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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, NO3, PO4 and SO4 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 Japanes encephalitis (Gopala Krishanan *et al*., 2013)[1]. 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) [2], thus establish one of the major health problems in almost all tropical and sub-tropical countries (Amarasingh and Dalpadado, 2014) [3]. Mosquito larvae are found in habitats possessing a wide range of physico-chemical factors (Yadav, 2009) [4]. Further, the larvae of mosquito in clear water of suitable pH, temperature and nutrient conditions have been found to thrive significantly (Russel, 1999) [5]. Diagnostic and scientific research has shown that many mosquito species prefer habitats without oxygen tension whilst some breed in open, sunlight pools (Okogun, 2005) [6]. In general, water of a near neutral ph of 6.8 – 7.2 is preferable for breeding of many species of mosquitoes (CDC, 2004) [7]. 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) [8].
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 [9]; Gimnig *et al*., 2001)[10]. 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)[11].
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) [9]. It was reported (Piyaratne *et al*., 2005) [12] 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, NO3,PO4 and So4 relative to mosquito breeding (Pemola *et al*., 2014) [13] 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 $30^0$19'N, longitude 78^0 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 28.59^0C/ 14.81^0C, 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)[14]. 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) [15, 16, 17]. The abundance of each type of mosquito larvae was determined as the mean frequency of occurrence per 100 dips (Teklu *et al*., 2010) [18].

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 physic-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) [19]. 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) [19].

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 to10 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. quinquesfasciatus* 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 ^{0}C) at L-2 Habitat (swamp marshy area) during Monsoon season while lowest (18.0^{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 SO4 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
An. culicifacies	O6	04	06	07	14	15	18	16	22	21	26	24
An. subpictus	08	06	10	08	15	18	20	22	26	22	25	28
An. stephensi	06	08	08	08	16	20	18	20	28	24	26	30
An. annularis	08	10	12	11	13	15	18	22	24	22	26	28
An. fluviatilis	04	08	10	11	14	12	14	18	24	23	25	27
An. aconitus	06	08	12	12	15	14	15	20	22	24	26	24
An. maculatus	10	12	10	12	12	10	12	12	14	16	18	20
An vagus	-	05	03	06	08	10	08	06	12	14	12	12
An. splendidus	03	-	04	06	06	08	08	06	10	12	10	12
An. gigas	-	06	06	04	06	08	08	07	08	08	06	06
Aedes aegypti	10	12	12	14	14	14	18	18	20	24	22	20
Ae. albopictus	-	10	10	08	08	10	07	06	12	10	12	12
Ae. vittatus	02	04	04	06	05	08	06	07	08	10	11	10
Cx. quinquefasciatus	02	02	04	04	02	03	03	03	04	06	08	08
Cx. vishuni	02	02	03	02	02	02	04	05	06	08	06	06
Cx. mimeticus	-	02	03	02	03	02	03	04	05	06	04	04

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

Parameters	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 µs/cm	1745	1675	1645	1695	1450	1350	1375	1360	1650	1510	1551	1575
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	1115	1080	980	1030	1087	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^{0}C. Temperature of the study ranged between 20-26^{0}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 alkalinophile mosquiro 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 µS/cm to1020 µS/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 physic- chemical parameters like temperature, ph and DO were found to vary significantly with mosquito larvae abundance.

As mosquitoes are cold blooded therefore their actively 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.

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References

1. Gopalakrishnan R, Das M, Baruah I, Veer V, Dutta P. Physico-chemical characteristics of habitats in relation to the density of container- breeding mosquitoes in Asom, India. J. Vector Borne Dis,2013:50:215-219.
2. Fradin MS. Mosquitoes and mosquito repellents; a culician's guide. Ann Intern Med, 1998:128(11):31-40.
3. Amarasingh LD, Dalpadado DR. Vector mosquito diversity and habitat variations in a semi urbanized area of Kelaniya in Sri Lanka. Int J Entomol Res,2014:2(1):15-21.
4. Yadav P. Factors affecting mosquito populations in created wetlands, thesis. EnvSc Grad Prog Ohio State University, 2009, 1-43.

5. Russell RC. Constructed wetlands and mosquitoes: health hazards and management options an Australian perspective. Eco Engineering,1999:12:107-24.
6. Okogun GR. Life table analysis of Anopheles malaria vectors; generational mortality as tool in mosquito vector abundance and control studies. J Vector Borne Dis,2005:42:45-53.
7. CDC. Centre for disease control and prevention, life stages of Anopheles mosquitoes MMWR, 2004:52:989-97.
8. Mutero CM, Ngaanga PN, Wekoyela P, Githure, J, Konradsen F. Ammonium sulphate fertilizer increases larval population of Anopheles arabiensis and culicine mosquitoes in rice field. Acta Trop, 2004:89:187-92.
9. Seghal SS, Pillai MK. Preliminary studies on the chemical nature of mosquito breeding waters in Delhi. Bull WHO,1970:42:647-50.
10. Gimnig JE, Ombok M, Kamau L, Hawley WA. Characteristics of larval anophelinae (Diptera: culicidae) habitats in western Kenya. J Med Entomol,2001:38:282-88.
11. Overgaard HJ, Tsuda Y, Suwonkerd W, Takagi M. Characteristics of *Anopheles minimus* (Diptera: culicidae) larval habitats in northern Thailand. Environ Entomol,2001:31:134-41.
12. Piyaratne MK, Amersinghe FP, Amersinghe PH, Konradsena F. Physico-chemical characteristics of *Anopheles culicifacies* and *Anopheles varuna* breeding water in a dry zone stream in Sri Lanka. J Vect Borne Dis,2005:42:61-67.
13. Pemola Devi N, Mondal R, Jauhari RK. Physico-Chemical Assessment of natural breeding habitats of mosquito larvae in outskirts of Dehradun city, Uttarakhand. J Comun Dis, 2014:46(3):29-39.
14. WHO. Manual on practical entomology in malaria. Part I. vector bionomics and organization of antimalaria activities- WHO division of malaria and other parasitic Diseases, WHO, 1975; Geneva:160.
15. Barruad PJ. The fauna of British India, Diptera. *Today and Tomorrow's Printers and Publishers*,1934:5:136-43.
16. Harbach RE. Pictorial keys to the genera of mosquitoes, subgenera of Culex and the species of Culex occurring in southwestern Asia and Egypt, with a note on the subgeneric placement of culex desericola (Diptera: Culicidae). J. Mosq. Sys,1985:17:83-107.
17. Nagpal BN, Sharma VP. Indian anophelines, New Delhi; Oxford and IBH Publishers Co. Pvt. Ltd, 1995; 416.
18. Teklu BM, Tekie H, McCartney M, Kibret S. The effect of physical water quality and water level changes on the occurrence and density of *Anopheles* mosquito larvae around the shoreline of the koka reservoir, central Ethiopia. Hydrol Earth Syst Sci,2010:14:2595-603.
19. APHA, AWNA, WEF. Standard methods for the examination of water and waste water (Eaton A.D., Clesceri I.S., Greenberg A.E., eds.), 21st ed. Amer Pub Hlth Assoc, Washington, DC, 2005, 1325.
20. Olayemi IK, Omalu IC, Famotele OI, Shegna SP, Idris B. Distribution of mosquito larvae in relation to physico-chemical characteristics of breeding habitats in Minna, North Central Nigeria. Rev Infect,2010:1:49-53.
21. Sanford MR, Chan K, Walton WE. Effects of inorganic nitrogen enrichment on mosquitoes (Diptera; Culicidae) and associated aquatic community in a constructed treatment wetlands. J Med Entomol,2005;42:766-76
22. White GB. *Anopheles gambiae* complex and disease transmission in Africa. Trans Roy Soc Trop Med Hyg, 1974:68:278- 301.
23. Bayoh MN, Lindsay SW. Effect of temperature on the development of the aquatic stages of *Anopheles gambiae* sensu stico (Diptera: Culicidae). Bull Entomol Res,2003:93:375-381.
24. Bayoh MN, Lindsay SW. Temperature related duration of aquatic stages of the Afrotropical malaria vector mosquito *Anopheles gamgiae* in the laboratory. Med Vet Entomol.2004; 18:174-179.
25. Bradley P, Kutz FW. Proceeding of the work shop on storm water management and mosquito control U.S. Environmental protection Agency, office of Research and development, 2006. EPA/903/R-06/004.
26. Adebote DA, Oniye SJ, Muhammed YA. Studies on mosquitoes breeding in rock pools on inselbergs around Zaria, Northern Nigeria. J Vector Borne Dis,2008:45:21-28.
27. MacGregor ME. *Mosquito survey*. London. Welcome Bureau of scientific research;1927; p-282.
28. Chatterjee S, Chakraborty A, Sinha SK. Spatial distribution and physic-chemical characterization of the breeding habitats of *Aedes aegypti* in and around Kolkata, West Bengal, India. Indian J Med Res (Suppl), 2015, 79-86.
29. Okogun GR, Anosike JC, Okere AN, Nwoke, BE. Ecology of mosquitoes of Midwestern Nigeria. J Vector Borne Dis,2005:42:1-8.
30. Adebote DA, Oniye SJ, Ndams IS, Nache KM. the breeding of mosquitoes (Diptera: Culicidae) in peridomestic containers and implications in yellow fever transmission in village around Zaria, Northern Nigeria. J Entomol,2006:3:180-8.
31. Afolabi OJ, Ndams IS, Mbah CE, Kogi E. The effects of alteration of pH on the breeding characteristics of mosquitoes in phytotelmata in Ahmadu Bello University Zaria, Nigeria. Int J. Bioscience, 2010:5:32-6.
32. Nayaka BMS. Physico-chemical characteristics of larval hatritat waters of mosquitoes in and around Bangalore, Karnataka, India. Int J Ent Res,2018:3:2:177-179.
33. Sattler MA, Mtasiwa D, Kiama M, Premji Z, Tanner M, Killeen GF. Habitat characterization and spatial distribution of Anopheles sp. mosquito larvae in Dar es Salaam (Tanzania) during as extended dry period. Malaria j.,2005:4:4.