Statistical Survey of Mosquito Vectors in the Vicinity of Waldhuni Water Body, District Thane-India

B. M. Nabar*, K. B.Shepal, H. M. Lele and S. P. Lokegaonkar
Department of Microbiology, Smt. Chandibai Himathmal Mansukhani College, India, Maharashtra, Thane, Ulhasnagar- 421 003
*Corresponding author; Email: *belamsn23@gmail.com*

Abstract

Mosquitoes are one of the most medically significant vectors, and they transmit parasites and pathogens, which have major impact on the human population. The vector borne diseases caused by mosquitoes, such as dengue, malaria, yellow fever, chickungunya and filariasis, the major health problems in India. The Waldhuni river of the Thane district is highly polluted and now termed as nalla. The purpose of the study was to document the diversity of the harmful mosquito population in the vicinity of the Waldhuni nalla. Water samples were collected from eight different sites of the Waldhuni nalla and were checked for *p*H, temperature, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and mosquito population. Respective sites were monitored for the cases of malaria, dengue and filariasis. The biostatistical analysis was performed to study the correlation between water pollution, mosquito population and the mosquito borne diseases. Positive correlation between BOD, COD and TSS with mosquito population was found. Similarly, the significant relationship among malarial cases and *Culex* population was observed. The study revealed that Waldhuni nalla and its vicinity are good habitat for the adult mosquito in spite of being rich in the pollution.

Introduction

Environmental factors are of prime importance to the transmission of vector-borne diseases and include those associated with the host or the vector. The vector-borne diseases caused by mosquitoes are of global concern. Mosquitoes transmit disease to more than 700 million people annually in Africa, South America, Central America, Mexico, Asia, Europe, Russia, Greenland, Canada, United States, Australia, New Zealand, Japan (Gubler, 1998). India is one of the countries where the incidence of mosquito borne diseases are more. Mosquitoes belong to the group dipterans which transmitts dengue, malaria, filariasis, yellow fever, chickungunya, West Nile virus, and encephalitis. (Blagoderov *et al.,* 2002, Dhiman *et al.,* 2005).

Mosquitoes are generally found in domestic and peridomestic situations. *Aedes aegypti* and *Culex quinquefasciatus* are such types of mosquitoes, which breed in any type of man-made containers or storage containers having even a small quantity of domestic waste water, which plays the important role in the spread of vector-borne diseases in urban region (Daniel *et al.,* 2007, Pimentel *et al.,* 2007, Barbazan *et al.,* 1998).

Thane district is one of the most industrialized districts in Maharashtra, constituting chemical industries like NRC Limited, Century Rayon, Dharamsi Morarji and other industrial estates developed by M.I.D.C. with full facility at Dombivli, Ambarnath and Badlapur. The District consists of six major rivers, out of which the Ulhas river is surrounded by maximum number of small scale and large scale industries.

Waldhuni River (Waldhuni Nalla) of Thane district covers the most of the suburbs like Kalyan, Ambernath, Titwala, Shahad,

Vangani and Ulhasnagar that cover about 300 industries.

The disposal of vast domestic and the indutrial wastes in to the Waldhuni nalla has resulted into the imbalanced of the ecosystem where nearby areas act as good breeding sites for insects vectors such as mosquitoes and many other insects.

In the present study investigation of the impact of Waldhuni nalla pollution on populations of mosquito vectors was carried out. Vectors responsible for transmission of dengue and malaria, and filariasis in nearby areas of Waldhuni nalla were collected and counted. The interaction between human population and the vectors were analyzed through data collected over 6 months in eight villages surrounding the nalla.

Materials and methods

Selection of area

Ambarnath, Ulhasnagar and Kalyan region of Thane district was selected for the study. Different areas near Waldhuni River were included. The topographical details of the selected sites are as follows:

Site 1: Ambarnath railway station, surrounded by several hutments and has an overhead road bridge in the area.

Site 2: Ashok nagar, well populated region near Ambarnath railway station.

Site 3: Sanjay Gandhi nagar, situated near Ulhasnagar railway station with several small-scale industries.

Site 4: Ulhasnagar railway station, situated at the edge of the Waldhuni nalla.

Site 5: Hiraghat region, a dhobi ghat region where all laundry washing work is being carried out from many years.

Site 6: Gholapnagar, which consists of many units of small-scale and middle-scale industries.

Site 7: Waldhuni, Godrej park, where Waldhuni nalla enters in Kalyan region.

Site 8: Barve gaon, the region of Waldhuni nalla prior to the point where nalla merges to Kalyan creek.

The Fig.1 represents the map of Waldhuni nalla and the sites of sample collection from where water samples and the adult mosquitoes were collected.

Collection of water samples

Water samples collected from the field were transported to the laboratory for estimation of the physicochemical characteristics of the water. Temperature, *p*H, total suspended solids (TSS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were determined for each water sample using standard methods (Rajneeta *et al.,* 2008).

Collection of adult mosquito samples

Mosquitoes were collected using nylon net trapping method (Kay *et al.,* 1992, Kay *et al*., 2000). A minimum of 10 adult mosquitoes were collected. Adult mosquitoes were collected from the given area in the evening time, 6.30–7.00 p.m. For each selected site the area collection was kept constant. Approximately 100 m of area was covered during each time of mosquito collection by net trapping. This process was repeated each

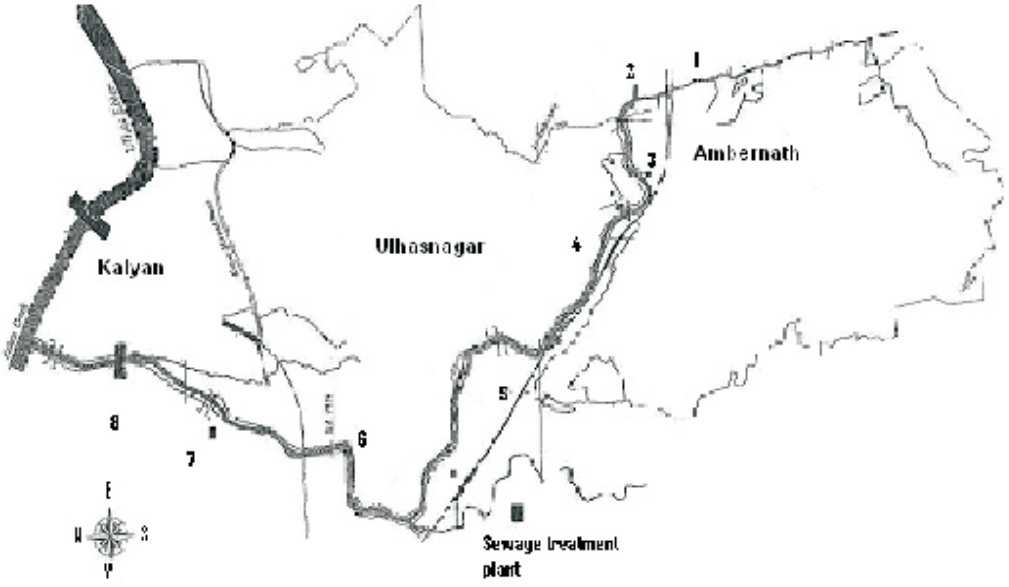

Fig. 1. Map of Waldhuni River showing the selected sites for the sampling. Water samples were collected from theses sites. Adult mosquitoes were collected from 100 m surrounding area from each sampling point.

month. Area and time for catching were kept constant. Collection and survey was carried out for 6 months, starting from June to November.

Identification of mosquitoes

Collected mosquitoes were identified by comparing their phenotypic characteristics, such as type of abdomen, proboscis, wings and legs with the standard reference (Michele *et al.,* 1998). All the mosquitoes were identified up to the genus level.

Survey of mosquito borne diseases

Data of cases of mosquito borne diseases were collected from physical practitioners and from municipal hospitals during the survey period after every 1 month interval. These cases were correlated with the population of adult *Anopheles* mosquitoes observed in that selected area in the same month. Similarly, cases of dengue were correlated with the population of adult *Aedes* mosquitoes and cases of filariasis were correlated with the population of adult *Culex* mosquitoes.

Biostatistical analysis

The results obtained were analyzed with the help of statistical package social science (SPSS) version 17. Descriptive analysis to find mean readings, and correlation statistics was performed with the help of contingency coefficient and one way ANOVA analysis.

Results

Waldhuni River area and its vicinity were selected for mosquito collection, and was also observed for increased level of pollution. Water flow of Waldhuni River was observed

to be steady in Ambernath, Ulhasnagar and Kalyan region due to deposition of solid wastes and polythene materials. Increase in the degree of pollution might be one of the factors responsible for such failure of control measures, and the nearby regions of this river can act as good breeding sites for mosquitoes. Water samples collected from selected sites showed high degree of pollution. The readings obtained for COD, BOD and TSS exceeds the permissible limits assigned by CPCB. The water samples were tested for *p*H, temperature, COD, BOD and TSS for 6 months. Mean readings are shown in Table 1.

Site1

Total 142 adult mosquitoes were collected from this site throughout the study. *Culex* mosquito dominated the mosquito population. Total of 86 *Culex*, 54 *Aedes* and 2 *Anopheles* mosquitoes were found. The count of *Culex* was constant for all months at this site, which ranged between 15–14. The Anopheles mosquitoes were found in the month of July, when the COD values was low.

Four patients, suffering from the mosquito borne diseases, were registered from this site. Two were suffering from Malaria and others with Dengue

Site 2

TABLE 1
Physicochemical parameters of water samples

Parameters	*Mosquito collection sites*								*Range*
	1	2	3	4	5	6	7	8	
*p*H	6.5	6.84	6.9	6.8	7.06	6.9	6.82	7.02	5.6–7.9
Temperature (°C)	30.8	30.8	30.4	30.2	30.4	30.4	30.4	30.4	30–31
BOD (mg/l)	418	4173	271	110	75	172	305	213	2 .4–19200
COD (mg/l)	2164	5700	1547	732	433	584	898	946	8–21400
TSS (mg/l)	14.9	16.8	280	300	81.4	84	400	40.5	0.1–2000

Mean readings of the physico-chemical parameters of the water of Waldhuni nalla from eight sites selected for the study. It represents the mean reading of 6 months.

Temperature of the water samples collected was between the ranges of 30–31 °C throughout the study period. The value of *p*H ranged between 5.6–7.13. The mean value of BOD was the second most among the total sites selected. It recorded maximum during the month of October, i.e.1080 mg/l. The range of COD was 136–8000 mg/l at this site. The lowest reading for COD at this site was recorded during September. In every month gradual reduction in the reading of TSS was observed.

The highest mean BOD and COD were recorded at this site. The BOD was maximum during June, i.e. 19400 mg/l, which showed a gradual reduction in later months. During same period the maximum reading of COD was recorded, i.e. 21400 mg/l. The TSS reading also showed reduction. The slight variation in temperature condition was observed at this site. The *p*H value ranged between 6.1–7.01.

Total number of adult mosquitoes

collected from this site was 127, which consists of 23 *Anopheles*, 61 *Culex* and 43 *Aedes*. This was the site where maximum *Anopheles* mosquito population was observed. The overall mosquito population was more during the months of October and November.

In July patient suffering from dengue was 1. Three malarial cases were found at this site during June, August and October.

Site3

The mean *p*H of the water collected from this site was 6.9 (Table 1), where the temperature range was 30–31 °C. The BOD was found to be more in October, i.e. 500 mg/l. The maximum value of COD was recorded in December, i.e. 3600 mg/l. High value mean of TSS was observed at this site, i.e. 280 mg/l. The maximum TSS at this site was recorded in June, i.e. 1400 mg/l.

Total number of mosquitoes collected from this site was 124. Similar values of mean mosquito population of *Aedes* and *Culex* were observed (Table 2). More *Aedes* population and less *Culex* population were observed in June, October and December. Four malarial cases were found from this site during the month of July.

Site 4

The *p*H range of the water samples of the Waldhuni nalla from this site was 6–7.5; mean temperature recorded was 30.2 °C. The COD was found to be increasing and was maximum during the month of December, i.e. 1400 mg/l. Least BOD value was recorded at this site in October. TSS was found maximum at this site in June, which decreased in later months. Total of 141 adult mosquitoes was collected. Maximum population was recorded in November and was less in June and July.

Site 5

Gradual increase in BOD was observed. The mean *p*H was 7.06. No significant variation was observed in *p*H and temperature. The TSS was more in June, i.e. 1400 mg/l. Total mosquito population at this site was 83, constituting 20 *Aedes* mosquito, 60 *Culex* mosquito and three *Anopheles* mosquito species. The maximum mosquito population was observed in August at this site, where BOD value was within the permissible limits. Two cases of malaria were found in November from this site. No anopheles adult mosquitoes were found from September to December.

Site 6

TABLE 2

Comparison of mosquito genera with respective mosquito borne diseases

	Mosquito collection sites							
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Culex	12.3	12.6	10.0	11.15	10	13	10.9	6
Aedes	7.7	7.2	12.6	10.2	4	10.2	11.2	10
Anopheles	2	4.6	1	3	3	1	5	4
Dengue	2	1	0	0	1	0	4	1
Malaria	2	3	4	3	2	4	1	5

The table represents the mean value of total observation.

The acidic conditions were observed at this site though *p*H ranged 5.8–7.6. The BOD and COD were maximum in December, i.e. 520 mg/l and 1120 mg/l, respectively, and least TSS was recorded in December, i.e. 0.3 mg/l.

Total of 139 mosquitoes were collected, where no *Anopheles* was found. The *Culex* population was maximum in December, while that of *Aedes* was less, i.e. 20 and 1, respectively. Four cases of malaria were observed from this site. No *Anopheles* population was found.

Site 7

Maximum TSS was recorded, i.e. 2200 mg/l in June, where COD and BOD values were minimum. The *p*H was in the range of 6.6–7.

Total of 133 adult mosquitoes was collected from this site. Maximum population of *Aedes* was recorded here, i.e. 76. *Culex* population was more in December only, where high BOD and COD were recorded.Eight *Anopheles* mosquitoes were found but no cases of malaria were found during the whole period of study from this site. Four cases of Dengue were registered from this site.

Site 8

Mean BOD value at this site was 213 mg/l, it was least at this site during September, i.e. 9.6 mg/l, while COD reading was also found within permissible limits of CPCB for effluents, though mean COD exceeds provided limits.

From this site a total of 138 adult mosquitoes was collected, which consists of 69 *Aedes*, 65 Culex and 5 *Anopheles* species. During December mosquito population was maximum at this site, where the COD and BOD readings recorded exceeded permissible limits. Five cases of malaria and 1 case of dengue were observed.

Mosquito population and pollution of Waldhuni water

The correlation statistics were performed to explore the relationship between mosquitoes and pollution level of Waldhuni (Table 3). The contingency coefficient value was used for the analysis. It is a measure of association based on the Chi square test. The value closer to 1 indicates a strong relationship between the variables.

TABLE 3

Correlation between the studied parameters and mosquito population based on contingency coefficient analysis

Parameters	*Contingency coefficient*		
	Aedes	Culex	Anopheles
*p*H	0.917	0.917	0.913
Temperature	0.764	0.816	0.76
BOD	0.926	0.926	0.913
COD	0.926	0.926	0.913
TSS	0.926	0.926	0.926

The contingency coefficient values obtained were in the range of 0.76–0.926. This indicates the strong relationship between the water pollution with the population of mosquito in the vicinity of Waldhuni nalla. *Aedes* and *Culex* mosquito population is related with the BOD, COD and TSS. Some degree of correlation was observed, i.e. 0.926. *Anopheles* population showed more relatedness with the TSS value of the Waldhuni water (Fig. 2).

Mosquito borne diseases and mosquito

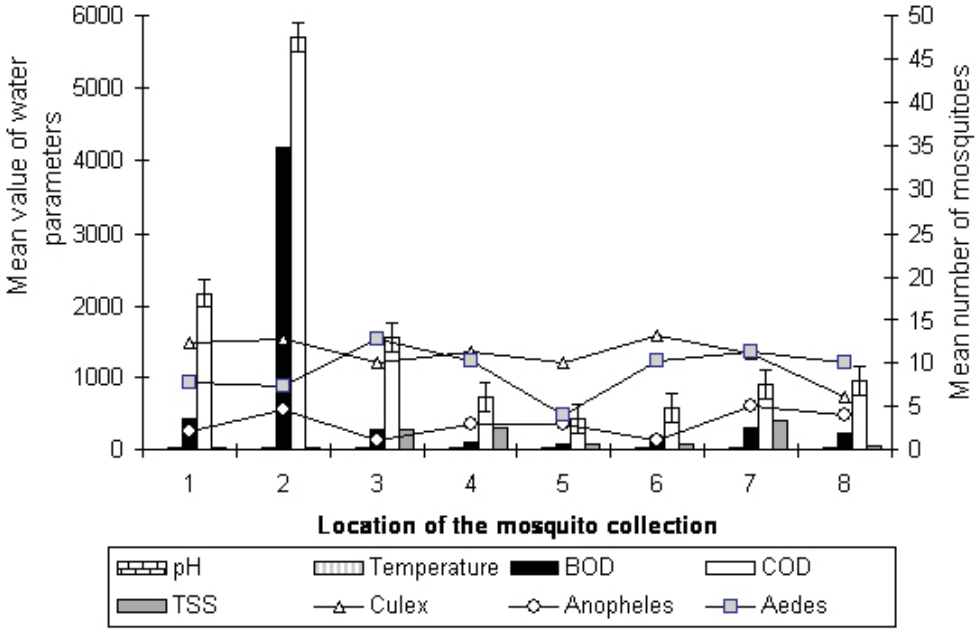

Fig. 2. Correlation of the adult mosquito population along with the physico-chemical parameters of Waldhuni river. Graph represents the mean of readings obtained during 6 months. BOD, COD, TSS contents are represented in mg/l units.

population of selected sites

The relation between the cases of malaria, dengue and the mosquito population constituting *Aedes*, *Culex* and *Anopheles* was assessed with the help of variance analysis (Fig. 3). The variation between the mean value of the mosquito population and mosquito borne diseases were calculated by performing one-way ANOVA (Table 4). The significance of less than 0.05 indicates the strong relationship.

The mean comparison of Dengue with the mosquito population did not show significant readings. Similarly, the mean *Culex* and mean malaria showed most significant result, $P = 0.05$, hence revealing association.

Discussion

Temperature has major effect on the biochemical system of mosquito reproduction. No significant variation was observed throughout the selected sites. It ranged from 30 to 31 °C (Table1), which is the optimum temperature for the growth of mosquito larvae. The optimum *p*H requirement by mosquito is around 8.0. The mean *p*H of the sites of Waldhuni nalla was neutral. Hence the mosquito population was found least affected by *p*H (Rydzanicz & Lonc, 2003).

The biological oxygen demand indicates the amount of oxygen required by the microorganisms for decomposition of organic matter. High BOD favours the microbial growth, which, in turn, acts as food for mosquito larvae. It was observed that, at

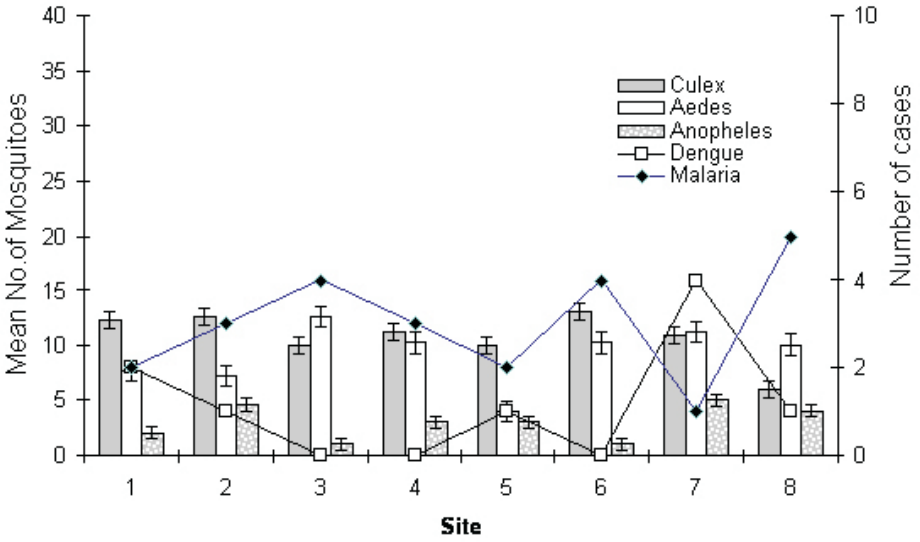

Fig. 3**.** Correlation between the mosquito borne diseases and mosquito vectors in the vicinity of Waldhuni river. The graph represents the comparison of the mean readings of the number of mosquitoes and number of cases of mosquito borne diseases in the vicinity of Waldhuni nalla.

TABLE 4

Correlation between mosquito population and mosquito borne diseases in the vicinity of Waldhuni nalla based one way ANOVA

	Malaria		*Dengue*	
Factor	*F-value*	*p- value*	*F-value*	*p- value*
Aedes	3.737	0.079	3.579	0.155
Culex	5.202	0.041*	0.757	0.448
Anopheles	0.381	0.70	NA	NA

Key: F value : ratio of mean square; NA: No statistics were calculated; *: Significant value (p value < 0.05); Mean value of mosquito population and mean of mosquito bone diseases were compared by using one way ANOVA.

site 5 of the Waldhuni nalla, the mosquito population was less, i.e. 83, and mean BOD was the least, i.e. 75.5 mg/l (Table 1). While other sites with high BOD had higher mosquito population, i.e. 127–142.

Ranjeeta *et al*. (2008) have elaborated negative correlation with BOD, where the decrease in mosquito population with high BOD was observed. Rydzanicz & Lonc (2003) reported no association between BOD and mosquito population.

Burke *et al.* (2010) had correlated septic tank condition, which shares similarity with respect to the biochemical conditions of the nalla, and identified as a good habitat for adult and larval mosquito population.

Chemical oxygen demand (COD) explains the extent of oxygen required for the

degradation of chemicals in the water. It was considered to exhibit harmful effect on the mosquito endurance. It was observed that Site 3, with least mean COD, had the least mosquito population (Table 1). While Site 1 and Site 2, with maximum COD, had 2164 mg/l and 5700 mg/l, respectively; high load of mosquito population was observed. The total solid content (TSS) was found to show positive association with mosquito population. The least mean TSS values were recorded at Site 1 and Site 2, i.e. 14.9 mg/l and 16.8 mg/l, respectively, where maximum mosquito population was observed (Table 2).

The mosquito population was also correlated with the incidence of the malaria and dengue cases from the respective selected site of the Waldhuni river. Positive correlation between the malaria and *Culex* population was observed (Table 4). While no significant relation was recorded between case of malaria and *Anopheles* population.

At Site 2 high population of *Anopheles* mosquito was observed, though the number of cases of malaria was least, while at Site 6 there was no *Anopheles* mosquito population but maximum malaria cases were recorded. At Site 2 high *Aedes* population was found but very few cases of dengue were observed. These results suggest the possibility of a shift in the vector transmission and host mosquito. This requires much detailed study.

It is generally thought that the abundance of clean, sun-lit, and shallow bodies of water makes rural populations especially vulnerable to increased contact with anopheline mosquitoes. Likewise, the absence of suitable habitat and increased water pollution generally inhibits the development of anopheline larvae in urban centers, resulting in fewer *Anopheles* mosquitoes (Rajneeta *et al.,* 2008, Kay *et al.,* 1992). But the water bodies such as Waldhuni nalla can act as good reservoir for mosquito larvae and the adult mosquito. The excessive mass of the biological material and the interference by the resident chemicals can reduce the effectiveness of insecticides (Rydzanicz and Lonc, 2003). The incidences of developing resistance due to biochemical changes in ecology of habitat have been reported by Lambert *et al.* (2003) and Whitty *et al.* (2004). The high biological and chemical demand fulfills the requirement of the mosquito larvae and supports their growth.

The infection from mosquito-borne diseases depends on the exposure of people to biting mosquitoes. Any factor contributing to increased mosquito populations, mosquito longevity and closer contact between humans and mosquito vectors can influence transmission dynamics. The sites selected for the study are well populated which include residential and the industrial parts of cities. Hence, populations adjacent to the nalla is vulnerable to the mosquito borne diseases.

The study was supported by Chinery *et al.* (1984) and Donald *et al.* (1980), who have studied the effect of ecological variations on mosquito population. Jeron *et al.* (2007) have elaborated waste stabilization ponds as good mosquito breeding sites because of their high nutritional value for insects. But the effect of pollution on mosquito population and its relation to mosquito-borne disease has not been studied.

Conclusion

From the study it was concluded that the population of *Culex* mosquitoes is constantly high throughout. Positive correlation between the water pollution and the mosquito population was observed. The mosquito population was found to increase with increase in pollution. When the relation between the mosquito-borne diseases and the mosquito population was explored, significant relation between the malarial cases and the *Culex* population was observed. Increasing level of pollution creates suitable environment for growth of these types of mosquitoes. The sites of Waldhuni nalla, selected in the study, indicate that the surrounding area of Waldhuni nalla is susceptible to mosquito borne diseases.

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