



Waste-tyres as Breeding Ground for Mosquitoes: An Environmental and Public Health Challenge in Nigeria

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ABSTRACT

Nigeria is a very populated country with a heavy dependence on road transportation. This dependence means that a lot of tyres are required to service the millions of vehicles used in the country and hence, there will be a lot of waste tyres generated. Waste tyres are known to pose various threats to the environment and public health when they are disposed indiscriminately. In Nigeria, poor waste tyre disposal is a major challenge as they can be found littered around the environment and used for various unconventional purposes. These waste tyres can hold water thereby becoming suitable breeding sites for different mosquito species that vector diseases such as malaria, zika virus, yellow and Dengue fever. This research focused at exposing the risks posed by waste tyres in the environment in relation to mosquito-borne diseases. Parameters that make waste tyres suitable oviposition sites for mosquitoes were discussed. *Aedes aegypti* and *Aedes albopictus* were identified as the most common tyre-breeding species due to their ability to adapt to the physico-chemical parameters of waste tyres. The business of tyre importation, management, disposal and recycling is very lucrative but has been underexplored in Nigeria resulting in unconventional techniques of use of waste tyres such as in shoe and furniture production, barricades in security checkpoints, ornamental purposes and playground construction. These practices, if not done properly can create various negative environmental challenges and cause public health problems. The paper also proffers control measures to mitigate these challenges such as urban planning strategies, Land use policies, technological advancements such as GPS enabled surveillance and the use of larvicides for the control of mosquitoes.

Keywords: Waste tyre; mosquitoes; recycling; environment; public health; Nigeria

Article information

Received 28 July 2024;

Accepted 17 August 2024;

Published 20 August 2024

DOI: <https://doi.org/10.26765/DRJPHET400197586>

Citation: Dawam, N. N., Ombugadu, A., Dawam, N. M., Nicholas, F. (2024). Waste-tyres as Breeding Ground for Mosquitoes: An Environmental and Public Health Challenge in Nigeria. Direct Research Journal of Public Health and Environmental Technology. Vol. 9(2), Pp. 183-191. <https://doi.org/10.26765/DRJPHET400197586>. This article is published under the terms of the Creative Commons Attribution License 4.0.

INTRODUCTION

Mosquitoes are a significant public health concern worldwide, primarily due to their role as vectors for numerous diseases, including malaria, dengue fever, Zika virus, and West Nile virus (Rozendaal, 1997). Mosquitoes are among the most intensively studied insects because of their role in noise nuisance, Sleeplessness, biting annoyance, allergic reactions and disease transmission (Hall & Tamir, 2021). The proliferation of mosquito populations is influenced by various environmental factors, including breeding sites. One such site that has been identified as a prolific breeding ground is discarded tires (Vezzani, 2007). Tires provide an ideal environment for mosquito larvae due to their ability to retain water and provide protection from predators and environmental fluctuations (Marten, 1990).

There is an upscale in motorization globally which has led to an increase in the demand for tyres. These tyres having lived their usefulness become waste that should be disposed appropriately. The chemical composition of tyres makes them slow to degrade thereby having an environmental impact. Due to this, ways of elongating its useful time should be investigated and people should be encouraged to repurpose the tyres (Valentini & Pegoretti, 2022). Currently in Nigeria, collection of waste tyres is carried out by individuals who use the services of scavengers to sort out what is needed. Since there are no organized form of collection and disposal of waste tyres, many are left littered around the environments which then possess serious environmental and health challenges.

The importation of low-grade or used tyres which usually have short lifespan leads to the generation of more waste tyres (Harrison-Obi, 2019). Collection centers and incentives for retrieval could encourage proper recycling of waste tyres (Okafor et al., 2020) however, very little is done in Nigeria which has led to the unconventional repurposing of these waste tyres. Proper repurposing should employ certain techniques such as perforation and filling of the tyres used outdoors to avoid water retention which could lead to public health challenges. This review throws light on the devastating effect of inappropriate disposal and use of waste tyres to the environment and public health. The paper highlights common unconventional use of waste tyres in Nigeria, it discussed the mosquito species found in discarded tyres and diseases transmitted by the vectors. The paper also suggests ways of mitigating the impact of these challenges.

Mosquito breeding sites

Mosquitoes are distributed all over the continents of the

globe except Antarctica (Hall & Tamir, 2021). They can successfully breed in different habitats ranging from streams, puddles, tree trunks, rice fields, wells, and different containers that can collect water (Lapang et al., 2019; Njila et al., 2023). They breed in both fresh and salt water (Oguche et al., 2023). Environmental factors such as temperature, rainfall, relative humidity and other physico-chemical properties of the water habitat including PH, Ammonia concentration, nitrate, and dissolved oxygen are the important components of the ecosystem that regulate the population density of mosquitoes at each breeding site (Walton, 2012). Parameters that affect the survival and abundance of larvae in the breeding sites include the chemical composition and variation in the aquatic environment, the presence or absence of organic detritus, presence or absence of light and so on. These play important role in the abundance, distribution, succession and female oviposition behaviour (Yee et al., 2020). There are generally two types of mosquito breeding sites; Natural and Man-made water bodies, with different groups having preferences that are usually determined by location and condition of such water bodies (Okoh et al., 2020). Both the natural and man-made water bodies support oviposition and emergence of mosquitoes (Oguche et al., 2023). The natural water bodies include streams and ponds while the artificial or man-made water bodies include artificial containers such as buckets and vehicle tyres (Lapang et al., 2019; Njila et al., 2023).

Tyres as breeding sites for mosquitoes

Tyres are non-biodegradable polymers that support the breeding of several mosquito species and proliferation (Abubakar et al., 2022). Mosquitoes are attracted to the colours of vehicle tyres which are usually black and when water collects in tyres, it usually remains cool thereby becoming suitable oviposition site by protecting the eggs from desiccation. Fast evaporation of water from tyres is also prevented by the sides of the tyre allowing time for the emergence of adults. The organic matters collected in the tyres are a source of food for the larvae (Low et al., 2022). The indiscriminate disposal and inappropriate use of tyres creates breeding sites for different species of mosquitoes which become a menace to the communities. Studies have shown that tyres provide a favourable microenvironment for mosquito larvae, offering protection from predators and fluctuating environmental conditions. The accumulation of organic matter in stagnant water inside tyres further supports the growth of mosquito larvae (Becker et al., 2020). Species of the genus *Aedes*, particularly *Aedes aegypti* and *Aedes albopictus*, are notable for their adaptation to urban habitats and their

ability to exploit stagnant water in human-made containers as breeding site. These mosquitoes have adapted well to urban environments due to their preference for small water-filled containers, including discarded tyres, which provide suitable conditions for larval development (Lounibos et al., 2003). The ecological significance of tyre-breeding habitats lies in their capacity to support mosquito populations close to human dwellings, increasing the risk of mosquito-borne disease transmission (Leishnam & Slaney, 2009).

Understanding the ecological dynamics of tyre-breeding mosquitoes is crucial for developing effective vector control strategies and mitigating public health risks associated with mosquito-borne diseases. This includes environmental management approaches to reduce breeding sites, targeted larval control measures, and community engagement to promote source reduction and awareness (Leishnam & Slaney, 2009).

Tyre importation and management in Nigeria

Nigeria as a nation has witnessed unprecedented importation of vehicles and tyres over the last few years (Adebote et al., 2011; Mohammed Rabi et al., 2019). Nigeria generates around 10 million tyres each year without environmentally friendly management traceability data (Nnodim, 2023). These tyres have a shorter replacement period and are disposed without appropriate measures and because these tyres are non-biodegradable, they accumulate rainwater which becomes perfect habitat for certain opportunistic organisms such as mosquitoes (Adebote et al., 2011). Despite the amount of waste tyres generated all over the nation (Nigeria), there is limited data on tyre management. In Nigeria, the National Environmental Standard and Regulations Enforcement Agency (NESREA) and Used Tyres Producers Responsibility Organization of Nigeria (UTPRON) are the agencies associated with disposal of used tyres in Nigeria (Harrison-Obi, 2019).

Common mosquito species found in waste-tyres

Mosquitoes that breed in tyres and other artificial containers play a significant role in urban and suburban environments worldwide. They have been identified as potential vectors for various diseases, making surveillance crucial where such tyres are commonly found (Jones et al., 2021). Among these, species of the genus *Aedes*, particularly *Aedes aegypti* and *Aedes albopictus* notable for their adaptation to urban habitats and their ability to exploit stagnant water in human-made containers as breeding sites. *Aedes aegypti*, known as the yellow fever mosquito, is a primary vector of dengue

fever, Zika virus, and yellow fever, thriving in urban environments where artificial containers, including discarded tires, provide ample breeding opportunities (Lounibos et al., 2003). *Aedes albopictus*, commonly known as the Asian tiger mosquito, has also adapted to tyre-breeding habitats and is a vector for various arboviruses, including chikungunya and dengue (Reiter, 2014). This species has demonstrated a remarkable ability to invade new territories through the transportation of used tires, contributing to its global distribution (Reiter, 2014). The invasion of *Anopheles stephensi* into Africa has increased the risk of malaria transmission as these vectors are resistant to many insecticides and shown to breed in different sites including abandoned vehicle tyres. The indiscriminate use of tyres contribute to the spread of *Anopheles stephensi* and other vectors that transmit diseases and leading to major setback in the fight against malaria. *Anopheles stephensi* a major vector of malaria in Asia has proliferated Africa as they have been found in Djibouti (Faulde et al., 2014). *Anopheles stephensi* have also been discovered in the horn of Africa in Ethiopia (2021) Somalia (2023) Sudan (2021) and recently in western Africa in Nigeria (2022) in Ghana (2023). In the different studies, larvae were collected from different habitats such as barrels, household water storage containers, and cement/metal/plastic tanks and tyres (Perco et al., 2023).

An entomological survey carried out in Hawassa city, Southern Ethiopia, showed that out of the 169 potential mosquito breeding sites, 4(2.4%) were discarded tyres and 2(50%) were found to be positive for mosquito larvae (Hawaria et al., 2023). A similar study was conducted in Kenya to detect the presence of *Anopheles stephensi*. The vectors were found to be present in old tires (Ochomo et al., 2023). Studies in Ghana have reported the presence of *Anopheles stephensi* in car tyres, such as during the raining season (Yaw et al., 2023) and tyres contributing about 1.9% of the total breeding sites for *Anopheles* mosquito species (Mattah et al., 2017). While in a study in Benin, tyres were found to constitute 14.6% of 163 breeding sites for *Anopheles* mosquitoes (Hessou-Djossou et al., 2022).

A study carried out in the Dominican Republic to assess the impact of discarded tyres as larval habitats for mosquitoes showed that out of the 396 tyres sampled, 14.4% contained larvae. The four genera found were *Anopheles*, *Aedes*, *Culex* and *Toxorhynchites* (González et al., 2020). In Connecticut, 9 tyre disposal sites were surveyed for the presence of mosquito larvae. Eight different mosquito species belonging to 4 genera were found. The most abundant were *Ae. atropalpus*, *Ae. triseriatus* and *Culex restuans* and *Culex pipiens*, *Culex territans* and *Culex salinarius*. *Aedes albopictus* was not identified which meant the species was not present in Connecticut at the time (Andreadis, 1988). Similarly, a survey of abandoned tyres in Spain to detect mosquito

species introduced to the country did not reveal any invasive species, eight species of mosquitoes were identified the most dominant been *Culex pipiens* and *Culiseta longiareolata*. The others were *Cx. hortensis*, *Cx. modestus*, *Anopheles atroparrus*, *An. clariger*, *Cs. annulate* and *Aedes caspius* (Roiz et al., 2007). Tyres have been reported as the most common mosquito breeding sites in Ethiopia (Ferede et al., 2018). A house-to-house survey carried out in Metema and Humera Ethiopia on the distribution and identification of *Aedes* breeding habitats found 57percent of the larvae in discarded tyres. In the study, 384 houses were surveyed and 98 were found to be positive for mosquito larvae and species identified were *Aedes aegypti* (49.3%) *Aedes vittatus* (6.5%) and *Culex* species were 44.2% (Ferede et al., 2018).

In Nigeria, water samples were collected from 250 abandoned tyres from nine localities in Minna Niger state Nigeria and mosquito larvae were found in 95 tyres. A total of 804 mosquito larvae were identified and 722 (89.8%) out were *Aedes aegypti* Linnaeus. The study reported that *Aedes aegypti* was the most predominant species and its presence in all locations studied suggests its preference for tyres as breeding site (Mohammed Rabi et al., 2019). A study on waste automobile tyres in Zaria, Kaduna state found larvae in 90 out of the 212 tyres surveyed. A total of 1179 larvae were collected, ten species of mosquitoes were found belonging to 2 genera, *Aedes* and *Culex*. *Aedes aegypti* (46.56%) and *Culex quinquefasciatus* (47.07%) were the most abundant species (Adebote et al., 2011). The characteristics of different mosquito breeding sites in selected locations within Kaduna metropolis were studied. A total of three hundred and five breeding sites were sampled out of which 180 (59.02%) were found positive for mosquito larvae, 50.82% of the water samples collected were from abandoned tyres and *Aedes aegypti* was the most predominant species 345(64.84%) followed by *Culex quinquefasciatus* 102(19.17). Other species found in the study include *Culex decens* 8(1.50%), *Aedes vittatus* 49 (9.32%), *Culex simpsoni* 8(1.50%), *Culex tigripes* 17 (3.30%) and *Anopheles gambiae* 3(0.50%) (Oguche et al., 2023).

In Aboekuta Nigeria, discarded tyres and domestic containers provided the highest amount of breeding sites. The tyres were found mostly in mechanic workshops and loitering around houses. The most prevalent species are *Aedes aegypti* 200 (90%) and *Culex decens* 200 (90%) (Mafiana et al., 1997). This signals the need for sensitization and proper waste tyre management. A total of 372 mosquito larvae were collected from the sampling sites, of which 209 (56.18%) from used tyres. Majority of mosquito larvae collected were *A. albopictus* 204 (54.8%) collected largely from old tyres 188 (89.95%) (Onyido et al., 2011). In Ifedore local government Ondo state Nigeria, 2051 larvae were collected from 33 different

breeding sites which include discarded tyres. The dominant mosquito species identified were *Culex* species followed by *Aedes* spp. then *Anopheles* spp. Other species were *Mansonia*, *Toxorhynchite* spp. and *Coquillettidia* spp. (Oniya et al., 2019).

Some diseases transmitted by tyre breeding mosquitoes

Tyre-breeding mosquitoes are particularly concerning because they are vectors for several pathogens, including viruses that cause diseases such as dengue fever, Zika virus infection, and chikungunya (Reiter, 2014). These diseases pose significant public health threats, especially in urban areas where high population densities and inadequate waste management contribute to the proliferation of mosquito breeding sites. The burden of arboviruses in Africa has not been understood due to limited laboratory facilities (WHO, 2024). Diseases transmitted by the *Aedes* mosquito includes yellow fever which is transmitted to humans through the bites of infected mosquitoes (primarily in the genus *Aedes*) (Adogo & Ogoh, 2019). Another disease transmitted by the *Aedes* mosquito is dengue fever, transmitted to humans by the bite of an infected female *Aedes* mosquito (Banerjee, 2017). Currently, dengue is endemic in 90 countries and outbreaks of dengue have been reported in 15 African countries (WHO, 2024) mostly developing nations, posing a risk to approximately 3.97billion people annually. The chikungunya virus is also transmitted to humans by the bite of infected mosquitoes of the genus *Aedes*. The disease has been identified in more than 110 countries in Africa, Asia, Europe and the Americas. infecting about 300,000 people with over 300 deaths with Americas and Europeans having the highest (WHO, 2024). The report for this virus is very poor as it has similar symptoms with malaria infection therefore misdiagnosis (Powers et al., 2000). The Zika virus is also transmitted by infected *Aedes aegypti* or *Aedes albopictus* mosquitoes (Malone et al., 2016). The ability of the virus to cause congenital defects in fetuses and infants as exemplified by the microcephaly epidemic in Brazil is an unprecedented feature in a mosquito – borne viral infection (Honein et al., 2017). Malaria is one of the most common vector-borne diseases prevalent in tropical and subtropical area of the world including Africa, Asia and America (WHO, 2023). This disease is caused by plasmodium species and is transmitted by the bite of infected female *Anopheles* mosquitoes (Zareen et al., 2016). In 2022, there was 249 million cases of malaria with 608000 deaths globally. Africa had 94% (233million) and 580000 deaths recorded. Nigeria accounts for 27% of cases with 31% deaths globally (WHO, 2023). There are several other diseases that are vectored by mosquitoes transmitted by the mosquitoes.

Since tyres are known to retain water for long periods after the rainy season, they tend to contribute greatly to dry season transmission of mosquito borne diseases.

Tyre recycling business in Nigeria

Recycling involves the transformation of waste from one product into other useful products. Recycling is usually not the goal but rather a means of efficiently managing natural resources hence, it should be understood within the context of resource efficiency (Worrell & Reuter 2014). Tyre recycling is the process of recycling automobile tyres that are no longer suitable for use due to wear or irreparable damage to produce a wide range of products creating revenue for the recycling companies and saving the environment from hazards brought about by other indiscriminate methods of disposal such as burning. Besides the revenue it generates, the recycling of End-of-Life Tyres (ELT's) is very necessary due to their large number, durability and non-biodegradable nature.

Nigeria is a very populous country and is largely dependent on Road transportation. This invariably means that there are many automobiles and hence, ELT'S. It is estimated that there are about 11.8 million vehicles in Nigeria (Agarwal et al., 2023). The waste tyres from these and other automobiles pose a serious environmental threat, but it could also be a source of raw materials and wealth if efficient recycling techniques are employed (Oriaku et al., 2013). However, in Nigeria, tyre recycling is skeletal at best. In most towns and cities, tyres are still disposed inappropriately making piles of them commonly found littered around causing environmental problems such as clogging of drainages and creating enabling environment for breeding of mosquitoes and other vectors of diseases.

The deficiency in the tyre and rubber recycling industry in Nigeria can be traced to a lot of factors some of which include source of start-up capital to establish industries, government policies and unfriendly business environment, access to land and adequate raw materials, inadequate information and technical Know-how e.t.c. The market is however expected to witness significant growth in the coming years due to increased demand for Tire-derived products, Tyre pyrolysis and increased ideas for repurposing. Tyres are composed primarily of Rubber and other materials such as Metal/ Steel and Textile. It is estimated that tyres are about 41-48 percent Rubber. End-of-Life-Tyres can therefore be broken down to fine rubber powders using appropriate machines and used for making various kinds of rubber products (Harrison-Obi, 2019).

Other common use of waste tyres in Nigeria

As stated earlier, Waste tyres are being used for various

other purposes besides recycling. These applications could sometimes pose threats to the environment such as being breeding sites for mosquitoes and other vectors. Some of the applications, however, are safe and very innovative and have been a source of revenue to entrepreneurs. A few of these other uses are highlighted below

Used in shoe and furniture production

Waste tyres are also used in manufacturing furniture such as tables and chairs. They are used in combination with other materials such as wood and leather to produce beautiful furniture for use both indoors and outdoors. Waste tyres can also be cut to pieces and used to produce soles of shoes. This is a more environmentally friendly use as the furniture are mostly covered however, if poorly made for outdoor use, could become breeding environments for vectors. In Nigeria, there are several ornamental uses of tyres such as planters in school premises and playgrounds, planters at homes, planters and decorations in gardens and event centers, police/military check points and most importantly; landfills and mechanic workshops as a form of advertisement. These tyres are potential home for mosquitoes as they collect rainwater and encourage large population of the opportunistic mosquitoes (Adebote et al., 2011; Mohammed Rabi et al., 2019).

Tyres in mechanic workshops and vulcanizer stops

In Nigeria especially, it is common to find waste tyres in roadside Mechanic and vulcanizer workshops. These tyres sometimes act as signs to potential customers showing services they render as majority of those workshops are make-shift without proper sign boards. Big tyres such as those of lorries are also used as seats in these workshops and storage for water and other tools. In addition to tyres, mechanic workshops may harbour other potential breeding sites, such as discarded containers, vehicle parts, and lubricants that can collect water. These underscore the importance of considering mechanic workshops as high-risk areas for mosquito breeding and implementing effective control strategies. The presence of Tyre breeding mosquitoes in Mechanic Workshops can have significant environmental and ecological implications. In addition to direct ecological impacts, the presence of Tyre breeding mosquitoes in Mechanic Workshops raises questions about waste management practices and environmental stewardship. Proper disposal and recycling of automotive parts, including tyres, are crucial for mitigating the environmental footprint of these automobile workshops. Moreover, the proximity of mechanic workshops to residential areas can

exacerbate the public health impact. Mosquitoes breeding in tyres can easily migrate to nearby homes, increasing the risk of disease transmission to residents (Ferede et al., 2018). This shows the interconnectedness of environmental factors and public health outcomes related to mosquito breeding in such settings.

Security checkpoints

Waste tyres are a common sight on Nigerian roads as security personnel deployed to checkpoints use them as barricades to stop vehicles to be searched. The use of tyres is due to their resistance to degradation and light weight making them easy to assemble and dismantle. However, this can be hazardous if they are not properly kept as they could retain water and create a breeding site for Mosquitoes.

Used in homes for ornamental purposes

Waste tyres have been used in various forms to beautify homes. They could be used as flower vessels and beds or decorated and placed strategically as ornaments both indoors and outdoors. These tyres also if not properly designed and treated could harbor mosquitoes and other vectors posing a danger to the inhabitants. It is advised that tyres used for ornamental purposes be perforated so that they don't retain water and dampness.

School playgrounds and environment

Tyres are widely used in School environments as ornaments or used in constructing playgrounds for the students. They are used as demarcations for different sections, Flower beds and makeshift swings. This practice needs to be checked as well to avoid the spread of mosquito-borne diseases (Harrison-Obi, 2019).

Used as toys by children

It is common to find children using tyres as toys. They use sticks or their hands in rolling them around for their pleasure. However, the tyres are mostly left littered around their houses and playgrounds making them hazardous to the environment.

Disposed inappropriately around homes and environment

Due to inadequacy of proper waste disposal practices, Waste tyres are usually found littered around homes and the environment. These waste tyres hold water and

moisture serving as breeding sites for vectors such as mosquitoes and even reptiles. It is recommended that waste tyres be properly discarded or recycled to avoid this menace.

Control

Several studies have highlighted the importance of urban planning strategies in mitigating the proliferation of tyre-breeding mosquitoes. For instance (Fornace et al., 2021) emphasized the importance of land use policies in controlling and reducing the potential for mosquito breeding near human habitation. In addition to regulatory measures, technological advancements have facilitated innovative approaches to mosquito control in urban areas. The use of gadgets such as the GPS-enabled mosquito surveillance systems allows authorities to pinpoint high-risk areas and implement targeted control measures (Jones et al., 2021). By integrating regulatory, community-driven, and technological solutions, mosquito populations can be effectively reduced and the risk of vector-borne diseases in urban environments mitigated. Furthermore, the use of larvicides has shown promise in controlling mosquito populations. Larvicides such as *Bacillus thuringiensis israelensis* (Bti) are specific to mosquito larvae and can be applied effectively in tire habitats to reduce mosquito populations. Land et al., (2023) demonstrated the efficacy of *Bacillus thuringiensis israelensis* (Bti) in targeting mosquito larvae in water bodies. Integrating larvicide application into routine workshop maintenance protocols, in schools and homes can contribute to sustained mosquito population reduction. The role of Community engagement and education can never be overemphasized as it plays a vital role in sustaining mosquito control efforts. Raising awareness about the health risks associated with mosquitoes and promoting proper tyre disposal practices can have great impact on long-term mosquito prevention. Owusu-Addo and Owusu-Addo (2014) demonstrated the effectiveness of community education programs in the prevention of diseases. Source reduction involves eliminating or modifying mosquito breeding habitats, such as removing discarded tires or puncturing them to prevent water accumulation. Source reduction is considered one of the most effective strategies for controlling tire-breeding mosquitoes by reducing larval habitat availability (Rochlin et al., 2013; Ochomo et al., 2024). Implementing these vector control strategies in a coordinated manner is essential for effectively managing tire-breeding mosquitoes and reducing the burden of mosquito-borne diseases in affected communities.

Future directions and research needs

Research on tyre-breeding mosquitoes has made

significant strides in understanding their ecology, behaviour, and implications for public health. However, several key areas warrant further investigation to improve vector control strategies and mitigate mosquito-borne disease transmission. Future research should focus on understanding how climate change and urbanization influence tire-breeding habitats and their suitability for mosquito development. Investigating the impact of temperature variations, precipitation patterns, and habitat modifications on mosquito populations can enhance predictive models and intervention strategies (Leishnam, 2009). Advancements in genetic and molecular techniques offer opportunities to study mosquito vector competence, microbial interactions, and the mechanisms underlying resistance to control measures. Investigating the dynamics of microbial communities in tyre habitats and their impact on mosquito biology is crucial. Future studies should explore the role of bacteria, fungi, and other microorganisms in modulating vector competence, disease transmission dynamics, and microbial-based control strategies (Saldaña et al., 2017). Evaluating the effectiveness and sustainability of integrated vector management (IVM) approaches tailored to tire-breeding mosquitoes is essential (Ochomo et al., 2024). Future research should focus on optimizing the integration of larval control, adult mosquito control, community engagement, and ecological monitoring to enhance control efforts and reduce disease transmission. Understanding the socioeconomic determinants and human behaviours influencing tire disposal practices and mosquito breeding site management is critical. Future research should integrate social sciences to develop targeted interventions that promote sustainable behaviour change and community participation in vector control. Lastly, legal consequences should also be in place for indiscriminate disposal of waste-tyres (Harrison-Obi, 2019).

Conclusion

In conclusion, tire-breeding mosquitoes represent a significant public health concern due to their adaptation to artificial container habitats and their role as vectors of diseases. Effective management strategies require a comprehensive understanding of the mosquitoes ecological preferences, interactions with human environments, and the factors that influence their population dynamics and disease transmission potential. Lastly proper management and disposal of waste-tyres is crucial considering the number of waste-tyres generated in Nigeria. This will prevent the loitering of tyres in the environment leading to grievous environment and health consequences. Most importantly information about the devastating impact of improper waste-tyre disposal on the environment and quality of life needs to be

communicated to individuals and communities.

REFERENCES

- Abubakar, I. R., Maniruzzaman, K. M., Dano, U. L., AlShihri, F. S., AlShammari, M. S., Ahmed, S. M. S., Al-Gehlani, W. A. G., & Alrawaf, T. I. (2022). Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South. In *International Journal of Environmental Research and Public Health* (Vol. 19, Issue 19). MDPI. <https://doi.org/10.3390/ijerph191912717>
- Adebote, D. A., Kogi, E., Oniye, S. J., & Akoje, F. (2011). Epidemiological significance of the breeding of mosquitoes in discarded automobile tyres in Zaria, Northern Nigeria. *The Journal of Communicable Diseases*, 43(3), 183–192.
- Adogo, L. Y., & Ogoh, M. O. (2019). Review Article: Yellow fever in Nigeria: A review of the current situation. *African Journal of Clinical and Experimental Microbiology*, 21(1), 1. <https://doi.org/10.4314/ajcem.v21i1.1>
- Agarwal, P., Abudu, D., Calabrese, L., & Chukwurah, O. (2023). *The automotive sector in Nigeria: Opportunities under the AfCFTA*. <https://www.econstor.eu/handle/10419/280304>
- Andreadis, T. G. (1988). A Survey of mosquitoes breeding in used tire stockpiles in Connecticut. *Journal of the American Mosquito Control Association*, 4(3), 256–260.
- Banerjee, I. (2017). *Nepal Journal of Epidemiology Dengue: The break-bone fever outbreak in Kerala, India*. <https://doi.org/10.1007/s00705-017-3429-7>
- Becker, N., Petric, D., Zgomba, M., Boase, C. M., Madon, M. B., & Kaiser, A. (2020). *Mosquitoes: identification, ecology and control* (Third edition). Springer Nature.
- Faulde, M. K., Rueda, L. M., & Khairah, B. A. (2014). First record of the Asian malaria vector *Anopheles stephensi* and its possible role in the resurgence of malaria in Djibouti, Horn of Africa. *Acta Tropica*, 139, 39–43. <https://doi.org/10.1016/j.actatropica.2014.06.016>
- Ferede, G., Tiruneh, M., Abate, E., Kassa, W. J., Wondimeneh, Y., Damtie, D., & Tessema, B. (2018). Distribution and larval breeding habitats of *Aedes* mosquito species in residential areas of northwest Ethiopia. *Epidemiology and Health*, 40. <https://doi.org/10.4178/EPIH.E2018015>
- Fornace, K. M., Diaz, A. V., Lines, J., & Drakeley, C. J. (2021). Achieving global malaria eradication in changing landscapes. In *Malaria Journal* (Vol. 20, Issue 1). BioMed Central Ltd. <https://doi.org/10.1186/s12936-021-03599-0>
- González, M. A., Rodríguez-Sosa, M. A., Vázquez-Bautista, Y. E., Rosario, E. D. C., Durán-Tiburcio, J. C., & Alarcón-Elbal, P. M. (2020). A survey of tire-breeding mosquitoes (Diptera: Culicidae) in the Dominican Republic: Considerations about a pressing issue. *Biomedica*, 40(3), 507–515. <https://doi.org/10.7705/biomedica.5200>
- Hall, M., & Tamir, D. (2021). Killing mosquitoes. In *Mosquitopia* (pp. 3–15). Routledge. <https://doi.org/10.4324/9781003056034-2>
- Harrison-Obi, C. N. (2019). Environmental impact of end of life tyre (ELT) or scrap tyre waste pollution and the need for sustainable waste tyre disposal and transformation mechanism in Nigeria. *Nnamdi Azikiwe University Journal of International Law and Jurisprudence*, 10(2), 60–70.
- Hawaria, D., Kibret, S., Zhong, D., Lee, M. C., Lelisa, K., Bekele, B., Birhanu, M., Mengesha, M., Solomon, H., Yewhalaw, D., & Yan, G. (2023). First report of *Anopheles stephensi* from southern Ethiopia. *Malaria Journal*, 22(1). <https://doi.org/10.1186/s12936-023-04813-x>
- Hessou-Djossou, D., Djègbè, I., Ahadji-Dabla, K. M., Nonfodji, O. M., Tchigossou, G., Djouaka, R., Cornélie, S., Djogbenou, L., Akogbeto, M., & Chandre, F. (2022). Diversity of larval habitats of *Anopheles* mosquitoes in urban areas of Benin and influence of their physicochemical and bacteriological characteristics on larval density. *Parasites and Vectors*, 15(1). <https://doi.org/10.1186/s13071-022-05323-6>
- Honein, M. A., Dawson, A. L., Petersen, E. E., Jones, A. M., Lee, E. H., Yazdy, M. M., Ahmad, N., Macdonald, J., Evert, N., Bingham, A.,

- Ellington, S. R., Shapiro-Mendoza, C. K., Oduyebo, T., Fine, A. D., Brown, C. M., Sommer, J. N., Gupta, J., Cavicchia, P., Slavinski, S., Jamieson, D. J. (2017). Birth Defects Among Fetuses and Infants of US Women With Evidence of Possible Zika Virus Infection During Pregnancy. *JAMA*, 317(1), 59–68. <https://doi.org/10.1001/JAMA.2016.19006>
- Jones, R. T., Ant, T. H., Cameron, M. M., & Logan, J. G. (2021). Novel control strategies for mosquito-borne diseases: Control of mosquito-borne diseases. In *Philosophical Transactions of the Royal Society B: Biological Sciences* (Vol. 376, Issue 1818). Royal Society Publishing. <https://doi.org/10.1098/rstb.2019.0802>
- Land, M., Bundschuh, M., Hopkins, R. J., Poulin, B., & McKie, B. G. (2023). Effects of mosquito control using the microbial agent *Bacillus thuringiensis israelensis* (Bti) on aquatic and terrestrial ecosystems: a systematic review. In *Environmental Evidence* (Vol. 12, Issue 1). BioMed Central Ltd. <https://doi.org/10.1186/s13750-023-00319-w>
- Lapang, P. M., Ombugadu, A., Ishaya, M., Mafuyai, M. J., Njila, H. L., Nkup, C. D., & Mwansat G. S. (2019). Abundance and Diversity of Mosquito Species Larvae in Shendam LGA, Plateau State, North-Central Nigeria: A Panacea for Vector Control Strategy. *Journal of Zoological Research*, 3(3), 25–33.
- Leishnam, P. T. & Slaney, D. (2009). *Urbanization and the increasing risk from mosquito-borne disease: Linking human well-being with ecosystem health*. Doctoral dissertation, Nova Science Publishers.
- Lounibos, L. P., O'Meara, G. F., Nishimura, N., & Escher, R. L. (2003). Interactions with native mosquito larvae regulate the production of *Aedes albopictus* from bromeliads in Florida. *Ecological Entomology*, 28(5), 551–558. <https://doi.org/10.1046/J.1365-2311.2003.00543.X>
- Low, R. D., Schwerin, T. G., Boger, R. A., Soeffing, C., Nelson, P. V., Bartlett, D., Ingle, P., Kimura, M., & Clark, A. (2022). Building International Capacity for Citizen Scientist Engagement in Mosquito Surveillance and Mitigation: The GLOBE Program's GLOBE Observer Mosquito Habitat Mapper. *Insects*, 13(7). <https://doi.org/10.3390/insects13070624>
- Mafiana, C. F., Anaeme, L., & Olatunde, G. O. (1997). Breeding sites of larval mosquitoes in Abeokuta, Nigeria. *Nigerian Journal of Entomology*, 14/15, 136–143.
- Malone, R. W., Homan, J., Callahan, M. V., Glasspool-Malone, J., Damodaran, L., Schneider, A. D. B., Zimler, R., Talton, J., Cobb, R. R., Ruzic, I., Smith-Gagen, J., Janies, D., Wilson, J., Hone, D., Hone, S., Bavari, S., Soloveva, V., & Weaver, S. (2016). Zika Virus: Medical Countermeasure Development Challenges. In *PLoS Neglected Tropical Diseases* (Vol. 10, Issue 3). Public Library of Science. <https://doi.org/10.1371/journal.pntd.0004530>
- Marten, G. G. (1990). Elimination of *Aedes albopictus* from tire piles by introducing macrocyclops albidus (copepoda, cyclopidae).
- Mohammed Rabi, H., Ahmed, A., & Abdulhamid Ahmed, C. (2019). A preliminary study on the abundance and species composition of mosquitoes breeding in discarded automobile tyres in Minna, Niger State, Nigeria. ~ 119 ~ *International Journal of Mosquito Research*, 6(1), 119–123.
- Njila, H. L., Sani, H. S., Ombugadu, A., & Tanko, N. S. (2023). Evaluation of Coloured Containers as Attractants to Gravid Mosquitoes for Oviposition. *Trends Tech Sci Res.*, 6(1), 555679. DOI: 10.19080/TTSR.2023.06.555679
- Nnodim, O. (2023). Automobile industry produces 10 million tyres annually-FG. *Punch Newspaper*.
- Ochomo, E. O., Milanoi, S., Abong'o, B., Onyango, B., Muchoki, M., Omoke, D., Olanga, E., Njoroge, L., Juma, E. O., Otieno, J. D., Matoke-Muhia, D., Kamau, L., Rafferty, C., Gimnig, J. E., Shieshia, M., Wacira, D., Mwangangi, J., Maia, M., Chege, C., ... Kariuki, L. (2023). Detection of *Anopheles stephensi* Mosquitoes by Molecular Surveillance, Kenya. *Emerging Infectious Diseases*, 29(12), 2498–2508. <https://doi.org/10.3201/eid2912.230637>
- Ochomo, E., Rund, S. S. C., Mthawani, R. S., Antonio-Nkondjio, C., Machani, M., Samake, S., Orefuwa, E., & Juma, E. O. (2024). Laurel Anne Lown 3, Damaris Matoke-Muhia 11. *Mohamed Moumine Traoré*, 23(11). <https://doi.org/10.1186/s12936-023-04829-3>
- Oguche D.O., Auta, I. K., Ibrahim, B., Yayock, H. C., & Johnson, O. (2023). Breeding sites Characteristics and mosquito abundance in some selected locations within kaduna metropolis. *fudma journal of sciences*, 6(6), 70–75. <https://doi.org/10.33003/fjs-2022-0606-1113>
- Okafor, C., Ajaero, C., Madu, C., Agomuo, K., & Abu, E. (2020). Implementation of circular economy principles in management of end-of-life tyres in a developing country (Nigeria). In *AIMS Environmental Science* (Vol. 7, Issue 5, pp. 406–433). American Institute of Mathematical Sciences. <https://doi.org/10.3934/environsci.2020027>
- Okoh, H. I., Akinfemiwa C A, Iyeh, Mogaji, Omonijo, A. O., & Awe, O. B. (2020). Spatial Distribution and Breeding Habitat Characterisation of *Anopheles* Mosquitoes in Ado-Ekiti, Ekiti State, Nigeria. *FUOYE Journal of Pure and Applied Sciences (FJPAS)*, 5(1), 154–162. <http://fjpas.fuoye.edu.ng/index.php/fjpas/article/view/123>
- Oniya, M. O., Adeyekan, A. L., & Olusi, T. A. (2019). *Journal of Ecology and The Natural Environment Ecological factors favouring mosquito breeding in Ifedore local government area of Ondo State, Nigeria*. 11(6), 68–74. <https://doi.org/10.5897/JENE2019.0756>
- Onyido, A. E., Agbata, V. O., Umeanaeto, P. U., & Obiukwu, M. O. (2011). Ecology of Malaria Vectors in a Rainforest Suburban Community of Nigeria. *African Research Review*, 5(2). www.afrrevjo.com
- Oriaku EC, Agulanna CN, Odenigbo J, & Nnoruka N. (2013). Waste to Wealth through the Incineration of Waste Tyres and Recovery of Carbon Black. *International journal of multidisciplinary sciences and engineering*, 4(7). www.rma.org/scraptypes/facts_figures.html
- Owusu-Addo, E., & Owusu-Addo, S. B. (2014). *Effectiveness of Health Education in Community-based Malaria Prevention and Control Interventions in sub-Saharan Africa: A Systematic Review*. 4(3). www.iiste.org
- Powers, J. C., Turangan, R., Joosse, B. A., & Hillyer, J. F. (2000). Adult Mosquitoes Infected with Bacteria Early in Life Have Stronger Antimicrobial Responses and More Hemocytes after Reinfection Later in Life. *Insects*, 11(331), 3–15. <https://doi.org/10.3390/insects11060331>
- Reiter, P. (2014). Surveillance and control of urban dengue vectors. *Dengue and Dengue Hemorrhagic Fever: Second Edition*, 481–518. <https://doi.org/10.1079/9781845939649.0481>
- Rochlin, I., Ninivaggi, D. V., Hutchinson, M. L., & Farajollahi, A. (2013). Climate Change and Range Expansion of the Asian Tiger Mosquito (*Aedes albopictus*) in Northeastern USA: Implications for Public Health Practitioners. *Public Health Practitioners. PLoS ONE*, 8(4), 60874. <https://doi.org/10.1371/journal.pone.0060874>
- Roiz, D., Eritja, R., Escosa, R., Lucientes, J., Marquès, E., Melero-Alcibar, R., Ruiz, S., & Molina, R. (2007). A survey of mosquitoes breeding in used tires in Spain for the detection of imported potential vector species.
- Rozendaal, J. (1997). *Vector control: methods for use by individuals and communities*. <https://books.google.com/books>
- Saldafía, M. A., Hegde, S., & Hughes, G. L. (2017). Microbial control of arthropod-borne disease. *Memorias Do Instituto Oswaldo Cruz*, 112(2), 81–93. <https://doi.org/10.1590/0074-02760160373>
- Valentini, F., & Pegoretti, A. (2022). *End-of-life options of tyres. A review*. <https://doi.org/10.1016/j.aiepr.2022.08.006>
- Vezzani, D. (2007). Review: Artificial container-breeding mosquitoes and cemeteries: A perfect match. *Tropical Medicine and International Health*, 12(2), 299–313. <https://doi.org/10.1111/J.1365-3156.2006.01781.X>
- Walton, W. E. (2012). Design and management of free water surface constructed wetlands to minimize mosquito production. *Wetlands Ecology and Management*, 20(3), 173–195. <https://doi.org/10.1007/s11273-011-9243-1>
- WHO. (2023). *World malaria report 2022*. <https://www.wipo.int/amc/en/mediation/>
- WHO. (2024). *Dengue- Global situation*. <https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON498>
- Yaw A. Afrane., Anisa Abdulai, Abdul R. Mohammed, Yaw Akuamoah-Boateng, Christopher Mfum-Asenso., Isaac K. Sraku., Yanney, Stephina., Keziah Malm., & Neil F. Lobo. (2023). First detection of *Anopheles stephensi* in Ghana using molecular surveillance.

Biorxiv.

Yee Id, D. A., Glasgow, W. C., & Ezeakacha, N. F. (2020). *Quantifying species traits related to oviposition behavior and offspring survival in two important disease vectors.*
<https://doi.org/10.1371/journal.pone.0239636>

Zareen, S., Rehman, H. U., Gul, N., Zareen, H., Hisham, M., Rehman, M. U., Bibi, S., Bakht, A., Khan, J., Saeed, K., Hameed, C., Rehman, U., & Ullah, I. (2016). Malaria is still a life threatening disease review. ~ 105 ~ *Journal of Entomology and Zoology Studies*, 4(5).