



## Spatial Distribution and Physico-chemical characteristics of the Natural Breeding Habitats of Mosquito larvae in and around Dehradun, Uttarakhand

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### Abstract

This study was planned to determine the physico-chemical characteristics of natural breeding habitats of mosquito larva having emphasis on distribution and abundance of potential mosquito vectors from March 2019 to February, 2020, covering all season in selected habitats viz., L-1 (Fresh water pond), L-2 (Swamp marshy area), L-3 (irrigation drain) and L-4(Grassy ditches) in and around Dehradun. A total of 10 species of *Anopheles*, three species each of *Culex* and *Aedes* were recorded. Various physico-chemical parameters viz., Temperature, pH, conductivity, turbidity, DO, TDS, Cl, NO<sub>3</sub>, PO<sub>4</sub> and SO<sub>4</sub> were estimated. It was observed that by altering various chemical and physical properties of breeding habitats it was possible to control the larvae survivability.

**Keywords:** *Aedes* mosquito, Physico-chemical parameters, breeding habitats

### Introduction

Mosquitoes are the most important group of insect vectors of human diseases like Malaria, Dengue, Chikungunya, Filariasis and Japanese encephalitis (Gopala Krishnan *et al.*, 2013)<sup>[1]</sup>. These mosquito borne diseases infecting more than 700 million people around the world each year, resulting in as many as two million deaths annually (Fradin, 1998)<sup>[2]</sup>, thus establish one of the major health problems in almost all tropical and sub-tropical countries (Amarasingh and Dalpadado, 2014)<sup>[3]</sup>. Mosquito larvae are found in habitats possessing a wide range of physico-chemical factors (Yadav, 2009)<sup>[4]</sup>. Further, the larvae of mosquito in clear water of suitable pH, temperature and nutrient conditions have been found to thrive significantly (Russel, 1999)<sup>[5]</sup>. Diagnostic and scientific research has shown that many mosquito species prefer habitats without oxygen tension whilst some breed in open, sunlight pools (Okogun, 2005)<sup>[6]</sup>. In general, water of a near neutral pH of 6.8 – 7.2 is preferable for breeding of many species of mosquitoes (CDC, 2004)<sup>[7]</sup>. Various chemical properties of the larval habitats observed in gutters, peri-domestic runoff and domestic areas are related to vegetation and a wide range of heavy metals, nutrients and physico-chemical 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)<sup>[8]</sup>.

Before planning strategies to control mosquitoes, a good knowledge and understanding of the relevant biology and ecology of the target species is of paramount importance (Seghal and Pillai, 1970<sup>[9]</sup>; Ginnig *et al.*, 2001)<sup>[10]</sup>. Moreover, the knowledge of the ecological characteristics of the breeding habitats and the environmental factors affecting mosquito abundance can help in designing optimal vector control strategies (Overgaard *et al.*, 2001)<sup>[11]</sup>.

Generally mosquitoes breed in a wide range of habitats with different types of waters that are known to be specific for many species. The physical and chemical nature of water

probably determines the selection of the breeding sites (Seghal and Pillai, 1970)<sup>[9]</sup>. It was reported (Piyaratne *et al.*, 2005)<sup>[12]</sup> that breeding water quality is an important determinant whether female mosquitoes will lay their eggs and whether the resulting immature stages will successfully complete their development to the adult stage.

In Dehradun, apart from comparatively little information on certain physical and chemical factors mainly temperature, Ph, conductivity, turbidity, DO (Dissolved oxygen) TDS, CL, NO<sub>3</sub>, PO<sub>4</sub> and So<sub>4</sub> relative to mosquito breeding (Pemola *et al.*, 2014)<sup>[13]</sup> no additional information is available. Hence, detailed studies on the physico-chemical property of the different types of mosquito breeding habitats in this area is lacking.

The objective of the present study, therefore, was to determine the physico-chemical characteristics of the mosquito larval habitats and their potential influence on the distribution and abundance of the vectors in distt Dehradun, Uttarakhand.

### Materials and Methods

#### Study area

The study was carried out in and around Dehradun (Latitude 30°19'N, longitude 78°04' E) from March 2019 to February 2020. The area was somewhat semi-cold arid climate with mean annual maximum/minimum temperature, relative humidity and rainfall of 28.59°C/ 14.81°C, 68.86% and 197.55 mm respectively. The climate of Dehradun city represents four distinct seasons being categorized as summer (Mar- May), Monsoon (Jun – Aug), post monsoon (Sept –Nov) and winter (Dec-Feb).

#### Mosquito Larval collection and Identification:

The natural habitats of mosquito larvae are categorized under 4 subheadings-freshwater ponds (L-1), swamp Marshy area (L-2), irrigation drain (L-3) and Grassy ditches (L-4). The ecological description of different sites is presented in table1.

Sampling was done between 0800 h and 1000h, using a standard 300 ml capacity dipper with a long handle (WHO, 1975)<sup>[14]</sup>. Water collected by dippers was emptied into a white enamel sorting tray, which was subsequently sorted out for mosquito larvae. Then the larva were transferred into a bowl and kept in cages to emerge into adults. The emerged

adult mosquitoes were identified using morphological characteristics to genus level using standard keys and catalogues (Barruad, 1934, Harbach, 1985 and Nagpal and Sharma, 1995)<sup>[15, 16, 17]</sup>. The abundance of each type of mosquito larvae was determined as the mean frequency of occurrence per 100 dips (Teklu *et al.*, 2010)<sup>[18]</sup>.

**Table 1:** Different habitats of location selected in Dehradun.

Habitat Type	Description
L-1 (Fresh water Pond)	Stagnant water with high transparency, less amount of algal bloom, water perennially present.
L-2 (Swamp marshy areas)	Semitransparent and stagnant water, presence of small pits, algal bloom present, water body perennial.
L-3 (Irrigation drains)	Flowing water type, water turbid and floating phytoplankton present, water accumulate in small blocks of mud can be found perennially.
L-4 (grassy ditches)	Water quality slightly turbid, stagnant, grassy outline, temporary water body.

#### Collection and fixing of water samples:

Water samples for physico-chemical analysis were collected concurrently with larvae from selected four habitat types (L-1 to L-4), using 500 ml capacity plastic wide mouth specimens bottles and immediately placed in a lightproof insulated box containing ice and transported to the laboratory for analysis (APHA, 2005)<sup>[19]</sup>. However, water temperature was determined at the sites during larval collection, using ordinary mercury thermometer. The physical features of water were recorded by observations, while the depth of water was calculated using measuring stick.

#### Physico-chemical analysis of water samples:

Water samples were analyzed for the physico-chemical parameters: pH, conductivity, turbidity (in nephrometric turbidity unit, NTU), dissolved oxygen (DO, mg/L), total dissolved solids (TDS, mg/l), concentration of chloride, nitrates, Phosphates and Sulphate using standard methods as described by APHA (2005)<sup>[19]</sup>.

#### Results:

##### Physical parameters of the selected sites:

Four sites were selected for the present study, their physical feature have been shown in table 1. At H-1 habitats, representing fresh water ponds, the sites were Sahaspur and Selaqui where water was found to be permanently present H-2 habitats representing swamp marshy areas were found at Mothorawala and Asan region. At mothorawala, there were stagnant water bodies, however at Asan wetland, the water was slowly moving.

H-3 habitats represents Ranipokhari and Lacchiwala, which included irrigational drains, where water was found perennially, water was slowly moving, turbidity being high.

H-4 Habitats represented by Sahastradhara and Doiwala, it includes grassy ditches, in permanent river is present in both locality.

##### Occurrence of mosquito larvae

In the present study a total of 2127 mosquito larvae were collected, out of them *Anopheles* forms highest percentage (75.60%) followed by *Aedes* (18.05%) and then *Culex* (6.35%). Table 2. Among three genera *Anopheles* accounted the highest abundance of 211 during post monsoon period at L -4 habitat (grassy ditches areas) while *Aedes* registered highest value of 45 at L -3 during post - monsoon period where large amount of water accumulate after rainfall occurs and *Culex* were recorded highest at

same L-2 site during post monsoon period.

Among *Anopheles* mosquitoes a total of 1608 immatures forms were found belonging to 10 species viz., *An. culicifacies*, *An. subpictus*, *An. stephensi*, *An. annularis*, *An. fluviatilis*, *An. aconitus*, *An. maculatus*, *An. vagus*, *An. splendidus* and *An. gigas* and *An. stephensi* showed highest contribution (13.18%) followed by *An. annularis*, *An. subpictus*, *An. aconitus* and so on. Among *Culex* three species were obtained as larval forms viz., *Culex quinquefasciatus*, *Cx. vishuni* and *Cx. mimeticus*. Species *Cx. quinquefasciatus* were very common in all the habitats. During the immature mosquito survey, a total of three species of *Aedes* viz., *Aedes aegypti*, *Ae. albopictus* and *Ae. vittatus* were found as common species.

##### Physico-chemical conditions of breeding Habitats:

Physico-chemical parameters of breeding habitats of mosquitoes in and around Dehradun during pre- monsoon, Monsoon and Post-monsoon are shown in Table 3 The water temperature was found to be the highest (26.0 °C) at L-2 Habitat (swamp marshy area) during Monsoon season while lowest (18.0°C) being at L-1 Habitat (Fresh water pond) during pre-monsoon season. Water pH was recorded highest 7.8 at L-1 habitat (fresh water pond) during post-monsoon season while the lowest was recorded at L-1 habitats in pre-monsoon with a value of 6.7. Highest value (1745 µs/cm) of conductivity was observed at L-1 habitat during pre monsoon season and lowest (1350 µs/cm) at L-2 habitat, at L-3 habitat during post monsoon season recorded the highest turbidity (10.5) and whereas at L-1 habitat during pre- monsoon season recorded had the lowest (3.5), Dissolve oxygen (DO) was recorded highest in L-2 Habitat (5.4) in pre monsoon season and lowest in L-2 habitat (4.2), maximum TDS was found in the monsoon season at L-1 habitat (1115) and minimum at L-2 habitat during pre monsoon season. Chloride concentration was found to be highest at monsoon season (98) in L-1 habitat in monsoon season and lowest (76) at L-2 habitat in pre monsoon season. Nitrate concentration was recorded highest (0.08) in L-4 locality and lowest (0.03) in L-3 locality during pre-monsoon season. Highest phosphate concentration (0.45) was found in L-3 locality during pre-monsoon season while lowest value (0.15) in L-3 locality during monsoon season. Similarly, the highest value of SO<sub>4</sub> was found highest (41.0) at L-1 locality during pre-monsoon and lowest (30.0) at L-2 locality during Monsoon

season.

**Table 2:** Distribution and composition of the mosquito larvae in selected sites in Dehradun from March, 2018 to February, 2019.

Species	Pre-monsoon				Monsoon				Post-Monsoon			
	L-1	L-2	L-3	L-4	L-1	L-2	L-3	L-4	L-1	L-2	L-3	L-4
<i>An. culicifacies</i>	06	04	06	07	14	15	18	16	22	21	26	24
<i>An. subpictus</i>	08	06	10	08	15	18	20	22	26	22	25	28
<i>An. stephensi</i>	06	08	08	08	16	20	18	20	28	24	26	30
<i>An. annularis</i>	08	10	12	11	13	15	18	22	24	22	26	28
<i>An. fluviatilis</i>	04	08	10	11	14	12	14	18	24	23	25	27
<i>An. aconitus</i>	06	08	12	12	15	14	15	20	22	24	26	24
<i>An. maculatus</i>	10	12	10	12	12	10	12	12	14	16	18	20
<i>An. vagus</i>	-	05	03	06	08	10	08	06	12	14	12	12
<i>An. splendens</i>	03	-	04	06	06	08	08	06	10	12	10	12
<i>An. gigas</i>	-	06	06	04	06	08	08	07	08	08	06	06
<i>Aedes aegypti</i>	10	12	12	14	14	14	18	18	20	24	22	20
<i>Ae. albopictus</i>	-	10	10	08	08	10	07	06	12	10	12	12
<i>Ae. vittatus</i>	02	04	04	06	05	08	06	07	08	10	11	10
<i>Cx. quinquefasciatus</i>	02	02	04	04	02	03	03	03	04	06	08	08
<i>Cx. vishuni</i>	02	02	03	02	02	02	04	05	06	08	06	06
<i>Cx. mimeticus</i>	-	02	03	02	03	02	03	04	05	06	04	04

**Table 3:** The Physico-chemical parameters of mosquito larval habitats.

Parameter s	Pre-Monsoon				Monsoon				Post-Monsoon			
	L-1	L-2	L-3	L-4	L-1	L-2	L-3	L-4	L-1	L-2	L-3	L-4
Water Temp.	18.0	21.0	20.5	19.8	25.6	26.0	25.2	24.4	21.0	22.0	21.0	23.0
PH	6.7	6.9	7.1	6.8	7.4	7.3	7.5	7.3	7.8	7.4	7.3	7.2
Conductivity $\mu\text{S}/\text{cm}$	174	167	164	169	145	135	137	136	165	151	155	157
Turbidity NTU	3.5	2.0	4.0	3.8	7.5	6.5	7.5	6.6	8.0	9.5	10.5	9.8
DO mg/l	5.0	5.4	4.6	4.8	4.8	4.2	5.2	5.0	4.8	4.5	5.2	4.8
TDS mg/l	916	852	892	870	111	108	980	103	108	965	968	972
Cl mg/l	86	76	82	78	98	88	91	94	91	88	91	92
NO3 mg/l	0.04	0.07	0.03	0.05	0.05	0.04	0.06	0.08	0.04	0.05	0.04	0.04
PO4 mg/l	0.45	0.37	0.45	0.42	0.42	0.26	0.15	0.22	0.28	0.32	0.31	0.32
SO4 mg/l	41	38	37	37.5	38	30	36	34	38	36	38	37

**Discussion**

For effective vector control measures the water ecology is essential, including the physical, biological and chemical properties of water as well as mosquito breeding sites and also larval habitat preferences (Olayemi *et al.*, 2010) [20]. The different breeding habitats in selected areas in and around Dehradun showed difference in their physico-chemical characteristics. 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 surrounding water (Sanford *et al.*, 2005) [21].

Mosquito immature stages are poikilothermic and therefore, their activity depends to a large extent on the temperature of the water they inhabit. Apart from the other factors like concentration of various nutrients and minerals, temperature is the main factor that affects the development and growth of mosquito larvae (White, 1974) [22]. In general, an increase in water temperature will result in faster development of aquatic stages, but will decrease the size of the emerging adults (Bayoh and Lindsay, 2003) [23] and at higher temperature fewer adults are produced due to increased mortality (Bayoh and Lindsay, 2004) [24]. WHO (1975) [14]

stated that the average optimum temperature for development of most mosquito species is around 25-27°C. Temperature of the study ranged between 20-26°C, this temperature is best for breeding of most mosquitoes species viz, *Anopheles*, *Culex* and *Aedes* in the tropics (Bradley and Kutz, 2006) [25]. In the present study pH ranged of 6.7 - 7.8 was found favourable for mosquito breeding, showing resemblance with finding on mosquito breeding in rock pools (Adebote *et al.*, 2008) [26]. MacGregor (1927) [27] recorded acidophile and alkaliphile mosquito larval species, like in the present study. Ph of the water was found to vary with the types of habitat. Mosquito larvae grow optimum in water of near neutral ph 6.8 to 7.2 (Chatterjee *et al.*, 2015) [28]. Since this ph weakens the egg shells for emerging of the first larval instar (Okogun *et al.*, 2005) [29]. As suggested by report from Nigeria, a ph of 7.4 was found to be ideal for *Aedes* mosquitoes (Adebote *et al.*, 2006) [30], Afolabi *et al.*, 2010) [31].

Conductivity ranged between 850  $\mu\text{S}/\text{cm}$  to 1020  $\mu\text{S}/\text{cm}$ . The presence of oxygen in water is a positive sign for growth, while its absence is signal of sever pollution. In the present study DO ranged from 4.5 mg/l - 6.0 mg/l breeding waters of *Aedes* showed higher oxygen content than those of *Culex* and *Anopheles* (Seghal and Pillai, 1970) [9]. Additionally, a low DO requirement of an aquatic habitat is an indirect reflection of lower concentration of TDS which in its respective higher concentration could reduce transparency and increase oxygen deficiency (Nayaka, 2018) [32]. In the present study in turbid breeding sites, culicine larvae were much more likely to present whereas *Anopheles* larvae were much more likely very less (Sattler *et al.*, 2005) [33].

Conclusively, based on the study, selected physico-chemical parameters like temperature, ph and DO were found to vary significantly with mosquito larvae abundance.

As mosquitoes are cold blooded therefore their activity depends on a large extent on the temperature of the water they inhabit. Besides nutrition, temperature is the main factor that affects the development and growth of mosquito larvae. It was observed that by altering various chemical and physical properties of breeding habitats it was possible to control the larval survivability.

**Acknowledgements**

Authors are thankful to Council for Scientific and industrial Research (CSIR), New Delhi for financial support. Thanks are also due to Principal and Head of Zoology Deptt, D.A.V.(P.G.) College, Dehradun for providing Adequate laboratory Facilities.

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