



## Assessing mosquito diversity & density in Nagpur city: Impact of Sewage Treatment plant

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### Abstract

A comparative study was carried out to determine the mosquito diversity and density near the domestic wastewater slow-flowing canal in Chaitanya Nagar, Nagpur, Maharashtra State, India, and the domestic wastewater slow-flowing canal established sewage-water treatment plant (STP) in Somalwada, Nagpur. An entomological parameter was used for comparison with the assistance of standard WHO guidelines. The observations showed a higher density of *Armigers* and *Culex* species, which are mosquitoes breeding in organically polluted water bodies, near the STP located at the domestic wastewater slow-flowing canal in Somalwada, Nagpur, as compared to the domestic wastewater slow-flowing canal in Chaitanya Nagar, Nagpur. The observed density range of *Culex quinquefasciatus* consistently exceeded the normal range. This study noted the potential transmission of lymphatic filariasis and other mosquito-borne diseases within a two km radius flight range of mosquitoes near the STP. It recommends urgent measures for mosquito control in the vicinity of the STP in Somalwada, Nagpur.

**Keywords:** *Armigers*, *Culex*, Filariasis, Nagpur, Sewage-water Treatment Plant (STP), Somalwada

### Introduction

Mosquitoes are medically important insects as they act as vectors for various diseases including malaria, filaria, dengue, chikungunya, Japanese encephalitis, Zika, West Nile virus, La Crosse encephalitis, and yellow fever. Annually, approximately 700 million people worldwide are affected by mosquito and vector-borne diseases. Malaria alone is responsible for 400,000 deaths, followed by dengue, which causes 40,000 deaths every year worldwide. Most of these deaths occur in children under the age of 5 years (WHO, 2024).

The main objective of a sewage treatment plant is to extract pollutants, remove coarse particles, eliminate toxicants, and kill potential pathogens so that the remaining clean water can be discharged back into the environment for various purposes (Alagha *et al.*, 2020 [2]; Villarin *et al.*, 2020). The plant stores and processes domestic wastewater for further treatment. This stagnant, organically polluted water body, enriched with high nutrients, acts as a major source for the proliferation of mosquitoes (Whelan, 1994; Asha *et al.*, 2014 [4]; Karlekar and Andrew, 2015) [8]. When sewage treatment plants are located relatively close to residential areas, they can give rise to large and continuous problems with mosquitoes (Whelan, 1988 [19]; Silva, 2023) [23]. Further, the flight dispersal of vector mosquitoes is an important aspect for controlling mosquito-borne diseases (Alexander *et al.*, 2012) [3].

Depending on improper design, construction, operation, maintenance and unsuitable methods of effluent disposal or dispersal, mosquito production from constructed systems can be much greater than from natural systems (Whelan and Darwin, 1997; Mayhew *et al.*, 2004 [11]; Carlson, 1986; Carlson and Knight, 1987 [6]; Xagorarakis and O'Brien, 2020) [26]. The disease lymphatic filariasis, transmitted by the organically polluted water body breeder mosquito *Cx. quinquefasciatus*, causes chronic suffering, lifelong morbidity, and disability (WHO, 2023). In the Maharashtra state, 17 districts are endemic for lymphatic filariasis (Gadchiroli, Chandrapur, Gondia, Bhandara, Wardha,

Nagpur, Amravati, Akola, Yawatmal, Jalgoan, Nandurbar, Nanded, Latur, Osmanabad, Solapur, Sindudurg, Thane). Out of these 17 districts, 9 districts in the Vidharbha region, including Nagpur city which contribute 80% of the cases in Maharashtra state (Mahakalkar *et al.*, 2017) [10]. Therefore, this study was conducted to find and compare the mosquito diversity, density, and health risks associated with mosquitoes near the canal-established STP plant at Somalwada, Nagpur, and the slow-flowing canal of Chaitanya Nagar, Nagpur.

### Material and Methods

Ten houses were selected from each Site. Site 1 was identified as the nearby locality of the canal where the STP plant was established at Somalwada, Nagpur, and Site 2 was selected at Chaitanya Nagar, Nagpur, where the slow-flowing canal does not have an STP plant. The duration of this study was six months, from August to January 2024. The catching of adult and larval mosquitoes was carried out according to standard entomological surveillance guidelines (WHO, 1975, 2003; Abeyasingha *et al.*, 2009) [1]. Upon entering each household, the purpose of the study was explained to the head of the selected households. Collected adult and larval forms of mosquitoes were brought to the laboratory. The larvae were reared up to emergence. All adult mosquitoes were identified using standard mosquito identification keys for each genus (Barraud, 1934 [5]; Christophers, 1933 [7]; Qutubuddin, 1960 [13]; Reinert *et al.*, 2004 [14]; Sirivanakarn, 1976 [17]; Knight, 1977 [9]; Reuben *et al.*, 1974; Nagpal *et al.*, 2005) [12].

Formula (WHO 1975, 2003, Abeyasingha *et al.*, 2009) [1]

$$\text{Mosquito Density} = \frac{\text{Total number of mosquitos collected}}{\text{Total time spent in hours for collection}}$$

### Result and Discussion

A total of 323 mosquitoes were collected from Site 1 and 90 from Site 2 (Table 1 and 2). The collected mosquitoes from

both sites belonged to the genera *Anopheles*, *Culex*, *Aedes*, and *Armigers*, including 11 species: *Ae. aegypti*, *Ae. albopictus*, *Ae. vitatus*, *An. subpictus*, *An. stephensi*, *An. culicifacies*, *Cx. quinquefasciatus*, *Cx. tritaeniorhynchus*, *Ar. subalbatus*, and *Ar. abturbans*. The population density of the species *Cx. quinquefasciatus* dominated all the observed species at both sites. The maximum density of mosquito species was observed in January 2024 at Site 1 (Fig. 1). A barrier and tank constructed to fulfil the required quantity of water to run the STP at Site 1 created stagnant

water bodies outside and inside the plant, favoring a high degree of breeding for organically polluted water body-breeding mosquitoes, such as *Cx. quinquefasciatus*, *Ar. subalbatus*, and *Ar. Abturbans*. The vector species identified at both Site 1 and Site 2 were *An. culicifacies* and *An. stephensi* for malaria, *Cx. quinquefasciatus* for lymphatic filariasis, *Cx. tritaeniorhynchus* for Japanese encephalitis, and *Ae. aegypti* and *Ae. albopictus* for dengue and chikungunya fever (Figs. A-L).

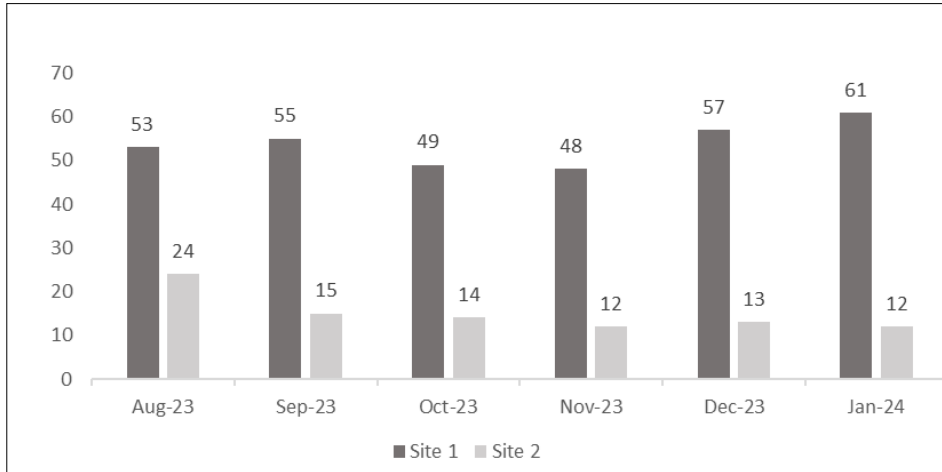


Fig 1: Month-wise mosquito density at Site 1 and Site 2



A



B



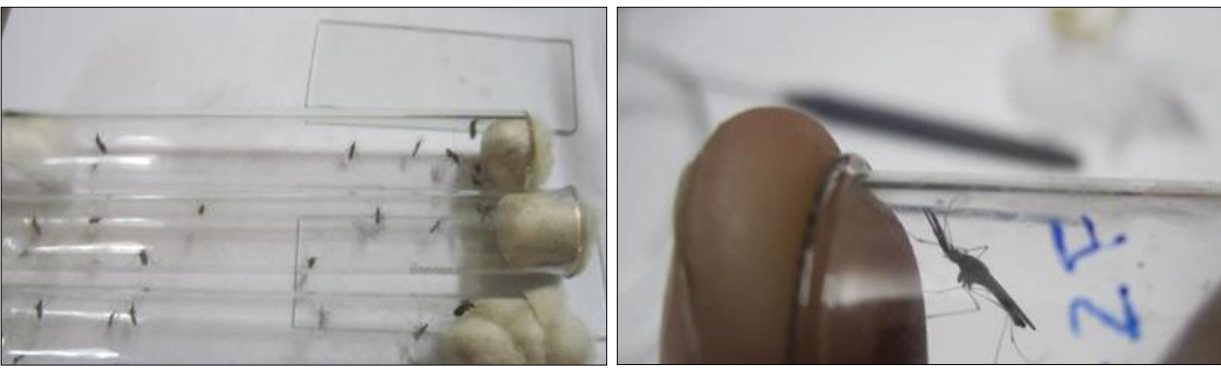
C



D



**Fig A-F:** A- *Culex quinquefasciatus* ; B- *Armigere subabalbatus*; C- *Anopheles stephensi*; D-Eggs of *Aedes aegypti*; E- Eggs of *Anopheles* species; F- *Armigere abturbans*.



**Fig G-L:** Collection and identification of mosquitoes.

Wastewater treatment systems can generate potential vectors of human diseases, emphasizing the need for the identification of mosquito breeding sources inside and nearby STPs (Xagorarakis and O'Brien, 2020) [26]. Carlson and Knight (1987) [6] found extremely high populations of *Cx. quinquefasciatus* near wastewater treatment plants in Florida. Similarly, this study observed a high density of *Cx. quinquefasciatus*, *Ar. subalbatus*, and *Ar. abturbans* at Site 1 consistently throughout the study period. Alexander *et al.*, (2012) [3] demonstrated that the flight range of *Cx. quinquefasciatus* was up to 2 km from the breeding

resource. Therefore, he observed high density of *Cx. quinquefasciatus* is cautionary for the transmission of lymphatic filariasis up to a 2 km radius range population around Site 1. The results of this study corroborate the need for emergency mosquito control measures to be continuously implemented in the nearby areas of STPs. Entomological control methods, along with simple changes in design principles and adequate maintenance can result in the reduction of the current problem of mosquito nuisance and mosquito-borne disease transmission near STP locations.

**Table 1:** Mosquito density near canal established STP Somalwada, Nagpur (Site 1).

Site of mosquito collection	August 2023	September 2023	October 2023	November 2023	December 2023	January 2024
	Total mosquito collected	Total mosquito collected	Total mosquito collected	Total mosquito collected	Total mosquito collected	Total mosquito collected
A	4	6	7	3	8	6
B	6	7	3	7	8	8
C	4	2	5	4	3	7
D	1	1	7	7	6	9
E	6	9	6	7	7	4
F	7	6	3	2	5	7
G	4	5	5	9	6	4
H	8	9	7	5	4	7
I	8	3	5	4	7	6
J	5	7	1	0	3	3
TOTAL	53	55	49	48	57	61
Density	21.2	22	19.6	19.2	22.8	24.4

**Table 2:** Mosquito density near slow flowing canal Chaitanya Nagar, Nagpur (Site 2)

Site of mosquito collection	August 2023	September 2023	October 2023	November 2023	December 2023	January 2024
	Total mosquito collected	Total mosquito collected	Total mosquito collected	Total mosquito collected	Total mosquito collected	Total mosquito collected
A	3	0	2	0	1	2
B	5	1	1	0	1	3
C	2	2	1	1	3	0
D	4	1	0	1	0	0
E	1	4	2	3	0	1
F	0	0	3	2	2	1
G	4	3	3	4	4	1
H	2	3	0	0	1	0
I	2	0	0	0	0	2
J	1	1	2	1	1	2
Total	24	15	14	12	13	12
Density	9.6	6	5.6	4.8	5.2	4.8

**References**

- Abeyasingha R, Yapabanadara A, Kusumawathie P, Perera D, Peiris B, Hewawitharane H. *Guideline for entomological surveillance of malaria vectors in Sri Lanka*. Anti-malaria campaign, Colombo,2009:10:1-67.
- Alagha O, Allazem A, Bukhari A, Anil I, Muazu N. *Suitability of SBR for wastewater treatment and reuse: Pilot-Scale reactor operated in different anoxic conditions*. Int J Environ Res Public Health,2020;17(5):1617-1623.
- Alexander TC, Cori LD, Meghan AR, Jason D, Gregory DE, Laura DK. *Dispersal of Culex mosquitoes (Diptera: Culicidae) from a wastewater treatment facility*. J Med Ent,2012;49(1):35-42.
- Asha A, Aneesh E. *Diversity of mosquito species (Diptera: Culicidea) at Irinjalakuda, Thrissur with special reference to their breeding habitats*. Int J Curr Micro App Sci,2014;3(2):536-541.
- Barraud PJ. *The Fauna of British India, including Ceylon and Burma. Diptera. Family Culicidae, Tribes Megarhinini and Culicini*, Taylor and Francis, London,1934:5:1-463.
- Carlson B, Knight R. *Mosquito production and hydrological capacity of Southeast Florida impoundments used for wastewater retention*. J Am Mosq Control Assoc,1987;3:74-83.
- Christophers S. *The Fauna of British India, including Ceylon and Burma. Diptera. Family Culicidae, Tribe Anophelini*, Taylor and Francis, London,1933:4:1-271.
- Karlekar S, Andrew R. *Mosquito diversity and vector species status in and around Nagpur city of Maharashtra state, India*. Int J Mosq Res,2015;2(2):19-23.
- Knight K, Stone A. *A Catalog of the Mosquitoes of the World (Diptera: Culicidae)*. Entomological Society of America, Maryland,1977:6:1-611.

10. Mahakalkar A, Sapkal H, Baig M. *Report of high genetic diversity of filarial worm, Wuchereria bancrofti from endemic region of Eastern Maharashtra (India)*. *Helminthologia*,2017;54(4):1-6.
11. Mayhew C, Raman D, Gerhardt R, Burns R, Younger M. *Periodic draining reduces mosquito emergence from free-water surface constructed wet lands*. *Transactions of the American Society of Agricultural Engineers*,2004;47(2):567-573.
12. Nagpal B, Srivastava A, Saxena R, Ansari M, Dash A, Das S. *Pictorial identification key for Indian Anophelines*. Malaria Research Centre (ICMR),2005:1-38.
13. Qutubuddin M. *Mosquito studies in the Indian subregion, Part I Taxonomy-A brief review*. *Pacific Insects*,1960;2(2):133-147.
14. Reinert J, Harbach R, Kitching I. *Phylogeny and classification of Aedini (Diptera: Culicidae), based on morphological characters of all life stages*. *Zoo J Lin Soc*,2004;142:289-368.
15. Reuben R, Tewari S, Hiriyan J, Akiyama J. *Illustrated keys to species of Culex associated with Japanese Encephalitis in Southeast Asia (Diptera: Culicidae)*. *Mosquito Systematics*,1994;26(2):75-96.
16. Silva J. *Wastewater treatment and reuse for sustainable water resources management: A systematic literature review*. *Sustainability*,2023;15(14):10940-10947.
17. Sirivanakarn S. *A revision of the subgenus Culex in the oriental region (Diptera: Culicidae)*. *Contr Amer Entom Inst*,1976;12(2):1-272.
18. Villarín M, Merel S. *Paradigm shifts and current challenges in wastewater management*. *J Hazard Mater*,2020;390:122–139.
19. Whelan PI. *Mosquito breeding and sewage treatment in the Northern Territory*. *Water J Aust Water Wastewater Assoc*,1988;15(5):34-37.
20. Whelan P, Darwin. *The prevention of mosquito breeding in sewage treatment facilities*. *Bulletin of Mosquito Control Association of Australia*,1997;10(3):19-28.
21. Whelan P. *Sewage effluent dispersal and mosquito breeding kings Canyon resort*. *Bulletin of Mosquito Control Association of Australia*,1994;7(3):1-12.
22. World Health Organization. *Manual on Practical Entomology in Malaria, Part II. Methods and Techniques*. World Health Organization: [H.M.S.O.], Geneva, [London],1975:1-191.
23. World Health Organization. *Malaria Entomology and Vector Control, Guide for Tutors*. World Health Organization: [H.M.S.O.], Geneva, [London],2003:18:1-41.
24. World Health Organization. *Fact sheet of lymphatic filariasis*. [Online] Available at: <https://www.who.int/news-room/fact-sheets/detail/lymphatic-filariasis>, 2023.
25. World Health Organization. *Fact sheet of mosquito-borne diseases*. [Online] Available at: <https://www.who.int/news-room/fact-sheets/detail/mosquito-borne-diseases>, 2024.
26. Xagorarakis I, O'Brien E. *Wastewater-Based Epidemiology for Early Detection of Viral Outbreaks*. *Nature*,2020:75-97.