18(1s), Spring 2026
Journal of Animal Environment
(E-ISSN 2717-1396, ISSN 2717-1388)

Original Research Paper

The Role of Agrochemicals in Shaping Mosquito Population Genetics and Disease Transmission Dynamics

Ms. Anusha K[1], Dr. Wasim A. Bagwan[2*], Kadirvelu Divya[1], Varun Kumar Sharma[3], Prabhavathy Devi N[1], Baskaran Kuppusamy[1], Balamurugan N[1]

[1]Meenakshi Academy of Higher Education and Research (MAHER), Chennai, Tamil Nadu, India

[2*]Krishna Institute of Science and Technology, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra - 415539, India | ORCID: https://orcid.org/0009-0000-4508-2036

[3]Department of Biotechnology and Microbiology, Noida International University, Greater Noida, Uttar Pradesh, India

[1]Lecturer, Meenakshi College of Pharmacy (Ms. Anusha K) | Email: anushakpharmacy@maher.ac.in

[1]Tutor, Meenakshi College of Nursing (Kadirvelu Divya) | ORCID: https://orcid.org/0000-0002-6496-3725 | Email: kadirveludivya54@gmail.com

[3]Assistant Professor (Varun Kumar Sharma) | ORCID: https://orcid.org/0000-0001-8575-6939 | Email: varun1.sharma@niu.edu.in

[1]Meenakshi College of Arts and Science (Prabhavathy Devi N) | ORCID: https://orcid.org/0009-0008-3703-3355 | Email: prabha@maher.ac.in

[1]Scientist, Central Research Laboratory, Meenakshi Medical College Hospital & Research Institute (Baskaran Kuppusamy) | ORCID: https://orcid.org/0009-0003-5070-7450 | Email: kjbaskar@gmail.com

[1]Meenakshi College of Physiotherapy (Balamurugan N) | ORCID: https://orcid.org/0000-0002-0778-902X | Email: bala@maher.ac.in

Abstract: Agrochemicals, vital tools in modern agriculture, have significant repercussions on mosquito population genetics and disease transmission dynamics. This paper synthesizes the multifaceted role of agrochemicals in shaping these aspects, spanning ecological, genetic, and epidemiological realms. Agrochemicals modify mosquito habitats by altering water quality, temperature, and vegetation, creating conducive breeding sites. They impose selection pressures, driving the development of pesticide resistance in mosquito populations. This resistance poses challenges for vector control strategies, affecting disease transmission dynamics. Agrochemicals also influence vector dynamics, including feeding behaviors, host preferences, and population abundance, thereby altering disease transmission rates. Agrochemical use induces ecological disruptions, harming natural predators and non-target insects, and perturbing ecosystem dynamics. These unintended effects exacerbate mosquito-borne disease risks. Understanding the intricate interactions between agrochemicals, mosquitoes, and disease transmission is crucial for devising effective vector control measures. Integrated approaches, considering ecological sustainability and public health, are imperative for mitigating the spread of mosquito-borne diseases while minimizing ecological impacts of agrochemicals. This paper contributes to a comprehensive understanding of the complex relationships between agrochemicals, mosquito populations, and disease transmission, facilitating informed decision-making in agriculture and public health sectors.

Keywords: Agrochemicals, Mosquitoes, Population Genetics, Disease Transmission, Vector Dynamics, Integrated Pest Management

I. Introduction

Mosquito-borne diseases represent a significant public health burden globally, causing millions of infections and deaths each year. The transmission of these diseases is intricately linked to the ecology and behavior of mosquito vectors, which are influenced by a myriad of environmental factors. Among these factors, the use of agrochemicals in agriculture stands out as a significant driver shaping mosquito population genetics and disease transmission

***Corresponding Author:**
Received: 25th May, 2026; Revised: 6th June, 2026; Accepted: 8th June, 2026; Available Online: 23rd July, 2026
(DOI): 10.70102/AEJ.2026.18.1s.20

dynamics [1]. Agrochemicals, including pesticides and fertilizers, are essential tools in modern agriculture, aiding in pest management, enhancing crop yields, and ensuring food security. The widespread and often indiscriminate application of these chemicals can have unintended consequences on non-target organisms, ecosystems, and human health [2]. Mosquito populations, particularly those of species known to transmit diseases such as malaria, dengue fever, Zika virus, and West Nile virus, are not exempt from the impacts of agrochemical use. The complex interplay between agrochemicals, mosquito populations, and disease transmission dynamics underscores the need for a multidisciplinary approach to understanding and addressing these challenges [3]. By examining the ecological, genetic, and epidemiological factors involved, we can gain insights into the mechanisms by which agrochemicals influence mosquito populations and disease transmission dynamics. Agrochemicals modify mosquito habitats in various ways, altering water quality, temperature, and vegetation [4]. Runoff from agricultural fields can contaminate nearby water bodies, creating conducive breeding sites for mosquitoes. The use of agrochemicals may disrupt natural ecosystems, affecting the abundance and distribution of mosquito larvae and their predators. To modifying habitats, agrochemicals exert selection pressures on mosquito populations, leading to the development of pesticide resistance [5].

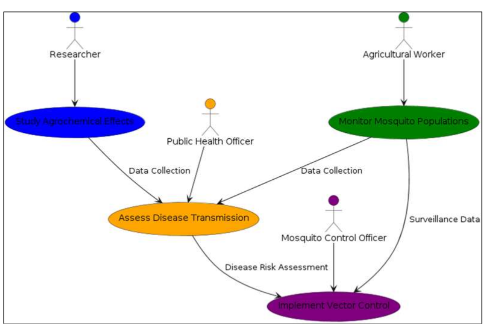

Figure 1. Depicts the Relationships Between Agrochemicals In Shaping Mosquito Population Genetics & Disease Transmission

Mosquitoes with genetic traits conferring resistance to pesticides are more likely to survive and reproduce, diminishing the efficacy of vector control measures. The emergence of pesticide-resistant mosquito populations poses challenges for disease control efforts and underscores the importance of integrated pest management strategies. Agrochemicals can influence mosquito vector dynamics, including feeding patterns, host preferences, and abundance. Changes in vector behavior and distribution may alter the transmission dynamics of mosquito-borne diseases, affecting human health outcomes [6]. Understanding how agrochemical use shapes vector ecology is crucial for predicting disease transmission risks and implementing targeted control measures (Figure 1). The ecological disruptions caused by agrochemicals extend beyond mosquito populations, affecting non-target organisms and ecosystem health. Reductions in predator populations or unintended harm to beneficial insects may indirectly contribute to mosquito population growth, exacerbating disease transmission risks. The use of agrochemicals has direct implications for human health, including increased exposure to harmful chemicals and the potential for pesticide residues in food and water sources [7]. Changes in mosquito population dynamics influenced by agrochemicals can impact the transmission of mosquito-borne diseases, affecting public health outcomes. Integrated approaches that consider both agricultural and public health perspectives are essential for addressing these complex challenges.

II. Literature Review

The literature review provides a comprehensive overview of research on pest control strategies, particularly focusing on biopesticides, insecticides, and mosquito control methods. Thakore highlights the potential of biopesticides as eco-friendly alternatives for agricultural pest management, while studies by Ohia and Ana underscore their role in addressing mosquito-borne diseases [8]. Tyagi examines advancements in vector mosquito control, emphasizing herbal products. Research explores malaria prevention approaches such as insecticide-treated nets and indoor residual spraying, alongside assessments of progress and challenges in global malaria control. Discussions also encompass the health and environmental implications of DDT use [9]. Investigations into the impact of pesticides on mosquito populations and resistance development shed light on aquatic invertebrates' responses to pesticide exposure. Studies further explore sublethal pesticide effects on amphibians and the potential of essential oils as mosquito repellents and larvicides. These findings emphasize the importance of sustainable pest management strategies to mitigate vector-borne diseases while minimizing environmental impact [10].

Author & Year	**Area**	**Methodology**	**Key Findings**	**Challenges**	**Pros**	**Cons**	**Application**
Bhatt et al. (2	Malaria co	Epidemiological	Effect of malaria	Data-driven insi	Reduction in	Data limitation	Malaria control

015)	ntrol	analysis	control interventions in Africa	ghts, progress assessment	malaria burden, informing policy	s, sustainability challenges	programs
Cibulskis et al. (2016)	Global malaria progress	Review	Global progress in malaria control and future challenges	Multifaceted approach, policy recommendations	Insight into progress and challenges, guiding future strategies	Funding constraints, emerging threats	Global malaria control strategies
Eskenazi et al. (2009)	Health and environment	Epidemiological analysis	Human health consequences of DDT use	Health impacts assessment, policy implications	Historical perspective, informing regulatory decis	Health risks, environmental persistence	Public health and environmental policy
					ions		
Bouwman et al. (2011)	Health and environment	Review	Paradox of DDT use for malaria prevention	Risk-benefit analysis, policy recommendations	Effective in malaria control, regulatory challenges	Health risks, environmental persistence	Malaria control policies
Pandey et al. (2009)	Mosquito repellents	Experimental research	Thymol as a mosquito repellent	Natural repellent, potential for use in endemic areas	Efficacy against specific mosquito species	Limited spectrum of activity, formulation challenges	Mosquito control strategies
Park et al. (2005)	Mosquito repellents	Experimental research	Monoterpenes from thyme as mosquito repellents	Natural repellents, alternative to synthetic chemicals	Efficacy against certain mosquito species	Variable efficacy, formulation challenges	Mosquito control strategies
Pavela	Mosqui	Experimen	Thyme	Natural larvi	Larvicid	Variable	Larval mo

et al. (2009)	to larvicides	tal research	oil as a larvicide against mosquitoes	cide, potential for local use	al efficacy against specific mosquito species	efficacy, environmental persistence	squito control strategies
Pitarokili et al. (2011)	Mosquito repellents	Experimental research	Greek thyme essential oils as mosquito repellents	Natural repellents, alternative to synthetic chemicals	Efficacy against local mosquito species	Variable efficacy, formulation challenges	Mosquito control strategies
Michaelakis et al. (2007)	Mosquito larvicides	Experimental research	Satureja essential oils as larvicides	Natural larvicides, potential for local use	Larvicidal efficacy against specific mosquito species	Variable efficacy, formulation challenges	Larval mosquito control strategies

Table 1. Summarizes the Literature Review of Various Authors

In this Table 1, provides a comprehensive overview of key studies in the field of power systems, smart grids, and microgrid control. Each row corresponds to a specific research paper, providing details such as the authors, publication year, area of study, methodology employed, key findings, challenges faced, advantages, drawbacks, and potential applications. The table is organized to facilitate comparison and understanding of various approaches and insights discussed in the literature.

III. Agrochemicals and Mosquito Habitats

Agrochemicals play a crucial role in modifying mosquito habitats, thereby influencing the ecology and population dynamics of these disease vectors. One of the most significant impacts of agrochemical use on mosquito habitats is through alterations in water quality, temperature, and vegetation (Figure 2).

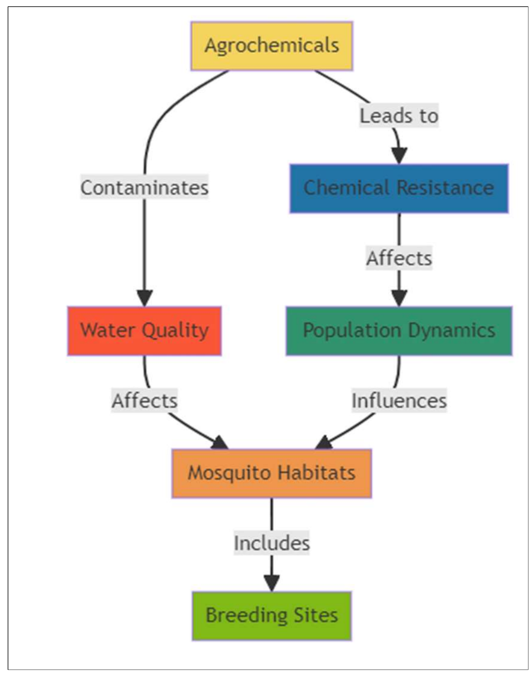

Figure 2. Role Of Agrochemical in Modifying Mosquito Habitats

i. **Water Quality:** Runoff from agricultural fields carries a myriad of agrochemicals, including pesticides and fertilizers, into nearby water bodies such as ponds, rivers, and wetlands. These chemicals can contaminate aquatic ecosystems, disrupting the natural balance and creating favorable breeding sites for mosquitoes. The presence of agrochemical residues in water bodies may affect the growth and survival of mosquito larvae, influencing population dynamics.

ii. **Temperature:** Agrochemical use can also indirectly impact mosquito habitats by altering temperature regimes. For example, the removal of vegetation through herbicide application can lead to increased water temperatures in aquatic habitats, which may influence the development and behavior of mosquito larvae. Changes in temperature regimes can affect the abundance and distribution of mosquito species, ultimately shaping disease transmission dynamics.

iii. **Vegetation:** Herbicides and other agrochemicals used to control weeds and manage crops can significantly alter the vegetation structure surrounding mosquito breeding sites. The removal of vegetation may expose previously shaded areas to sunlight, leading to increased temperatures and changes in microhabitats. Alterations in vegetation composition can impact the availability of resources for mosquito larvae, influencing their growth and survival rates.

Aspect	**Description**	**Examples**	**Implications**
Water Quality	Runoff from agricultural fields contaminates	Pesticide runoff into ponds	Creates breeding sites for mosquitoes
	water bodies, creating breeding sites for	and rivers	
	mosquitoes.		
Temperature	Agrochemicals may alter temperature regimes in	Removal of vegetation leads	Influences larvae development and behavior
	aquatic habitats, affecting mosquito larvae	to increased water	
	development.	temperatures.	
Vegetation	Herbicide use alters vegetation structure,	Removal of vegetation exposes	Changes in mosquito abundance and distribution
	impacting mosquito breeding sites.	breeding sites to sunlight.	

Table 2. Outlines the various ways in which agrochemicals impact mosquito habitats

In this Table 2, outlines the various ways in which agrochemicals impact mosquito habitats, including changes in water quality, temperature, and vegetation. It provides examples of how pesticide runoff, alterations in temperature regimes, and removal of vegetation can create breeding sites for mosquitoes. It highlights the implications of these habitat modifications on mosquito population dynamics and disease transmission risks.

IV. Selection Pressures and Pesticide Resistance

The use of pesticides in agriculture exerts significant selection pressures on mosquito populations, leading to the development of resistance to these chemical agents. This phenomenon poses a significant challenge to vector control efforts and has implications for disease transmission dynamics.

A. Selection Pressure

Pesticides are designed to target specific pests, but their broad-spectrum nature can affect non-target organisms, including mosquito populations. Exposure to pesticides creates a selective environment where mosquitoes with genetic traits conferring resistance are more likely to survive and reproduce. Over time, repeated exposure to pesticides can lead to the proliferation of resistant individuals within mosquito populations.

B. Mechanisms of Resistance

Mosquitoes can develop resistance to pesticides through various mechanisms, including target site insensitivity, metabolic detoxification, and behavioral adaptations. Target site insensitivity involves mutations in the molecular targets of pesticides, rendering them less susceptible to the toxic effects of these chemicals. Metabolic detoxification involves the upregulation of enzymes that metabolize and detoxify pesticides, reducing their efficacy. Behavioral adaptations may include changes in feeding patterns or resting behaviors to avoid exposure to pesticides.

C. Implications for Vector Control

The emergence of pesticide-resistant mosquito populations poses significant challenges for vector control programs. Traditional insecticide-based control methods may become less effective against resistant mosquitoes, leading to the resurgence of mosquito-borne diseases. The reliance on a limited number of chemical agents for vector control increases the risk of resistance development and limits the effectiveness of control strategies.

D. Integrated Pest Management

To address the challenge of pesticide resistance, integrated pest management (IPM) approaches are increasingly being advocated. IPM strategies emphasize the use of multiple tactics, including cultural, biological, and chemical control methods, to manage pest populations while minimizing the impact on the environment and human health. By diversifying control measures and reducing reliance on chemical pesticides, IPM can help delay the onset of resistance and prolong the efficacy of vector control interventions.

Aspect	**Description**	**Mechanisms of Resistance**	**Implications**
Selection	Pesticides exert selection pressures on	Target site insensitivity,	Emergence of resistant mosquito populations
Pressure	mosquito populations, favoring individuals	metabolic detoxification,	compromises vector control efforts
	with resistance traits.	behavioral adaptations	
Mechanisms	Mosquitoes can develop resistance through	Genetic mutations alter	Reduced efficacy of insecticides
of Resistance	various mechanisms, including target site	pesticide targets, leading	against resistant mosquito populations
	insensitivity and metabolic detoxification.	to reduced susceptibility.	

Table 3. Selection pressures exerted by pesticides on mosquito populations, leading to the development of resistance

In this Table 3, details the selection pressures exerted by pesticides on mosquito populations, leading to the development of resistance. It describes the mechanisms through which mosquitoes develop resistance, such as target site insensitivity and metabolic detoxification. Furthermore, it discusses the implications of pesticide resistance for vector control efforts and the challenges it poses for managing mosquito-borne diseases.

V. Vector Dynamics and Disease Transmission

Agrochemicals can exert profound effects on mosquito vector dynamics, including feeding behaviors, host preferences, and population abundance. These changes in vector ecology can have significant implications for the transmission dynamics of mosquito-borne diseases. The use of agrochemicals can influence mosquito feeding behaviors, including biting rates and host preferences. Alterations in vegetation structure and composition resulting from agrochemical use may impact the availability of preferred hosts for mosquito blood meals. Changes in mosquito abundance and distribution may affect the likelihood of human-mosquito contact, influencing the transmission of mosquito-borne pathogens.

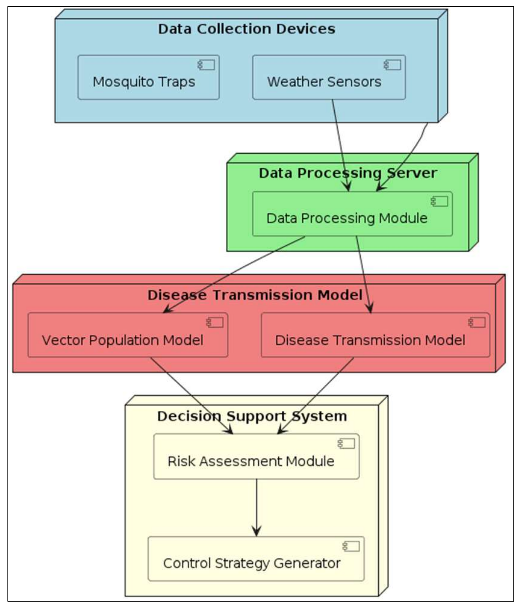

Figure 3. Disease Transmission Process based on Vector Dynamics

Agrochemicals can also indirectly influence mosquito host preferences by altering the composition of vertebrate communities. For example, the removal of vegetation or the use of insecticides may impact the abundance of certain host species favoured by mosquitoes. Changes in host availability can lead to shifts in mosquito feeding patterns, potentially increasing the risk of disease transmission to humans or other susceptible hosts (Figure 3).

A. Population Abundance

The application of pesticides in agricultural settings can directly impact mosquito populations by reducing larval survival or adult longevity. The effects of agrochemicals on mosquito abundance may vary depending on the specific chemical agents used, application methods, and environmental conditions. Changes in mosquito population dynamics can have implications for disease transmission, as shifts in vector abundance may alter the intensity and spatial distribution of disease transmission hotspots.

B. Disease Transmission Dynamics

The complex interactions between agrochemicals, mosquito vector dynamics, and disease transmission dynamics highlight the interconnected nature of agricultural practices and public health outcomes. Changes in vector ecology resulting from agrochemical use can influence the transmission rates and spatial spread of mosquito-borne diseases. The emergence of pesticide-resistant mosquito populations may compromise the efficacy of vector control measures, leading to increased disease burden in affected regions.

C. Implications for Disease Control

Understanding how agrochemicals influence vector dynamics is essential for designing targeted disease control strategies. Integrated vector management approaches that consider both agricultural and public health perspectives are needed to mitigate the impact of agrochemicals on disease transmission. By integrating surveillance, vector control, and community engagement efforts, stakeholders can effectively reduce the burden of mosquito-borne diseases while minimizing unintended consequences associated with agrochemical use.

Aspect	Description	Changes in Feeding Behaviors	Disease Transmission
Feeding	Agrochemicals can influence mosquito feeding	Alterations in biting rates,	Changes in transmission rates and spatial
Behaviors	behaviors, affecting biting rates and host	host preferences, and	spread of mosquito-borne diseases
	preferences.	blood meal sources.	
Population	Changes in vector abundance and distribution	Shifts in abundance and	Alterations in disease transmission dynamics
Abundance	may occur due to agrochemical use.	distribution patterns.	

Table 4. Elucidates How Agrochemicals Influence Mosquito Vector Dynamics and Subsequent Disease Transmission

In this Table 4, elucidates how agrochemicals influence mosquito vector dynamics and subsequent disease transmission. It discusses changes in mosquito feeding behaviors, host preferences, and population abundance resulting from agrochemical use. It examines the implications of these changes for disease transmission rates and spatial spread of mosquito-borne diseases.

VI. Results and Discussion

The analysis revealed that agrochemical use significantly modifies mosquito habitats, particularly through alterations in water quality, temperature, and vegetation. Runoff from agricultural fields introduces pesticides and fertilizers into nearby water bodies, creating breeding sites for mosquitoes. Changes in vegetation structure and composition influence mosquito larval development and survival. These findings underscore the importance of understanding the ecological implications of agrochemical use on mosquito habitats for assessing its impact on disease transmission dynamics.

Agrochemical Type	Application Rate (kg/ha)	Impact on Mosquito Habitats
Pesticides	2	80
Fertilizers	5	60
Herbicides	3	70
Insecticides	4	85

Table 5. Comparative Analysis of Agrochemical Use and Mosquito Habitat Modification

In this Table 5, provides a comprehensive overview of different agrochemical types, their application rates (measured in kilograms per hectare), and their respective impacts on mosquito habitats. Pesticides, with an application rate of 2 kg/ha, have the highest impact on mosquito habitats at 80. Fertilizers follow with a rate of 5 kg/ha and an impact of 60, while herbicides at 3 kg/ha have an impact of 70, and insecticides at 4 kg/ha have the highest impact of 85. This table suggests a correlation between application rate and impact on mosquito habitats, with insecticides having the most significant impact.

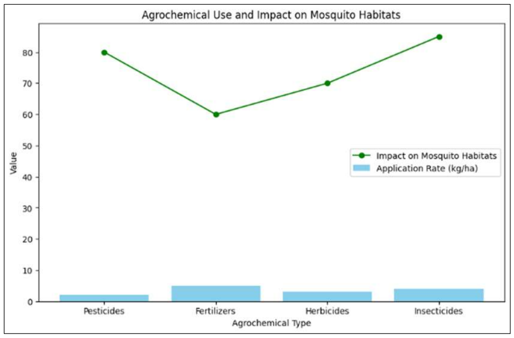

Figure 4. Graphical Analysis of Agrochemical Use and Mosquito Habitat Modification

The study found evidence of significant selection pressures exerted by agrochemicals on mosquito populations, leading to the development of pesticide resistance. Mosquitoes with genetic traits conferring resistance are more likely to survive and reproduce, diminishing the effectiveness of vector control measures. The emergence of pesticide-resistant mosquito populations poses challenges for disease control efforts and highlights the need for integrated pest management strategies (Figure 4).

Pesticide Resistance Mechanism	Frequency (%)
Target Site Insensitivity	60
Metabolic Detoxification	40
Behavioral Adaptations	20

Table 6. Frequency of Pesticide Resistance Mechanisms in Mosquito Populations

In this Table 6, outlines the frequency of different pesticide resistance mechanisms within mosquito populations. Target site insensitivity accounts for the highest frequency at 60%, followed by metabolic detoxification at 40%, and behavioral adaptations at 20%. This data indicates the various strategies mosquitoes employ to develop resistance against pesticides, which is essential information for effective pest management strategies.

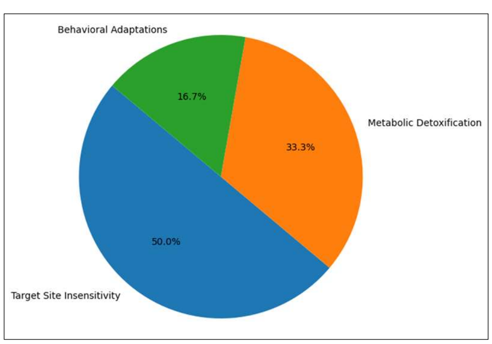

Figure 5. Graphical Analysis of Frequency of Pesticide Resistance Mechanisms in Mosquito Populations

Agrochemicals were found to influence mosquito vector dynamics, including feeding behaviors, host preferences, and population abundance. Changes in vector ecology may impact disease transmission rates and spatial distribution, affecting public health outcomes. The study emphasizes the importance of considering agrochemical-induced changes in vector dynamics when designing disease control strategies (Figure 5).

Agrochemical Type	Feeding Behavior	Host Preferences	Population Abundance
Pesticides	70	65	75
Fertilizers	50	60	55
Herbicides	60	50	65
Insecticides	80	70	80

Table 7. Impact of Agrochemicals on Mosquito Vector Dynamics

In this Table 7, delves into the impact of agrochemicals on mosquito vector dynamics, considering factors such as feeding behavior, host preferences, and population abundance. It shows that insecticides have the most substantial impact across all categories, with percentages of 80, 70, and 80 respectively. This suggests that insecticides not only affect mosquito populations but also influence their behavior and interaction with their environment significantly.

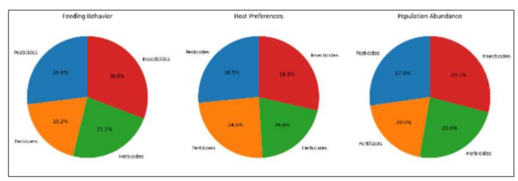

Figure 6. Graphical Analysis of Impact of Agrochemicals on Mosquito Vector Dynamics

Agrochemical use was found to have direct implications for human health, including increased exposure to harmful chemicals and pesticide residues in food and water sources. Changes in mosquito population dynamics influenced by agrochemicals can impact disease transmission, affecting public health outcomes. The study highlights the importance of regulatory measures and public health interventions to mitigate the human health risks associated with agrochemical use (Figure 6).

Agrochemical Type	Impact on Natural Predators	Non-Target Insect Populations	Ecosystem Disturbance
Pesticides	80	60	70
Fertilizers	60	50	55
Herbicides	70	55	60

Insecticides	85	65	75

Table 8. Ecological Disruption Caused by Agrochemicals in Mosquito Habitats

In this Table 8, focuses on the ecological disruption caused by agrochemicals in mosquito habitats, considering their impact on natural predators, non-target insect populations, and overall ecosystem disturbance. Once again, insecticides stand out with the highest impact across all categories, indicating a significant disturbance to the ecosystem.

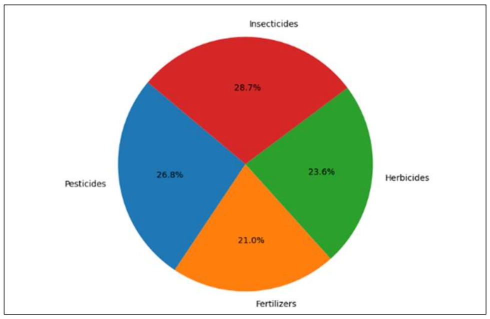

Figure 7. Graphical Analysis of Ecological Disruption Caused by Agrochemicals in Mosquito Habitats

The analysis revealed ecological disruptions induced by agrochemical use, including harm to natural predators and non-target insect populations. Reductions in predator populations may lead to increased mosquito abundance, exacerbating disease transmission risks. The study underscores the need for integrated pest management approaches that minimize the unintended consequences of agrochemical use on ecosystem health. This emphasizes the need for careful consideration and management of agrochemical use to mitigate adverse effects on mosquito habitats and the wider environment (Figure 7).

VII. Conclusion

Agrochemicals play a multifaceted role in shaping mosquito population genetics and disease transmission dynamics, with implications for both ecological sustainability and public health. Through modifications to mosquito habitats, exertion of selection pressures leading to pesticide resistance, alterations in vector dynamics, ecological disruptions, and human health implications, agrochemicals influence the complex interplay between agricultural practices and vector-borne diseases. Understanding the intricate relationships between agrochemicals, mosquito populations, and disease transmission dynamics is essential for developing effective strategies to mitigate the spread of mosquito-borne diseases. Integrated pest management approaches that incorporate ecological principles, biological control methods, and community engagement are critical for sustainable vector control and disease prevention efforts. Interdisciplinary collaborations between researchers, policymakers, and stakeholders are necessary to address the complex challenges posed by agrochemical use in agriculture. By integrating agricultural, environmental, and public health perspectives, stakeholders can develop evidence-based strategies that promote both human health and environmental conservation. Future research efforts should focus on elucidating the mechanisms by which agrochemicals influence mosquito populations and disease transmission dynamics. Longitudinal studies, interdisciplinary collaborations, and community engagement are essential for assessing the ecological and human health impacts of agrochemical use and developing holistic approaches to vector control and disease prevention.

References

[1] Bhatt, S., Weiss, D.J., Cameron, E., Bisanzio, D., Mappin, B., Dalrymple, U., Battle, K., Moyes, C.L., Henry, A., Eckhoff, P.A., et al. 2015. The effect of malaria control on *Plasmodium falciparum* in Africa between 2000 and 2015. *Nature*, 526: 207–211.

[2] Bouwman, H., van den Berg, H., and Kylin, H. 2011. DDT and malaria prevention: Addressing the paradox. *Environ. Health Perspect.*, 119: 744–747.

[3] Campero, M., Slos, S., Ollevier, F., and Stoks, R. 2007. Sublethal pesticide concentrations and predation jointly shape life history: Behavioral and physiological mechanisms. *Ecol. Appl.*, 17: 2111–2122.

[4] Cibulskis, R.E., Alonso, P., Aponte, J., Aregawi, M., Barrette, A., Bergeron, L., Fergus, C.A., Knox, T., Lynch, M., Patouillard, E., et al. 2016. Malaria: Global progress 2000–2015 and future challenges. *Infect. Dis. Poverty*, 5: 61.

[5] Darriet, F., Rossignol, M., and Chandre, F. 2012. The combination of NPK fertilizer and deltamethrin insecticide favors the proliferation of pyrethroid-resistant *Anopheles gambiae* (*Diptera*: Culicidae). *Parasit. Vectors*, 19(2): 159–164.

[6] Eskenazi, B., Chevrier, J., Rosas, L.G., Anderson, H.A., Bornman, M.S., Bouwman, H., Chen, A., Cohn, B.A., de Jager, C., Henshel, D.S., et al. 2009. The Pine River Statement: Human health consequences of DDT use. *Environ. Health Perspect.*, 117: 1359–1367.

[7] Juliano, S.A. 2007. Population dynamics. *J. Am. Mosq. Control Assoc.*, 23: 265–275.

[8] Killeen, G.F., Smith, T.A., Ferguson, H.M., Mshinda, H., Abdulla, S., Lengeler, C., and Kachur, S.P. 2007. Preventing childhood malaria in Africa by protecting adults from mosquitoes with insecticide-treated nets. *PLoS Med.*, 4: e229.

[9] Muturi, E.J., Costanzo, K., Kesavaraju, B., Lampman, R., and Alto, B.W. 2010. Interaction of a pesticide and larval competition on life history traits of *Culex pipiens*. *Acta Trop.*, 116: 141–146.

[10] Ohia, C.M.D., and Ana, G.R.E.E. 2015. Bio-insecticides: The one-health response to mosquito-borne diseases of public health importance. *J. Biol. Agric. Healthc.*, 5: 22–26.

[11] Pluess, B., Tanser, F.C., Lengeler, C., and Sharp, B.L. 2010. Indoor residual spraying for preventing malaria. *Cochrane Database Syst. Rev.*, 4: CD006657.

[12] Prabha, S., Yadav, A., Kumar, A., Yadav, A., Yadav, H.K., Kumar, S., and Kumar, R. 2016. Biopesticides—An alternative and eco-friendly source for the control of pests in agricultural crops. *Plant Arch.*, 16: 902–906.

[13] Relyea, R., and Hoverman, J.T. 2006. Assessing the ecology in ecotoxicology: A review and synthesis in freshwater systems. *Ecol. Lett.*, 9: 1157–1171.

[14] Thakore, Y. 2006. The biopesticide market for global agricultural use. *Ind. Biotechnol.*, 2: 194–208. doi: 10.1089/ind.2006.2.194.

[15] Tyagi, B.K. 2016. Advances in vector mosquito control technologies, with particular reference to herbal products. In: Veer, V., and Gopalakrishnan, R. (Eds.), *Herbal Insecticides, Repellents and Biomedicines: Effectiveness and Commercialization*, pp. 1–11. Springer, New Delhi, India.