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POTENTIAL OF MALARIA TRANSMISSION WINDOWS IN AN URBAN AND RURAL AREA OF WEST BENGAL, INDIA

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Abstract

Periodic epidemics of malaria occur every five to seven years in West Bengal. According to IPCC (Intergovernmental Panel on climate change), the vector borne diseases will be increased day by day due to global climate change. Ambient temperature, relative humidity, rainfall and wind speed are the major influencing factors of the dynamics of vector borne diseases. The breeding activity of Anopheles mosquitoes in association with meteorological parameters may be considered as one of the major environmental causes of malaria transmission. Our study addresses the malaria transmission probability in an urban and rural site of West Bengal. Kolkata (22.57^{0}N, 88.37^{0}E) and Digha (22.38^{0}N, 87.32^{0}E) are selected as an urban and a rural site in this study. Meteorological Parameters for the period 1997 to 2007 of these sites are analyzed to find the probability of malaria transmission windows throughout the year along with the malaria incidences. It is observed that broad transmission window (Temp: 160 – 40^{0}C, RH: 55% – 80%) extends eight months in a year. The two sites have equal probability of transmission but malaria incidences in Digha are too small. Hence other environmental parameters such as slum area, drainage, population density, agricultural practices and health services are to be considered for monitoring malaria transmission.

INTRODUCTION

Malaria is one of the devastating infectious vectors borne disease in developing countries. Vectors and parasites are very sensitive to climatic parameters particularly of ambient air temperature. Our environment is under threat due to climate change. Intergovernmental Panel on Climate Change[1] has reported the probability of the increase of temperature by 1.8^{o}C- 4^{o}C at the end of 2100 and hence the vector borne diseases will spread both temporally and spatially all over the tropical countries. An increase of temperature will cause the transmission of malaria to higher latitudes and altitudes whereas the present locations of vector borne disease have negative feedback[2, 3]. Hence impact on public health due to the dynamics of vector borne disease will strongly depend on local meteorological parameters and geographical locations. The distribution and abundance of mosquitoes directly or indirectly will controlled by the climate to some extent. Climate is the deciding factor of the survival range of malaria parasites[4-7]. However mosquito populations may be controlled by the use of insecticides or modifying the habitats[8]. Modernization of live stocks, farming and development of socio economic status has prevented the possibility of malaria epidemic in Europe. The use of quinine in malaria fever and keeping cattle's from human settlements may reduce the malaria incidences. However the degree of prevention by improving social economic structure, health education and agriculture practice is not yet crystal clear due to the fact that malaria is a disease of tropical and developing countries[9-12]. The distribution of malaria at present and ten years back have pointed out that the shift and new introduction of malaria prone regions in Tropics.

The impact of climate on malaria has been carried out in different countries by several investigators[5, 13-19]. Existing opinion regarding the dependence of different meteorological parameters on malaria are conflicting each other. To some opinion, the spread of malaria are due to drug resistance rather than temperature change while some reported the cause due to meteorological conditions[20-22]. The transmission of malaria is a complex interaction among anopheline mosquitoes, Plasmodium parasites and human[23].

The extrinsic incubation period of parasites in a mosquito changes with diurnal temperature range provided the temperature is in between 16°C- 36°C[24]. Moreover the digestion speed is increased with temperature resulting the increase of interaction between vector and host[25, 26]. The average duration of sporogony is illustrated in Table 1. Sporogony cycle stops below 16°C and if the life span of mosquito is less than the development of pathogen, the transmission stops[27, 28]. Optimum temperature for anopheline mosquito to mature takes 10 days at temperature 28°C. The duration is reduced with increase of temperature. Lifespan of mosquito may changes by one weak with 1°C temperature change provided the temperature remain 18°-26°C and malaria vectors cannot survive above 40°C[29-31]. The survival rate is 90% when the temperature is 16-36°C. Social, economic, environmental stresses and climate may influence the malaria burdens. It is therefore needed to highlight the probable days (either seasonally or annually) of malaria transmission in a regional basis so that prevention can be taken to combat the burst of malaria incidences.

METHODOLOGY

Study area: The study is conducted using ground based meteorological data of two India Meteorological Centers Alipur (22.57^{0}N, 88.37^{0}E, 9 m above msl) and Digha (22.38^{0}N, 87.32^{0}E, 6 m above msl). Alipur is in Kolkata and Digha is coastal station of East Midnapur district of West Bengal. Population density of Kolkata is high 25,000/sq.km and slum population per square km is 32.55. Digha is a tourist place at the coast of Bay of Bengal. Local population is low but the place is very congested throughout the year due to presence of large number of hotels, markets, travelers, cars, different types of local vehicles *etc*.

Methods: Daily records of temperature, relative humidity, wind speed, rainfall and rainy days are used in our analysis for the period 1997 to 2007. The data are taken twice daily at 8:30 hrs and 17:30 hrs respectively. In addition, report of malaria incidences are collected from the vector control office of Kolkata Municipal Corporation for the same period. Daily surface weather data are classified into four windows I to IV according to the reports of different investigations and practical entomology [27]. Temperature ranges (20^o-25^oC), (25^o-30^o C), (30^o-35^oC) and (16^o-40^oC) are assigned as transmission windows I, II, III and IV respectively. Ranges of relative humidity for all categories are kept in between 55% and 80%. Inter annual variation of meteorological parameters and frequency of the occurrences of different windows is computed from the available data.

RESULTS AND DISCUSSION

The time series of all the surface data at two observing times 08:30 and 17:30 hrs (IST) for the two locations Kolkata and Digha are shown in Fig 1(a) and Fig 1 (b). The variational pattern of surface temperature, relative humidity, wind speed and rainfall are almost identical for both the observing sites. Rainfall is observed from March to November but dominates from June to October with maximum at September. Relative humidity is low from the month December to February. Mean annual variation of the parameters in a month expressed by standard deviation is given in Fig 2. It is observed that standard deviation of relative humidity is high from January to March and from June the variation decreases and again starts to increase in November. However both the sites show similar trend of temperature, average wind speed and precipitation throughout the year.

Table 2 represents the frequency of mean monthly distribution of transmission windows for both the sites. Frequency of the occurrences of transmission window on both sides is similar. Analysis shows that possible transmission is high in months April and May. It was reported earlier that 20^o-30^oC temperature with RH> 60% is optimal for the survival of anopheles mosquito [28, 32]. According to the report of vector control office (KMC) mean positive cases of malaria increases from the month May and attains maximum in September. Then it starts to decrease and become minimum in January (< 2000). Malaria incidence is negligible at Digha though there is a possibility of malaria transmission as obtained from the computation of different categories of temperature windows. Correlation between mean monthly temperature and malaria incidences for the study period is found to be 0.84. The relation of vector and parasite with temperature is not linear[31, 33, 34].

Longevity is one of the key factors for malaria spreading[35]. *P. vivax* needs 10.7 days and *P. falciparum* take 13 days to breed sporozoite in mosquito body[27]. However temperature range may persists over a period for completion of sporogony. Again the survival depends on wet and dry season. Completion of sporogony of *P. vivax* at 16^{o}C needs 55 days but at 28^{o}C it takes only seven days. Anopheles mosquito cannot survive above 40^{o}C. At relative humidity 20% to 100% and 35^{o}C temperature the mosquitoes survive only for 4-10 days[36]. The mean monthly temperature remains 20^{o}C-30^{o}C throughout the year which falls within the transmission window and hence endemic region of malaria.

The correlation between rainfall and malaria incidences at Kolkata is found 0.48. Strong association between malaria incidences and rainfall are reported by several investigators [37-40]. Rain may have both beneficiary and adverse effect to mosquitoes. Wet day or moderate rainfall may increase the breeding while torrential rainfall may flush out the larvae. Usually malaria transmission occurs after heavy rain[41, 42].

In addition to mean temperature and relative humidity, temperature fluctuations around low temperature may intensify the transmission speed. Transmission rate also depends on the daily maximum and minimum temperature. Diurnal temperature range (DTR) *i.e.* the difference between maximum and minimum temperature was found an important driver of malaria transmission. Variation of mean monthly malaria incidences with DTR are depicted in Figure 3. Many malaria transmissions are reported for DTR varying from 5 to 20. Fluctuation may increase the potential of transmission at lower temperature and block at higher temperature[3, 24, 43-45]. In our case the observed malaria incidences with DTR ≥ 12^{0}C increase with decrease of DTR and vise versa.

Table 3 shows the percentage of positive malaria cases in West Bengal. It is evident from the table that more than 70% cases are registered in Kolkata. Positive cases of malaria incidences in Midnapur district negligibly small though the analysis shows equal probability of malaria transmission windows when compared with Kolkata. Digha is not vulnerable to malaria indicating other factors *viz* socio-economic development, geographical locations, health services, drainages and slum areas may be responsible for malaria spreading.

CONCLUSION

Malaria caused by *P. falciparum* has raised sharply (50%) and remaining are *P. vivax* and a small proportion of *P. malariae.* Chloroquine resistant *P. falciparum* was first reported in 1973 in Assam [46]. No evidence has yet got for chloroquine resistance of *P. malariae* [47, 48]. Climate has both positive and negative feedback on malaria transmission. Meteorological parameters are not alone the deciding factors of malaria spreading. Abundance of anopheles mosquitoes varies with time of the year, habitats and mobility of human hosts [49-51]. 40% of the world population is under malaria threat. About 2 million deaths out of 500 million cases of malaria have reported each year. Risk factors for fatal include lack of medical care and diagnosis. It can be controlled by Socio economic conditions, accessibility of medical health services, integrated environmental management to destroy breeding sites and regular monitoring. This study gives the climate determinants and potential of malaria transmission but is not conclusive one. The transmission also depends on the prevailing socio economic status and adaptability of population. Hence integrated study covering all the factors will give better result and useful tool for control measure of malaria transmission.

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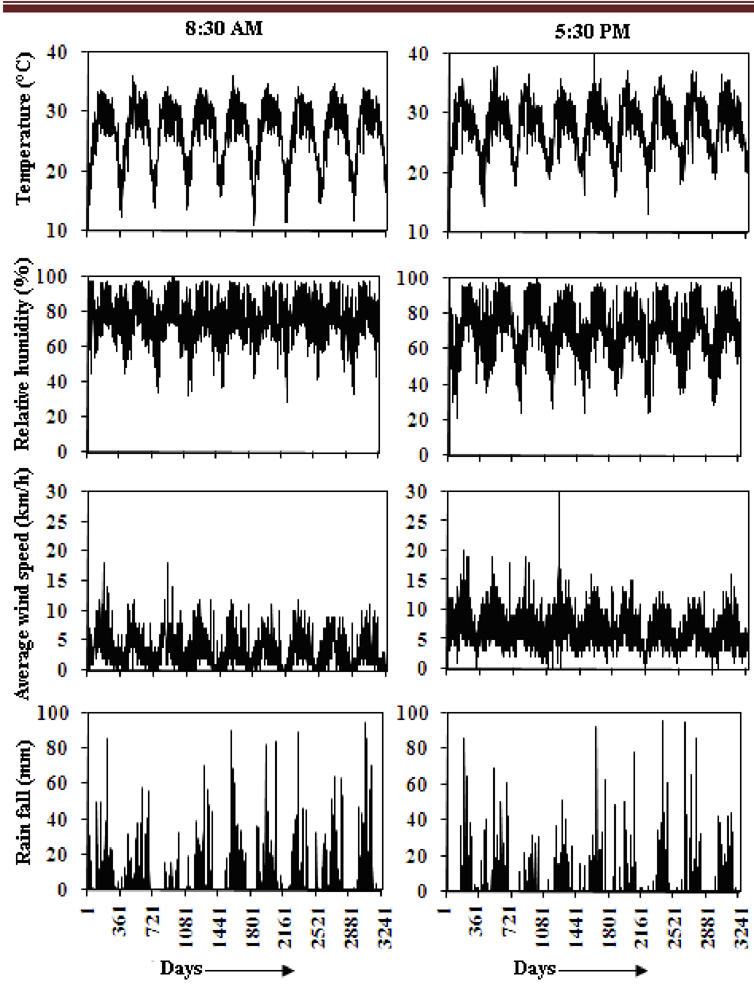

Figure 1(a) Time series of surface weather parameters at Kolkata during 1997 – 07

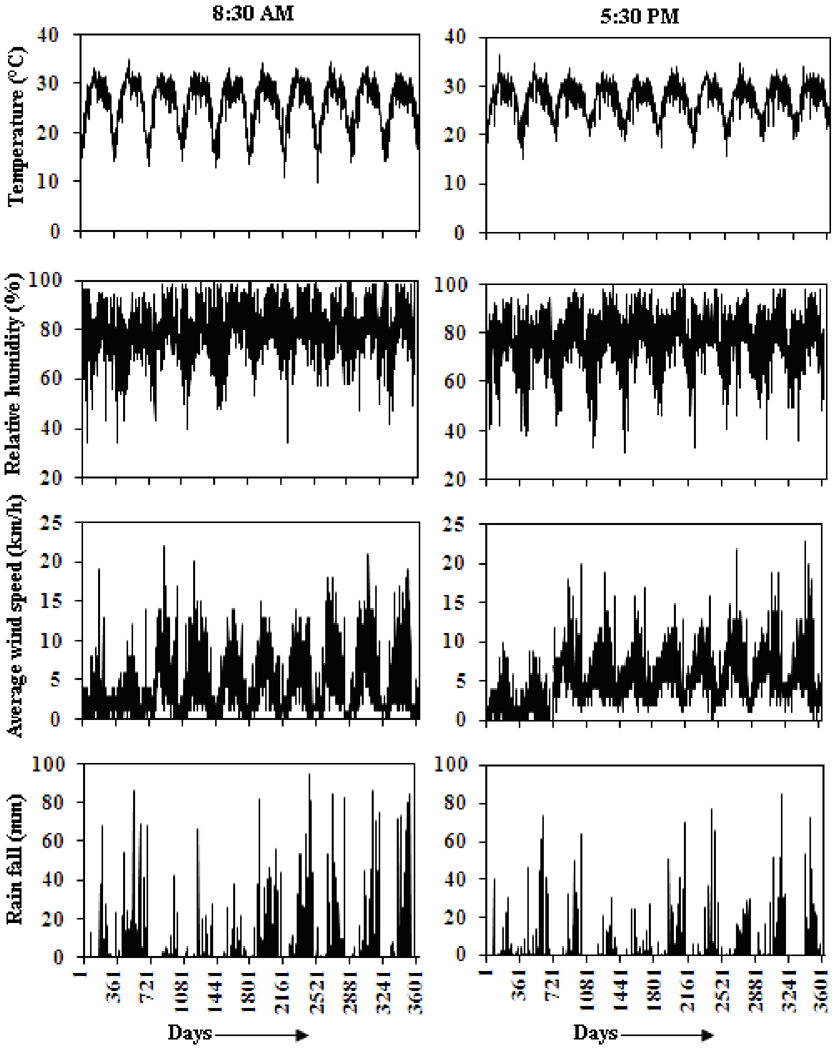

Figure 1(b) Time series of surface weather parameters at Digha during 1997 -07

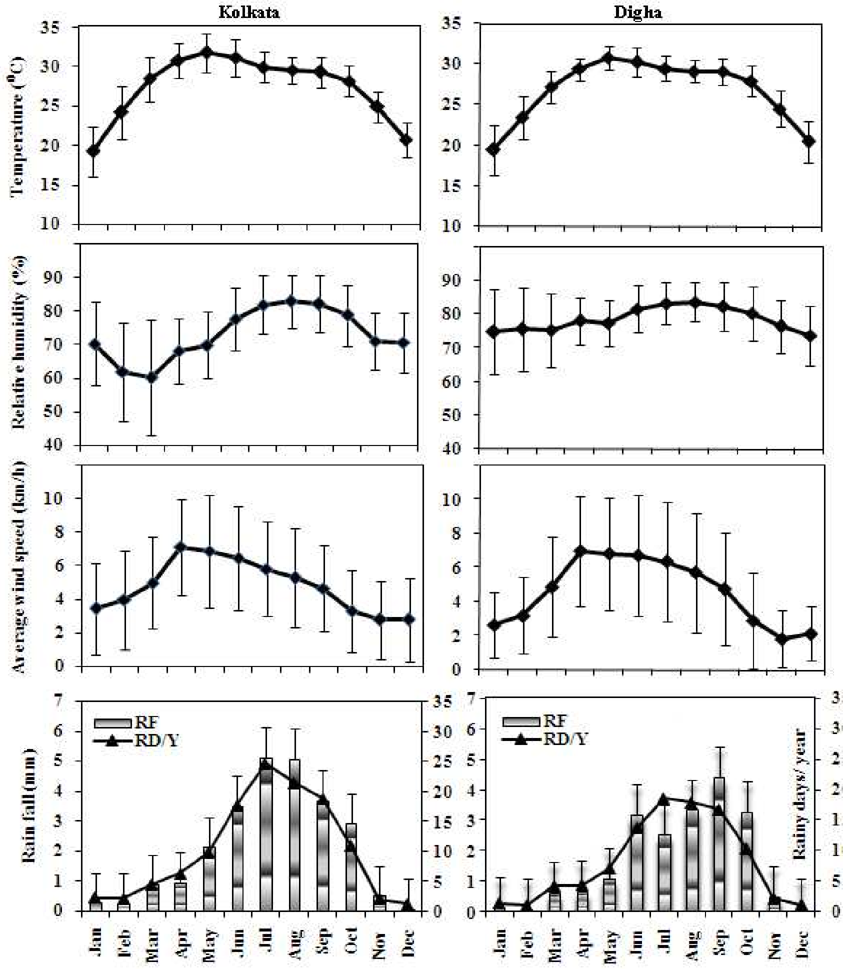

Figure 2 Mean monthly variations of surface weather parameters

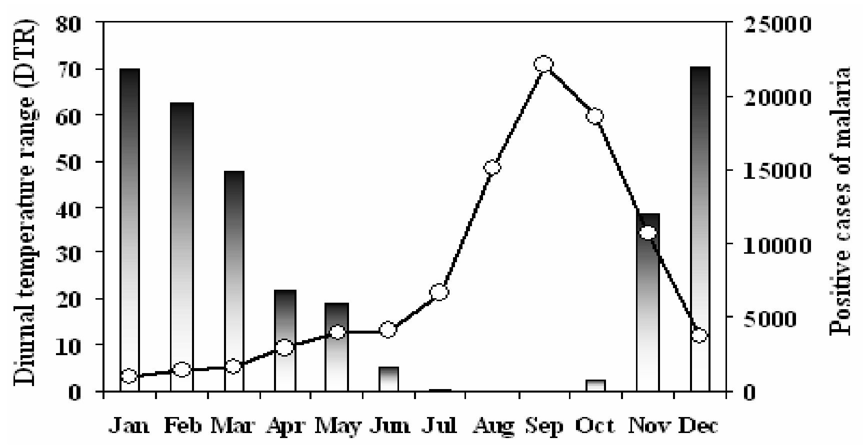

Figure 3 Diurnal temperature range and malaria incidences

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Table 1

Temperature and malaria parasites

Temperature (^{o}C)	life cycles (days)	Temperature(^{o}C)	Sporogony cycles (days)
15-20	15-25 (Pv)	≤ 16^{o}C	Stops
20-25	10-20 (Pv) 20-30 (Pf)	20^{o}C	16-17 (Pv) 22-23 (Pf)
25-30	06-10 (Pv) 15-25 (Pf)	25^{o}C	9-10 (Pv) 12-14 (Pf)
30-35	08-12 (Pf)	DTR ≥ 12^{o}C	Intensify transmission

(Pv) *Plasmodium vivax*, (Pf) *Plasmodium falciparum*

Table 2

Frequency of malaria transmission windows

Sites	Kolkata				Digha			
Windows	I	II	III	IV	I	II	III	IV
January	32.66	2.00	0	63.32	30.21	0.33	0	48.77
February	30.32	16.66	0.60	53.61	27.19	17.53	0	53.31
March	5.04	33.51	9.01	47.57	6.78	48.95	0.48	56.22
April	0.74	19.18	66.85	86.78	1.01	30.32	25.79	57.12
May	0	11.51	68.70	80.22	0	9.60	53.17	62.77
June	0	2.97	56.61	59.40	0	5.69	38.29	43.97
July	0	2.16	38.56	40.90	0	5.52	31.82	37.34
August	0	4.32	34.41	38.74	0	6.97	22.37	29.34
September	0	6.69	38.29	44.98	0	12.39	30.82	43.22
October	0	37.83	22.52	60.36	1.13	37.70	16.67	55.50
November	39.21	45.16	0	84.39	36.12	33.78	0	71.74
December	61.12	1.26	0	94.76	47.41	1.29	0	77.66

Table 3

District wise annual mean malaria incidences to the total positive cases

Districts	Cases (%)	Districts	Cases (%)	Districts	Cases (%)
Bankura	0.76	**Hoogly**	0.20	**Midnapur(W)**	2.63
Birbhum	0.48	**Howrah**	3.33	**Murshidabad**	3.37
Burdwan	0.12	**Jalpaiguri**	4.06	**Nadia**	0.73
Coochbihar	0.58	**Kolkata**	71.73	**North 24 Parganas**	3.03
Darjeeling	0.27	**Malda**	1.40	**Purulia**	3.36
Dinajpur(N)	0.11	**Midnapur(E)**	0.80	**South 24 Parganas**	2.79
Dinajpur(S)	0.26				

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