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Comparison of *Ae. aegypti* breeding in localities of different socio-economic groups of Delhi, India

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Abstract
An entomological survey was carried out in different socio-economic groups of selected localities in Delhi during June, 2013 to May, 2014 with a view to study the prevalence and distribution of *Aedes aegypti* mosquito for appropriate interventions. A door-to-door entomological survey was carried out to find out the *Aedes* breeding in all types of water filled containers present in and around houses and their premises and immature stages of *Aedes* mosquitoes were collected. In larval survey, different indices were used to record *Aedes aegypti* density level. In all the localities surveyed during transmission season, solid waste was observed to be most preferred breeding site whereas overhead tanks (OHTs) and curing tanks were found to be the most preferred breeding containers during non-transmission season. Plastic containers (29%) in low income group (LIG); solid waste (27%) and plastic containers (26%) in Medium Income Group (MIG); and solid waste (27%) and curing tanks (21%) in High Income Group (HIG) were the most preferred breeding containers for the breeding of *Aedes aegypti*. The house index was higher in the months of August and September in LIG, June- July in MIG and June in HIG households. The BI in MIG households was below critical level (i.e. 20) while it was observed to be higher in HIG & LIG households during the month of September i.e 22.45 & 25.22 respectively. The CI was observed to be higher in all the three types of colonies which were 8.35, 7.5 & 13.49 in HIG, MIG & LIG respectively, in the month of September. Containers found in Low income group (LIG) is contributing more to the *Aedes aegypti* breeding than MIG and HIG localities. The over head tanks and curing tanks are the preferred breeding sites in non transmission season whereas solid waste and plastic containers are amongst preferred breeding sites during transmission season. The study concluded that the targeted intervention including sustained vector surveillance could help in controlling the sudden upsurge of dengue in a densely populated city like Delhi.

Keywords: Dengue, *Aedes aegypti*, Larvae, Indices, Surveillance

1. Introduction
Dengue fever is commonly known to pose a significant threat to public health, spread throughout tropical and sub-tropical regions of the world [1]. It is a serious arbo-viral infection caused by any of the four flavivirus serotypes i.e. DEN-1, DEN-2, DEN-3 and DEN-4, mainly transmitted by *Aedes aegypti* and *Aedes albopictus* mosquitoes [2, 3]. *Aedes aegypti* is a principal dengue vector in India [4] and has a widespread distribution in many urban [5, 6] as well as rural parts of India [7, 8]. Since 1965, *Aedes aegypti* is one of the dominant species of *Aedes* in Delhi [9, 10, 11]. *Aedes* mosquitoes is a container breeder and breeds in variety of natural and man-made containers, like overhead tanks, cement tanks, plastic tanks, water storage jars, iron/metal drums, flower vases, curing tanks, and trash, such as plastic bottles, glass, cans, rubber tires and coconut shell etc [12]. Out of these breeding sites, domestic containers such as cement tanks and plastic containers are the major breeding source for *Aedes* mosquitoes in India [13].
India is one of the most susceptible countries to dengue epidemics. Major dengue ⁄ DHF outbreaks were recorded over the last few decades, from almost all parts of the country including Delhi [14]. In 2013, dengue outbreak occurred which recorded 75454 cases and 167 deaths in India, out of which Delhi's contribution was 5574 dengue cases and 6 deaths [15]. Delhi is one of the states of north India that has been endemic for dengue from past several years [16, 17]. Over last few decades, major dengue outbreaks have been reported by several studies [18, 19, 20].

Delhi has warm climate and monsoon season which provides a favorable environment for *Aedes* mosquitoes breeding. The major factors that contribute to Delhi being an epidemic potential are poor water management system including interrupted water supply that encourages water storage practices, including poor sanitation, large numbers of slums and lack of awareness [21, 22].

In this context, mosquito larval investigation was carried out in localities of Delhi where dengue cases were reported persistently during the last three years. The aim of the present study was to conduct an entomological survey to determine the larval indices of *Aedes* and to identify the areas in Delhi that are at risk for dengue outbreak.

2. Material & Methods

2.1 Selection of study areas: The National Capital Territory of Delhi covers an area of 1,484 km2 (573 sq mi). It has a length of 51.9 km (32 mi) and a width of 48.48 km (30 mi) with population of 17.8 million approximately. The study was conducted in 18 localities of Delhi (Figure. 1) in collaboration with Municipal Corporation of Delhi (MCD) from June, 2013 through May, 2014. All localities were selected on the basis of confirmed dengue cases reported during the last three years and on socioeconomic factors. These localities were categorized on the basis of their socio-economical characteristics as High, Medium and Low Income group (6 localities each) as per categorization of residential built up areas by Delhi Development Authority (DDA). The study areas were visited once every month during study period.

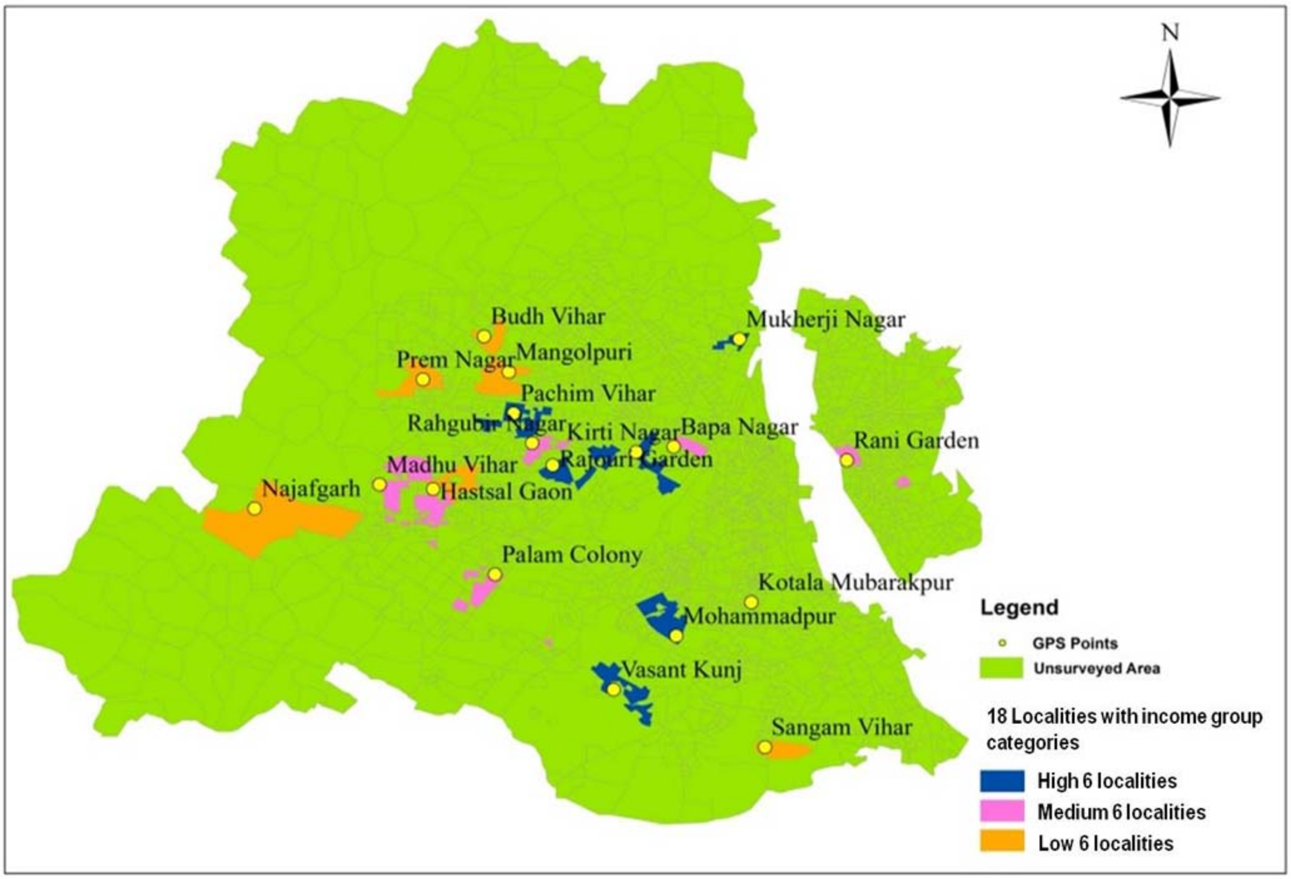

Fig 1: Map of Delhi showing 18 localities included in the study

2.2 Entomological Surveys

A door-to-door entomological survey was carried out to find out the *Aedes* breeding in all types of water filled containers present in and around houses and their premises. Both immature and mature stages of *Aedes* mosquitoes were collected. The larval collections were made from each locality with the help of flash-light, by dipping and pipetting methods (WHO, 1975).

All kinds of breeding habitats in the study areas like overhead tanks, curing tanks, plastic containers (tubs/ drums/ tanks, iron drums, coolers, curing tanks, daubers, Solid Waste (Disposal Glass, Thermocol Pot, wash basin, Tire dump, Booster pump, Cement Pot, Iron Pipe, Plastic Sheet, Plastic tray, Iron Pot, Plastic Chair, Trollies, disposal pot, fire box, dustbin, Almirah rejected, plastic bucket, dump plastic containers, Plastic bags) and others (flower pots, junk materials, broken glass wares, bottles etc) were screened for the presence of immature stages of *Aedes* mosquitoes. All larvae and pupae were reared to adult stage for species identification.

In larval survey, different indices were used to record *Aedes aegypti* density level. These indices are House index (HI), container index (CI), Breteau index (BI) and Pupal index (PI) [23].

3. Results

The result revealed that all localities were found positive for *Ae. aegypti* mosquitoes irrespective of their income group. In HIG, 2387 houses were surveyed in transmission season. Out of these, 88 houses had *Aedes* breeding with HI of 3.69. Although, 5526 water holding containers were identified, of which 256 containers had *Aedes* mosquito breeding with CI of 4.63. During non-transmission season, 2244 houses were surveyed and out of these 61 were found to have mosquito breeding sites in their premises with HI of 2.72. A total 4454 containers were identified as water holding containers and out of these 87 were found positive for mosquito breeding with CI of 1.95 (Table-1). The value of BI was calculated for HIG in transmission & non-transmission season which was recorded as 10.72 & 3.87 respectively.

In MIG, 2763 houses were surveyed in transmission season & Out of these, 145 houses were found to have *Aedes* breeding with HI of 5.25. In premises of these houses, 5790 water containers were identified and out of these containers 307 were found to have *Aedes* mosquito breeding with C.I of 5.3. A total 2179 houses were surveyed in non-transmission season and out of these 69 houses were found positive for mosquito breeding with HI of 3.17. During this season 4311 water holding containers were identified in MIG localities, of which 111 containers had *Aedes* mosquito breeding with CI of 2.57 (Table-1). The value of BI in MIG colony during transmission & non-transmission season was recorded as 11.11 & 5.09 respectively.

Similarly in LIG, 2811 houses were surveyed in transmission season & out of these 151 houses were found to have *Aedes* breeding with HI of 5.37. A total of 5316 water holding containers were identified from total houses surveyed in LIG and 387 containers showed positivity for *Aedes* breeding with CI of 7.28. During non-transmission season 2477 houses were surveyed and 89 houses were observed to have mosquito breeding with HI of 3.59 respectively. Likewise 113 containers out of 4529 water holding containers were found positive for *Aedes* breeding and observed CI was 2.5 (Table-1). The value of BI for LIG colonies in transmission & non-transmission season was observed as 13.76 & 4.56 respectively.

Table 1: House, Container, Breteau and Pupal index of *Aedes aegypti* in HIG, MIG, LIG

	High		Medium		Low	
	Trans (%)	**Non-Trans (%)**	**Trans (%)**	**Non-Trans (%)**	**Trans (%)**	**Non-Trans (%)**
No. of House Checked	2387	2244	2763	2179	2811	2477
No. of House Positive	88	61	145	69	151	89
HI	3.69	2.72	5.25	3.17	5.37	3.59
No. of Containers Checked	5526	4454	5790	4311	5316	4529
No. of Containers Positive	256	87	307	111	387	113
CI	4.63	1.95	5.3	2.57	7.28	2.5
BI	10.72	3.87	11.11	5.09	13.76	4.56
No. of Pupae Found	27	15	40	20	52	28
PI	1.13	0.67	1.45	0.92	1.85	1.13

The PI for HIG, MIG and LIG in transmission season was found to be 1.13, 1.45 & 1.85 respectively whereas PI for HIG, MIG and LIG in non transmission season was 0.67, 0.92 & 1.13 respectively.

To test the difference of entomological indices among three income groups one way ANOVA was performed. There was a significant difference in house index (HI) of all three income groups F (5) = 2.519, p= .05 during transmission and non transmission season. Also the BI & CI were found to be significantly different for all three income groups; F (5) = 5.17, p= .002 and F (5) = 5.268, p= .001 respectively

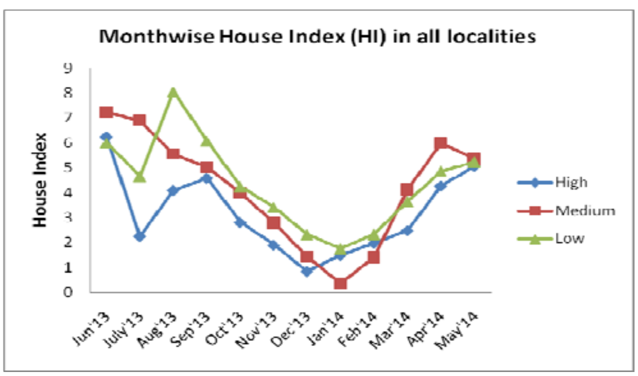

Fig 2: House Index (HI) in HIG, MIG, LIG localities

The house index was higher in the transmission months August and September in LIG, June- July in MIG and June in HIG colony (Figure 2). The house index was below 10% in all three income groups throughout the year. The value of CI was found to be higher in the month of September for HIG, MIG & LIG i.e. 8.35, 7.5 & 13.49 respectively (Figure 3).

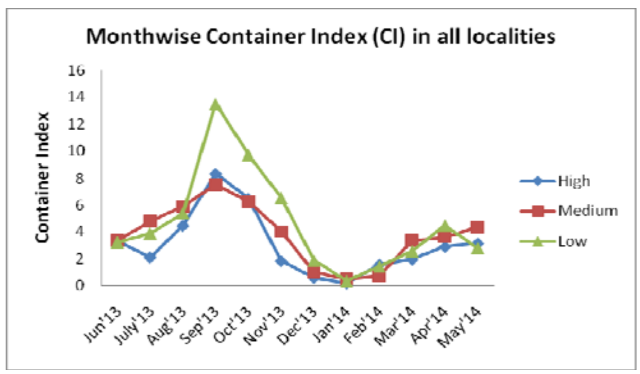

Fig 3: Container Index (CI) in HIG, MIG, LIG localities

The BI in MIG colonies were below critical level (i.e. 20) while it was observed to be higher in HIG & LIG colony during month of October i.e 22.45 & 25.22 respectively (Figure 4).

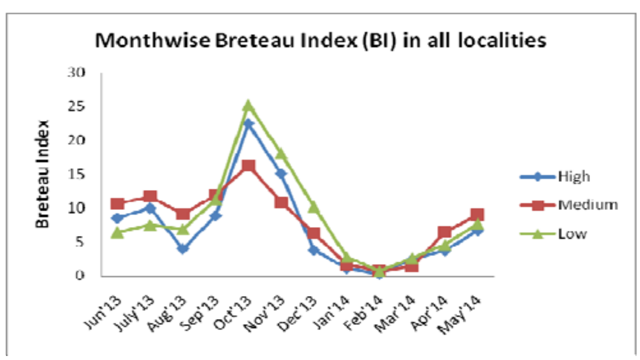

Fig 4: Breteau Index (BI) in HIG, MIG, LIG localities

The value of PI was found to be highest in the month of April for HIG and MIG i.e. 2.7 and 3.29 respectively but PI for LIG was highest in the month of June (3.25) and August (3.2) as shown in Figure 5. No pupae were found during November to March in HIG, November to February in MIG and December to February in LIG localities (Figure 5).

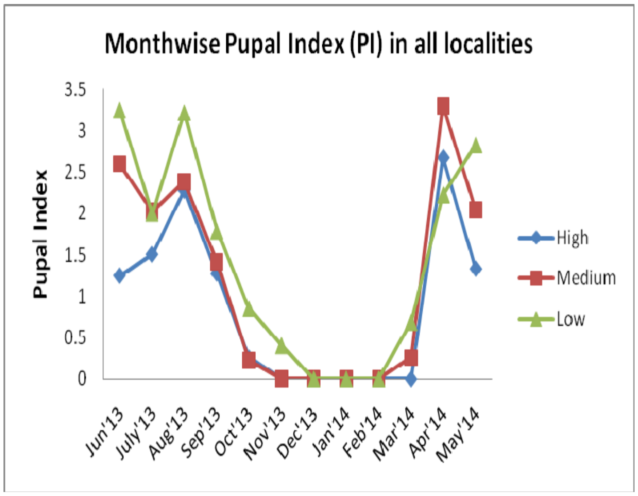

Fig 5: Pupal Index (PI) in HIG, MIG, LIG localities

During present study, it was observed that *Aedes* breeding was detected in all kinds of water filled containers present in and around areas of the houses surveyed. The six types of water containers were found to be infested with *Ae. aegypti*: (i) Over head tanks (ii) curing tanks (iii) plastic containers ⁄ drums for water; (iv) solid waste (v) coolers (vi) bird feeder pots.

In all the localities surveyed during transmission season, solid waste containers was most preferred breeding site followed by curing tanks, plastic containers, OHTs, coolers and bird pots. In non-transmission season, OHTs and curing tanks were found to be primary and the most preferred breeding containers followed by coolers, plastic containers. In LIG localities, plastic containers (29%), solid waste (22%), curing tanks (17%) and coolers (14%) forms highest positive breeding containers for *Aedes* mosquitoes (Figure. 6) whereas in MIG localities, solid waste (27%), plastic containers (26%), curing tanks (15%) and coolers (11%) were the most preferred breeding containers (Figure. 7).

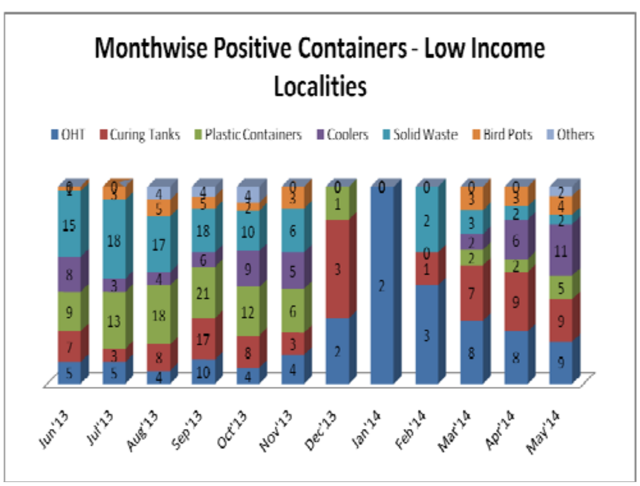

Fig 6: Preferred breeding containers in Low Income Localities

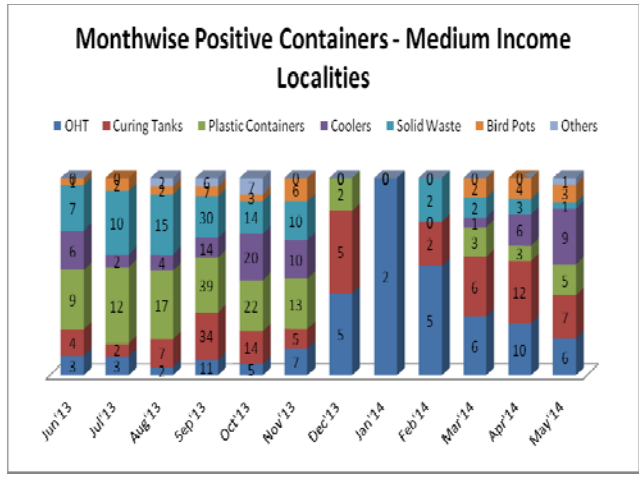

Fig 7: Preferred breeding containers in Medium Income Localities

In HIG localities, solid waste (27%), curing tanks (21%), OHT's (15%) were the most preferred breeding containers and are contributing maximum for the breeding of *Aedes aegypti* (Figure. 8).

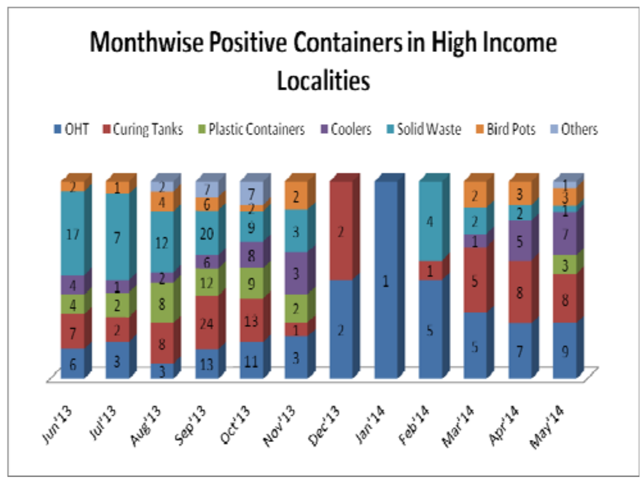

Fig 8: Preferred breeding containers in High Income Localities

4. Discussion

Our results demonstrated that highest breeding was found in LIG localities with plastic containers to be the main containers positive for *Aedes* breeding which is in contrast with a similar kind of study carried by Singh S *et al.* in Dehradun, Uttarakhand in which HIG colonies showed higher breeding than LIG and MIG with Desert cooler and discarded tires were reported to be the most preferred source for *Aedes* breeding [24]. The over head tanks and curing tanks are the only containers that showed *Aedes* mosquitoes breeding throughout the year and therefore are the key breeding sites for mosquito breeding. These overhead tanks and curing tanks acts as mother foci for *Aedes* mosquitoes in non transmission season and soon after the rainfall, during transmission season the breeding of *Aedes aegypti* spreads from these mother foci to other containers like solid waste containers, coolers, plastic containers etc. With the onset of winters, during non transmission season the breeding gets restricted to the mother foci *i.e.* OHTs and curing tanks, due to less availability of other containers. These mother foci must be surveyed during non transmission season so as to prevent the spread of dengue in transmission season. Dengue is closely associated with poor environmental sanitation, inferior housing and inadequate water supplies. In LIG and MIG localities due to intermittent water supply the residents are bound to store water in various containers, according to their need and thus increase the potential for *Aedes* breeding. Whereas HIG localities have regular water supply and there is not much need to store water for their daily use and thus less breeding was found in these localities. These water storing containers acts as potential source for *Aedes* breeding as they are mostly kept uncovered, undisturbed inside the houses and are rarely cleaned, thus resulting in high *Aedes* breeding. Such water storage practices of the residents are mainly responsible for the *Aedes* breeding [13].

Our study also showed that the number of *Aedes* larvae was higher in the transmission season than in the non-transmission season which is in consistent with the previous studies carried out in many parts of Thailand [25, 26]. The larval indices (CI, BI and HI) increase from August to October and decreases thereafter. This increase in breeding larval indices during these transmission months was due to the rains in the prior months, which lead to the increase in the number of potential *Aedes* breeding sites. Environmental factors like temperature, rainfall and relative humidity affect the mosquito breeding activity and can contribute to the variations in the larval indicies [27]. Our results demonstrated that the house index was below 10% in all localities which is consistent with a study conducted in Malaysia [28] but is in contrast with another study done by Katyal R *et al* in Tauru village of Delhi NCR region in 1996 with HI, CI and BI as 33.3%, 21.0% and 40.0, respectively [29]. The HI was observed to be less than the critical index but the presence of *Aedes* breeding in all type of containers with in all localities is a major concern and can act as source for *Aedes* mosquitoes breeding. In the month of September, the BI was above the critical index in LIG & HIG localities. These indices can be above the critical index, indicating impending outbreak, if appropriate control measures are not taken on time. The reason can be attributed to the water storage practices, changes in life style and socio-cultural behaviors among different communities.

In this study, we observed that people belongs to high income group had comparatively better knowledge and information of dengue. It was also seen that they translate this knowledge into better pragmatic preventive practices consequently showing more concern by understanding the severity of the problem than people residing in areas with low income group. This finding is consistent with previous studies conducted on dengue and its association with preventive practices, in Brazil and Thailand [30, 31].

5. Conclusion

In the present study it has been observed that the containers found in low income group are contributing more to the *Aedes aegypti* breeding than MIG and HIG localities. The number of *Aedes* larvae was higher in the transmission season than in the non-transmission season. The over head tanks and curing tanks are the key breeding sites in non transmission season whereas solid waste and plastic containers are amongst preferred breeding sites during transmission season. Vector surveillance is an important aspect of dengue disease control, so as to warn the community before the disease spreads in their area. The role of public participation in vector control is the core strategy for the reduction in dengue transmission in the absence of dengue vaccine.

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