1. A highly mosquitogenic area in an urban situation was been selected. The aim was to find out means and ways to control the ubiquitous breeding habit of *Culex quinquefasciatus* in prevailing insanitary condition in that circumscribed area.

2. The area is known as Bidhannagar (Salt Lake City), a sophisticated ultramodern satellite township (area 12.52 sq. km), situated 7.5 km away from the heart (i.e east side) of the city of Calcutta. Bidhannagar lies between 22°33' N and 22°36' N latitudes, 88°24' E and 88°26'30" E meridians, inhabited by 1.25000 population, in more than 10 thousand dwelling units.

3. The city is demarketed in the south-west by waste water disposal drain of DuttaBad Region (DBR, 3 km in length) and Eastern Metropolitan Bypass, in the north-east by KrishnaPur Canal (KPC, 6km in length) and VIP Road, in the south-east by Eastern Drainage Channel (EDC, 5km in length) and wet lands of South 24 parganas (Fig - 1). Consisting of five sectors having 76 blocks. Per capita water supply per day is 220 litres approximately.

4. The potential mosquitogenic spots were two canals namely KPC and EDC contributed 19000 sq. metres, temporary drains (k-drain) contributed 5000 sq. metres, 'U' - drains contributed 2530.5 sq. metres, cesspools contributed 470.9 sq. metres and gullypits contributed 6133.6 sq. metres potential surface area for *Culex quinquefasciatus* breeding (Table - 5).

5. The immatures and adults were monitored twice in a month for one year following WHO guidelines. The immature monitoring places were KPC, EDC, DBR and G.pits. In addition to that immature monitoring was done in the water surface covered with water hyacinth (*Eichhornia crassipes*) in KPC and EDC. The adult monitoring places were brick built room in KPC, temporary hutment in DBR and jhupries in EDC area for indoor resting collection during early morning (6-8 A.M.) In addition outdoor collection was done from the fixed gullypit during day time (12 Noon to 1P.M.).
6. Before the control operation was started a survey was conducted for collection of baseline data of immatures and adults. In immatures, *Culex quinquefasciatus* (94.64%) was dominating over *Culex vishnui* complex (8.15%), *Anopheles subpictus* (1.09%) and other species (*Lutzia raptor*, *Anopheles vagus* and *Armigeres subalbatus*) (0.12%). The annual mean density of *Culex quinquefasciatus* immature measured as larvae and pupae per dip was 44.44, 48.78, 75.67 and 1.72 in EDC, KPC, DBR and G.Pit respectively. On water surface covered with water hyacinth the immatures density was 61.52 and 48.42 in EDC and KPC respectively.

7. Amongst adult *Culex quinquefasciatus* (92.76%) was dominating over *Aedes aegypti* (3.2%), *Anopheles stephensi* (0.1%) and other species (*Anopheles subpictus*, *Anopheles vagus*, *Culex vishnui* complex and *Armigeres subalbatus*) (3.94%). The annual mean per man hour density of *Culex quinquefasciatus* adult in indoor resting collection spots were 47.21, 20.88 and 45.58 in EDC, KPC and DBR respectively. Out of total 5532 *Culex quinquefasciatus* adult collections in outdoor shelters 74.01% was male and 25.99% was female. Amongst female, 16.54% was unfed.

8. Seasonal prevalence of *Culex quinquefasciatus* was also studied both for immatures and adults (before the control operation). Out of total immatures collected throughout the year the density of immatures per dip was 1.7, 94.84 and 31.43 in the rainy, the winter and the summer season respectively. Similarly adult density per man hour was 28.29, 48.25 and 37.13 in the rainy, winter and summer season respectively.

9. In urban situation *Culex quinquefasciatus* immatures dominating over any other species of mosquitoes collected. Maximum density of immatures was observed in k-drain (temporary drain) and minimum in the storm water gullypits. Water hyacinth provided better shelter to the immatures of *Culex quinquefasciatus*.

10. Like immatures, adult *Culex quinquefasciatus* was also dominating over any other species of mosquitoes. Maximum density of adult was observed in the *Jhupites* (temporary dwelling) and minimum in the brick built rooms. In outdoor shelters adult mosquitoes were collected when the density of adult was high. Males of *Culex quinquefasciatus* out numbered the female and amongst female unfed (newly emergent mosquitoes) was found to be maximum.

11. Maximum density of adults and immatures was observed during the winter seasons and minimum during the rainy season. More specifically mosquito plague was started from the month of December which lasted up to the month of April, with maximum in the month of March and minimum in August.

12. To study the factors leading to mosquitogenic condition, physical (temperature and
water current) and chemical (dissolved oxygen, salinity and pH) factors of the water of different breeding places were estimated by standard methods and correlation of these factors with immature density of *Culex quinquefasciatus* mosquitoes was sought. The ecological factors of the water where guppy fish was established were monitored.

13. Certain important physical and chemical factors were determined affecting breeding of the mosquito. The breeding of *Culex quinquefasciatus* was found between 19.5 and 32.2 °C temperature of water. But maximum density of immature (65.32 larvae and pupae per dip to 144.38 larvae and pupae per dip) was found between 20.38 and 26.75 °C. The compatible range of water current was between 0 and 9.05 cm/sec for breeding. But maximum breeding (62 larvae and pupae per dip to 205 larvae and pupae per dip) was found between 1.8 and 3.9 cm/sec of water velocity.

14. Breeding of *Culex quinquefasciatus* was found between 0 and 8.4 mg/lit of dissolved oxygen content of water. Maximum breeding (between 48.18 and 144.38 larvae and pupae per dip) was found between 0.2 and 1.2 mg/lit. The salinity (Cl- content) of breeding water ranged between 4.2 mg/lit and 410.3 mg/lit. Maximum breeding was observed between 72.73 mg/lit and 138.95 mg/lit. The pH of water ranged between 6.8 and 8.3 and maximum breeding occurred between 7.52 and 7.97.

15. There was an inverse correlation (r = -0.84) between temperature of breeding water and the immature density. By changing the temperature, control of the *Culex quinquefasciatus* breeding could be achieved. The favourable temperature ranged for breeding was below 27°C. Similarly, there was an inverse correlation (r = -0.69) between water velocity and immature density. Favourable water velocity for breeding was below 4 cm/sec.

16. Dissolved oxygen content of water had an inverse correlation with immature density. Favourable range was below 1.2 mg/lit. For salinity the favourable range was below 138.95 mg/lit. Slightly alkaline pH was necessary for the breeding of *Culex quinquefasciatus* (favourable range was > 7.5).

17. After collection of baseline data by one year survey, a number of measures were applied to evaluate the effect of such integrated control measures. Chemical methods involved use of fenthion (0.1 - 0.15 ppm) as larvicide and malathion (5% - one hour exposure) as adulticide as and when required. Biological method was by release of larvivorous guppy fish (*Poecilia reticulata*) in selected habitats. Environmental methods included filling of breeding sources, channelling of different 'U' surface drains, flushing of water in the canals and removal of weeds (water hyacinth, *Eichhornia crassipes*) from the water surface. Physical methods were such items as closing vent pipe of septic tank.
sealing cracks and crevices of water tanks and providing cover for open gullies.

Personal protection was emphasised i.e. use of bed nets and mosquito repellents. Health education to augment community participation was attempted through local newspapers, video shows, group meetings and door-to-door visit.

18. Application of chemical methods as larvicide caused a drop in the immature density of *Culex quinquefasciatus* (larvae and pupae per dip). Before application the value was 42.65. After application the value fell to 3.77. Reduction was observed in all the four study areas – EDC (44.4 to 6.39), KPC (48.78 to 3.83), DBR (75.67 to 4.86) and gullies (1.72 to 0.02).

19. Biological measures (larvivorous fish) was tried out in gullies and in k-drains (temporary drain). In gullies the immature density of *Culex quinquefasciatus* (larvae and pupae per dip) was 2.24 before application and 0.16 after application. In K-drains the values were 41.84 before application and 0.32 after application. Guppy fish were found to tolerate pH between 6.8 and 7.3, temperature between 20.5°C and 30.5°C, dissolved oxygen content between 0 and 4.42 mg/lit and salinity (chloride content) between 4.2 mg/lit and 79.9 mg/lit.

20. By environmental methods immature density as larvae and pupae per dip of *Culex quinquefasciatus* decreased from 54.97 to 9.13.

21. By use of physical measures, immature density as larvae and pupae per dip of *Culex quinquefasciatus* decreased from 7.07 to 2.24.

22. During health education, it was found that 100% of the population was already using bed nets at night. Consciousness about mosquitogenic factors was found in 66% inhabitants. 30% of the population was using some mosquito repellent devices.

23. Adult mosquito density (per man hour density i.e. pmd) was utilised to assess the overall impact of all the control measures applied. Before application of such integrated control measures the density of adult *Culex quinquefasciatus* was 37.87 pmd which came down to 21.14 pmd after application. In the different study areas the reduction was 47.21 to 23.37 in EDC, 20.88 to 12.83 in KPC and 45.58 to 27.21 in DBR. Total collection of adults from outdoor shelters fell from 5532 before application to 479 after application of integrated control measures.

24. It was thus observed that chemical methods produced a net reduction of 11.31 times for *Culex quinquefasciatus* in immature density (p < 0.001).

25. Biological methods produced a reduction of *Culex quinquefasciatus* immature to the extent of 13.7 times in gullies and 130.75 times in K-drains. Guppy fishes showed
maximum predation during the winter. Out of 120 guppy fish dissected in each season, 52 were positive for immatures in the winter, 16 in the summer but none in the rainy season (p < 0.05).

26. Environmental measures produced a reduction of *Culex quinquefasciatus* immature to the extent of 6.02 times which was statistically significant (p < 0.05).

27. Physical measures produced a net reduction of 3.15 times of the immature density of *Culex quinquefasciatus* mosquitoes with p < 0.05.

28. It was realised that without community participation no control measure can be successful.

29. For integrated control management physical and environmental measures are essential. They are cost effective and do not cause ecological disharmony. Biological measures are also helpful, cost effective and ecofriendly. If the situation appears uncontrolled by such combination of efforts then chemical measures should be applied as and when required. But chemical (larvicide) and biological (larvivorous fishes) can not be use at the same site.

It may be summarised as intervention at three successive plans:

**Plan one**: Community participation through community awareness with use of physical and environmental methods.

**Plan Two**: Use of biological methods in addition in selected places.

**Plan Three**: Application of chemical (larvicide/adulticide) methods in appropriate places (where biological method is not possible) as and when required.

In planning integrated control measures for any vector population in an urban area, this approach of intervention at three successive plans (moving from one to the next if desirable control has not already been achieved) would be most logical and can be treated as model for any urban mosquito nuisance problem in tropics.