Spartial Variation in Physicochemical Characteristics of Wetland Rice Fields Mosquito Larval Habitats in Minna, North Central Nigeria

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***Abstract*—**Selected physicochemical parameters of mosquito larval habitats were studied in the wetland rice agro ecosystem in Minna, North Central Nigeria. Rice field's larval habitats were randomly selected from four widely spaced sites located in Fadikpe, Bosso, Chanchaga, and Maitumbi areas of the city. Water samples collected from these habitats were analyzed for physicochemical parameters. The results indicated variations in some physicochemical parameters among rice fields in different locations. Statistical analysis using ANOVA shows that Temperature, P^H, Turbidity, Alkalinity, Hardness, Phosphate, Carbon dioxide, Chloride, Dissolved Oxygen, and Biochemical Oxygen Demand were not significantly different ($P>0.05$) among the rice fields. However, conductivity, Sodium, Nitrate, and Ammonia varied significantly ($P<0.05$) among the rice fields. This study provides information on Mosquito ecology in relation to prevailing physicochemical characteristics of breeding habitats, which may have implication for vector distribution and disease transmission.

***Keywords*—**Larval habitats, Physicochemical, Rice field, Wetland.

I. Introduction

LARGE-scale environmental modification concomitant with processes such as forest clearing, irrigation development, human settlement and rice cultivation inevitably result in changes in surface water quality, and affect the survival of mosquito's species breeding in surface water habitat.

Mosquitoes exploit all kinds of lentic aquatic habitats for breeding, prevailing physicochemical parameters in these habitats are important factors for survival and development of mosquitoes. Larvae of *Anopheles* mosquitoes have been found to thrive in aquatic bodies such as Fresh water marshes, Mangrove swamp, Rice fields, grassy ditches, the edges of streams and rivers and small temporary rain pools [1]. Many species prefer habitats with vegetation while some breed in open, sunlit pools. A few species breed in tree holes or leaf axils of some plants [2]. However, high water current and flooding have been reported to lead to *Anopheles* species larvae death due to reduction in oxygen tension causing physical harm to larvae [3]. Water of near neutral pH 6.8 – 7.2 was found most optimal for the weakening of the egg shells for first instars stage to emerge [4].

The attractiveness of gravid females for oviposition largely depends on the interactions between the physicochemical parameters and also on the availability of suitable water bodies [5]. Mosquitos' species differs in the type of aquatic habitats they prefer for oviposition based on location, the physicochemical conditions of water body, and the presence of potential predators [6]-[7]. Physicochemical factors that influence oviposition, survival and the spartio-temporal distribution of mosquito species includes Salts, Dissolved organic and inorganic matter, Degree of eutrophication, Turbidity, Presence of suspended mud, Presence or absence of plants, Temperature, Light, Shade and Hydrogen ion concentration [8].

Rice agro- ecosystem perfectly fit the ecological requirement of mosquitoes vectors and specifically suitable for pioneer species, members of the *Anopheles gambiae* complex [9]. Physicochemical factors of Rice field agro- ecosystem also impacted significantly on temporal distribution and abundance of mosquito species [10]. Nitrogenous fertilizer could enhance the mosquito larvae population in Rice field [11]. [12]. found that the height of the rice plant, water temperature, dissolved Oxygen, Ammonia, and Nitrate Nitrogen strongly influence the abundance of immature mosquitoes in India. Application of synthetic Nitrogen fertilizers to the Rice field was followed by rise in concentration of Ammonia Nitrogen and subsequent increase in Nitrate Nitrogen level in the Rice field water which can increase the density of Mosquito larvae [12].

The question of physicochemical content of potential water has been investigated by several authors, but no precise conclusions were drawn beyond the fact that it can be highly variable.

II. Materials And Methods

A. Study Area

The study was carried out in Minna, the Capital of Niger State, North- central Nigeria. Minna, is located within longitude $6^o33'$E and latitude 9^0 37'N, covering a land area of $88km^2$ with an estimated human population of 1.2 million. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20^0C, 61.00% and 1334.00mm, respectively. The climate presents two distinct

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seasons; a rainy season between May and October, and a dry season between November and April. The vegetation in the area is typically grass dominated Savannah with scattered trees.

The study covers four rice fields in four widely spaced sites located in Fadikpe, Bosso, Maitumbi and Chanchaga areas of the city. The ecotype of all these four sites is that of Fadama wetland rice agro-ecosystem with temporary stagnant fresh water pools of various sizes constituted by rains.

B. Collection and Fixing of Water Samples for Physicochemical Analyses

Water samples were collected concurrently with larval sampling from the four Rice fields investigated, between 08:00 – 10:00hours at depths of about 5cm on each sampling day. From each sampling point 125ml of water was collected to make 500ml per sampling site using 500ml capacity specimen bottles to ensure adequate representation. The water was fixed immediately using the procedures described by [13] in preparation for laboratory analysis. Water Temperature, pH and Conductivity were determined at the sites during larval collection using ordinary mercury thermometer and conductivity meter respectively.

C. Physicochemical Analyses of Water from Rice field Larval Breeding Habitats

Water samples were analyzed for the following physicochemical parameters. Temperature, P^H, Conductivity, Turbidity, Alkalinity, Hardness, Potassium (K), sodium (N), phosphate (PO_4), Nitrate (NO_3), Ammonia (NH_4) , Carbon dioxide (CO_2) chloride (CL), Dissolved Oxygen (D.O) and Biochemical Oxygen Demand (B.O.D). Analyses of these parameters were carried out in Water Resources and Fisheries Technology (WAFT) Laboratory, Federal University of Technology, Minna, Nigeria.

D.Statistical Analysis

Data obtained were analyzed using SPSS Software (Version 20). The results of Physicochemical Variables of Rice field breeding habitats were analyzed using one-way ANOVA, and Duncan multiple range test was employed to separate their means, and P<0.05 was considered significant.

III. Results

Tables 1 provide details of physicochemical conditions of breeding water in the various rice fields in minna from which breeding water was collected. The results show that water samples from Chanchaga had the highest level of Ammonia (0.106 mg/l), but with equal values of Alkalinity and Phosphate in Maitumbi. The highest levels of Sodium (12.7mg/l), Dissolved Oxygen (D.O) (8mg/l) and Biochemical Oxygen Demand (B.O.D) (3.7mg/l) were also recorded in Maitumbi, but Bosso recorded the highest levels of pH (7.4), Conductivity (189.7µS/cm), Hardness (105mg/l) and Potassium (11.4mg/l). Turbidity (0.44 JTU), Nitrate (2.9mg/l), Chloride (28mg/l), and Carbon dioxide (CO_2) (2.62mg/l) were very high in Fadikpe.

Table 2 provides results for statistical analysis of the physicochemical characteristics (Mean±SE) of water in rice field's mosquito larval breeding habitats. Statistically, Temperature, pH, Turbidity, Alkalinity, Hardness, Phosphate, Ammonia, Carbon dioxide (CO_2), chloride, Dissolved oxygen (D.O), and Biochemical Oxygen Demand (B.O.D) were not significantly different (P>0.05) among the four rice fields breeding habitats. However, the same cannot be said for the remaining physicochemical parameters that varied significantly (P<0.05) among rice fields.

Conductivity in Bosso was significantly higher than recorded in Fadikpe, Chanchaga and Maitumbi. Potassium in Maitumbi and Chanchaga was not significantly different (P>0.05), but differ significantly (P<0.05) in Fadikpe and Bosso.

TABLE 1
MEAN PHYSICOCHEMICAL CHARACTERISTICS OF RICE FIELDS MOSQUITO LARVAL HABITATS IN MINNA

Physicochemical Parameters	FADIKPE	BOSSO	MTB	CHG	SUM	MEAN	SD	SE
Temperature (°C)	29.6	29.3	29.8	30.1	118.3	29.7	0.30	0.15
P[H]	7.1	7.4	7.1	7.3	28.9	7.2	0.15	0.08
Turbidity (J.T.U)	0.44	0.23	0.24	0.25	1.16	0.29	0.10	0.05
Conductivity (µS/Cm)	178	189.7	184.7	180.7	733.1	183.3	5.10	2.55
Alkalinity (mg/l)	117.8	116.9	118	118	470.7	117.7	0.50	0.25
Hardness (mg/l)	94	105	100	103.7	403.4	100.8	4.90	2.45
Phosphate (mg/l)	0.1	0.06	0.35	0.35	0.86	0.22	1.20	0.60
Sodium (mg/l)	11.3	12.3	12.7	10.2	46.5	11.6	1.10	0.50
Potassium (mg/l)	5.3	11.4	4.6	4.7	26	6.5	3.30	1.65
Nitrate (mg/l)	2.9	1.29	1.87	1.58	7.64	1.91	0.70	0.35
Ammonia (mg/l)	0.13	0.104	0.07	0.106	0.41	0.103	0.20	0.10
Carbon dioxide (mg/l)	2.62	1.35	2.2	1.24	7.41	1.85	0.70	0.36
Chloride (mg/l)	28	20.7	24	27.8	100.5	25.1	3.50	1.75
Dissolve Oxygen (mg/l)	7.3	7	8	7	29.3	7.3	0.50	0.25
Biochemical Oxygen demand (mg/l)	3	2.7	3.7	3	12.4	3.1	0.40	0.20	0.10

Note: ^{0}C= degree celcius, JTU= Jackson Turbidity Unit, µS/cm= micromhos per centimeter, mg/l = milligram per liter.

TABLE 4.2.2
PHYSICOCHEMICAL CHARACTERISTICS (MEAN ±SE) OF WATER IN RICE FIELDS MOSQUITO LARVAL BREEDING HABITATS IN MINNA

Physicochemical parameters	FADIKPE	BOSO	MTB	CHG	AGREEGATE
Temperature (°C)	29.66±0.13 ^{a}	29.37±0.34 ^{a}	29.80±0.129 ^{a}	29.87±0.49 ^{a}	29.68±0.14
PH	7.07±0.13 ^{a}	7.37±0.18 ^{a}	7.07±0.09 ^{a}	7.27±0.49 ^{a}	7.19±0.07
Turbidity (J.T.U)	0.44±2.00^a	0.33±0.15 ^{a}	0.24±0.00 ^{a}	0.25±0.01 ^{a}	0.79±0.51
Conductivity (µS/cm)	78.00±4.00 ^{ab}	189.66±2.33 ^{a}	184.66±2.19 ^{ab}	180.66±0.67 ^{a}	184.00±1.52
Alkalinity (mg/l)	117.17±2.17 ^{a}	116.80±3.43 ^{a}	118.33±4.41 ^{a}	118.33±3.33 ^{a}	118.66±1.54
Hardness (mg/l)	94.00±3.46 ^{a}	105.00±0.58 ^{a}	100.67±2.19 ^{a}	103.67±2.19 ^{a}	103.33±1.18
Phosphate (mg/l)	0.05±0.00 ^{a}	0.66±0.02 ^{a}	0.20±0.15 ^{a}	0.20±0.08 ^{a}	0.13±0.43
Sodium (mg/l)	11.30±0.76 ^{ab}	12.27±0.22 ^{a}	12.70±0.64 ^{a}	10.20±0.05 ^{b}	11.62±0.36
Potassium (mg/l)	5.30±13.12 ^{ab}	11.32±1.75 ^{a}	4.58±0.05 ^{a}	4.69±0.05 ^{a}	7.26±1.14
Nitrate (mg/l)	2.90±0.37 ^{a}	1.96±0.45 ^{a}	1.88±0.19 ^{a}	1.58±0.30 ^{a}	2.14±0.22
Ammonia (mg/l)	0.13±0.01 ^{a}	0.10±0.00 ^{a}	0.07±0.00 ^{a}	0.11±0.00 ^{a}	0.10±0.01
Carbon dioxide(mg/l)	2.64±0.49 ^{a}	1.35±0.21 ^{a}	2.18±0.02 ^{a}	1.24±0.09 ^{a}	1.73±0.17
Chloride (mg/l)	28.43±3.64 ^{a}	20.78±3.09 ^{a}	24.03±0.49 ^{a}	27.80±040 ^{a}	24.51±1.28
Dissolve Oxygen) (mg/l)	7.33±0.67 ^{a}	7.10±0.59 ^{a}	8.00±0.58 ^{a}	7.00±1.00 ^{a}	7.36±0.33
Biochemical Oxygen demand (mg/l)	3.00±0.58 ^{a}	2.67±0.33 ^{a}	3.67±0.33 ^{a}	3.33±0.33 ^{a}	3.17±0.21

Values followed by same superscript alphabets in rows are not significantly different at P > 0.05 level of significance.

IV. Discussions

Mosquito ecology is often studied to gathered information on factors that may determine oviposition, survival as well as spartial and temporal distribution of mosquito vectors. Water is an important component of ecosystem and its quantity in the breeding site is an important determinant of oviposition, growth and survival of mosquito immature [7]. Generally, information on surface water quality of Rice field larval habitats in Minna is scarce. Available data on physicochemical characteristic of water in mosquito larval breeding habitats in Minna shows that Temperature,

Phosphate, Carbonate, and Transparency are not significantly different among habitats (P>0.05) [14]-[15]. The present study revealed that Temperature, pH, Turbidity, Alkalinity, Hardness, Phosphate, Carbon dioxide Chloride, Dissolved Oxygen and Biochemical Oxygen Demand do not varied significantly (P>0.05) among the various rice fields habitats (Table .2). The study revealed an evidence of organic pollution in Chanchaga rice fields as indexed by high Ammonia in the area. This perhaps results from high amount of domestic and industrial effluents in the area, because waste water from residential homes as well as the Scientific Equipment Center, and the IBB specialist Hospital, all floods towards the sampling Rice fields. The high level of Dissolved Oxygen recorded in Maitumbi could result from photosynthetic activities of the rice crops and other aquatic vegetations. This can certainly influence the abundance and distribution of mosquito species in such habitats. [16], reported that various chemical properties of the larval habitats in relation to vegetation, pH, Temperature, Ammonia, Nitrate and Sulphate have been found to affects growth and development of mosquitoes. Pesticides and Herbicides applications played a role in the high levels of Turbidity, Alkalinity, Hardness, Conductivity, Potassium, Nitrate, Chloride and Carbon dioxide recorded in Fadikpe (Table 1). On average, turbidity was lower than WHO guideline value of 5 JTU in all the habitats. This was because there were no Agricultural activities going on at the time of water collections in all the rice fields. Similarly, average hardness in all habitats was lower than 120(mg/l). [15], investigated the physicochemical characteristics of mosquito breeding habitats in an irrigation development area and reported that, mosquito breeding water was low in ammonia, nitrate, phosphate and sulphide content and highly variable in relation to the other tested chemical parameters. Several parameters varied significantly among different mosquito breeding habitats. Temperature was highest in ground and riverbed pools that were usually fully exposed to the sun. Hydrogen ion concentration (pH), dissolved oxygen and phosphate levels were highest in riverbed pools; carbon dioxide, silica and total alkalinity in streambed pools; nitrate in canal turnouts; chloride in streambed pools and marshes; and total hardness in streambed pools and samples from flowing streams. Ammonia, sulphide and sulphate levels did not vary significantly among different habitats. The major variations in the physicochemical characteristics of the rice fields in Minna, were the high levels of Turbidity in Fadikpe, Potassium in Bosso, Ammonia in Chanchaga as well as Phosphate in Maitumbi and Chanchaga.

Phosphate, Nitrate and Ammonia levels in particular, indexed the extend of organic pollution, attributed mainly to contamination from human and domestic animal faecal matter [17]. However, domestic animal wastes and agrochemicals are likely to raise surface water Ammonia, Nitrate, Sulphate and Phosphate levels in the wetland rice fields of Minna

V. Conclusion

The study has established the physicochemical factors of rice fields' mosquito larval habitats that may determine oviposition, survival as well as spartial distribution of mosquito vectors. Several physicochemical parameters varied significantly among the breeding sites. However, evidence of organic pollution was reported in Chanchaga as indexed by high ammonia in the area.

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