



International Journal of Mosquito Research

ISSN: 2348-5906
CODEN: IJMRK2
IJMR 2018; 5(5): 25-30
© 2018 IJMR
Received: 23-07-2018
Accepted: 24-08-2018

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Mosquito borne diseases and Sanitation in Ghaziabad district, Uttar Pradesh, India

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Abstract

Rapid urban growth has led to lack of basic amenities among which sanitation has influenced health of people. This has effected mosquito breeding and hence transmission of various mosquito borne diseases. Study area Ghaziabad district, Uttar Pradesh, is facing rapid population growth and sanitation problems hence influence mosquito breeding. In selected PHCs mosquito breeding sites were identified as polluted and unpolluted. This study shows that polluted breeding sites and sewerage has become ideal breeding site for mosquitoes like *Culex* and some species of *Anopheles*. Water storage increased breeding of *Aedes* mosquito in man-made breeding sites. Analysis of health data shows that Ghaziabad is at risk of diseases. Malaria is decreasing while dengue is increasing in Ghaziabad due to availability of breeding places of their mosquito vectors. *Culex quinquefasciatus*, a vector of Japanese encephalitis and lymphatic filariasis and *An. subpictus*, recently described as vector of malaria are breeding profusely and may be responsible for emergence of these diseases in Ghaziabad.

Keywords: urbanization, sanitation, mosquito vector, prevalence

1. Introduction

Urban growth in India started very early and remained very rapid during the post-independence era leading to deprivation in basic services [1]. The main increase in population seen in 19 to 20th century due to large scale development in trade and industries [2]. By 2011 census, the trend of urbanization in last 50 years (1961-2011) was random in which the growth rate increased from 3.23 in 1971 to 3.79 in 1981. Declining growth rate was observed till 2001 but in last few years there is unexpected inclined growth rate. Thus it is very difficult to determine the pattern of urban growth in the next few years [3]. The urbanization in Indian cities is unplanned with very slow pace of development as compared to rate of population growth leading to lack of basic amenities like water supply, sanitation, electricity, housing, etc. with limited urban land in cities has resulted in people started moving towards adjoining areas in search of more living places. Sometimes migrated people have no choice but to move to slums and other unauthorized settlements to meet their housing needs. India has 40-50 % slum population with Delhi having the highest share [4]. These slum dwellers live in substandard houses made of mud and grass without proper bathing & toilet facility. They have no basic amenities like electrification, sanitation, drinking water etc.

All Urban settlements generate solid waste, waste water, sewage etc. Open sewage and poor drainage systems are a major threat for human settlement. Irregular water supply leads to extra storage of water in open containers which creates breeding den for mosquitoes [5]. Due to unhygienic conditions urban people are vulnerable to all kinds of parasitic and vector borne diseases like cholera, diarrhea, encephalitis, TB, onchocerciasis and many more (CDC, WHO). Unsafe water and sanitation was first time related to diarrhea in 1990 but later most of the diseases were by water, hygiene and sanitation [6]. Nuisance of *Culex pipiens fatigans* is reported in cities like Hyderabad and Mysore due to poor sanitation [7]. National urban sanitation policy was launched by Government of India in 2008 for creating totally sanitized cities. A list of 436 cities was prepared where cities were rated on the basis of their sanitation achievements and processes. There are four category of cities "red category" (cities needed immediate action) about 40% cities, "black category" (needed considerable improvement) more than 50%, "blue category" (recovering) less than 10%, while in "green category" (healthy and clean city) not a single city., Ghaziabad was rated which was shown it to be improved therein.

Ghaziabad is a city facing similar sanitation problems and was among black category city in above list of 2009-10 [8]. Thus the aim of the study is to find out the sanitation conditions in Ghaziabad and nearby peri-urban areas and its health impact.

2. Materials and methods

2.1. Study area

Ghaziabad is a good example of urbanization as it has growth at a very rapid pace leading to migration of people [9]. The reason for inflow being 0 km distance from Delhi. It is not less than any metropolitan city in having malls, shopping complexes, 5 star hotels, commercial markets, industrial establishments, institutions, all range of apartments with luxurious facilities. It also has a large number of big hospitals, nursing homes, pathology centres, educational institutions etc. It has natural forest Sai Upvan in city and man-made city forest near Hindon River. To make it a best city more projects are underway for further enhancement of transportation like roads, bridges, metro extension, for settlement like apartments, group housing, individual housing etc. [10]. Although government is spending large sum of money in developing Ghaziabad and accommodating increasing population still it needs considerable improvement in sanitation related problems.

2.2 Identification of survey sites and collection of larva

Survey was conducted in PHCs based on unsanitary conditions. PHCs Bhojpur, Muradnagar, Razapur, Loni were selected as rural, Ghaziabad PHC with Ghaziabad city as urban and its surrounding showing rapid change were selected as peri-urban. Rural have polluted natural breeding sites and unpolluted pits and pools present during rainy season. Peri-urban villages and urban areas have polluted natural breeding sites as well as man-made breeding sites. The mosquito collection was carried out during morning hours from 0600 hrs to 1100 hrs by insect collectors from indoors as well as outdoors from April 2014-Jan 2016. All expected breeding sites of mosquitoes like tanks, irrigation channels, drains, containers, drums, pots etc. were searched for breeding of mosquito larva and was collected from the same. 10-15 dips were taken for confirmation of presence or absence of larva. Other parameters like presence of vegetation, predators of larva were also noted. The identified breeding sites were categorized to natural and man-made. Natural breeding sites further divided to polluted and unpolluted. All polluted and unpolluted breeding sites were searched for adult mosquitoes (Figure 1).

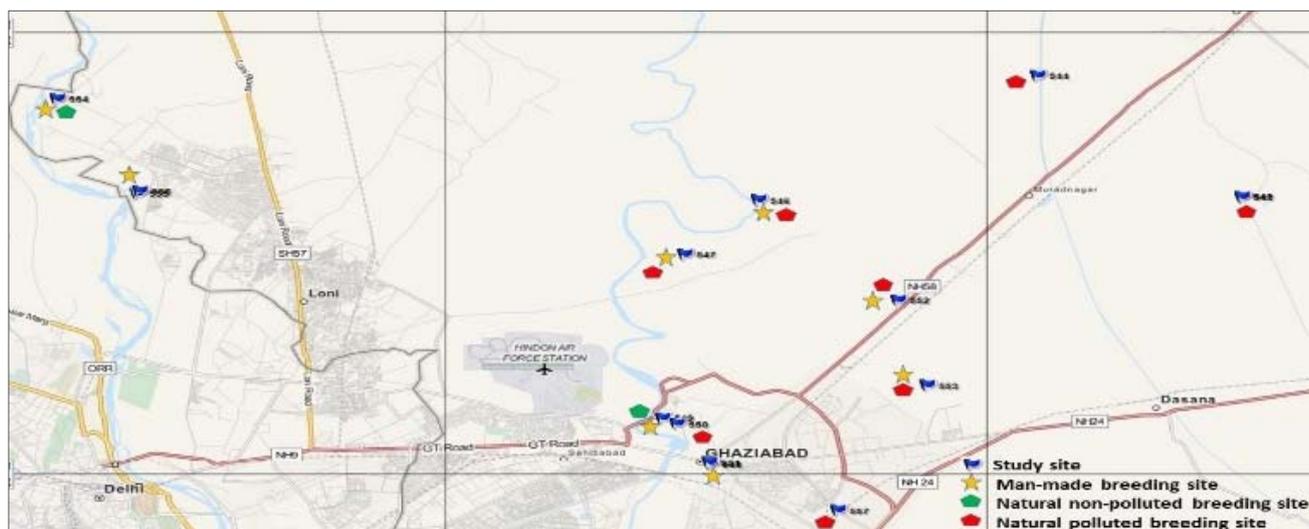


Fig 1: A Map of Ghaziabad district showing survey sites and type of breeding sites

2.3 Morbidity, mortality and health data

The health data was taken from annual health survey report for Ghaziabad district 2011-2015.

2.4 Epidemiological trends of VBDs in Ghaziabad

Diseases caused by mosquito breeding due to sanitation and water storage are vector borne diseases like dengue, malaria, lymphatic filariasis and Japanese encephalitis [11-13]. Malaria-cases of Malaria in Ghaziabad from 1977-2015 (NVBDCP 2105).

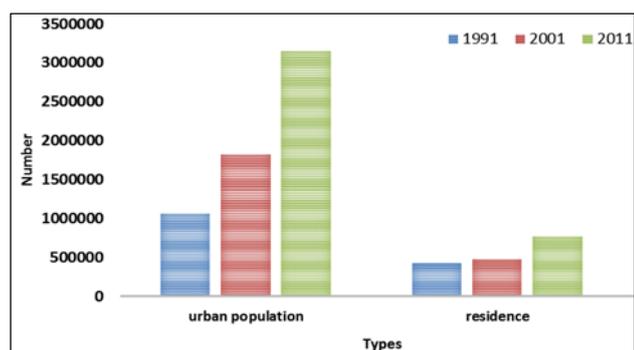
Dengue- reported cases for dengue from 2004-2015 for Ghaziabad district was obtained from districts health department Ghaziabad (Ghaziabad PHC 2015).

Filariasis, Japanese encephalitis, Chikungunya, Zika-no reported cases of these diseases in Ghaziabad (Ghaziabad PHC 2015).

3. Results

3.1 Study area, demography and pollution

Urban Population in Ghaziabad is increasing at a rapid rate in last few years. The number of residence are also increasing at the same pace (figure 2). According to census, the urban population of Ghaziabad was around 50,000 in 1901 that has gone beyond 31 lakh in 100 years. In 20 years i.e. 1991 to 2011 the urban population has become thrice while residence doubled. According to census 2001, the slum population in Ghaziabad city is around 26 %.



Source: Census 1991, 2001, 2011

Fig 2: Urban population and habitation in Ghaziabad

Solid waste was found mainly around commercial places, residential areas, markets, slums, hospitals, hotels and restaurants, construction and demolition waste and industries in urban. Under construction red mall has construction debris where water got collected during rains and act as breeding site. Hindon River is polluted with waste from surrounding areas and was grey in color. Sai upvan is a current dumping ground in Ghaziabad which is connected to Hindon River also contributes. Kavi Nagar slum has a canal in which dumping of all kind of waste by residents has further contribute to its population. Pond in Adarsh nagar colony was muddy while pools of water choked drainage system led to water stagnation in colony were polluted emitting foul smell. In rural and peri-urban rivers Yamuna, Ganga and Hindon are polluted at some places. The ponds in Ghaziabad rural and peri-urban were most polluted with poor quality of water due to eutrophication, siltation and garbage deposition as found in Didauli and Bhanaira (Muradnagar), Kalchhina and Manaki (Bhojpur) and Sadarpur (Ghaziabad). The canal in Duhai is completely covered in solid waste. Drains were mostly open all over Ghaziabad.

3.2 Larval collection and habitat characterization

Survey was conducted from 2014 to 2016 in which three

mosquito genera was found breeding (Table 1). Collected larva and pupa were emerged in insectary and identified for species. *An. culicifacies* was found breeding in few clean natural water sources like rivers, ponds (Didauli), and canals (Manaki, Bhadoli, Bhanaira), seasonal pits and pools (all villages) and rice fields (*An. pulcherrimus* in Didauli). It's breeding in pond, Adarsh Nagar (urban) and seasonal pits in urban and rural was also found.

In urban and peri-urban *An. stephensi* breeds in man-made breeding sites and *An. subpictus* and *An. nigerrimus* in polluted breeding sites. *An. stephensi* was found breeding in cemented tanks and tube wells in mathurapur village, ground tanks, OHTs, containers in peri-urban villages (sadarpur and duhai) and in OHTs, underground tanks, pits of cements under construction sites (red mall), cemented tanks, containers and drums (Kavi nagar, Vaishali).

An. subpictus, was found in rural, peri-urban and urban breeding in large density in polluted rivers, muddy ponds and pits.

Aedes was found breeding mainly in coolers and drums of peri-urban and urban, OHTs (Didauli) and containers in rural (Manaki), peri-urban and urban. Other urban breeding sites for *Aedes* were thermocol container, plant pots, bird pots etc. Normally *Aedes aegypti* was encountered except once in nursery of Kavi nagar.

Culex quinquefasciatus was breeding profusely in polluted ponds in rural (Bhanaira, Bhadoli, Didauli and Kalchhina) and in drains, pools of water and polluted canals in peri-urban and urban.

Of the *Anopheles* found in rural major contribution was from unpolluted i.e. 45%. *An. subpictus* is breeding in these polluted sites (as seen by emergence in insectary). Similarly in urban unpolluted contributed about 25% of the total anopheles. *Aedes* was mainly found in urban with 88 % in unpolluted and 3 % in polluted breeding sites. *Culex* mosquito was found only in polluted breeding sites of urban as well as rural (figure 3).

Table 1: Mosquitoes found in polluted and unpolluted breeding sites in Ghaziabad

Polluted/ Unpolluted	Type	Mosquito	Pre monsoon	Monsoon	Post monsoon
Polluted	Urban	<i>Anopheles</i>	2	2	1
		<i>Aedes</i>	1	0	0
		<i>Culex</i>	38	32	17
	Rural	<i>Anopheles</i>	1	11	0
		<i>Aedes</i>	0	0	0
		<i>Culex</i>	28	24	20
Unpolluted	Urban	<i>Anopheles</i>	3	9	2
		<i>Aedes</i>	7	11	12
		<i>Culex</i>	0	0	0
	Rural	<i>Anopheles</i>	2	8	3
		<i>Aedes</i>	1	2	0
		<i>Culex</i>	0	0	0

3.3 Diseases related to sanitation in Ghaziabad

Ghaziabad population is at risk of various diseases. The diseases related to sanitation found in Ghaziabad are diarrhoea, Tuberculosis, Malaria and Dengue. Diarrhoea is decreasing in both rural and urban while Tuberculosis is increasing in both rural and urban Ghaziabad. Malaria in rural

is decreasing but in urban malaria as well as dengue is increasing. No dengue case is found in rural Ghaziabad (figure 3). Morbidity and mortality data shows lesser rate of decrease in diseases related to sanitation like diarrhoea and fever in urban (Annual Health survey UP 2010-2013).

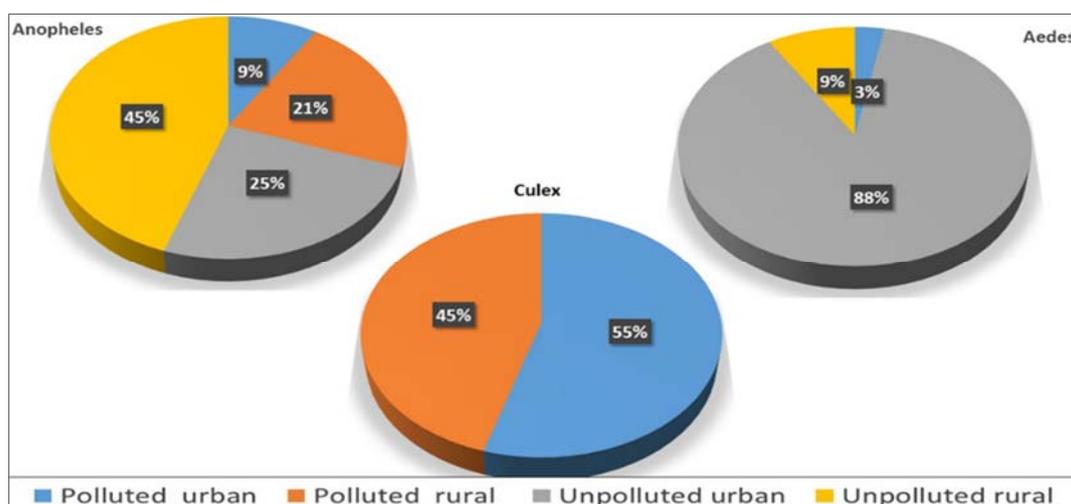
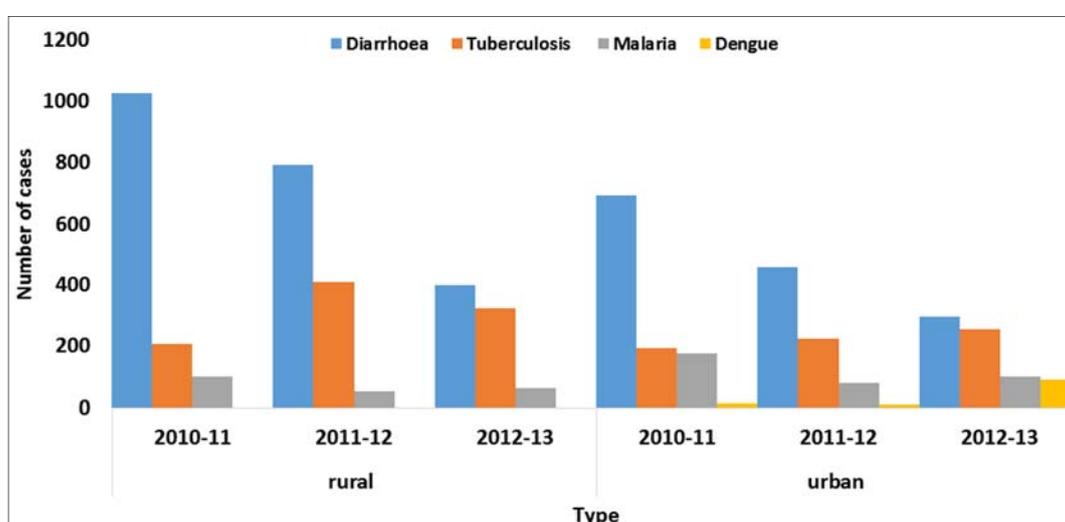


Fig 3: Polluted vs unpolluted breeding sites of mosquitoes



Source: Annual health survey Ghaziabad (2010-2013) and Ghaziabad PHC

Fig 4: Diseases in rural and Urban Ghaziabad (2010-2013)

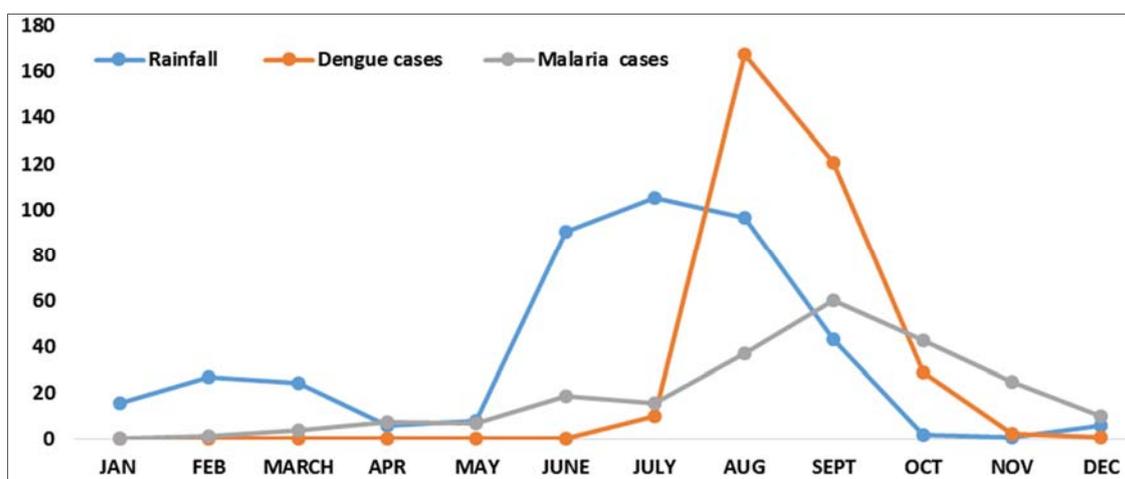
3.4 Epidemiological trends of mosquito borne diseases (malaria and dengue)

Malaria and dengue are vector borne diseases that affects health of people indicated in this district (Table 2). Ghaziabad was endemic for malaria with seasonal transmission of *Plasmodium vivax* and *Plasmodium falciparum* through vector *Anopheles culicifacies* since 1977. With increasing population malaria has decreased from more than 20,000 cases in 1977 to less than 300 cases in 2015 while Dengue appeared in Ghaziabad around 2004 reportedly and has increased rapidly since then. Both *Aedes aegypti* and *Aedes albopictus* are responsible for transmitting dengue in Ghaziabad. Loni and Ghaziabad PHC has similar trend in which prevalence of malaria first decreased and then increased after 2008. In Bhojpur and Muradnagar PHC malaria first decreased then it has become constant (Ghaziabad PHC). *Culex quinquefasciatus* is responsible for Japanese Encephalitis and Filariasis in neighbouring districts but in Ghaziabad no cases has been reported so far.

3.5 Association of rainfall with mosquito and mosquito borne diseases

Rainfall has impact on cases of malaria and dengue in Ghaziabad. An association of Malaria and dengue with

rainfall was found for 2011-2015 (figure 5). Rainfall contributes to breeding of mosquitoes as pools and pits created due to water collection as well as discards act as breeding sites. It is important in terms of sanitation too as with rainfall polluted natural breeding become cleaner thus breeding of *Anopheles* increases. Pools of drain water, solid waste with rain water collection also contributes to breeding of mosquitoes like *Culex* and some species of *Anopheles*. Average rainfall during the months of May–September represents more than 90% annual rains. When the data of malaria and dengue were pooled for 5 years dengue showed peak cases during the months of August and reduces till November whereas the cases of malaria peaked in the month of September. This may be associated with the indoor container breeding habit of *Aedes aegypti* due to which the Peak of cases comes one month earlier than malaria. There are though many other reasons for the difference in peaks like Vectorial capacity, temperature, humidity and susceptible population and presence of pathogen in the system.



Source: Rainfall data (Indian Meteorological Department), Dengue and malaria cases (Ghaziabad PHC)

Fig 5: Relationship of dengue and malaria with rainfall from 2011-2015

Table 2: Vector borne diseases prevalent in Ghaziabad

Year	Population	Malaria cases	Dengue cases
2004	3084	1015	3
2005	2933	931	14
2006	2933	540	66
2007	2930	436	34
2008	3789	254	14
2009	3789	368	13
2010	3314	699	24
2011	3597	460	12
2012	4764	341	14
2013	3174	251	89
2014	3418	238	14
2015	3418	178	1519

Source: NVBDCP and Ghaziabad PHC

*No cases of Japanese encephalitis, Chikungunya and lymphatic filariasis has been reported in Ghaziabad

4. Discussion

Among communicable diseases due to sanitation mosquito vectors causes water related diseases. Mortality and morbidity reduces with more hygiene and waste disposal practices, in particular infants and children^[14].

Since population growth is higher and the resources are limited, improper development, creation of slums and waste disposal practices in Ghaziabad led to creation of breeding sites for many diseases causing mosquito vectors. A study shows Ghaziabad having unsatisfactory sanitation with improper sewerage and drainage system^[15]. Another study on Ghaziabad showed changing transmission of malaria by change in mosquito breeding sites^[16].

Water pollution, water storage practices and other breeding sites by constructions are playing major role in increase of mosquito population. Improper sanitation in Ghaziabad has led to collection of wastewater in and around residential areas forming new habitats. Waste water collection on roads and in pits in Adarsh nagar colony has *Culex quinquefasciatus* breeding. Polluted water bodies like ponds, rivers, and canals in villages like Kalchhina, Bhadoli, Mathurapur, Bhanaira, didoli have become grey and acting as habitat for *Culex quinquefasciatus* and *Anopheles subpictus*. Hindon River, canal in Kavi nagar in Ghaziabad city and containers, tanks, swimming pool with polluted water have *Culex* mosquito. *Culex* reportedly is associated with unclean water in many studies and is related to diseases like West Nile virus,

encephalitis, and filariasis^[17-19]. In India it is responsible for causing Japanese Encephalitis and Filariasis^[20, 21]. In Ghaziabad so far no reported cases from *Culex* but it is suspected to cause disease in near future. A study on Nanded, Maharashtra filariasis caused by *Culex quinquefasciatus* has become common in rural while *Aedes* and *Anopheles* distribution have changed like in our study due to urbanization^[22]. *An. subpictus* has recently been described as a vector of malaria recently in states of India. It breeds in polluted water as reported in other studies too^[23].

Water storage due to non-continuous supply of drinking water has led to storage of water in utensils, containers etc. and sometimes water get collected in tires, cans, or any other item and serve as breeding place for mosquitoes like *Aedes* and *Anopheles stephensi*. Asia and Africa has increasing incidence of diseases like dengue and lymphatic filariasis in urban due to sanitation^[14]. Another study has found similar breeding sites of *Aedes* and *Culex* in urban and suburban parts of Malaysia^[24]. Considering *Culex* as an indicators of pollution as it is a breeder of polluted water Ghaziabad district is having sanitation problem while breeders of clean and fresh water *Anopheles* and *Aedes* were comparatively lesser. Rainfall influences breeding of mosquitoes by creating breeding sites. In Ghaziabad both malaria and dengue increases with rainfall but the breeding of *Culex* decreases. Thus development in Ghaziabad brings with it sanitation problem and affected transmission of mosquito borne diseases. Malaria have decreased in Ghaziabad in last few years but dengue caused by *Aedes* has emerged in last few years. Diseases like Japanese Encephalitis and filariasis caused by *Culex* mosquito and malaria due to *An. subpictus* may appear if conditions prevailed.

5. Conclusion

The study shows large scale breeding of *Culex* mosquito in Ghaziabad district due to pollution and *Aedes* due to urbanization. Malaria has decreased in last few years due to decrease in breeding sites of *Anopheles* vector which breeds in clean vector except *An. stephensi* (Urban Vector) and *An. subpictus*. Sanitation need to be improved by application of new or revised to improve environmental conditions and hence improves health.

6. Acknowledgement

Authors are thankful to Indian Council of Medical Research (ICMR) for funding, under the research fellowship (3/1/3/JRF-2012/HRD-14 (30404)) to Alka Rani. Author also like to thank Ghaziabad district Health Department for providing epidemiological and entomological data.

7. Data statement

All the data is presented here.

8. Ethics in publishing

All entomological surveys and collections conducted on private lands or in private residential areas were done with the owners'/residents' permission, consent and presence. These studies did not involve human as well as endangered or protected species.

9. Declaration in interest

Authors show no competing interest

10. Submission Declaration and verification

This work has not been published previously and is not under consideration for publication elsewhere

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