	5	11	0	4	8	0	2	9	2	7	9
AKUGOM-EBE	1	Pond	Dirty with vegetation cover	0	11	3	0	13	2	0	11	5	0	3	3	2	4	2	4	8	3
(AK)	2	Palm fruit mortar	Dirty and exposed	0	3	16	0	2	12	0	3	13	0	2	16	0	4	12	0	9	9
EPENTI	1	Spring	Clean with vegetation cover	0	16	8	0	8	2	0	3	6	2	12	2	4	3	2	5	11	6
(EP)	2	Sream	Exposed	0	4	2	0	1	13	0	2	0							0	1	2
AFREKPE	1	Drinking pot	Clean but uncovered	0	18	0	0	13	0	0	5	0	0	7	0	0	5	0	0	6	0
(AF)	2	Stream	Clean with vegetation cover	0	12	16	0	12	18	0	7	10	0	3	9	3	4	7	0	9	9
EPENTI BEACH	1	River bank	Clean and exposed	0	2	0	0	7	0	0	6	0	2	5	0	1	4	0	2	2	0
(EB)	2	Stream	Dirty with no vegetation cover	0	19	2	0	15	3	0	17	2	0	12	2	0	6	4	0	13	2
OKONOBONGHA	1	Pond	Dirty with no vegetation cover	0	10	8	0	12	20	0	8	12	0	4	6	0	8	4	0	9	0
(OK)	2	Well	Dirty with no vegetation cover	0	12	4	0	10	3	0	9	5	0	6	4	0	4	3	2	8	0
EDANG	1	Gutter	Dirty with no vegetation cover	0	5	18	0	11	10	0	11	14	0	10	12	0	9	2	0	10	4
(ED)	2	Pond	Dirty with no vegetation cover	0	7	17	0	5	13	0									0	8	6
AKUGOM-NKPATU	1	Sream	Clean with vegetation cover	0	8	4	0	11	2	0	2	4	1	7	4	0	5	2	2	9	2
(AN)	2	Pond	Dirty with vegetation cover	0	10	12	0	6	13	0	8	14	0	4	3	0	7	14	0	9	9
AJERE	1	Pot hole	Dirty but no vegation cover	0	10	14	0	5	13		4	7	0	6	2	0	6	3	0	7	2
(AJ)	2	Well	Dirty but no vegation cover	0	9	12	0	10	14	0	12	6	0	5	1	0	3	6	0	10	6
AJERE BEACH	1	River bank	Clean and exposed	0	6	0	0	6	3	0	3	1	4	2	0	2	3	0	3	4	0
(AB)	2	Sream	Dirty with vegetation cover	0	6	3	0	5	16	0	7	10	0	4	9	0	3	5	0	7	9
NTAN	1	Pond	Dirty with vegetation cover	0	4	20	0	14	9	0	3	13	0	8	4	0	5	4	0	12	9
(NT)	2	Drinking pot	Clean and uncovered	0	13	0	0	10	0	0	12	0	0	8	0	0	3	0	0	13	0
NTAMKPO-NTAN	1	Pond	Dirty with vegetation cover	0	4	11	0	3	8	0	4	6	0	2	10	0	5	9		9	9
(NN)	2	Spring	Clean with vegetation cover	0	12	18	0	8	15	1	6	3	0	5	2	0	6	5	2	11	3
KEKOMKOLO	1	Pond	Clean with vegetation cover	0	14	3	0	16	4	0	10	2	3	8	3	4	15	4	4	7	2
(KK)	2	Cistern	Clean, no vegetation cover	0	18	5	0	21	6	0	8	1	2	4	1	3	2	3	3	12	6
NEW EKORI	1	Pond	Dirty, no vegetation cover	0	3	21	0	2	13	0	4	9	0	3	8	0	3	10	0	4	9
(NE)	2	Sewer	Dirty with stinking odour		10	6	0	9	15	0									0	5	8

Fig 1b: The different breeding sites, their physical conditions, the types and numbers of mosquito larvae caught per month during rainy season.

LOCATION OF SITE AND ITS CODE	SAMPLE CODE	TYPE OF BREEDING SITTE	PHYSICAL APPEARANCE OF THE BREEDING SITE	RAINY SEASON																	
				SUB-FAMILIES AND NUMBERS																	
				MAY						JUNE						JULY					
				EARLY			LATE			EARLY			LATE			EARLY			LATE		
				An	Cu	Ae	An	Cu	Ae	An	Cu	Ae	An	Cu	Ae	An	Cu	Ae	An	Cu	Ae
LEKPANKOM	1	Pond	Dirty and exposed	0	10	16	0	13	40	0	16	112	0	9	150	0	8	13	0	11	10
(LE)	2	Pond	Dirty with vegetation cover	0	18	10	0	11	0	0	8	32	0	12	30	0	4	10	0	9	13
AKUGOM-EBE	1	Pond	Dirty with vegetation cover	12	3	0	8	0	48	18	7	0	27	0	0	8	0	4	11	0	2
(AK)	2	Palm fruit mortar	Dirty and exposed	0	8	14	0	14	6	0	18	142	0	13	268	0	7	10	0	6	15
EPENTI	1	Spring	Clean with vegetation cover	14	8	5	12	0	0	20	8	0	30	0	0	10	7	3	9	4	3
(EP)	2	Sream	Exposed	0	8	13	0	4	17	0	12	16	0	15	21	0	6	7	0	10	7
AFREKPE	1	Drinking pot	Clean but uncovered	0	16	1	0	13	0	0	21	0	0	19	0	0	18	0	0	4	0
(AF)	2	Stream	Clean with vegetation cover	0	10	7	0	15	4	0	10	35	0	20	32	0	6	10	0	6	5
EPENTI BEACH	1	River bank	Clean and exposed	9	2	0	7	5	0	10	4	0	16	6	0	4	6	0	5	0	2
(EB)	2	Stream	Dirty with no vegetation cover	14	1	2	10	0	0	10	18	8	19	4	2	6	8	5	8	4	3
OKONOBONGHA	1	Pond	Dirty with no vegetation cover	0	11	18	0	13	40	0	24	13	0	32	11	0	6	6	0	18	10
(OK)	2	Well	Dirty with no vegetation cover	10	0	0	6	11	0	8	15	0	22	9	0	5	7	5	6	4	0
EDANG	1	Gutter	Dirty with no vegetation cover	0	13	14	0	14	3	0	13	8	0	18	12	0	9	11	0	11	15
(ED)	2	Pond	Dirty with no vegetation cover	0	13	9	0	26	9	0	20	30	0	21	28	0	10	8	0	10	9
AKUGOM-NKPATU	1	Sream	Clean with vegetation cover	12	5	2	8	2	8	11	6	0	8	11	0	8	6	5	5	2	9
(AN)	2	Pond	Dirty with vegetation cover	0	10	5	0	28	0	0	17	5	0	10	16	0	12	10	0	11	16
AJERE	1	Pot hole	Dirty but no vegation cover	0	7	10	0	16	9	0	15	6	0	18	13	0	8	9	0	12	10
(AJ)	2	Well	Dirty but no vegation cover	0	11	5	0	0	12	0	11	20	0	16	26	0	4	8	0	13	6
AJERE BEACH	1	River bank	Clean and exposed	0	13	2	6	0	0	16	4	0	19	10	0	5	13	0	5	3	2
(AB)	2	Sream	Dirty with vegetation cover	0	16	1	0	11	23	0	14	30	0	15	29	0	7	8	0	6	11
NTAN	1	Pond	Dirty with vegetation cover	0	11	6	0	10	16	0	12	19	0	16	25	0	14	13	0	9	12
(NT)	2	Drinking pot	Clean and uncovered	0	13	2	0	17	0	0	25	0	0	30	0	0	8	0	0	3	0
NTAMKPO-NTAN	1	Pond	Dirty with vegetation cover	0	10	14	0	19	30	0	16	10	0	15	13	0	8	0	0	3	0
(NN)	2	Spring	Clean with vegetation cover	0	8	13	0	16	11	0	28	30	0	22	28	2	6	11	0	12	10
KEKOMKOLO	1	Pond	Clean with vegetation cover	10	3	2	6	3	0	6	8	3	22	0	0	4	6	2	12	4	2
(KK)	2	Cistern	Clean, no vegetation cover	7	2	1	9	0	0	12	7	5	14	2	8	5	7	4	4	3	3
NEW EKORI	1	Pond	Dirty, no vegetation cover	0	14	3	0	3	40	0	0	150	0	0	348	0	11	20	0	12	14
(NE)	2	Sewer	Dirty with stinking odour	0	6	12	0	9	18	0	24	31	0	22	34	0	12	11	0	12	11

Tables 1a and 1b present the types of the breeding sites surveyed during study period, their true physical appearances, the types of mosquito larvae and their total numbers per month per village each month

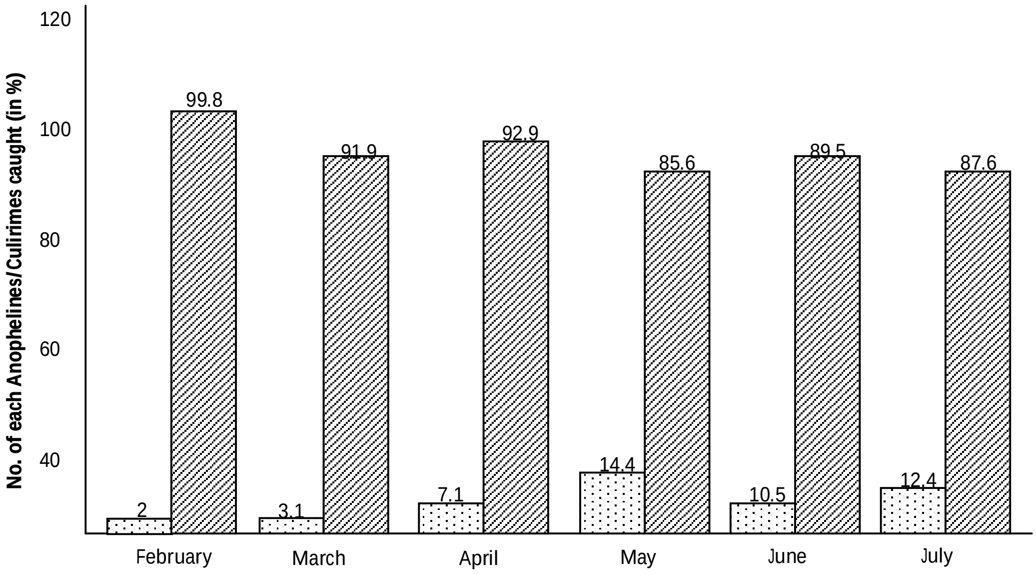

Figure 2: Summary of monthly larvae collections for the six months study period

Figure 2 depicts the percentage representation of the monthly distribution of mosquito larvae collected from February to July, and it shows that for anophelines, only 2 (0.3%) were caught in February, 18 (2.76%) in March, 46 (7.60%) in April, 168 (25.76%) in May, 298 (45.71%) in June, and in July 120 (18.40%). High collections started in the month of May, with a peak in June, and dropped drastically in July (Figure 1). In the monthly summary of culicine caught, February had a total of 1,019 (15.44%), March had 572 (8.67%), April had 610 (9.25%), May had 999 (15.15%) larvae, June and July, 2,545 (38.59%) and 850 (12.89%) larvae, respectively. May and June had the highest numbers of larvae.

Table 2: Seasonal mosquito larvae collections per village per village (Dry and Rainy seasons)

VILLAGE	SEASONAL COLLECTION								GRAND TOTAL
	DRY SEASON				RAINY SEASON				
	FEB.	MARCH	APRIL	TOTAL	MAY	JUNE	JULY	TOTAL	
LEKPANKOM (LE)	0	33	74	107	2	130	466	598	705
AKUGOM-EBE (AK)	2	61	84	147	88	85	492	665	812
EPENTI (EP)	6	49	35	90	400	94	100	594	384
AFREKPE (AF)	5	86	60	151	0	175	108	283	434
EPENTI BEACH (EB)	5	93	13	111	120	73	24	217	328
OKONOBONGHA (OK)	0	82	79	161	59	157	103	319	480
EDANG(ED)	0	58	86	144	0	192	163	355	499
AKUGOM-NKPATU (AN)	3	68	73	144	54	138	93	285	429
AJERE (AJ)	0	70	78	148	0	148	142	290	438
AJERE-BEACH (AB)	6	45	57	108	62	109	128	299	407
KEKOMKOLO (KK)	0	80	50	130	0	193	102	295	425
NTAN (NT)	0	55	87	142	0	187	218	405	547
NTAMKPO-NTAN (NN)	12	116	32	160	128	64	38	230	390
NEW EKORI (NE)	0	34	92	126	0	134	709	843	969
TOTAL	39 (2.1)	930 (50.8)	900 (49.2)	1873 (25.8)	613 (11.4)	1879 (39.5)	2886 (39.8)	5678 (78.3)	7247

In terms of the two seasons, that is, dry season (February to early April) and Rainy season (late April to July), a total of 1,869 (25.79%) larvae were collected in the dry season. Of this number, only 39 (2.09%) were anopheline (i.e. 14 (35.90%) *An. funestus* and 25 (64.10%) *An. gambiae*). Culicines dominated with 1,830 (97.91%).

Table 3: Distribution of adult anopheles species in the study area

VILLAGE	MALE ANOPHELES			FEMALE ANOPHELES		
	gambiae	funestus	Total	gambiae	funestus	Total
LEKPANKOM (LE)	4	2	6	21	3	24
AKUGOM-EBE (AK)	5	1	6	17	1	18
EPENTI (EP)	5	2	7	16	4	20
AFREPE (AF)	2	0	2	18	4	22
EPENTI BEACH (EB)	4	1	5	15	0	15
OKONOBONGHA (OK)	5	1	6	14	3	17
EDANG (ED)	3	0	3	13	2	15
AKUGOM-NKPATU (AN)	6	0	6	19	1	20
AJERE (AJ)	6	1	7	1	2	13
AJERE-BEACH (AB)	5	0	5	22	0	22
KEKOMKOLO (KK)	6	0	6	11	1	12
NTAN (NT)	6	1	7	13	2	15
NTAMKPO NTAN (NN)	7	2	9	1	5	16
NEW EKORI (NE)	5	0	5	23	2	25
TOTAL	69	11	80	224	30	254

Besides the numbers of each species of *Anopheles* mosquito larvae collected during the study, Table 3 also gives the sexes and their numbers. The rainy season collections on the other hand, recorded 5,678 (78.3%) larvae out of which 613 (11.39%) were anophelines, i.e., 153 (24.96%) *An. funestus* and 460 (75.04%) *An. gambiae*), and 4,765 (88.61%) were culicines.

Tables 4a and 4b depict the variable values of physico-chemical parameters of the various mosquito breeding sites in Ekori, taken during the dry and rainy seasons of the study period. Variations were observed between the physico-chemical parameters of water samples obtained during the dry season and those of the rainy season. For example, the pH, which was lightly alkaline in the water samples of the dry season, became completely alkaline in those obtained during the rainy season. Similarly, the values of DO varied with the seasons and locations of the breeding sites. Other parameters like nitrate, phosphate, chloride, etc., though they were under tolerable limit also fluctuated widely according to seasons and site locations. High levels of DO were observed mostly in water samples collected during the rainy season, and could probably be due to absence of pollutants in those sites where weeds were present and their photosynthetic activities had helped to aerate the water. Polluted sites on the other hand showed less DO and high CO_2 values. The most common contaminants found in some habitats during this study were agricultural pesticides, laundry detergents, oils and other petroleum products, and all the habitats with these pollutants had very scanty numbers of mosquito larvae. Some larvivorous organisms such as water spiders, water boatman and other forms of water insects and fish fries were also observed in some habitats during this study.

Table 4a: Physico-chemical properties of the water samples collected in February (the peak of dry season) from the mosquito breeding/oviposition sites

Village	Physico-chemical measurements for Dry season (February)										
	HCO_3^- mg/l	Cl^- mg/l	NO_3-N mg/l	DO mg/l	CO_2 mg/l	pH pH	Cond. µs/cm	CO_3^{2-} mg/l	Turb. FTU	Temp. °C	Depth M
LE	54.9	290	2.5	2.5	0	6.5	806	35.1	0	29.6	0.3
	85.4	258.7	1.4	4	0	6.3	719	54.6	27	23	0.3
AK	170.9	682.2	1.3	4.2	0	6.7	1896	109.1	57	20.2	0.3
	97.6	381	2.1	3.6	1	7.2	106	62.2	17	41.3	0.1
EP	12.2	30.9	1.4	4	1.5	6.8	86.3	7.8	5	18.5	0.2
	30.5	34.7	1.9	1.4	1	7.2	152	19.5	10	20.4	0.3
AF	13.3	34.3	1.3	3.7	1.6	6.7	93.4	8.4	5	18.8	0.3
	29.6	30.6	1.8	1.6	1.1	7.8	163	17.8	12	24.2	0.5
EB	18.2	76.6	2.9	1	1	7.2	213	11.7	22	19.6	1.6
	24.4	38.9	2.6	1.7	0	6.5	108	15.6	24	23.8	0.3
OK	36.4	45.2	1.9	1.8	1.5	6.7	75.2	12.8	18	26.2	0.3
	45.3	36	2.8	2.6	1	7.3	672	48.7	14	20.3	1.3
ED	24.4	41.4	1.9	3.7	1	6.7	115	18.6	89	25.2	0.5
	48.8	90.3	2.6	2.5	1	7.2	251	31.2	22	38.6	0.2
AN	79.3	33	1.8	4.2	0	7	918	50.7	36	23.6	0.2
	24.9	201.8	1.8	3	0	6.9	561	15.6	18	28.7	0.3
AJ	61	169.4	2.8	0.8	0	7.4	471	89	21	31.6	0.1
	79.3	263	2.1	3.8	1	6.1	731	50.7	15	19.4	1.2
AB	18.3	42.4	1.4	3.3	2	6.9	118	11.7	40.7	16.9	1
	48.8	112.2	1.9	1.5	1.5	6.8	312	31.2	84	20.1	1.3
NT	73.2	110.4	2.2	1.6	1	7.1	307	46.8	44	24.1	0.2
	183	561.6	2	0.4	1.5	6.8	156	117	49.4	19.2	0.2
NN	36.6	83.1	1.2	1.6	1	6.8	231	23.4	75	27.4	0.2
	78.8	92.8	2.4	3.3	1	7.1	258	31.2	4	21.6	0.2
KK	36.6	225	1.7	3.8	1	7	625	23.4	5	26.4	0.3
	48.4	225.2	1.3	3.8	0	7.4	626	31.2	10	23.5	0.4
NE	146.4	320.2	1.3	0.6	0	7.1	890	93.6	89	27.6	0.9
	18.3	27.4	1.3	3.6	3.3	7.8	76.3	11.7	10	31.7	0

DISCUSSION

This study has shown that different water bodies including even domestic drinking water in pots (clay or plastic types) constitute the common temporary and permanent breeding sites for mosquitoes in the area, from which 7,247 mosquito larvae were caught. In line with the observed seasonal variations in the physcico-chemical parameters of the mosquito breeding sites, there was a corresponding variation in the mosquito larvae abundance as well as mosquito species in the various sites. Thus, normal DO favoured anopheline mosquito larvae abundance while low levels of DO enhanced the abundance of culicine mosquito larvae which do not normally discriminate against breeding sites because they have the capacity to breed even in habitats with very harsh conditions. The influence of fluctuating physico-chemical parameters on the mosquito larval abundance has confirmed the findings of *Patra et al*., (2010) on the seasonal variation in physico-chemical parameters of chilika Lake in India.

Table 4b: Result of Physico-chemical measurements of the water samples collected in February (the peak of dry season) the mosquito breeding/oviposition sites

Village	Physico-chemical measurements for Dry season (February)										
	HCO_3^- mg/l	Cl^- mg/l	NO_3-N mg/l	DO mg/l	CO_2 mg/l	pH pH	Cond. µs/cm	CO_3^{2-} mg/l	Turb. FTU	Temp. °C	Depth M
LE	51.7	280	2.6	3.6	1	7.5	810	35.6	0	19.4	0.5
	82.3	248.4	1.4	5.8	0.2	7.7	717	55.2	28	16.4	0.4
AK	161.8	598.2	1.3	5.6	0.1	5.8	1899	110.8	56.2	19.2	0.5
	113.2	292.6	2	4.7	1.8	7.6	24	63.8	16	20.4	0.3
EP	18.6	31.8	1.8	5.1	1.6	7.4	88.6	8.2	4	16.2	0.5
	26.4	32.7	1.3	2.1	1.5	7.6	154.2	20.5	8	17.3	0.6
AF	14.4	33.8	1.4	4.2	1.9	7.7	95.3	9.3	4	15.7	0.5
	27.3	28.6	3.6	2.5	1.4	7	164.3	16.7	10	19.4	0.4
EB	17.3	722.3	2.9	2.2	1.2	7.1	214	11.5	21	16.1	2.1
	26.4	36.6	1.7	1.9	0	6.8	110	16.6	22	19.8	0.5
OK	34.5	50.1	2.8	1.9	1.7	6.9	76.8	12.4	11	21.6	0.5
	43.8	36.7	1.7	2.3	1.5	7.5	675	60.5	13	17.3	1.9
ED	26.3	40.6	2.5	4.2	1.6	7	125	17.4	79	21.3	0.3
	49.9	89.4	1.4	2.8	1.3	7.8	255	32.1	13	18.1	0.4
AN	78.4	35	1.6	4.7	0	7.1	921	51.5	28	19.6	0.5
	26.1	202.8	2.7	3.6	0	7	563	18.2	16	23.4	0.4
AJ	63	169.9	2.1	1.2	1	7.6	474	39.8	17	25.1	0.1
	79.9	263.8	1.2	4.3	1.2	6.8	735	52.6	12	14.7	1.8
AB	20	38.4	2	3.7	1.6	6.9	120	11.9	39.6	15.3	1.5
	48.6	113.4	2.2	2	2.1	7.7	316	33	18	19.4	0.5
NT	75	108.3	2.1	1.8	2.2	7.5	310	48.9	40	21.2	0.4
	183.5	551.9	1.3	1	2	7	150	118.1	49.3	14.6	0.6
NN	37.8	82.8	2.5	1.9	5.4	7.2	232.3	25.6	71	20.1	0.5
	79.6	90.8	2	4.7	5.5	7.4	259	34.4	2.5	16.5	0.6
KK	37.8	222.2	1.4	4.5	1.7	7.1	626	25.7	3	22.1	0.6
	48.8	224.1	1.5	4.6	0	7.6	627.2	33.1	7	19.8	0.6
NE	146.2	330.2	1.6	1.4	0	7	902	90.2	88	22.6	0.5
	18.9	26.5	2	4.2	2.6	6.2	78.1	11.9	6.2	27.4	0.1

It could also be suggested that the same impact may have been made by fluctuations in the levels of temperature, carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) pH, nitrate ion (NO_3^-), chlorine ion, and turbidity and the depth of water, as well as by the presence or absence of vegetation cover, thereby resulting in the variation of mosquito larval densities in the different breeding sites. Compared to the culicines, the anopheline mosquito larval densities generally tended to be relatively low in habitats that showed low DO perhaps due to pollution, except in fresh and clean water habitats such as ponds with vegetation cover, streams, springs, cisterns, and clean river banks and drinking water in pots. This implies that the abundance and types (or species) of mosquito larvae in a given habitat depend to some extent upon the type of habitat, location, dissolved constituents and other environmental attributes such as presence and absence of vegetation cover within and around the habitats. Similar observations have been reported by Mustapha and Omotosho (2005) in their study of the physico-chemical properties of Moro Lake in Kwara State, Nigeria. However, the observed influence of physico-chemical and biological parameters on the mosquito larval density and the intra-stream variation of the larval abundance of anopheline species (*An. gambiae* s.s complex and *An. funestus*) which also resulted from physical and vegetational variability of the habitats, have both agreed with the findings of Overgaard *et al*., (2003) on the characteristics of *An. minimus* (Diptera: *Culicidae*) larval habitats in Northern Thailand, and those of Robert *et al*. (1998) on the ecology of *An. arabiensis* (Diplera: *Culicidae*) in the market Garden wells in Urban Dakar, Senegal.

Statistical Analysis of the relation between physico-chemical parameters and mosquito larval abundance showed significance ($P < 0.05$). It was also found that the high abundance of the two species of anopheles (*An. gambiae* and *An. funestus*) in Ekori, were favoured by water bodies that had warm temperature (between 28 and 30°C); clean and clear shallow waters with high DO content, low concentration of NO_3^- and CL^-; and presence of water lettuce vegetation within or around the habitat (WHO, 1992a). Correspondingly, breeding sites or habitat with physico-chemical and biological measurements contrary to those mentioned above may have impaired oviposition, development and survival of the gravid female mosquitoes generally, as in the case of anophelines, hence, low density of anopheline mosquito larvae.

The low mosquito larvae density observed in habitats polluted with agricultural pesticides, laundry detergents, oils and other petroleum products, thick canopy of vegetation cover could be attributed to the presence of these contaminants. The later may have altered the aesthetics of the habitats thereby making it unfavorable for successful oviposition by gravid females. This finding has agreed with earlier reports by Allan (1995), Teng *et al*. (1998) and Murihead-Thomson (1940a) who explained pollutants such as those mentioned above, and thick canopy constitute a limiting factor for mosquito larvae abundance.

However, a t-test analysis to compare the influence of seasonal variations on the available mosquito species and larval population generally, proved significant ($P < 0.05$). The result of these analyses showed that seasonal fluctuations in the physico-chemical parameters of the breeding sites were significant enough to bring about observable variations in the larvae abundance either within or between seasons. This may be true because in the month of March, for instance, a drastic drop in larval density was observed perhaps due to the drying up of some breeding sites following absence of rain. The presence of larvivorous organisms in some mosquito habitats may have equally contributed to the low mosquito larval densities recorded in those habitats.

CONCLUSION

Besides identifying the different mosquito breeding sites in the area and their physical, chemical and biological conditions, this study has also, established the effect of biophysico-chemical parameters on mosquito larval population or density, as well as on the mosquito species (*Anopheles gambiae* and *Anopheles funestus*) transmitting malaria in Ekori.

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REFERENCES

Allan, J. D. (1995). *Stream Ecology*: *Structure and Function of Running waters.* Champman & Hall, London

Bourne, D (2003). “Permanent” and “Transient” waters. *North American Mosquito Habitats Environment.*

Despommier, D., Gwadz, R. W., Hotez, P. J., Knirsch, C. A. (2000). *Malaria: Parasitic Diseases*. New York: Apple Trees.

Despommier, D. and Chen, X. J. (2003). Medical Ecology. *Infectious Diseases*. New York: Apple Trees Publications.

Gilles, M. T. and Meillon, B. D. (1968). The *Anophelines* of Africa (Ethiopian Zoogeographical Region). South Africa. *Publication of South African Institute of Medical Research*. 54:1-19, 131-224.

MAC, (2003). Larval Mosquito Habitats Wakefield. *Bulletin of Stedman Mosquito Abatement Center*.

Mustapha, M. K. and Omotosho, J. S. (2005). Assessment of the physico-chemical properties of Moro Lake, Kwara State, Nigeria. *African Journal of Applied Zoology & Environmental Ecology,* 7:73-77.

Muirhead-Thomson, R. C. (1940a). Studies on the behavior of *Anopheline minimus*. Part 1. The selection of the breeding place and the influence of light and shades. *India Journal of Malaria Institute*. 3:265-394

NJMCA, (2003). Larval Habitats of Mosquitoes Florida, *Bulletin of Jersey Mosquito Homepage*. New Jersey: Mosquito Control Association Wing Beats.

Overgaard, J., Tsudo, Y., Sumonkerd, W., Takagi, M., (2002). Characteristics of *Anopheles minimus* (Diptera: *Culicidae*) larval habitats in Northern Thailand. *Environmental Entomology*. 31 (1), 134-141.

Pasche, E. (1980). Silicon in the physiological ecology of phytoplanktons. *Studies in Ecology I* (editor: I. Moris) Oxford. Blackwells. pp 259-284

Patra, A. P., Patra, J. K., Mahapatra, N. K., Das, S. and Swain, G. C. (2010). Seasonal variation in physico-chemical parameters of Chilika Lake after opening of new mouth near Gabakunda, Orissa, India. *World Journal of Fish and marine Sciences,* 2(2):109-117.

Ribeiro, H. and Ramos, C. (2003). *Identification Keys of the Mosquitoes* (Diptera: *Culicidae*) *of the Continental Portugal, Acores and Madeira*. Lisboa: Madeira Publishers.

Ramlingam, S. T., Pereira, S. and Pereira, C. T. (1977). The Mosquitoes: *Modern Biology for Secondary Schools*. Singapore: FEP International Private Publishers Limited.

Robert, V., Awono-Anbene, H. P., Thioulouse, J. (1998). Ecology of larval mosquitoes, with special reference to *Anopheles arabiensis* (Diptera: *Culicidae*) in Market-Garden wells in Urban Dakar, Senegal. *Journal of Medical Entomology*. 35 (6): 948-955.

Sidneit, M. T., Fakio, A. L. T., Maria, C. R., Francises, A. E. and Adaunto, F. (1992). Seasonal variations of some limnological factors of lagoa do Guarana, a varzea lake of the Rio Parana State of Mato Groso do Sul, Brazil. *Revised Hydrobiology,* 25:269-276.

Teng, H. J., Wu, Y. L., Wang, S. J., and Lin, C., (1998). Effect of Environmental factors on abundance of *Anopheles minimus* (Diptera: *Culicidae*) larvae and their seasonal fluctuation in Thailand, Japan. *Environmental Entomology*. 27:324-328.

Williams, N. V. (1990).Studies on aquatic pulmonates snails in Central Africa, I. Field distribution in relation to water chemistry. *Malacologia* 10:153-162.

WHO, 1992a. *Entomological Field Techniniques for Malaria Control*. Part 1, Tutor's Guide, Geneva..

WHO, 1992b. *Entomological Field Techniniques for Malaria Control*. Part 2, Tutor's Guide, Geneva.