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Mapping of Spatio-Temporal Distribution of Mosquito Vector Density in Sitheri Hills Using GIS Technology

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Abstract Rural remote villages located on top hills where lack of basic amenities including health and transportation facilities. Also vector control is a major task in tribal areas, because storage of water in different vessels are one of the essential practices in their lifestyle, So numbers of vector breeding sources are created by them due to poor awareness about vector borne diseases. In the present study involves mapping the spatio-temporal distribution and mosquito species in and around Sitheri hills located in Dharmapuri district of Tamil Nadu. For this study, the thematic maps like location, water storage sites, settlements, and spatio-temporal distribution of mosquitoes and potential mosquito breeding sites and its abundance map were prepared. Mosquitoes were collected from 10 villages in the study area using aspirator and resting bed net by indoor resting, outdoor landing and dusk collection for the years of 2012 and 2013. The spatio-temporal analysis was performed by the IDW interpolation techniques were used at GIS environment. The study provides information about density and spatial distribution of mosquito species record in the study area. The study concludes that the map of breeding sites and population density of mosquito vectors in Sitheri hills are essential for vector control and also useful for monitoring of Vector Borne Diseases (VBDs) in remote areas.
Keywords *Inverse Distance Weighed Technique; Mosquito Species; Spatial Distribution; Sitheri Hills; VBDs*

1. Introduction

Distribution and the fast dynamics of vector borne diseases are important public health problem in India. Mosquitoes are a single group of insect which belongs to the family of Culicidae. It is mostly important to public health, which transmits various diseases such as malaria, yellow fever, filariasis, dengue fever, encephalitis, and equine encephalitis. These are mainly caused by various mosquito species such as *Anopheles species*, *Aedes aegypti*, and *Culex species* [1, 2, 3].

Naturally, all types of mosquitoes are aquatic habitats for breeding. The breeding resources in terms of food, predators and competitors present in the habitat determine the population status of larval mosquitoes, both qualitatively and quantitatively [4, 5]. In addition, each species has specific needs and habitats e.g. rice fields, plantations, forests, forest fringes, foothills, tree holes and artificial containers etc., Moreover, mosquito distribution and abundance are varied based on the environmental factors and environmental changes such as temperature, humidity, rainfall and urbanization, deforestation, vegetation clearance for crop plantations and large scale population movement [6]. So, the change of environmental conditions may have direct or indirect effect on disappearance [7] of some species as well as reappearance of new species [5]. Also, the biological richness of mosquitoes was varied based on altitude ranges. The study area, Sitheri hills have altitude range of 1400-3200 ft. [8, 9]. In addition, this area people are tribes not aware about vector borne diseases and also insufficient medical and transport facilities. There are the possibilities for the formation of mosquito-borne diseases outbreak in the study area.

For assessment of mosquito borne diseases and mosquito density is very difficult do by manual method in a large area. Hence an appropriate method found be used for rapid and accurate determination of breeding places of mosquitoes [1]. The presence and spatial distribution of mosquito vector species are determined by both abiotic (e.g. temperature, water disposal, and topography) and biotic factors (e.g., abundance of vertebrate hosts and availability of larval habitats). Many of the researchers [10] make an effort to predict the potential mosquito breeding by using this technique. Therefore this study was conducted to determine the mosquito density through spatial and temporal distribution analysis, bio-statistical analysis and mapping their potential abundance in Sitheri hills, Dharmapuri district, Tamil Nadu, India.

2. Materials and Methods

2.1. Study Area

Sitheri hills is one of the segments of Eastern Ghats of Tamil Nadu, within the geographical limit of 78°15’00’’ – 78°45’00’’E longitude and 11°44’00’’ – 12°08’00’’N latitude. The total area is about 736.18 sq.km situated at Pappireddipatti Taluk, 28 Km distance from Harur town in Dharmapuri District. Sitheri hills are covered by four forest ranges including Harur, Morappur, Theerthamalai and Kottapatti under Harur Forest Division in the state. The total area of Sitheri hills consists of 59 hamlets and all the hamlets are under the control of one Panchayat President. It has one Primary Health Centre which is located in Sitheri village and four Health Sub Centers; they are situated in Suriyakadai, Nochikuttai, Ammapalayam, and Kalasapadai. Table 1 shows that geographical location and altitude ranges (ft) of ten sampling villages. The soil pattern of Sitheri hills is generally shallow and reddish-loam, varying in fertility and often mixed with gravel and boulders. Moreover, the black soil is seldom found throughout the forest.

2.2. Mosquito Survey and Identification

Entomological survey was conducted for two years 2012 and 2013. Survey was done within a radius of 2 km around the sampling sites in seasonally. The methods of indoor resting, outdoor landing and dusk collection were carried out from selected sites as well as in random sites. In indoor sites mosquito samples are collected from human dwelling, cattle sheds, mixed dwelling and outdoor situations such as bushes, plantations, standing crops, etc. by hand catch method using suction tubes. Per man hour (PMH) density was monitored and reported in standard prescribed format. The collected specimens were preserved in plastic vials at room temperature for later identification. Immature forms of mosquitoes were collected by dipper method (WHO 1975) [11] and reared in enamel trays in the laboratory. The emerged adults were collected and stored in vials and all the collected mosquitoes

were identified in Centre for Research in Medical Entomology, Madurai using the standard keys of Barraud (1934) [12] and Christopher (1933) [13].

Table 1: *Latitude and Longitude of Selected Sampling Villages in the Study Area*

Sampling Villages	GPS (Range)	Altitude in Feet
Nochikuttai	N11.54.071 - N11.52.098 E078.27.107 - E078.27.142	3158 - 3187
Sitheri	N1153.365 - N1153.431 E078.30.600 - E078.30.659	3108 - 3170
Pudhur	N11.54.893 - N11.54.924 E078.32.602 - E078.32.638	2716 - 2737
Pereri	N11.54.584 - N11.54.619 E078.32.194 - E078.32.256	2721 - 2740
Sulakurichai	N11.55.214 - N11.55.238 E078.33.629 - E078.33.643	2560 - 2581
Suryakadai	N11.55.666 - N11.55.726 E078.34.001 - E078.34.049	2564 - 2596
Thekkalpatti	N11.56.534 – N11.56.692 E078.56.137 – E078.56.244	1762 - 1792
Selur	N11.50.113 - N11.50.249 E078.34.795 - E078.34.928	1569 - 1592
Shanmugapuram	N11.54.388 - N11.49.401 E078.33.741 - E078.33.754	1580 - 1581
Ammapalayam	N11.49.900 - N11.49.956 E078.32.940 - E078.32.993	1463 - 1482

2.3. GIS Analysis and Map Preparation

The boundary maps of Sitheri hills were prepared from topographical maps (58 I/5, 58 I/6, 58 I/9, 57 L/12) by digitizing in Arc GIS10 software in the scale of 1:50,000. A well location map (Figure 1) 10 sampling sites was also digitized and entomological data was attached with this well location point map in the form of an attribute table. Also, this software used for determination of spatio-temporal distribution of mosquitoes in selected ten villages based on seasonal mosquito survey by IDW (Inverse Distance Weighed) interpolation method. Species wise abundance and surveillance of mosquito vectors in the study area was mapped by Inverse Distance Weighted Interpolation technique. Inverse distance interpolation is used to read the gray level values for an arbitrary number of pixel locations in order to generate a raster image based upon interpolation between the specified gray levels. This method of interpolation combines the idea of Thiessen polygon with the gradual change of trend surface. It considers weighted moving average. Weights are computed from a linear function of distance between sets of points and the points to be predicted. In this method the size of the starting radius is specified, which defines the starting search area for interpolation points around grid point.

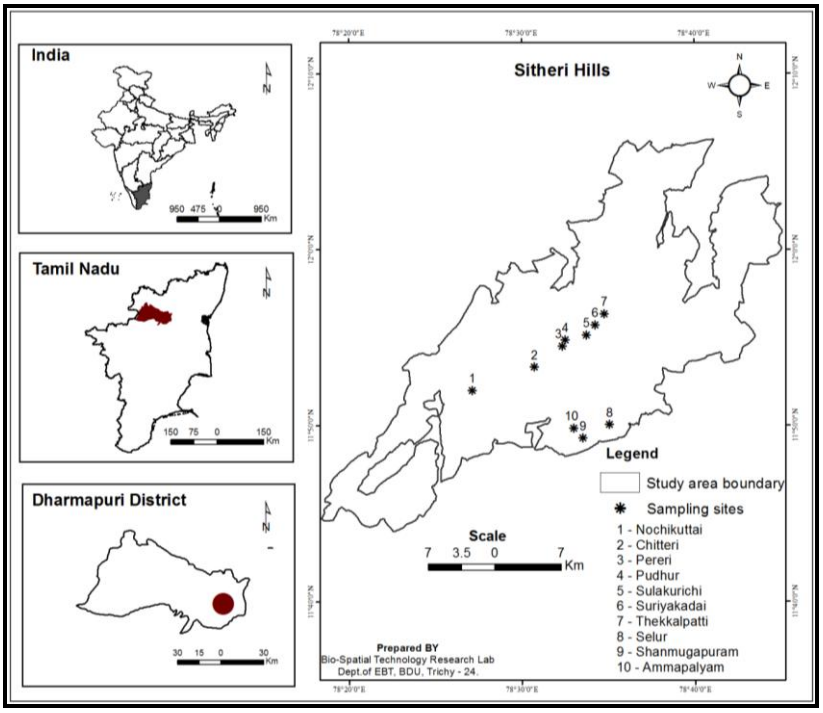

Figure 1: *Location Map of the Study Area*

2.4. Overlay Analysis

For the identification of species richness area, topographical parameters, environmental factors (rainfall and temperature) and spatial distribution of mosquito map layers are overlaid by fuzzy overlay method then the potential mosquito abundance were classified and mapped in 5 categories such as very low, low, medium, high and very high.

3. Results and Discussion

The study area having different temperature ranges such as 21°C - 35°C in pre monsoon (March-June), 16°C - 33°C in monsoon (July-September) and 13°C - 29°C in post monsoon (October-December) season. Over the study period the maximum annual average rainfall is 250 mm and humidity range from 70 - 86 percentages maximum rainfall was observed in August month (monsoon). The lifespan and occurrence of mosquito species was influenced by variations in climatic conditions, and hence there is diversity in distribution and habitats of different vector species.

From the mosquito survey results, more number of immature mosquitoes were collected from paddy fields, tree holes and the adults were collected in and the around cattle shed and human dwellings. The water storage site map gives the details of rivers, streams, wells, strings and dry tanks presence in the study area (Figure 2). Figure 3 shows settlements in the study area which includes the hamlets, schools, buildings and a health centre etc.

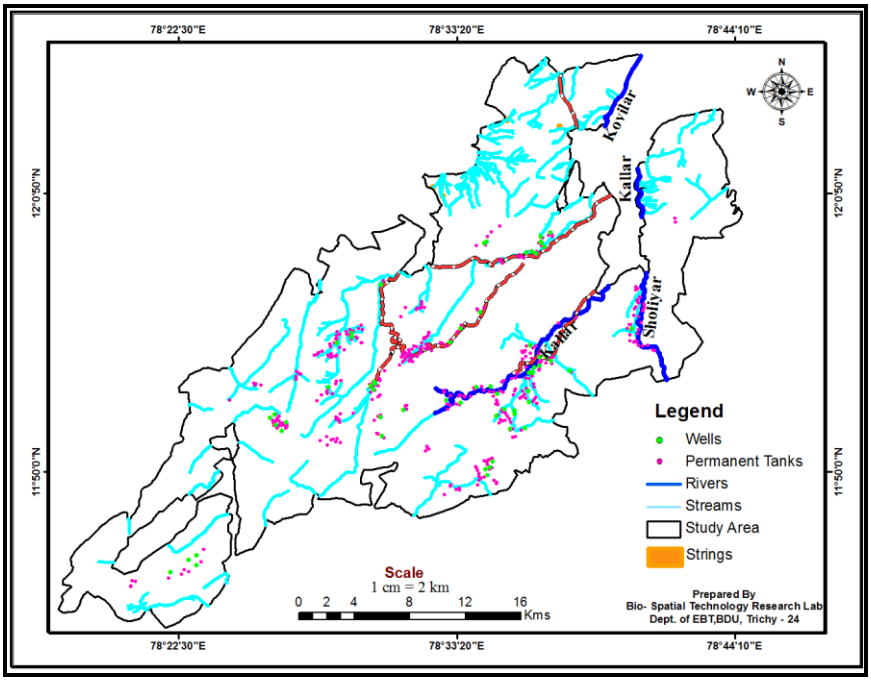

Figure 2: *Water Storage Sites Map*

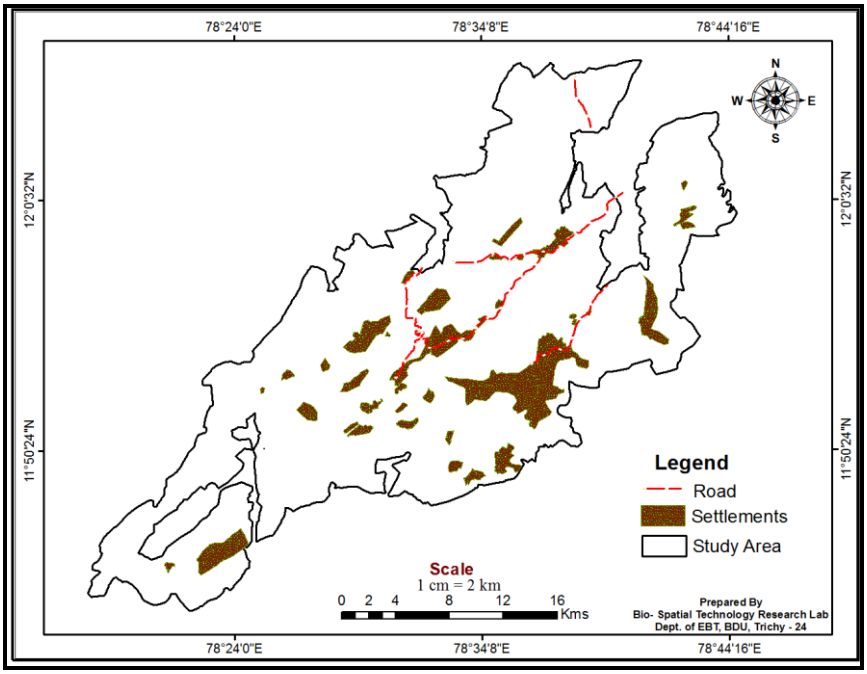

Figure 3: *Settlements in the Study Area*

Table 2: *Collection of Mosquito Species in the Year of 2012 and 2013*

S. No.	Sampling Sites	2012			2013		
		Pre-monsoon	Monson	Post-monsoon	Pre-monsoon	Monson	Post-monsoon
1.	Nochikuttai	51	212	78	204	103	47
2.	Sitheri	347	782	598	269	263	236
3.	Pereri	69	191	118	212	104	59
4.	Pudhur	211	445	276	197	90	139
5.	Sulakurichi	56	129	49	59	22	11
6.	Suriyakadai	78	183	97	82	58	54
7.	Thekkalpatti	73	387	209	592	257	120
8.	Selur	104	251	58	159	92	110
9.	Shanmugapuram	47	292	159	319	109	99
10.	Ammapalayam	138	189	164	168	105	47
	Total	**1174**	**3061**	**1806**	**2261**	**1203**	**922**

A total of 10,427 mosquito individuals comprised on 53 species under eleven genera have been recorded in both the years (Table 2). The findings of mosquito collected revealed that maximum number of individuals 58.49% of mosquitoes (6041) was found in first year under 11 genera and 46 species. In second year 41.50% (4286) of individual mosquitoes were collected from 9 genera 39 species. Therefore, the reduction percentage of mosquitoes in 2nd year is 16.99 %.

Figure 4 and 5 illustrated that spatio-temporal distribution of mosquito species in 2012 and 2013. In 2012 maximum number of species distribution present in monsoon lowest range 129 - 188 and highest range from 722 - 781. But, in 2013 pre monsoon have large number of species distribution the lowest range from 59 - 112 and highest range from 538 - 591. Mosquito survey report revealed that the presence of the mosquitoes were varied seasonally and also sampling site-wise. It was due to environmental factors and topography which was varied in each sampling sites. The Sitheri hill is a reserve forest, hilly terrain and subtropical region and it has various seasonal changes. Environmental variables are significantly influence both the biology and the availability of resources in the habitats. According to our findings the year of 2012 mosquito habitats was highly available in monsoon season seems that the presence of the mosquito breeding sites are highly available during this season due to high rain fall. Moreover, in post monsoon also present many of the mosquitoes compare to pre monsoon because after rainy season, many habitats are presented due to temporary water pools, paddy fields, crop lands, and other plantations [15]. But in 2013 the high number of mosquitoes recorded in pre monsoon followed by post monsoon, it may be associated with major environmental changes including rainfall, modified agricultural practices and others. So, the species richness mainly depends on structure and quality of the habitats and also each species grows in a particular environment such as fresh water, rainwater, sewage, drainage at specific temperature [14].

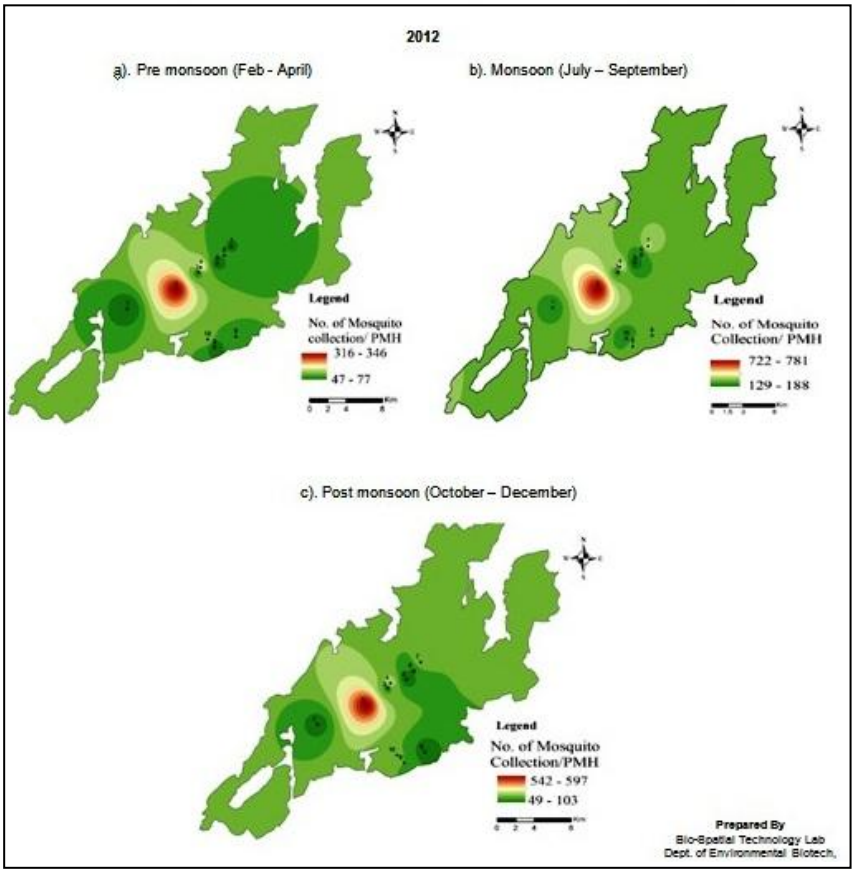

Figure 4: *Map of Spatio-Temporal Distribution of Mosquito Vectors in the Year of 2012*

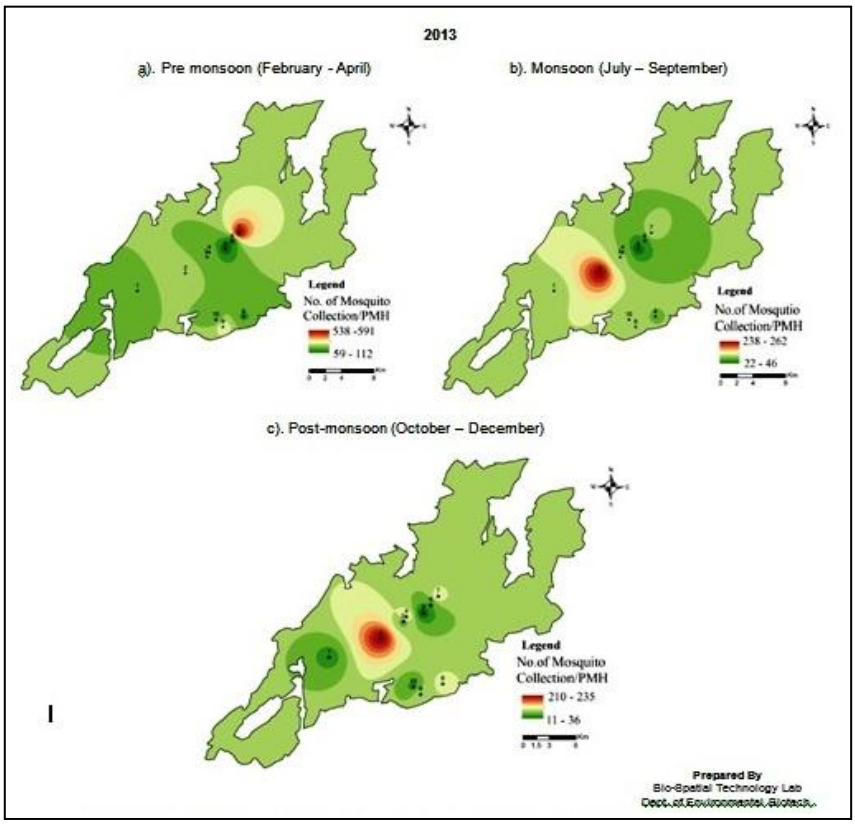

Figure 5: *Map of Spatio-Temporal Distribution of Mosquito Vectors in the Year of 2013*

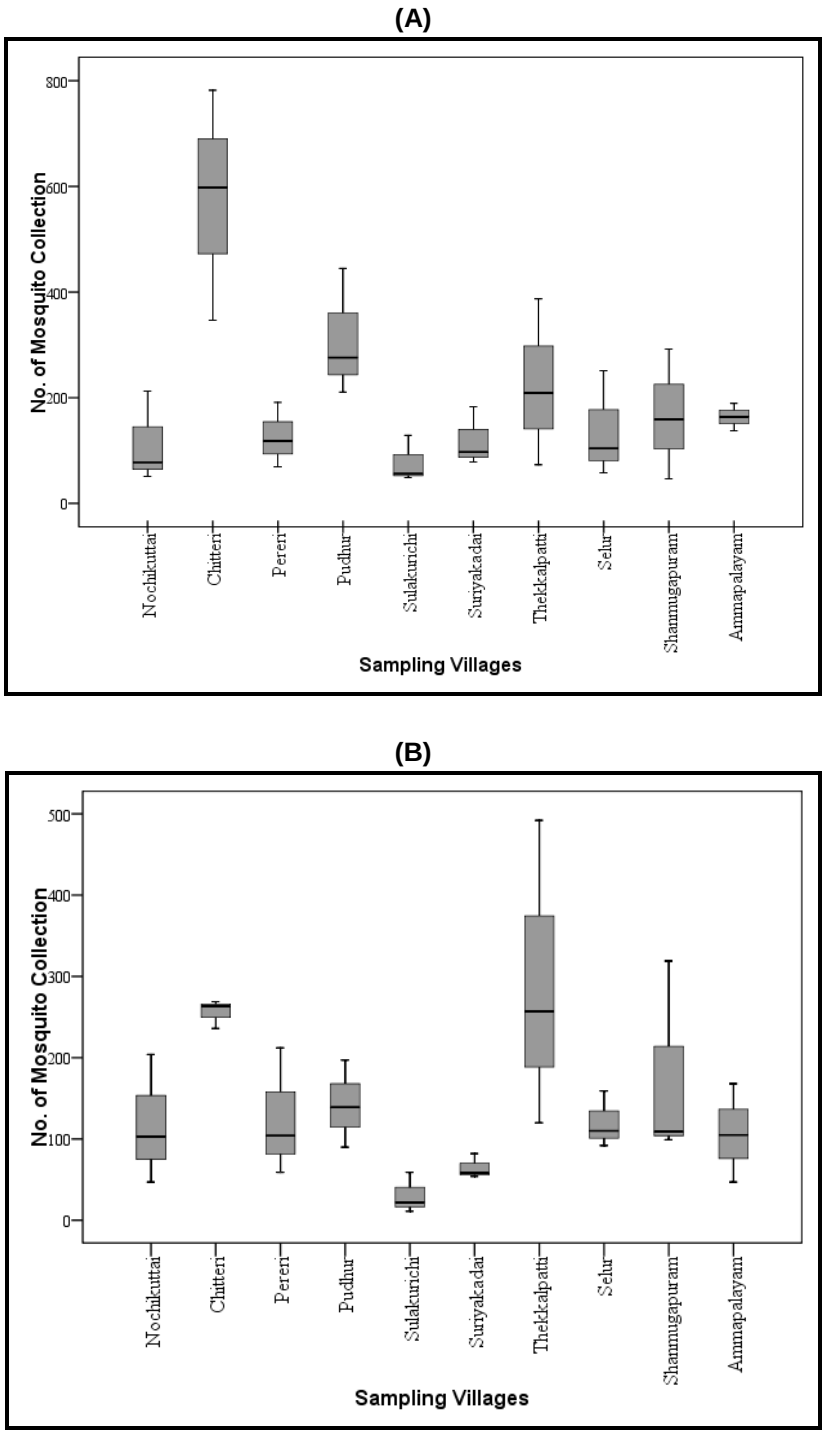

Figure 6: *Box-Plot for Mosquito Collection from Ten Different Villages during Seasons at Sitheri Hills* ***(A)*** *2012 (First Year) (****B****) 2013 (Second Year)*

Box plot analysis (Figure 6) was done for calculate yearly average of mosquito abundance in selected sampling sites. By this result, 2012 highest numbers was found in Sitheri (576 individuals) and lowest in Sulakurichi (78 individuals). Although, 2013 highest species was recorded in Thekkalpatti (289 individuals) and lowest was recorded in Sulakurichi (31 individuals). Potential mosquito abundance sites in the study area were classified by using overlay of spatio-temporal distribution maps (Figure 7). From this map observed that mosquitoes are highly present in the Sitheri village and surrounded area. It is due to the presence of maximum mosquito breeding habitats such as river, streams, paddy field, tree holes, rock holes, bamboo stem, cement container, dead plant leaves etc. Also, Dutta, et al.

(2010) reported that the maximum breeding of mosquitoes was detected Dibru-Saikhowa biosphere reserve from the habitat of slow flowing stream followed by ground pool, drain beside paddy field, stream margin, sandy pool, flood leaf axil, tree stump hole of dead tree, artificial container etc.

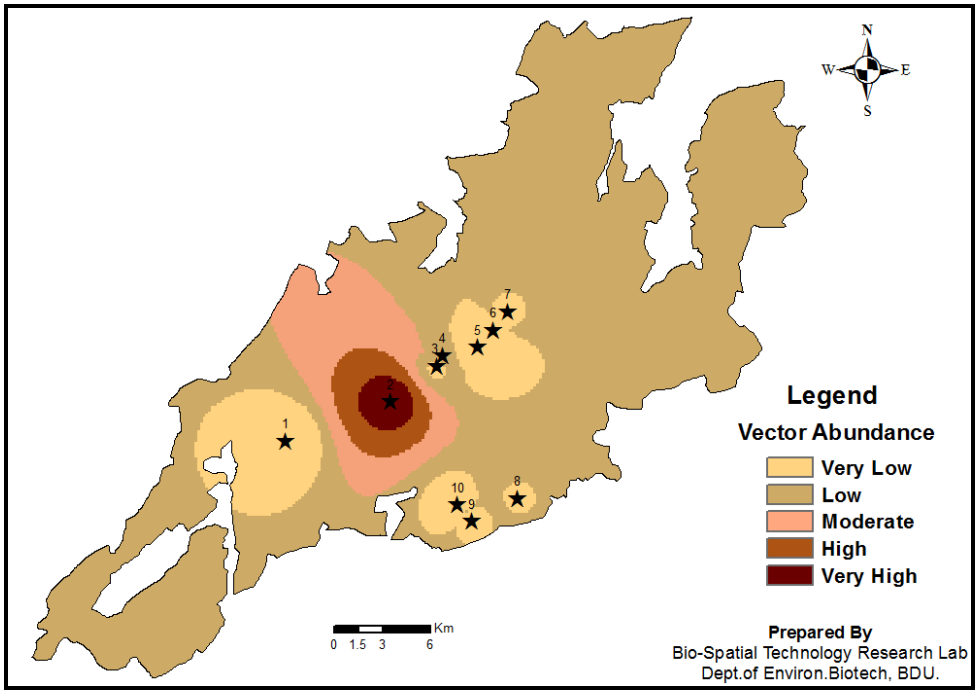

Figure 7: *Vector Abundance Potential Map of the Study Area*

The seasonal prevalence of study area was varied both the year may be due to rain fall and temperature. During monsoon season, none of adult mosquitoes could be collected, whereas a relatively much lower mosquito occurrence was observed in Sulakurichi as compared to other study areas. The reason for detection of less number of mosquito species during monsoon season was due to low rainfall. We were found highest mosquito species occurrence in 1st year than 2nd year because of breeding sites, human activities etc. [7].

4. Conclusion

The present study concludes that spatial and temporal distributions of mosquitoes are varied based on the climatic factors and man-made activities. The highest number of mosquito species is observed in settlement, agricultural plantation and deforestation areas than forest area. Also, it is more borne to the mosquito breeding sites. The GIS map overlay results shows that anthropogenic activities influence the major cause of abundance of mosquitoes in the study area. Moreover, lack of awareness about waste water disposal and poor sanitation are the key factor for abundance of mosquitoes. The results of the study we can use as a baseline data for the control of mosquito density in Sitheri hills.

Acknowledgement

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