Rutuja Shivdatta Kalyankar, 2025, 13:3
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology

An Open Access Journal

Real-Time Automated Mosquito Detection and Elimination Systems to Combat Vector-Borne Diseases in Pune

Rutuja Shivdatta Kalyankar
Tilak Maharashtra Vidyapeeth

Abstract- Mosquito-borne diseases have increasingly become a public health threat in Pune, majorly due to poor waste management and stagnant water accumulation. Traditional methods like fogging, pesticides, and mosquito nets offer only temporary relief and fail to address the root causes. This review paper explores current technological gaps and proposes a real-time, automated mosquito detection and elimination system. Leveraging sensor-based detection, AI, and IoT solutions, this system aims to proactively reduce mosquito populations before disease outbreaks. The study evaluates previous work, current solutions, and the scope of advanced technologies to establish a foundation for future development.

Keywords- Mosquito-borne diseases, Pune, Dengue, Malaria, Chikungunya, Vector control, Stagnant water, Waste management, Traditional mosquito control methods

I. INTRODUCTION

Urban areas like Pune face increasing mosquito infestations due to improper waste disposal, stagnant water in public spaces, and limited long-term vector control systems.

This has led to rising cases of mosquito-borne diseases, putting pressure on the healthcare system. Traditional solutions like pesticides and fogging offer only temporary relief and contribute to environmental degradation. There is an urgent need to transition to intelligent, automated, and sustainable mosquito management systems.

Statement of the Problem

Despite continuous efforts by municipal authorities, mosquito-borne diseases remain a major challenge in Pune. Temporary relief methods fail to address the root causes such as stagnant water and garbage accumulation. There is no real-time or location-specific mosquito monitoring system in place. Thus, a proactive, automated solution is required to detect and eliminate mosquitoes before disease outbreaks occur.

Aims of the Study

- To evaluate existing mosquito detection and control technologies.
- To explore the integration of AI, IoT, and sensors for real-time mosquito monitoring.
- To highlight technological gaps and propose feasible solutions tailored to urban settings like Pune.
- To assess environmental and social implications of automated systems.

Research Questions

- What are the main contributors to mosquito breeding in Pune?
- How effective are current mosquito control methods in Indian urban environments?
- Can AI and sensor-based technologies improve real-time mosquito detection?
- What are the environmental and ethical considerations for automated mosquito control?

Hypotheses

- **H1:** Existing mosquito control strategies provide short-term relief and lack sustainability.
- **H2:** Sensor- and AI-based systems can accurately detect mosquitoes in real-time.
- **H3:** Automated mosquito elimination can reduce the frequency and need for harmful chemical use.
- **H4:** Public health outcomes can improve with proactive detection systems installed in critical locations.

Data Collection and Procedure

This paper is based on an in-depth literature review of existing academic and technical sources. Research includes scientific papers, WHO data, municipal health reports, and relevant AI and IoT studies. No primary human subject data was collected, making this study entirely reliant on credible secondary sources.

Limitations of the Study

- The study is theoretical and lacks field implementation.
- Most of the proposed technologies are still in developmental or pilot phases.
- Urban settings vary greatly, so results may not be universally applicable.
- Limited region-specific data on mosquito behavior and sensor responses.

Value of the Study

The paper aims to bridge a gap between technology and public health. By exploring a data-driven, automated approach to mosquito control, it contributes to long-term, scalable solutions for urban environments. The findings can assist public health agencies, startups, and researchers in developing and implementing intelligent mosquito management systems.

Introduction

This chapter presents a comprehensive review of existing literature related to mosquito control strategies, sensor technologies, and AI-based detection systems. The objective is to examine what has been researched, implemented, or proposed in the domain of mosquito surveillance and elimination, with a focus on how these methods relate to the context of Pune and other urban areas in India. It also aims to identify gaps that current technologies fail to address and suggest how future research can contribute toward more effective solutions.

II. LITERATURE REVIEW

Traditional Methods of Mosquito Control

Traditional mosquito control methods have relied heavily on chemical, physical, and behavioral strategies:

- **Chemical Controls (fogging, pesticides):** These are common but provide only temporary relief. Over time, mosquitoes develop resistance to chemicals such as pyrethroids, leading to reduced effectiveness.
- **Physical Barriers (mosquito nets, window screens):** These methods are effective indoors but are impractical for outdoor or large-scale applications in public spaces.
- **Source Reduction:** Community clean-up drives and removal of stagnant water sources are useful but rely heavily on human participation and consistent municipal oversight, which is often lacking in Indian cities.
- **Biological Controls:** Use of larvivorous fish or bacterial agents like Bacillus thuringiensis israelensis (BTI) in water bodies shows promise but is localized and requires regular maintenance.

Limitation: These approaches are reactive, labor-intensive, and not scalable for dynamic urban environments like Pune.

Role of Technology in Mosquito Surveillance

Advancements in computing and sensor technology have enabled smarter and more proactive mosquito surveillance methods. These include:

Acoustic Sensors

- Mosquitoes have unique wingbeat frequencies, typically between 300–600 Hz.
- AI models can classify species by analyzing sound frequencies.
- Studies (e.g., Potamitis et al., 2015) achieved over 90% accuracy in controlled environments.

Infrared and Thermal Sensors

- Mosquitoes are warm-blooded seekers; thermal cameras can detect their movement near human bodies.
- Used in prototype traps to trigger activation only when mosquitoes are present.

Optical Recognition and Image Processing

- Cameras with ML algorithms can visually recognize mosquitoes.
- OpenCV-based projects detect motion and compare shape data to distinguish mosquitoes from other insects.

Use of Artificial Intelligence (AI)

AI plays a crucial role in mosquito detection and behavior prediction. Common techniques include:

- Deep Learning (CNNs) for classifying mosquito species based on audio/image input.
- Reinforcement Learning for optimizing trap placement based on past mosquito density data.
- Predictive Models using climatic, geographic, and waste distribution data to forecast breeding patterns.

Example: A 2020 study by Biryukov et al. used an ensemble neural network to predict mosquito density with an accuracy of 89.3%.

IoT and Smart Traps

The integration of Internet of Things (IoT) devices with sensors enables:

- Real-time mosquito population tracking across multiple locations.
- Alert systems for high-density areas.
- Remote monitoring and automatic activation of killing mechanisms (e.g., UV light traps, CO_2-based traps).

Case Study: Singapore's NEA implemented Gravitraps with GPS and sensor modules for city-wide mosquito density tracking.

Case Studies from India and Abroad

- **India:** Bengaluru Smart Mosquito Trap Pilot by a private tech startup showed success in detecting Aedes mosquito spikes before dengue outbreaks.
- **USA:** Microsoft's "Project Premonition" uses drones to capture mosquitoes and AI to analyze disease-carrying species.
- **Africa:** WHO-led programs use drones and data modeling to identify mosquito breeding grounds in marshy regions.

Environmental and Social Considerations

- Pesticide Overuse leads to environmental toxicity.
- Public Perception affects adoption—residents are more willing to accept technology-based, non-chemical solutions.
- Ethical Use of Surveillance Cameras must be regulated to prevent privacy violations in public and private spaces.

Gaps in Current Research

- Limited field deployment data in Indian urban areas.
- Most AI models lack generalizability across species and environmental conditions.
- No unified platform integrates sensor data, predictive analytics, and automated elimination in real-time.
- Affordability and power supply challenges hinder long-term deployment in low-income or high-density areas.

Summary of Findings

- Traditional methods offer limited long-term relief.

- Sensor-based systems show potential but lack real-world scalability.
- AI and IoT can provide real-time mosquito detection, but require further development and region-specific training.
- Multi-disciplinary collaboration (tech + health) is essential to design a sustainable, automated mosquito control system.

This chapter outlines the methodology adopted for conducting the review study. It includes the research design, data collection strategies, data analysis techniques, ethical considerations, and limitations faced during the study process.

III. RESEARCH DESIGN

A qualitative and exploratory research design was adopted. The study relies entirely on secondary sources such as journal articles, reports, and case studies. The objective was to analyze and synthesize information on existing mosquito detection and control technologies and assess their applicability in Pune.

Data Collection Methods
Secondary Sources:

- Peer-reviewed research papers from journals like IEEE, Elsevier, and Springer.
- WHO publications and Pune Municipal Corporation health records.
- Conference proceedings and government white papers.

Online Databases:

- Google Scholar
- ResearchGate
- IEEE Xplore
- PubMed

Media Sources and Blogs:

- Technology articles on mosquito-related innovation
- Interviews and blogs from public health professionals and IoT developers

Data Analysis Techniques
Comparative Analysis:
Existing mosquito mitigation methods were compared with sensor-based and AI-driven systems.

Thematic Analysis:
Key themes such as sensor accuracy, cost-efficiency, and ethical deployment were identified across sources.

Feasibility Analysis:
Studies were evaluated for their practical implementation in an Indian urban context, with factors such as cost, power consumption, and scalability.

SWOT Analysis (Optional):
A strengths-weaknesses-opportunities-threats matrix was used to evaluate the proposed automated system.

Ethical Considerations
Academic Integrity:
All sources were credited and cited to avoid plagiarism.

Non-human Study:
No human participants were involved, thus eliminating the need for informed consent or personal data protection.

Environmental Responsibility:
The proposed solutions emphasize environmentally safe practices over harmful chemical usage.

Transparency and Objectivity:
The analysis was conducted without bias to promote honest scientific discussion.

Research Limitations
No Real-world Testing:
The study is based on theoretical models and past case studies without field trials.

Limited Local Data:
Data specific to Pune's mosquito species, climate, and urban infrastructure is limited.

Generalizability:
While focused on Pune, solutions may require modification for use in other cities or rural areas.

Technology Adoption Barriers:
Infrastructure and funding constraints may limit the adoption of proposed solutions.

This final chapter summarizes the findings of the study and provides concluding remarks on the importance and future potential of automated mosquito detection and control systems. It reiterates the relevance of adopting a technology-based solution to tackle mosquito-borne diseases in urban areas.

IV. CONCLUSION

The persistent issue of mosquito-borne diseases in Pune stems from ineffective waste management and traditional control practices. Current methods are reactive, not proactive, often leading to temporary relief. This review has identified that integrating AI, sensor technologies, and IoT can offer a scalable and automated solution to detect and eliminate mosquitoes in real-time. Such innovations can drastically reduce disease transmission, improve public health outcomes, and lessen environmental impact.

However, for such systems to be successful, collaboration between municipal bodies, technologists, and researchers is essential.

REFERENCES

1. World Health Organization. (2022). Mosquito-borne diseases overview.
2. Pune Municipal Corporation. (2023). Public Health Annual Report.
3. Biryukov, M. et al. (2020). "Automated mosquito detection using wingbeat frequency and deep learning." IEEE Sensors Journal.
4. Shrivastava, S. & Jain, R. (2021). "Review of IoT-based mosquito traps."
5. International Journal of Environmental Research.
6. Ghosh, A. (2023). "Urban vector control strategies: Case study of Indian metros."
7. Public Health Today.
8. Ahmed, F. et al. (2019). "Sensor networks for real-time health monitoring."
9. Journal of Smart Systems.
10. Kaur,P. & Reddy, V. (2022). "Role of AI in public health." AI & Society Journal.