The Effect Of Total Dissolved Solids, Salinity And Electrical Conductivity Parameters Of Water On Abundance Of Anopheles Mosquito Larvae In Different Breeding Sites Of Kapiri Mposhi District Of Zambia.

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Abstract: Malaria is a global public health problem, caused by malaria parasites transmitted by the vector adult female Anopheles mosquitoes. The life cycle of Anopheles mosquito (Order: Diptera) has six stages egg, four larvae instars and pupa. The immature stages are aquatic and determine the abundance, distribution and fitness of the adult Anopheles mosquito. The physicochemical parameters (Conductivity, Salinity and Total Dissolved solids) of water affects survival and development of the larvae. The district was surveyed for various breeding sites and classified as dam, river, marshlands, swamps and temporal water ponds. The car tracks, animal hove prints, garden water ponds which dries up after some few weeks were pooled together and classified as temporal water ponds were identified. Ten replicate samples were taken per breeding site on a weekly basis and the physicochemical parameters were recorded and the Anopheles larvae was surveyed and collected from these breeding site. The calibrated multi parameter meter (explorer GLX Pasco) was used to measure physicochemical parameters in the field following the manufacturer's guidelines the water. The results of physicochemical parameters when compared to standard ranges the water was classified as fresh mineral domestic water. A total of 556 Anopheles larvae were collected and from the available breeding sites using the World Health Organization 350ml Standard Dipper for scooping. These larvae were reared in the insectary and only 267 emerged as adults. The emerged adults were morphologically identified. The 267 emerged adults were profiled to species level using the quantitative polymerase chain Reaction (qPCR).the results of qPCR were 40% An.gambiae s.s, 35% An.arabiensis Paton 5% non-amplified profiles there was no An.Funestus.the breeding site with the most abundant anopheles siblings was the temporal water ponds. A significant positive linear relationship existed between the predictor variables and larvae abundance with R value of 0.302 whose significant F.chnage value is 0.000 less than the P-value of 0.05.A positive significant Pearson correlation between Salinity(r=0.240, p= 0.000), Electrical Conductivity(r=0.120 p=0.003) and Larvae abundance existed while a correlation between Total dissolved Solids and larvae abundance(r=0.018 p=0.663) is not significant. The physicochemical parameters (conductivity and Salinity) have significant relations while Total Dissolved Solids have insignificant positive linear relationship on the abundance of Anopheles mosquito in various breeding sites of Kapiri Mposhi districts.

Index Term: Anopheles, Larvae, Conductivity, Salinity, Total Dissolved Solids breeding sites, Kapiri Mposhi

1.0 Introduction

Malaria is a global public health problem, caused by malaria parasites transmitted by the vector female Anopheles mosquitoes. Kapiri mposhi district has recorded over 171800 cases of malaria from January to October,DHIS$_2$ [1].The District Medical Office attributed the increased incidences of malaria to ineffective use of treated mosquito nets. The refusal by some households to take-up malaria interventions such as Indoor Residue Spray (IRS) due to complaints by some people that the chemical being used makes them develop sores and nausea. There are no malaria intervention strategies which incorporates the immature stages of the mosquitoes so far. Therefore, new strategies needs to be developed. Several environmental factors affect larval density which may influence the development and survival rate of the malaria vector larvae. The physicochemical (Electrical Conductivity, Total Dissolved Solids and salinity) of water has an effect on the oviposition, distribution and abundance of the Anopheles mosquitoes however, very little is known about the effects of physicochemical parameters on the larvae.

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Surprisingly, very few studies are directed at understanding the biology and ecology of the aquatic immature stages which are determinants on the abundance, dynamics and fitness of the adults. As a consequence, malaria transmission is still a challenge, among both the rural peri-urban and urban communities. The larval control measures are intended to reduce malaria transmission by preventing propagation of mosquito vectors and subsequently reducing human vector pathogen contacts Keiser etal.,[2]. Physicochemical characteristics of mosquito breeding sites may have some effect on mosquito vectors oviposition, survival and spatial distribution. Physicochemical parameters such as temperature, salinity, conductivity, Total Dissolved Solids (TDS) and pH have a significant influence on the occurrence and larval abundance among mosquito species Imam etal.,[3],and Oyewole etal., [4]. High levels of conductivity may be due to the application of agricultural fertilizers, pesticides and herbicides Garba etal., [5].Several studies on Anopheles breeding habitats in urban areas of Africa, characterized the breeding places Scattler [6]

2.0 MATERIALS AND METHODS

2.1 Breeding Sites

The district was divided into four zones and each zone was surveyed for different breeding sites. The breeding sites were categorized as temporal water ponds, swamps, marshlands, rivers and dams. Water samples were collected from various breeding sites for the analysis of physicochemical parameters (Total Dissolved Solids (TDS),Electrical Conductivity and Salinity) and Anopheles mosquito larvae were surveyed on a weekly basis. Ten (n=10) replicate samples were collected from different points on each breeding site.

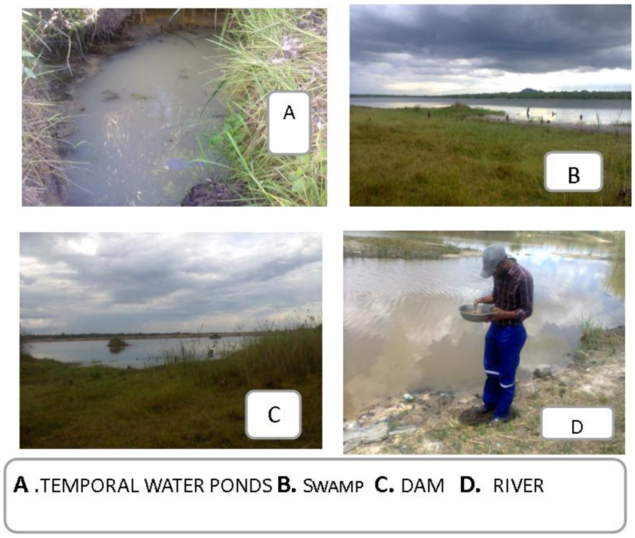

***Fig**. 1. Various breeding sites in kapiri mposhi district.*

2.2 Total Dissolved Solids Monitoring

The physicochemical parameter of water was recorded in the field from the various breeding sites of kapiri mposhi district using a calibrated multi parameter meter (explorer GLX Pasco) based on the manufacturer's guidelines as shown in (fig.2). On a Weekly basis samples were collected and TDS measurements were five replicates from each breeding site were taken in the four zones. The weekly average TDS was determined and subsequently the average for a month was calculated as follows:

Average TDS for the month (ppm) = $(ATDS_1 + ATDS_2 + ATDS_3 + ATDS_4)/4$

Where:
$ATDS_1$ = Average Total Dissolved Solids for week one
$ATDS_2$ = Average Total Dissolved Solids for week two.
$ATDS_3$ = Average Total Dissolved Solids for week three
$ATDS_4$ = Average Total Dissolved Solids for week four

***Fig**.2. Insitu measurement of physicochemical parameters*

2.3 Electrical Conductivity monitoring.

A calibrated multi parameter meter (explorer GLX Pasco) fig.2. was used to measure the electrical conductivity of water samples collected from the various breeding sites. Ten (n=10) replicate samples were taken at different points from each breeding site and recorded on a weekly basis. The average was calculated from the four zone. Samples were taken from the available breeding sites in the four zones. The weekly average EC was determined and for the month in each zone. Monthly average of Conductivity (μS) = $(AC_1+AC_2+ AC_3+AC_4)/4$
AC_1 = Average Conductivity for week one
AC_2 = Average Conductivity week two.
AC_3 = Average Conductivity week three.
AC_4 = Average Conductivity week four.

2.4 Salinity monitoring.

The salinity of the water samples collected from various breeding sites was measured using a calibrated multi parameter meter (explorer GLX Pasco) fig.2. Based on the manufactures guidelines. Ten (n=10) replicate samples from a breeding site were taken and the salinity was recorded on a weekly basis. The average monthly salinity was calculated based on weekly average

Average Monthly Salinity(S) (ppm) = $(AS_1+AS_2+ AS_3+AS_4)/4$
AS_1 = Average Salinity for week one
AS_2 = Average Salinity week two.
AS_3 = Average Salinity week three.
AS_4 = Average Salinity week four.

2.5 Anopheles mosquito larvae collection.

The larvae collection from various breeding sites was done on a weekly basis. The World Health Organization 350ml standard dipper was used for scooping the larvae from the water, random sampling was done around each breeding site. The larvae collected were preserved in a sample bottles for rearing in the insectary. The Anopheles sp position their body parallel to the water surfaces while the Culex sp suspends there respiratory appendages at 45^0 to the water surfaces a feature which is particular to this species in water only fig.3. A total number of 556 Anopheles mosquito larvae were collected from the breeding sites and reared at the insectary. From all the breeding sites surveyed 48% emerged as adults and these were morphologically identified using a morphological key as guided by Gillies etal.,[7]. Anopheles mosquito adults were preserved in silica gel for further molecular identification of their sibling species by quantitative Polymerase Chain Reaction (qPCR).

***Fig**.3. Larvae collection in various breeding sites.*

3.0 RESULTS AND DISCUSSION

Fig.4 below shows the distribution of physicochemical parameters and the larvae density in various breeding sites around Kapiri Mposhi district. Marshlands had the highest average conductivity and salinity levels followed by the dams and temporal water ponds. The larvae density was highest in the temporal water ponds of the district. The river and the dam had the lowest Total Dissolved Solids owing to the facts that water was running hence at the time of sampling the mineral salts and other materials would have been diluted at that time.

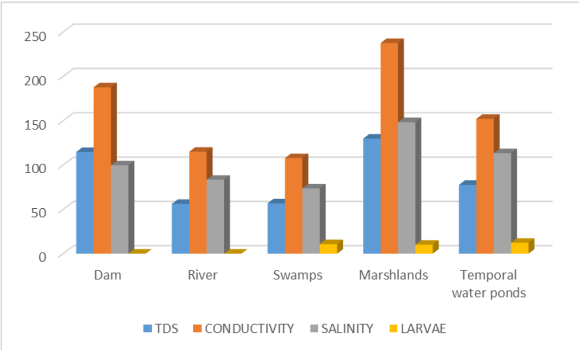

Fig. 4. *Average physicochemical parameters and larvae in different breeding sites.*

When molecular analysis was done for the Anopheles sibling using qPCR, it was found that 60% An.gambiae s.s and 35% An.arabiensis Paton and 5% non-amplified. The most abundant species and highly prevalent An.gambiae s.s in temporal water ponds then followed by An.arabiensis Paton in the swamps. It was noted that the rivers and dam breeding sites had no Anopheles larvae hence no adult mosquitoes were observed. **Fig. 5**. Below shows the average and distribution of the anopheles sibling species in various habitats around Kapiri Mposhi district.

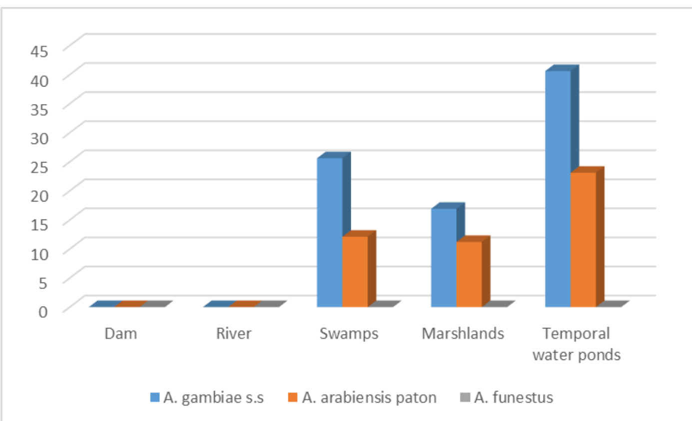

Fig*.5.average Anopheles sibling species in various breeding sites.*

The physicochemical parameters of water was measured in various mosquito habitats of the district the results were compared against the standard ranges as in **table.1.**which shows the physicochemical parameters when compared to standard range. The water in these breeding sites was categorized as fresh mineral domestic spring water. It has been established that Anopheles mosquito breeds in clear water of suitable pH, temperature and nutrient composition Okorie [8] This type of water is favorable for the breeding of Anopheles mosquito.

Table1

Physicochemical parameter when compared to standard categories of different breeding sites

Breeding Site	**Physicochemical parameter**	**Range (min-max)**	**Standard range Kelvin etal., [9]**	**Description Kelvin etal., [9]**
Dam	Total dissolved solids(ppm)	60-197	< 400	Mineral spring
			≥ 400	High contamination
	Salinity (ppm)	70-156	< 500	Fresh water
			≥ 500	Polluted water
	Conductivity (µS)	130-391	< 800	Domestic water
			≥ 800	Highly polluted
River	Total dissolved solids(ppm)	50-69	< 400	Mineral spring
			≥ 400	High contamination
	Salinity (ppm)	51-98	< 500	Fresh water
			≥ 500	Polluted water
	Conductivity (µS)	110-133	< 800	Domestic water
			≥ 800	Highly polluted
Swamp	Total dissolved solids(ppm)	29-98	< 400	Mineral spring
			≥ 400	High contamination
	Salinity (ppm)	33-140	< 500	Fresh water
			≥ 500	Polluted water
	Conductivity (µS)	47-211	< 800	Domestic water
			≥ 800	Highly polluted
Marshlands	Total dissolved solids(ppm)	36-376	< 400	Mineral spring
			≥ 400	High contamination
	Salinity (ppm)	32-320	< 500	Fresh water
			≥ 500	Polluted water
	Conductivity (µS)	78-523	< 800	Domestic water
			≥ 800	Highly polluted
Temporal Water Ponds	Total dissolved solids(ppm)	23-177	< 400	Mineral spring
			≥ 400	High contamination
	Salinity (ppm)	32-320	< 500	Fresh water
			≥ 500	Polluted water
	Conductivity (µS)	50-367	< 800	Domestic water
			≥ 800	Highly polluted

The **Table 2**. below shows a model summary of the relationship between the independent variables (Total Dissolved Solids, Conductivity and Salinity) and the dependent variable(abundance of Larvae) the R value of 0.302[a] denotes that a fair and weak linear relationship exist between predictor variables and the density of the larvae in various breeding sites that was surveyed. This relationship is significant with a significant F. change value of 0.000.the R squared value of 0.091 implies that only 9.1% of the variation in the density of Anopheles larvae is due to variation in the predictor variables in the breeding sites that where surveyed. The research findings is in line with Imam [3] publication in which it highlights that physicochemical parameters of water affects the Anopheles larvae abundance and occurrence in various breeding sites

***Table 2**. Model Summary*

Model	R	R Square	Sig. F Change
1	0.302[a]	0.091	0.000

Table 3. below shows a summary of coefficients a multi regression analysis equation was developed the coefficients and explains the relationship that existed at the time of research between the predictor variables and the dependent variables (abundance of larvae).

$Y= a+ bX_1 + cX_2 + dX_3$

$Y = 2.862+0.017X_1 + 0.071X_2 – 0.023X_3$

Where:

Y = Dependent variable - abundance of larvae

X_1 = independent variable - Total Dissolved Solids

X_2 = independent variable - Salinity

X_3 = independent variable – Electrical Conductivity (EC).

a = Constant.

From the equation above a linear positive relationship exists between the abundance of Anopheles larvae and the predictor variables. This relationship is significant as p-values are less than α value of 0.05.

Table. 3

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.862	1.089		2.628	.009
	SALINITY	.071	.011	.445	6.677	.000
	EC	-.023	.007	-.220	-3.288	.001
	TDS	.017	.008	.091	2.101	.036

a. Dependent Variable: LARVAE

***Table. 4**.*

Correlations

		LARVAE	SALINITY	Conductivity	Total Dissolved Solids
LARVAE	Pearson Correlation	1	.240**	.120**	.018
	Sig. (2-tailed)		.000	.003	.663
SALINITY	Pearson Correlation	.240**	1	.770**	-.092*
	Sig. (2-tailed)	.000		.000	.030
EC	Pearson Correlation	.120**	.770**	1	.143**
	Sig. (2-tailed)	.003	.000		.001
TDS	Pearson Correlation	.018	-.092*	.143**	1
	Sig. (2-tailed)	.663	.030	.001	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4. Above shows the Pearson correlations between the predictor variable and the dependent variables. It can be noted that A positive significant Pearson correlation between Salinity(r=0.240, p= 0.000), Electrical Conductivity(r=0.120 p=0.003) and Larvae abundance while a correlation between Total dissolved Solids and larvae abundance(r=0.018 p=0.663) is not significant.Therefore,we reject the null hypothesis for Total dissolved solids (TDS).we fail to reject the null hypotheses for Salinity and Electrical Conductivity because the p-Values are significant and fail in the acceptance region of two tailed normal distribution curve.

4.0 CONCLUSION

The physicochemical parameters (Total Dissolved Solids, Salinity and Conductivity) of water in various breeding sites of Kapiri Mposhi which is a peri- urban district has an effect on the abundance of Anopheles larvae. This research has also shown that Anopheles mosquitoes thrive better in fresh mineral domestic water. It has also shown that the most abundant anopheles siblings in Kapiri mposhi district is An.gambiae s.s and breeds well in temporal water ponds which were found near human habitations. The other species that was found in the study area was An.arabiensis Paton. These mosquito species are the vectors of malaria in the districts. The research was conducted during the rainy season. The dam and river had no Anopheles larvae that were found at the time of the study. Further research needs to be conducted in dry season so that an understanding can be made on how the physicochemical parameters interact with research has laid foundation knowledge for future scholars on the effect of physicochemical parameters of different breeding sites on the Anopheles larvae abundance in Kapiri Mposhi district.

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6.0 References

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