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## Impact of Physicochemical Parameters in the Development of *Anopheles gambiae* Sensu Lato Larvae in their Breeding Sites in Couffo Department in South-Western Republic of Benin, West Africa

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### Abstract

The effective control of malaria through larva source management requires the information on the breeding sites and the physicochemical parameters present in them. This study aims to establish the correlation between the presence of physicochemical parameters in breeding sites of *Anopheles gambiae* sensu lato and the larval development. *Anopheles gambiae* s.l. mosquito larvae were collected from September to November 2024 during the small rainy season and from March to July 2025 during the great rainy season in the six districts of Couffo department which were Aplahoué, Djakotomey, Dogbo, Klouékanmè, lalo and Toviklin districts. Then, the measurements of physicochemical parameters in breeding sites were done in laboratory using a spectrophotometer DR5000. The other methods employed were: Thermometric, Potentiometric and Electrical conductometric. The results showed that the breeding sites with higher physicochemical parameters such as: Hydrogen Potential, Conductivity, Total Hardness and Alkalinity conferred the development to *Anopheles gambiae* s.l. larvae. However, there was a negative correlation between some parameters such as Total Dissolve Solids and Salinity and *Anopheles gambiae* s.l. larval development. Different ions such as ammonia, calcium, magnesium, iron and phosphate were present in *Anopheles gambiae* s.l. larval habitats and served as nutrient composition to the larvae. The breeding sites of *Anopheles gambiae* s.l. are influenced by many physicochemical parameters and there is a relationship between the presence of physicochemical parameters in *Anopheles gambiae* s.l. breeding sites and the development of these mosquito larvae.

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Physicochemical parameters, *Anopheles gambiae*, larval development, Republic of Benin

## Introduction

Mosquito belongs to the family Culicidae, order Diptera. Over 3,000 known species had been identified. The family Culicidae is a large, abundant, well-known and important group of flies. The early stages; egg, larval and pupal are aquatic. Mosquito larvae or wigglers are found in variety of aquatic situations such as ponds, pools, water in artificial containers, in tree holes with each species occurring in particular type of aquatic habitat (Azari-Hamidian, 2011; Kenawy *et al.*, 2013). The larvae of most species feed on algae and organic debris but a few are predaceous and feed on other mosquito larvae. When considering human welfare, mosquitoes are important because the females of many species are blood suckers, they annoy humans and other animals, and they may transmit the pathogens that cause human and animal diseases. The pathogens transmitted by mosquitoes include viruses (arboviruses), filarial worms (helminths) and protozoa. Mosquitoes are the indirect cause of more morbidity and mortality among humans than any other group of organisms (Harbach, 2016).

Mosquito vector distribution is to a large extent influenced by climatic conditions and species habits across the globe (Manguin, 2013; Hay *et al.*, 2010; Sinka *et al.*, 2012). Their population densities vary with seasons due to fluctuating availability of favourable breeding sites (Shililu *et al.*, 2003). Availability, distribution and abundance of mosquitoes depend on types of breeding sites including water surface area and other biological factors (Carlson *et al.*, 2004; Liu *et al.*, 2012).

Mosquito vectors spend three quarter of their life stages in aquatic environment. Consequently, anything that affects the condition and composition of the water body may invariably cause changes in the water ecosystem, which may also impact negatively on the breeding behavior, diversity and larva population of the mosquito fauna (Gimmig *et al.*, 2001). Urbanization, Human and industrial activities are various factors that cause changes in the water ecosystem. These changes affect different kinds of water related organism. Mosquito is far the most sensitive organism that respond to ecosystem changes (Anderson and Harrington, 2005).

Physicochemical parameters are the products of the changes that take place in the water ecosystem. These parameters affect the composition of local fauna (Nkookar *et al.*, 2017).

Very few researches were published on the impact of physicochemical parameters in the development of *Anopheles gambiae* sensu lato larvae in Republic of Benin. Therefore, there is a need to carry out new researches for this purpose.

The goal of the current study is to investigate on the environmental physicochemical parameters in breeding sites of *Anopheles gambiae* s.l. mosquito larvae influencing their development.

## Materials and Methods

### Study area

The study area is located in Republic of Benin (West Africa) and includes the department of Couffo. Couffo department is located in the south-western Benin and the study was carried out more precisely in the six districts of this department (Figure 1). The choice of the study site took into account the economic activities of populations, their usual protection practices against mosquito bites and peasant practices to control farming pests. We took these factors into account to evaluate the impact of physicochemical parameters in the development of *Anopheles gambiae* sensu lato larvae in their breeding sites in Couffo department in south-western Republic of Benin. Couffo has a climate with four seasons, two rainy seasons (March to July and August to November) and two dry seasons (November to March and July to August). The temperature ranges from 25 to 30°C with the annual mean rainfall between 900 and 1100 mm.

### Mosquito sampling

*Anopheles gambiae* s.l. mosquitoes were collected from September to November 2024 during the small rainy season and from March to July 2025 during the great rainy season in the six districts of Couffo department which are Aplahoué, Djakotomey, Dogbo, Klouékanmè, Lalo and Toviklin districts. Larvae were collected from breeding sites using the dipping method (O'Malley, 1995) and kept in labeled bottles (Figure 2). The samples were then carried out to the insectary of Laboratory of Pluridisciplinary Researches of Technical Teaching (LaRPET) in Department of Sciences and Agricultural Techniques of Normal High School of Technical Teaching (ENSET) located in Dogbo district (Figure 3). These larvae were reared in insectary until became adult mosquitoes.

### Measurements of physico-chemical parameters in breeding sites of *Anopheles gambiae* s.l

The measurements of physicochemical parameters in breeding sites of *Anopheles gambiae* s.l. were done using spectrophotometer DR 5000. The other methods employed were: Thermometric, Potentiometric, Electrical conductometric, Ethylene Diamine Tetra-acetic Acid and so on. The measurements of physicochemical parameters were done in Laboratory of Applied Hydrology (LHA) at National Institute of Water (INE) in University of Abomey-Calavi (UAC). A total of nineteen (19) physicochemical parameters were measured in the water of the breeding sites of *Anopheles gambiae* sensu lato larvae. Parameters measured were Temperature, Hydrogen Potential, Conductivity, Total Dissolve Solids, Total Hardness, Dissolved Oxygen, Alkalinity, Turbidity, Salinity, Nitrate, Ammonia, Calcium, Magnesium, Iron, Chloride, total Phosphate, Sulphate, Zinc and Cadmium.

### Statistical analysis

Data collected in the current study were analyzed using SPSS software (version 10 for windows, SPSS inc. Chicago, IL) and Analysis of variance (ANOVA) was used as test statistics.

### Results and Discussion

A total of nine (09) physicochemical parameters (which are not ions) were measured in the water of the breeding sites of *Anopheles gambiae* sensu lato larvae and the results obtained were showed in table 1.

The analysis of table 1 showed that the values of physicochemical parameters (which are not ions) obtained in water contained *Anopheles gambiae* larvae such as Temperature, Hydrogen Potential, Conductivity, Total Hardness, Alkalinity and Turbidity were superior to those obtained in water without *Anopheles gambiae* larvae whereas the values of physicochemical parameters (which are not ions) obtained in water contained *Anopheles gambiae* larvae such as Total Dissolve Solids, Dissolved Oxygen and Salinity were inferior to those obtained in water without *Anopheles gambiae* larvae.

A total of ten (10) physicochemical parameters (ions) were measured in the water of the breeding sites of *Anopheles gambiae* sensu lato larvae and the results obtained were showed in table 2.

The analysis of table 2 showed that the values of physicochemical parameters (ions) obtained in water contained *Anopheles gambiae* larvae such as Ammonia, Calcium, Magnesium, Iron and Cadmium were superior to those obtained in water without *Anopheles gambiae* larvae whereas the values of physicochemical parameters (ions) obtained in water contained *Anopheles gambiae* larvae such as Nitrate, Sulphate and Zinc were inferior to those obtained in water without *Anopheles gambiae* larvae.

In the current study, the values of physicochemical parameters (not ions) obtained in water contained *Anopheles gambiae* larvae such as Temperature, Hydrogen Potential, Conductivity, Total Hardness, Alkalinity and Turbidity were superior to those obtained in water without *Anopheles gambiae* larvae whereas the values of physicochemical parameters (not ions) obtained in water contained *Anopheles gambiae* larvae such as Total Dissolve Solids, Dissolved Oxygen and Salinity were inferior to those obtained in water without *Anopheles gambiae* larvae.

Regarding the values of physicochemical parameters (ions) obtained in water contained *Anopheles gambiae* larvae such as Ammonia, Calcium, Magnesium, Iron and Cadmium, they were superior to those obtained in water without *Anopheles gambiae* larvae whereas the values of physicochemical parameters (ions) obtained in water contained *Anopheles gambiae* larvae such as Nitrate, Sulphate and Zinc were inferior to those obtained in water without *Anopheles gambiae* larvae.

These results showed that the breeding sites with higher physicochemical parameters such as: Hydrogen Potential, Conductivity, Total Hardness and Alkalinity conferred the development to *Anopheles gambiae* s.l. larvae. However, there was a negative correlation between some parameters such as Total Dissolve Solids and Salinity and *Anopheles gambiae* s.l. larval development. Our results corroborated with those obtained in Nigeria by Oyewole *et al.*, (2009) who had shown that physicochemical characteristics of Anopheles breeding sites had an impact on fecundity and progeny development. Prevailing physicochemical parameters in mosquito aquatic habitats for breeding are important factors for survival and development of mosquito.

Different ions such as ammonia, calcium, magnesium, iron and Phosphate were present in *Anopheles gambiae* s.l. larval habitats and served as nutrient composition to the larvae.

Figure.1 Map of Republic of Benin showing the six districts surveyed in Couffo department

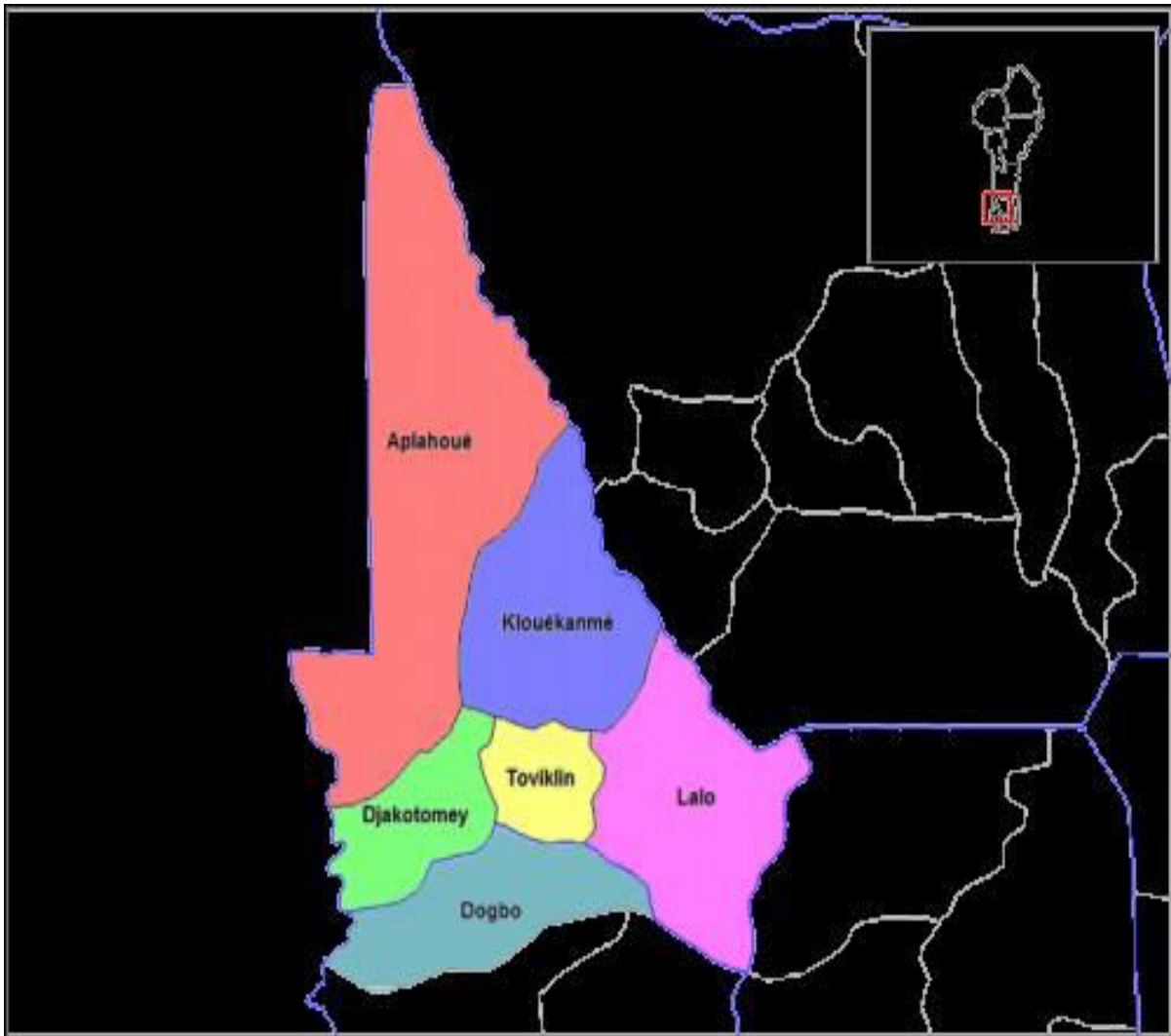


Figure.2 Mosquito larvae collection in a breeding site



Figure.3 Larvae in labeled plastics in insectary



**Table.1** Influence of physicochemical parameters (which are not ions) in the development of *Anopheles gambiae* sensu lato larvae collected in their breeding sites

Parameters	Unities	Symbols	Values obtained in water contained <i>Anopheles gambiae</i> larvae	Values obtained in water without <i>Anopheles gambiae</i> larvae
Temperature	°C	T	26.0	17.5
Hydrogen Potential	-	pH	8.24	7.5
Conductivity	µS/cm	C	713	< 700
Total Dissolve Solids	mg/L	TDS	356	< 500
Total Hardness	mg/L	TH	453.703	75
Dissolved Oxygen	mg/L	O2	5.01	8.11
Alkalinity	mg/L	HCO3-	195.26	110
Turbidity	FTU	-	38	<15
Salinity	%	-	0.03	< 0.20

**Table.2** Influence of physicochemical parameters (ions) in the development of *Anopheles gambiae* sensu lato larvae collected in their breeding sites

Parameters	Unities	Symbols	Values obtained in water contained <i>Anopheles gambiae</i> larvae	Values obtained in water without <i>Anopheles gambiae</i> larvae
Nitrate	mg/L	NO3-	<0.001	<0.03
Ammonia	mg/L	NH4+	0.472	<0.2
Calcium	mg/L	Ca <sup>2+</sup>	128.53	<80
Magnesium	mg/L	Mg <sup>2+</sup>	32.24	<20
Iron	mg/L	Fe	<0.001	0.000
Chloride	mg/L	Cl <sub>2</sub>	0	0
Total Phosphate	mg/L	Pt	0.153	<0.5
Sulphate	mg/L	SO4 <sup>2-</sup>	43.76	<250
Zinc	mg/L	Zn	0.2241	0.3
Cadmium	mg/L	Cd	0.0091	0.001

Our results also corroborated with those obtained by Oyewole *et al.*, (2009) who had shown that some ions profited as nutrient composition to larvae of *Anopheles* mosquitoes present in the different larval habitats surveyed.

The breeding sites of *Anopheles gambiae* sensu lato are influenced by many physicochemical parameters and there is a relationship between the presence of physicochemical parameters in *Anopheles gambiae* sensu lato breeding sites and the development of these mosquito larvae.

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### Author Contributions

Nazaire Aïzoun: Investigation, formal analysis and writing original draft. Eloi Honvoh, Guévara Nonviho and Arlette Adjatin: Validation, methodology, writing-reviewing and editing. Daniel Chougourou: Investigation and writing-reviewing.

### Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethical Approval:** Not applicable.

**Consent to Participate:** Not applicable.

**Consent to Publish:** Not applicable.

**Conflict of Interest:** The authors declare no competing interests.

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