2026 International Virtual Science Symposium

Carla Cristina Rodrigues Gomes, Cryslla Beatriz Penha Costa, Saulo Pereira Fróes, Bruno Lucas Cirqueira Cunha, Roure Santos Ribeiro, Hilton Costa Louzeiro, Suzanna de Sousa Silva, Aline Bessa Veloso, Aslei Andrade da Silva, João Paulo Tenório da Silva Santos, Adilson Matheus, Ailson Gomes Araujo, Daianny Rackelly Martins E Martins, Jamilly De Jesus Pereira Rodrigues, Livia Maria Pinto Oliveira, Pablo Mickael Martins Ribeiro, Ramon Vinicius Mendes Pinheiro, Sarah Khevenny Ribeiro Costa, Hennry Pyettro Campos Mendes, Jhoseph David Dos Santos Silva, Joao Davi De Araujo Carvalho, Maria Clara Castro Azevedo, Maria Luisa Lisboa Ribeiro, Thiago Souza Soares, Wenderson Pereira Da Silva e Michel Jeferson Pinheiro Pereira.

1. Title

"GEOSPATIAL ANALYSIS OF AEDES AEGYPTI BREEDING SITES AND BASIC SANITATION CONDITIONS IN THE MUNICIPALITY OF PINHEIRO, MARANHÃO, BRAZIL, USING CITIZEN SCIENCE AND GLOBE PROTOCOLS"

Pinheiro /MA– Brasil

Teacher: João Paulo Tenório da Silva Santos

E-mail: joao.tenorio@ufma.br

February 30, 2026

Abstract

Arboviral diseases represent one of the greatest challenges to public health in Brazil, with a pronounced impact on municipalities that face deficiencies in basic sanitation and socio-environmental vulnerabilities. In Pinheiro, located in the lowlands of Maranhão, irregular water supply, the lack of adequate sanitary sewage systems, and inefficient solid waste management, combined with local environmental characteristics, favor the formation of breeding sites for vector mosquitoes, particularly Aedes aegypti and Culex sp.This study aimed to analyze the correlation between basic sanitation conditions and the presence of breeding sites of mosquitoes of epidemiological relevance in Pinheiro, using the protocols of the GLOBE Program as the central tool for environmental and entomological monitoring. The research adopted a qualitative and quantitative approach of descriptive and analytical nature, integrating citizen science, spatial analysis, and environmental education.The methodology involved the participation of primary and higher education students, who were trained to identify breeding sites, perform photographic records, and georeference mosquito foci using the GLOBE Observer application, specifically through the Mosquito Habitat Mapper protocol. The organized data enabled the creation of thematic and heat maps, which revealed the spatial distribution of mosquito breeding sites according to the sanitary conditions of the observed areas.The results indicated that the highest concentration of breeding sites occurs in locations with poor sanitation, inadequate water storage, and proximity to open sewage. These findings confirm the direct relationship between sanitation, environment, and public health, emphasizing that the integration of citizen science and public policies is essential for the control of arboviral diseases.

3. Introduction

The transmission of diseases by mosquitoes, as occurs with arboviral diseases, is one of the most serious public health issues today. In Brazil, the persistent presence of diseases such as dengue, Zika, and chikungunya demonstrates how population health is strongly dependent on the way urban spaces are managed. The circulation of these viruses and the increase in mosquito populations are linked to the social and economic determinants that shape cities, where the interaction between climate and human occupation creates ideal conditions for the reproduction of these hematophagous insects (Costa & Natal, 1998; Flauzino et al., 2009).

In this context, Aedes aegypti stands out due to its high adaptability to urban environments, using virtually any object that accumulates water as a site for oviposition. The lack of efficient basic sanitation, interruptions in water supply, and deficiencies in solid waste collection lead to the emergence of numerous breeding sites within and around households. Studies indicate that without a robust sanitation infrastructure, mosquitoes find optimal conditions for survival, increasing risks to communities and making disease control considerably more challenging in densely populated neighborhoods (Ferreira Filho, 2017; Valladares et al., 2019).

This situation becomes particularly evident in Pinheiro, where the natural characteristics of the Maranhão lowlands directly influence vector dynamics. Intense rainfall and flood-prone areas, typical of the region, generate high humidity levels which, combined with constant heat, accelerate larval development. In addition to climatic factors, the infrastructure of Pinheiro is still affected by the absence of sewage networks and effective drainage systems, resulting in water accumulation in improvised containers and improperly disposed waste, thereby increasing breeding sites for Aedes aegypti and Culex species (Lima-Camara, 2024).

To address this issue, the use of mapping and geolocation technologies has been essential for identifying breeding sites and supporting the planning of vector control teams. Alongside spatial mapping, citizen science emerges as a strategy that promotes community engagement in environmental management. In Pinheiro, the application of GLOBE Program protocols in schools enables the systematic collection of local data while fostering environmental education and encouraging community participation in risk mitigation and public health protection (Cavalcante et al., 2013; Baixo et al., 2021; Silva & Witt, 2024)

4. Materials and Methods

As primary materials, mobile devices with access to the GLOBE Observer application were used, specifically through the Mosquito Habitat Mapper protocol, in addition to electronic spreadsheets for data organization. Geoprocessing tools were also employed for spatial analysis, as well as field materials for photographic records and environmental observation. The use of the application was essential to ensure that data were recorded in a standardized manner and integrated into the global database of the GLOBE Program (Baixo et al., 2021).

The research involved the active participation of primary and higher education students, who underwent prior training. During this training, theoretical and practical activities were conducted addressing arboviral diseases, basic sanitation, identification of breeding sites, larval recognition, and guidance on the use of the GLOBE Observer application. This participation characterizes the study as a citizen science practice (Baixo et al., 2021).

Field activities consisted of organized inspections in environments within and around households, including backyards, outdoor areas, vacant lots, public streets, and locations near open sewage systems. During the visits, various artificial objects capable of accumulating water were evaluated, such as tires, plastic bottles, assorted containers, buckets, water tanks, plant pots, and animal drinking containers.

For each identified breeding site, information was recorded regarding the type of container, the presence of water, the observation of larvae or adult mosquitoes, and local sanitation conditions. Photographic records were also obtained, and geographic coordinates (GPS) were collected. After data collection, the information was submitted to the GLOBE Program platform and subsequently exported for organization and final analysis.

Study Area

The study was conducted in the municipality of Pinheiro, Maranhão, located in the Baixada Maranhense, a region characterized by extensive floodplains, high rainfall levels, and environmental dynamics strongly influenced by water bodies. The municipality comprises urban and peri-urban areas with heterogeneous infrastructure, including sectors with deficient drainage systems, irregular solid waste collection, and inadequate water storage practices. These characteristics make the territory favorable for the formation of artificial and natural breeding sites of vector mosquitoes.

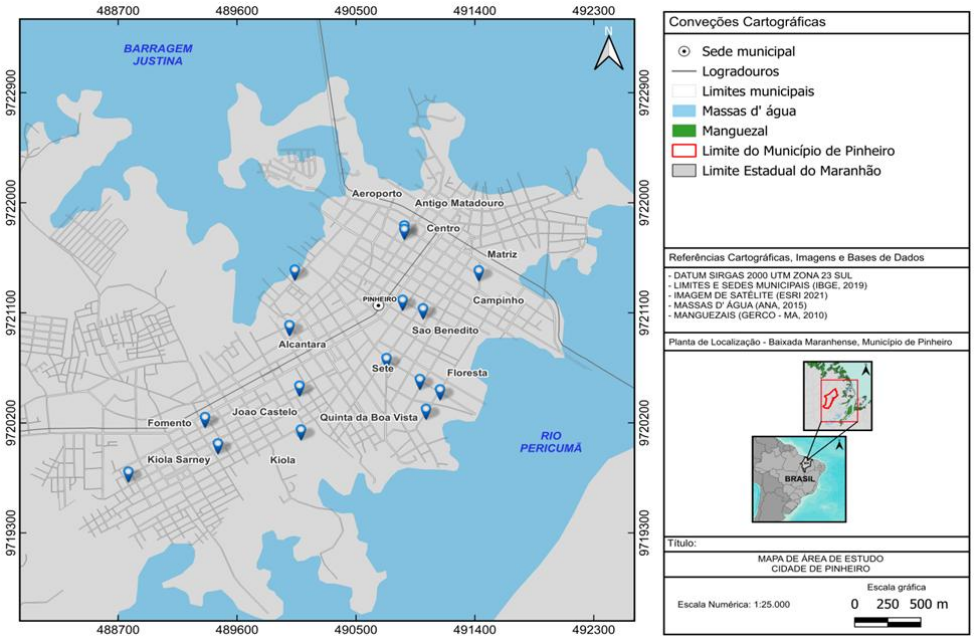

Figure 2. Study area. Blue points correspond to the sampling locations

Data Collection

Data collection for this study followed the Mosquito Habitat Mapper protocol, a tool designed for the identification and analysis of different types of mosquito breeding sites. To define the sampling locations, information provided by the Municipal Health Department of Pinheiro was used, allowing the prioritization of areas with a higher risk of arbovirus vector presence.

In total, 39 sampling points were analyzed in the municipality of Pinheiro between September 2024 and March 2025. From this overall monitoring, 16 specific points were selected and classified as critical areas for mosquito presence. Inspections were carried out by the students themselves within their communities, where they completed detailed spreadsheets containing information on the type of site, the nature of the breeding habitat, the material of the container, and the presence of larvae or adult mosquitoes. Whenever conditions allowed, the mosquito genus was also identified.

The collected information was organized and categorized according to habitat type, being classified as artificial, natural, or capture sites. In addition, the data were grouped based on container type and the characteristics of each location. This organization enabled an in-depth analysis of how breeding sites are distributed throughout the urban environment, integrating

geographic data with the field reality of the Baixada Maranhense. To illustrate this spatial distribution within the territory of Pinheiro, the following map presents the dispersion of the sampling points monitored during the study.

5. Results and Discussion

The data collected during monitoring in Pinheiro revealed a strong connection between chronic deficiencies in basic sanitation and the constant presence of mosquito breeding sites. Through the application of the Mosquito Habitat Mapper protocol, it was observed that the distribution of breeding sites follows the pattern of urban precariousness within the municipality. Areas with the highest density of breeding sites are precisely those where infrastructure is most deficient, particularly in neighborhoods affected by the absence of sewage networks and irregular potable water supply. This scenario confirms the findings of Ferreira Filho (2017) and Valladares et al. (2019), who point out that inadequate sanitation is the main driver sustaining arboviral diseases in Brazilian cities.

Analysis of the materials identified showed that most breeding sites were associated with artificial water-holding containers resulting from improper solid waste disposal. Items such as bottles, cans, plastic packaging, and discarded tires were identified as favorable environments for larval development. When exposed to the intense rainfall regime of the Baixada Maranhense, these objects become ideal breeding sites due to the accumulation of clean, shaded water. The structural characteristics of these materials favor oviposition by Aedes aegypti, allowing its life cycle to occur with minimal disturbance. These findings reinforce the discussions by Costa and Natal (1998) and Flauzino et al. (2009) regarding how urban environments, when burdened by poorly managed waste, provide the necessary support for the reproduction of these vectors.

In addition to improperly discarded waste, the dynamics of water supply in Pinheiro directly influence the availability of breeding sites. Intermittent water services force residents to store water in tanks, buckets, and improvised containers that often lack adequate sealing, turning essential reservoirs into mosquito breeding sites. Conversely, the lack of adequate sanitary sewage systems creates conditions in which the genus Culex finds ideal environments in areas with open sewage and high organic matter content. This demonstrates that inadequate sanitation in Pinheiro sustains different biological risks, as observed by Lima-Camara (2024), requiring an integrated approach that connects urban infrastructure and public health.

The persistence of these breeding sites indicates that traditional control measures are insufficient without continuous structural investment. In this regard, the citizen science strategy adopted in this study proved valuable, as it enabled students to act as active observers in areas that formal surveillance often cannot adequately cover. By documenting sanitation deficiencies near their residences, students produced a realistic diagnosis of local vulnerabilities. This participation

generated robust data for the GLOBE Program platform and promoted critical awareness of the relationship between the environment and community health, serving as a foundation for more effective future public policies in the region (Baixo et al., 2021; Silva & Witt, 2024; Nascimento et al., 2023).

Figure 3. Types of containers and their respective indication regarding the presence of larvae and/or adult mosquito vectors of arboviral diseases.

5. Conclusion

The study on the relationship between basic sanitation and the presence of mosquito breeding sites in Pinheiro clearly demonstrated that the lack of sanitary infrastructure is the primary factor influencing the reproduction of these vectors. The large number of artificial breeding sites identified—resulting from improvised water storage, waste accumulation, and the absence of sewage networks—reinforces that sanitation is the main pillar of public health in the region, as highlighted by Costa and Natal (1998), Flauzino et al. (2009), and Ferreira Filho (2017).

The use of thematic and heat maps was essential in demonstrating that the problem is not randomly distributed throughout the city but rather concentrated in specific areas of greater vulnerability. These geoprocessing tools proved to be powerful allies for planning more efficient and targeted interventions, enabling authorities to identify where actions are most urgently needed to control disease risks (Cavalcante et al., 2013; Bastos et al., 2019).

Furthermore, the application of the GLOBE Program protocols demonstrated that it is possible to conduct high-quality scientific research by integrating technology with a global database. In this process, citizen science emerged as the core of the study, as it actively engaged students, transforming data collection into a moment of learning and environmental awareness (Baixo et al., 2021; Silva & Witt, 2024).

Finally, the results indicate that controlling mosquito populations alone is insufficient; it is necessary to address the underlying causes of their reproduction. Pinheiro requires public policies that integrate environmental education, health surveillance, and, above all, substantial investments in basic sanitation. Continuing initiatives that bring the community closer to science and technology represents the most promising path to confronting the challenges of arboviral diseases in vulnerable contexts, as emphasized by the Ministry of Health (Brazil, 2025) and Vasconcelos and Luna (2020)

REFERENCES

BRASIL. Ministério da Saúde. Aedes aegypti. Disponível em: <https://www.gov.br/saude/pt- br/assuntos/saude-de-a-a-z/a/aedes-aegypti>. Acesso em: 3 mar. 2025.

FIGUEREDO, Sara A. et al. Perfil epidemiológico de arboviroses no estado do Maranhão durante os anos de 2017 a 2021. ResearchGate, 2023. Disponível em: <https://www.researchgate.net/publication/372875811_

PERFIL_EPIDEMIOLOGICO_DE_ARBOVIROSES_NO_ESTADO_DO_MARANHAO_DURANTE_OS_ANOS_DE_2017_A_2021>. Acesso em: 3 mar. 2025.

MINISTÉRIO DA SAÚDE. Mobilização nacional nas escolas reforça o enfrentamento às arboviroses por meio da educação. Disponível em: <https://www.gov.br/saude/pt-br/assuntos/noticias/2025/fevereiro/mobilizacao-nacional-nas-escolas-reforca-o-enfrentamento-as-arboviroses-por-meio-da-educacao>. Acesso em: 3 mar. 2025.

NASCIMENTO. Graciele N. et al. Educação em saúde como estratégia de enfrentamento às arboviroses. Anais do Congresso Nacional de Saúde, 2023. Disponível em: <https://ime.events/conasc2023/pdf/19773>. Acesso em: 4 mar. 2025.

VASCONCELOS, P. F. C.; LUNA, E. J. A. Arboviroses emergentes e desafios para a saúde pública no Brasil. Revista de Saúde Pública, 2020. Disponível em: <https://ime.events/conasc2023/pdf/19773>. Acesso em: 4 mar. 2025.

Zika no município de São Luís, Maranhão, Brasil. 2018. Dissertação (Mestrado) – Universidade Federal do Maranhão, São Luís, 2018. Disponível em: http://tedebc.ufma.br:8080/jspui/bitstream/tede/2299/2/AdrianaAraujo.pdf . Acesso em: 30 ago. 2025.

BAIXO, R.; BOGER, R.; NELSON, P.; KIMURA, M. Dados de ciência cidadã do GLOBE Mosquito Habitat Mapper 2017–2020. GeoHealth, v. 5, e2021GH000436, 2021. Disponível em: https://doi.org/10.1029/2021GH000436 . Acesso em: 27 jul. 2025.

BASTOS, Ismael Brioso et al. Georreferenciamento dos imóveis com foco positivo do mosquito Aedes aegypti no município de Sobral (CE). Revista de APS, v. 22, n. 1, 2019.

BONIXE, Lucas. Geojornalismo no Brasil: produção de mapas na cobertura jornalística de desastres naturais. Revista Brasileira de Estudos de Jornalismo, v. 9, n. 2, p. 38-59, 2020. DOI: https://doi.org/10.21168/rebej.v9n2.p38-59.

BRASIL. Lei nº 11.445, de 05 de janeiro de 2007. Estabelece as diretrizes nacionais para o saneamento básico. Diário Oficial da União, Brasília, DF, 08 jan. 2007. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/l11445 .htm. Acesso em: dez.2024.

CAVALCANTE, Micheline Pimentel Ribeiro et al. Análise geoespacial: um estudo sobre a dengue. Acta Paulista de Enfermagem, v. 26, p. 360–368, 2013.

COLOMBO, Tatiana Elias et al. Performance of CDC Trioplex qPCR during a dengue outbreak in Brazil. Journal of Clinical Virology, v. 121, p. 104208, 2019. DOI: https://doi.org/10.1016/j.jcv.2019 .104208. Acesso em: dez.2024.

COSTA, Antonio Ismael Paulino da; NATAL, Delsio. Distribuição espacial da dengue e determinantes socioeconômicos em localidade urbana no Sudeste do Brasil. Revista de Saúde Pública, v. 32, n. 3, p. 232–236, 1998. Disponível em: https://www.scielosp.org/article/ssm/content/raw/?resource_ssm_path=/media/assets/rsp/v32n3/p232-236.pdf . Acesso em: 08 nov. 2025.

COSTA, Luana Dias da et al. Percepção da população sobre a atuação das autoridades e das comunidades no controle das arboviroses. Saúde em Debate, v. 46, p. 790-802, 2022. DOI: https://doi.org/10.1590/0103-1104202213414i. Acesso em: dez.2024.

DA SILVA COSTA, Diógenes Felix et al. Análise geoestatística aplicada na distribuição de arboviroses emergentes no município de Caicó–RN. In: Os desafios da Geografia Física na fronteira do conhecimento. v. 1, p. 5462–5474, 2017.

DONALISIO, Maria Rita; FREITAS, André Ricardo Ribas. Chikungunya no Brasil: um desafio emergente. Revista Brasileira de Epidemiologia, v. 18, n. 1, p. 283-285, 2015. DOI: https://doi.org/10.1590/1980-5497201500010022. Acesso em: dez.2024.

FEITOSA, Manuella Carvalho et al. Avaliação da qualidade metodológica de diretrizes de

vigilância e manejo clínico de dengue e chikungunya. Cadernos de Saúde Pública, v. 36, n. 7, p. e00050919, 2020. DOI: https://doi.org/10.1590/0102-311x00050919. Acesso em: dez.2024.

FERNANDES, Maria da Conceição Rodrigues; MONTE, Washington Sales do; BEZERRA, Francisco Silvestre Brilhante. Avaliação do desenvolvimento tecnológico em saúde a partir da ocorrência das epidemias de zika e chikungunya no Brasil. Cadernos de Saúde Pública, v. 39, p. e00090022, 2023. DOI: https://doi.org/10.1590/0102-311xpt090022. Acesso em: dez.2024.

FERREIRA FILHO, David Figueiredo. Fatores ambientais que contribuem para a proliferação do mosquito da dengue no bairro praia grande no distrito de Mosqueiro, Belém–PA. In: VIII Congresso Brasileiro de Gestão Ambiental Campo Grande, MS. Instituto Brasileiro de Estudos Ambientais. 2017. Acesso: 30/10/2024 link: https://www.ibeas.org.br/congresso/Trabalhos2017/V-016.pdf

FIGUEIREDO, Luan Andrade de et al. Dengue, geoprocessamento e saúde: estudo de caso na zona urbana do município de Santa Helena (2022 a 2024). 2024. Trabalho acadêmico. Disponível em: https://revistas.uepg.br/index.php/conexao/article/download/23150/209209219338 . Acesso em: 03 set. 2025.

FLAUZINO, Regina Fernandes; SOUZA-SANTOS, Reinaldo; OLIVEIRA, Rosely Magalhães. Dengue, geoprocessamento e indicadores socioeconômicos e ambientais: um estudo de revisão. Revista Panamericana de Salud Pública, v. 25, n. 5, p. 456–461, 2009. Disponível em: https://www.scielosp.org/pdf/rpsp/2009.v25n5/456-461/pt . Acesso em: 02 dez. 2025.

JUSTINO, Renato Nunes et al. Análise descritiva e espacial dos casos de vírus Zika e Chikungunya nos municípios do estado de Goiás. Movimenta, v. 14, n. 2, p. 188–197, 2021
.

LIM, Ah-Young et al. Uma revisão sistemática dos dados, métodos e covariáveis ambientais usados para mapear o risco de transmissão de arbovírus transmitidos pelo Aedes. BMC Infectious Diseases, v. 23, n. 1, p. 708, 2023.

LIMA-CAMARA, T. N. Dengue is a product of the environment: an approach to the impacts of the environment on the Aedes aegypti mosquito and disease cases. Revista Brasileira de Epidemiologia, v. 27, p. e240048, 2024. DOI: https://doi.org/10.1590/1980-549720240048 .

MARQUES, Jonatan Marques Campos. Estações climáticas e sua relação com casos notificados de Dengue no Brasil: um estudo ecológico. Barbacena – MG: Faculdade de Medicina de Barbacena (FAME/FUNJOBE), 2024.

MASULLO, Yata Anderson Gonzaga; CARVALHO, Ana Carolina Coutinho; RANGEL, Mauricio Eduardo Salgado. Geotecnologias aplicadas ao monitoramento do vetor Aedes aegypti na área Itaqui-Bacanga, São Luís–MA. Revista Geográfica de América Central, v. 2, n. 47E, 2011. Disponível em: https://www.revistas.una.ac.cr/index.php/geografica/article/download/2009/1908 . Acesso em: 09 set. 2025.

MOTA, Suianne Letícia Antunes et al. Arboviroses no Brasil: desafios para a saúde pública e o papel crucial do saneamento básico. Aracê, v. 6, n. 4, p. 11997–12010, 2024. Disponível em: https://periodicos.newsciencepubl.com/arace/article/view/1980 . Acesso em: 19 out. 2025.

MOTA, Suianne Letícia Antunes et al. Arbovírus no Brasil: desafios para a saúde pública e o papel crucial do saneamento básico. Aracê, v. 4, p. 11997–12010, 2024. DOI: 10.56238/arev6n4-066. Disponível em: https://periodicos.newsciencepubl.com/arace/article/view/1980 . Acesso em: 21 abr. 2025.

NEVES, David Pereira; ALAIN, Lani; DI MÉRIO, Pedro; LINARES, Marcos; W., Ricardo; ALMEIDA, Victor. Parasitologia humana. 12. ed. Rio de Janeiro: Atheneu, 2011.

OLIVEIRA, Raiane Fontes de et al. Dimensões da vulnerabilidade à dengue a partir da Região Metropolitana do Rio de Janeiro: das escalas de produção do espaço à reprodução do processo saúde-doença-atenção. 2024. Tese (Doutorado) – Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 2024. Disponível em: https://www.bdtd.uerj.br:8443/bitstream/1/23230/2/Tese%20-%20Raiane%20Fontes%20de%20Oliveira%20-%202024%20-%20Completa.pdf . Acesso

em: 21 nov. 2025.

ORGANIZAÇÃO MUNDIAL DA SAÚDE. Dengue: diretrizes para diagnóstico, tratamento, prevenção e controle: nova edição. Genebra: Organização Mundial da Saúde, 2009.

RIBEIRO, Marisa O. et al. Analytical and clinical performance of molecular assay used by the Brazilian public laboratory network to detect and discriminate Zika, Dengue and Chikungunya viruses in blood. Brazilian Journal of Infectious Diseases, v. 25, p. 101542, 2021. DOI: https://doi.org/10.1016/j.bjid.2021.101542 .

ROCHA, Adriano Moura da. Geotecnologias e educação ambiental como estratégia para o monitoramento da dengue no ambiente urbano: pesquisa participativa na Vila Cruzado, município de São Luís (MA). 2009. Dissertação (Mestrado) – Universidade Federal do Maranhão, São Luís, 2009. Disponível em: https://rosario.ufma.br/jspui/bitstream/123456789/2321/1/Adriano%20Moura%20da%20Rocha.pdf . Acesso em: 12 jul. 2025.

SENA, Brena F. et al. Advancing arbovirus diagnosis in Brazil: strengthening diagnostic strategies and public health data collection. Brazilian Journal of Infectious Diseases, v. 28, p. 103766, 2024. DOI: https://doi.org/10.1016/j .bjid.2024.103766.

SILVA, Fabiano Couto Corrêa da; WITT, Amanda Santos. Ciência Cidadã: Monitoramento Participativo da Dengue. Anais do Encontro Nacional de Pesquisa em Ciência da Informação, Vitória, ES, 2024.

SILVA, Júlio Cesar Barreto da; MACHADO, Carlos José Saldanha. Associações entre dengue e variáveis socioambientais nas capitais do Nordeste brasileiro por análise de agrupamentos. Ambiente & Sociedade, v. 21, 2019.

SIQUEIRA, A. S. P. et al. ArboAlvo: stratification method for territorial receptivity to urban arboviruses. Revista de Saúde Pública, v. 56, p. 39, 2022. Disponível em: https://doi.org/10.11606/s1518-8787.2022056003546 . Acesso em: 05 nov. 2025.

SOUZA, Jessica Suzarte Carvalho de et al. Modelagem espaço-temporal das arboviroses nas regiões de saúde do estado da Bahia: uma abordagem epidemiológica e ambiental. 2022. Dissertação (Mestrado) – Universidade Federal da Bahia, Salvador, 2022.

Disponível em: http://200.128.81.65:8080/bitstream/tede/1561/2/Dissertacao_v_15_versao_imprimir_e_encadernar.pdf . Acesso em: 18 ago. 2025.

TWIDDY, S. S.; HOLMES, E. C.; RAMBAUT, A. Inferring the Rate and Time-Scale of Dengue Virus Evolution. Molecular Biology and Evolution, v. 20, n. 1, p. 122–129, jan. 2003. DOI: https://doi.org/10.1093/molbev/msg010 .

VALLADARES, Gustavo Souza et al. Influência de variáveis ambientais na ocorrência da dengue utilizando geoprocessamento em Teresina, Piauí. Hygeia: Revista Brasileira de Geografia Médica e da Saúde, v. 15, n. 34, p. 102, 2019. Disponível em: https://seer.ufu.br/index.php/hygeia/article/download/47771/28541/222469 . Acesso em: 14 out. 2025.

WILDER-SMITH, A. et al. Dengue. The Lancet, v. 393, n. 10169, p. 350–363, 2019. DOI: https://doi.org/10.1016/S0140-6736(18)32560-1 .

YARI, Jiyan et al. MAPAEDES: sistema de mapeamento georreferenciado de focos de larvas e mosquitos Aedes aegypti L. e suas patologias. Revista Foco, v. 16, n. 8, p. e2614, 2023.

ARAUJO, Adriana Soraya et al. Análise espacial de casos prováveis de febre pelo vírus Zika no município de São Luís, Maranhão, Brasil. 2018. Dissertação (Mestrado) – Universidade Federal do Maranhão, São Luís, 2018. Disponível em: http://tedebc.ufma.br:8080/jspui/bitstream/tede/2299/2/AdrianaAraujo.pdf . Acesso em: 30 ago. 2025.

BAIXO, R.; BOGER, R.; NELSON, P.; KIMURA, M. Dados de ciência cidadã do GLOBE Mosquito Habitat Mapper 2017–2020. GeoHealth, v. 5, e2021GH000436, 2021. Disponível em: https://doi.org/10.1029/2021GH000436 . Acesso em: 27 jul. 2025.

BRASIL. Lei nº 11.445, de 05 de janeiro de 2007. Estabelece as diretrizes nacionais para o saneamento básico. Diário Oficial da União, Brasília, DF, 08 jan. 2007. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/l11445 .htm. Acesso em: dez.2024.

CAVALCANTE, Micheline Pimentel Ribeiro et al. Análise geoespacial: um estudo sobre a dengue. Acta Paulista de Enfermagem, v. 26, p. 360–368, 2013.

COLOMBO, Tatiana Elias et al. Performance of CDC Trioplex qPCR during a dengue outbreak in Brazil. Journal of Clinical Virology, v. 121, p. 104208, 2019. DOI: https://doi.org/10.1016/j.jcv.2019 .104208. Acesso em: dez.2024.

COSTA, Luana Dias da et al. Percepção da população sobre a atuação das autoridades e das comunidades no controle das arboviroses. Saúde em Debate, v. 46, p. 790-802, 2022. DOI: https://doi.org/10.1590/0103-1104202213414i. Acesso em: dez.2024.

DA SILVA COSTA, Diógenes Felix et al. Análise geoestatística aplicada na distribuição de arboviroses emergentes no município de Caicó–RN. In: Os desafios da Geografia Física na fronteira do conhecimento. v. 1, p. 5462–5474, 2017.

DONALISIO, Maria Rita; FREITAS, André Ricardo Ribas. Chikungunya no Brasil: um desafio emergente. Revista Brasileira de Epidemiologia, v. 18, n. 1, p. 283-285, 2015. DOI: https://doi.org/10.1590/1980-5497201500010022. Acesso em: dez.2024.

FEITOSA, Manuella Carvalho et al. Avaliação da qualidade metodológica de diretrizes de vigilância e manejo clínico de dengue e chikungunya. Cadernos de Saúde Pública, v. 36, n. 7, p. e00050919, 2020. DOI: https://doi.org/10.1590/0102-311x00050919. Acesso em: dez.2024.

FERNANDES, Maria da Conceição Rodrigues; MONTE, Washington Sales do; BEZERRA, Francisco Silvestre Brilhante. Avaliação do desenvolvimento tecnológico em saúde a partir da ocorrência das epidemias de zika e chikungunya no Brasil. Cadernos de Saúde Pública, v. 39, p. e00090022, 2023. DOI: https://doi.org/10.1590/0102-311xpt090022. Acesso em: dez.2024.

FERREIRA FILHO, David Figueiredo. Fatores ambientais que contribuem para a proliferação do mosquito da dengue no bairro praia grande no distrito de Mosqueiro, Belém–PA. In: VIII Congresso Brasileiro de Gestão Ambiental Campo Grande, MS. Instituto Brasileiro de Estudos Ambientais. 2017. Acesso: 30/10/2024 link: https://www.ibeas.org.br/congresso/Trabalhos2017/V-016.pdf

FIGUEIREDO, Luan Andrade de et al. Dengue, geoprocessamento e saúde: estudo de caso na zona urbana do município de Santa Helena (2022 a 2024). 2024. Trabalho acadêmico. Disponível em: https://revistas.uepg.br/index.php/conexao/article/download/23150/209209219338 . Acesso em: 03 set. 2025.

FLAUZINO, Regina Fernandes; SOUZA-SANTOS, Reinaldo; OLIVEIRA, Rosely Magalhães. Dengue, geoprocessamento e indicadores socioeconômicos e ambientais: um estudo de revisão. Revista Panamericana de Salud Pública, v. 25, n. 5, p. 456–461, 2009. Disponível em: https://www.scielosp.org/pdf/rpsp/2009.v25n5/456-461/pt . Acesso em: 02 dez. 2025.

LIM, Ah-Young et al. Uma revisão sistemática dos dados, métodos e covariáveis ambientais usados para mapear o risco de transmissão de arbovírus transmitidos pelo Aedes. BMC Infectious Diseases, v. 23, n. 1, p. 708, 2023.

LIMA-CAMARA, T. N. Dengue is a product of the environment: an approach to the impacts of the environment on the Aedes aegypti mosquito and disease cases. Revista Brasileira de Epidemiologia, v. 27, p. e240048, 2024. DOI: https://doi.org/10.1590/1980-549720240048 .

MARQUES, Jonatan Marques Campos. Estações climáticas e sua relação com casos notificados de Dengue no Brasil: um estudo ecológico. Barbacena – MG: Faculdade de Medicina de Barbacena (FAME/FUNJOBE), 2024.

MASULLO, Yata Anderson Gonzaga; CARVALHO, Ana Carolina Coutinho; RANGEL, Mauricio Eduardo Salgado. Geotecnologias aplicadas ao monitoramento do vetor Aedes aegypti na área Itaqui-Bacanga, São Luís–MA. Revista Geográfica de América Central, v. 2, n. 47E, 2011. Disponível em: https://www.revistas.una.ac.cr/index.php/geografica/article/download/2009/1908 . Acesso em: 09 set. 2025.**6. Emblem Descriptions**

I Am a GLOBE Researcher

Students from participating schools were actively engaged throughout the study, collecting data in their neighborhoods and documenting detailed information on the surveyed sites. The research support team was responsible for conducting field surveys, data analysis, and the preparation of the results and discussion sections.

I Am an Earth System Scientist

During the execution of field activities, the climate–mosquito relationship was addressed, highlighting the climatic variables that optimize the vectors' life cycle and examining their interaction with the local geography of the study area.

I Make an Impact

The study had a significant societal impact, as students—through data collection, the exchange of information provided by the Municipal Health Department, which collaborated in selected field activities, and learning about disease-vector mosquitoes—shared this knowledge with their families. These family members reported changes in behaviors that could otherwise favor the proliferation of these insects. As a result, a positive impact on the community can be observed.