

Eco-Friendly Dengue Vector Control: The Application of a Phytotherapy Bio-Spray and Environmental Aromatherapy in Palembang Indonesia

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Abstract

Dengue Hemorrhagic Fever (DHF) remains an unresolved public health issue in Indonesia. One area experiencing fluctuating DHF prevalence is Kertapati District. In response to this situation, the Gas and Steam Power Plant (PLTGU) Unit Keramasan in Kertapati District implemented a Corporate Social Responsibility (CSR) program as part of its institutional social commitment. This initiative introduced a social innovation in the health sector: the launch of a natural bio-spray insecticide that combines a dual phytotherapeutic approach involving natural insecticide and environmental aromatherapy, with the aim of reducing the incidence of dengue hemorrhagic fever in the PLTGU Keramasan operational area, specifically Kertapati District. The program included health education sessions and training on the production of natural insecticides, involving 75 participants from the Kertapati community. The Corporate Social Responsibility (CSR) initiative has had a positive impact, contributing to a reduction in DHF cases in Kertapati District while also enhancing community creativity and innovation.

Keywords: *Aedes aegypti*, dengue hemorrhagic fever, natural insecticide.

Abstrak

Demam Berdarah Dengue (DBD) merupakan masalah kesehatan masyarakat yang belum teratasi dengan sempurna di Indonesia. Salah satu wilayah yang mengalami fluktuasi prevalensi demam berdarah dengue yaitu Kecamatan Kertapati. Berangkat dari situasi ini, Pembangkit Listrik Tenaga Gas dan Uap (PLTGU) unit Keramasan Kecamatan Kertapati melaksanakan program *Corporate Social Responsibility* (CSR) sebagai bagian dari tanggung jawab social instansi dengan menginisiasi program inovasi social dalam aspek kesehatan peluncuran bio spray insektisida alami yang menggabungkan pendekatan fitoterapi ganda insektisida dan aromaterapi lingkungan dengan tujuan menurunkan angka kejadian demam berdarah dengue di wilayah kerja PLTGU unit Keramasan yaitu Kecamatan Kertapati. Program ini terdiri dari kegiatan penyuluhan dan pelatihan pembuatan insektisida alami pada 75 orang peserta yang merupakan warga dari Kecamatan Kertapati. Program *Corporate Social Responsibility* (CSR) memberikan dampak positif dalam menekan angka kejadian demam berdarah dengue di Kecamatan Kertapati dan meningkatkan kreativitas serta inovasi masyarakat Kecamatan Kertapati.

Kata Kunci : *Aedes aegypti*, demam berdarah dengue, insektisida alami.

Introduction

Mosquitoes are insects of the order Diptera that significantly contribute to fluctuations in global public health due to their role in transmitting pathogens.^{1,2} Diseases transmitted by mosquito vectors pose a substantial risk to public health.³ There are approximately 2,500 mosquito species that have the potential to act as vectors for various diseases. *Aedes aegypti* and *Aedes albopictus* are the two primary mosquito species responsible for transmitting dengue hemorrhagic fever (DHF).⁴ Dengue Hemorrhagic Fever (DHF) is an arboviral infectious disease transmitted by mosquito vectors through the dengue virus.⁵ The dengue virus is

transmitted through the bite of infected female mosquitoes.⁶ Diseases transmitted by arthropod vectors cause significant morbidity and mortality.⁷

Dengue fever transmission occurs rapidly, particularly in tropical and subtropical regions.⁸ Indonesia is one of the countries with a tropical climate.⁸ *Aedes aegypti* reproduces optimally in areas with warm and humid climates.⁹ The World Health Organization (WHO) reports that dengue hemorrhagic fever infects more than 2.5 billion people worldwide.¹⁰ Based on projected estimates for 2080, dengue hemorrhagic fever is expected to affect 50% of the global population.¹¹ The number of annual cases reaches 100 to 400 million.¹² Southeast Asia, South Asia, and Latin America are regions with high prevalence of DHF.¹³ The prevalence of DHF in Indonesia places the country among the 30 highest dengue-endemic nations worldwide.¹⁴

Dengue hemorrhagic fever infection in Indonesia has been a public health concern since 1968, when a total of 58 cases were reported.¹⁵ The prevalence of this disease has continued to increase annually.¹⁶ In 2016, dengue hemorrhagic fever in Indonesia reached epidemic levels, with the number of cases increasing from 21,092 in 2015 to 25,336 in 2016.¹⁷ In 2021, DHF cases in Indonesia, recorded from January to December, totaled 51,048, with a mortality count of 472 individuals. Among these cases, 30.46% were children aged 5–14 years.¹⁸ Dengue hemorrhagic fever is influenced by multiple factors, including environmental, behavioral, and biological factors. Age is one of the biological factors that affects the risk of dengue hemorrhagic fever. According to a study conducted in Mexico from 2020 to 2021, the majority of hospitalized dengue hemorrhagic fever patients were aged 60 years and above.¹⁹

Climate change is one of the environmental factors that contributes to increased mosquito vector density and geographic expansion, thereby enhancing the incidence and prevalence of infection.²⁰ Climate change affects environmental elements such as temperature and rainfall.²⁰ High rainfall leads to the formation of stagnant water. Stagnant water has been shown to be an environmental factor that facilitates the occurrence of dengue hemorrhagic fever.²¹ A study conducted in Central Java Province, Indonesia, showed that extreme weather conditions and anomalies influence the risk of dengue hemorrhagic fever.²² Plastic waste accumulation also provides an ideal breeding site for mosquito vectors. Human behaviors that contribute to the occurrence of dengue hemorrhagic fever include going outdoors at night, not wearing long-sleeved clothing during nighttime, and not using bed nets while sleeping.²³

Integrated and comprehensive efforts to eliminate dengue hemorrhagic fever are being continuously intensified in every country. Since certain risk factors cannot be controlled by humans, preventive and control measures are necessary to prevent further increases in dengue hemorrhagic fever incidence. Control measures begin with the management of infection surveillance through weekly reporting of suspected or confirmed dengue hemorrhagic fever cases.¹⁹ One of the measures for preventing dengue infection is vaccination. However, the availability of dengue vaccines remains limited. Symptomatic treatment strategies for dengue-infected patients include the administration of antipyretics to reduce fever and analgesics to relieve headache and joint pain.²⁴

One of the vector control measures for dengue infection is the use of chemical insecticides. However, the use of chemical insecticides is increasingly considered ineffective due to potential environmental contamination, the development of vector resistance, and non-target mortality.¹ To address the problems associated with conventional insecticides that lead to new issues, alternative natural insecticides are used, which pose no harmful potential to the environment or human health. Natural or botanical insecticides are derived from natural organic materials such as microorganisms, plants, and other organic substances. Currently, the development of botanical insecticides has expanded significantly, with various raw materials being used. Natural materials that have been proven effective as natural insecticides include onion peel extract, orange peel extract, lemongrass extract, and organic waste.^{8,4,25}

Natural insecticides can be formulated as liquids that are then developed into bio-sprays, as well as lotions applied directly to the skin. Corporate Social Responsibility (CSR) is a type of program that reflects a company's commitment to social responsibility, aiming to support and contribute to the achievement of the Sustainable Development Goals (SDGs). CSR does not focus solely on medical aspects but also encompasses environmental and community education components. The Gas and Steam Power Plant (PLTGU) Unit Keramasan in Palembang City has taken a strategic role in implementing CSR through a dual phytotherapy approach, utilizing a plant-based bio-spray as a natural insecticide that effectively kills mosquito larvae without causing harmful chemical side effects.

The CSR activities carried out by the PLTGU Keramasan Unit in Kertapati District, Palembang City, are focused on eliminating dengue hemorrhagic fever in Kertapati District, which is the operational area of the PLTGU Keramasan Unit. Over the past three years, the number of dengue hemorrhagic fever cases has decreased based on reports from the Kertapati Community Health Center. In 2023, the number of DHF cases was recorded at 188. In 2024, the number decreased to 165 cases. By mid-2025, there were 65 DHF cases reported in the working area of the Kertapati Community Health Center. In addition, in an effort to reduce organic waste volume and support an environmentally friendly lifestyle.

PLTGU Keramasan has developed a bio-spray and natural aromatherapy derived from the utilization of plastic waste and food scraps. This innovation not only benefits the environment but also produces high-value products that contribute to improving health quality. In addition, the aromatherapy produced from the application of bio-spray in the environment is used to create an atmosphere unfavorable to mosquitoes, while also providing a calming effect that promotes residents' health and comfort. This Corporate Social Responsibility (CSR) initiative aims to ensure that community members develop awareness and are able to produce natural insecticides and carry out regular spraying in their home environments and public facilities, thereby establishing a sustainable vector control practice.

Materials And Method

The Corporate Social Responsibility (CSR) activity was conducted in 2025 in Kertapati District, Palembang City, South Sumatra Province, Indonesia, with a total of 75 participants. The CSR program adopted a creative learning approach, an innovative method that presents materials in an engaging and interactive manner. The parties involved in the counseling and training activities on the production of bio-spray using organic waste as raw material, including food scraps and household waste, were the PLTGU Keramasan Unit and the partner community groups from Kertapati District. The Corporate Social Responsibility (CSR) activity on this topic was conducted in several stages. The first stage involved education and counseling on Dengue Hemorrhagic Fever (DHF) and its prevention measures. This was followed by the second stage, which was a practical session on the production of bio-spray. The final stage consisted of a discussion and question-and-answer session.

During the bio-spray production practical session, participants were provided with knowledge about plants and natural materials, such as organic waste, and proper waste sorting methods that can be used to create mosquito-repellent compounds. They were also introduced to simple techniques for producing natural insecticides. The process of making natural bio-spray insecticide begins with preparing the tools and materials. The tools used in the production process include a closed container for fermentation, spray bottles, measuring cups, droppers, knives, sieves, scales, stirrers, and cutting boards. The natural materials used in the bio-spray production are clean water and organic waste that has undergone sorting and microbial fermentation for several days. The organic waste used consists of food scraps, preferably including orange peels, coffee and tea grounds, onion skins, lemongrass leaves, lemongrass stems, and other vegetable waste.

The sorted materials prepared by the participants are then fermented or naturally distilled, depending on the intended product. For bio-spray, microbial fermentation is carried out over several days to produce an active liquid that is safe for use as a disinfectant and insect repellent. For aromatherapy, steam distillation is carried out to extract essential oils from the selected materials. Following this, the training session on bio-spray production is conducted. The final stage is the discussion and question-and-answer session. During this stage, participants are given the opportunity to engage in discussion, ask questions, seek further information, and deepen their understanding regarding organic waste sorting, dengue hemorrhagic fever control, and the production of bio-spray insecticide.

Results

The Corporate Social Responsibility (CSR) program implemented by PLTGU Keramasan Unit represents the company's social and environmental responsibility toward the broader community. This activity also aims to reduce the prevalence rate of dengue hemorrhagic fever in the operational area of the PLTGU Keramasan Unit through the training programs conducted. This training also aims to minimize the amount of organic waste generated by the community, encouraging the application of recycling and waste reduction principles. The organic waste used is predominantly derived from household organic waste containing carbon, volatile compounds, and essential oils, which have the potential to be utilized as raw materials for natural or botanical insecticides.

Bio-spray is a liquid made from natural or plant-based ingredients and is formulated for various functions, such as an insecticide or insect repellent, as well as an indoor air freshener. Bio-spray used as an air freshener can provide a relaxing effect, improve mood, and reduce stress levels. Active compounds such as limonene found in orange peel, citronellal in lemongrass stems, and eugenol in citrus leaves possess antifungal and antibacterial properties, as well as strong aromatic characteristics.²⁶ Furthermore, bio-spray is also used as an insect-repellent insecticide. Bio-spray with a high essential oil content has greater effectiveness in repelling insects, particularly mosquitoes, with increased repellency proportional to the concentration of essential oils.²⁷

The prevalence of dengue hemorrhagic fever in Kertapati District has decreased over the past three years. Various programs related to dengue control efforts have been initiated in Kertapati District, with the aim of achieving elimination. The following is a table showing the number of dengue hemorrhagic fever cases in Kertapati District over the past three years.

Table 1. Number of DHF Cases in Kertapati District

No	Year	DHF Cases
1	2023	188
2	2024	165
3	2025	66

Based on the table above, dengue hemorrhagic fever cases in Kertapati District have decreased annually. The Corporate Social Responsibility (CSR) program implemented by PLTGU Keramasan Unit, through the activity of bio-spray production, involves a phytotherapeutic product that utilizes plant extracts possessing natural insecticidal and repellent properties. The following are photos of the training and counseling activities conducted for the partner community.



Figure 1. Training and Counseling on the Production of Aromatherapy Insecticide Bio-Spray

The aromatherapy insecticide bio-spray is sprayed inside homes, around residential areas, and in public facilities, aiming not only to repel mosquitoes but also to improve air quality and enhance the psychological well-being of the community. Residents are expected to carry out regular spraying in their home environments and public facilities, thereby establishing a sustainable vector control practice. The advantages of this bio-spray include its environmental friendliness, as it is made from natural ingredients, and its effectiveness in repelling mosquitoes, which has been supported by several studies showing that herbal active compounds can reduce mosquito larval populations or decrease mosquito density by 70–80%, as well as help prevent mosquito resistance. The following is a photo of the bio-spray product ready for use.



Figure 2. Bio-Spray Product

The CSR program by PLTGU Keramasan Unit has multidimensional impacts: the combination of bio-spray and aromatherapy has significantly reduced mosquito density, contributing to a decline in dengue hemorrhagic fever cases, thereby effectively lowering the incidence rate of the disease in Kertapati. The reduction of plastic waste resulting from educational activities and campaigns promoting plastic waste reduction and the proper management of organic waste, which can serve as mosquito breeding sites, has had a positive effect on environmental cleanliness and waste volume reduction. Next, community empowerment is achieved by involving residents in spraying activities and environmental management to enhance awareness and social responsibility. The success of this program can serve as a replicable model for companies in other regions facing similar challenges, integrating herbal and environmental solutions through a Corporate Social Responsibility (CSR) program approach.

Discussion

An effective *Aedes aegypti* vector control program is essential for the elimination of dengue hemorrhagic fever (DHF). In Indonesia, vector control, particularly of mosquitoes, still largely relies on the use of insecticides. The use of insecticides is considered effective and rapid in reducing mosquito vector populations. However, this control method falls under chemical-based approaches, which have both positive and negative aspects.²⁸ The positive aspect of chemical-based control is that it is effective and efficient in eliminating vectors. However, the negative aspect is the ongoing challenge of mosquito resistance to insecticides, which continues to emerge and spread. Therefore, innovations in insecticide application approaches are continuously being developed.

Biological control using natural or plant-based materials as raw ingredients to produce natural insecticides to eliminate mosquito vectors has been introduced to reduce reliance on chemical insecticides. The compounds saponin, flavonoids, and alkaloids found in lime peel extract (*Citrus aurantifolia*) are toxic to mosquito vectors and act as botanical or natural insecticides.²⁸ The higher the concentration of lime peel extract in the insecticide solution, the higher the percentage of mosquito vector mortality. This has been demonstrated by various studies on the efficacy of lime peel extract as a botanical insecticide, one of which was conducted by Dipahayu and Anurijati in 2022.²⁹ Mosquitoes that are attracted to and inhale a medium containing lime peel extract insecticide will experience nerve paralysis and respiratory distress, leading to death.³⁰

Lemongrass is also a plant that mosquitoes avoid due to its strong scent and chemical composition. Lemongrass contains active compounds such as geraniol and citronellol, which are toxic and absorb moisture from the mosquito's body, leading to dehydration and eventual death.³¹ The production of lemongrass-based insecticides has undergone various trials and has been found effective in repelling mosquitoes in multiple regions.³² Lemongrass is a naturally available raw material that is easily accessible. In addition, the aroma of lemongrass is known to remain effective in the air for a relatively long period.³³ Natural insecticides derived from materials such as lime peel and lemongrass also produce a calming aromatic effect. In addition to lemongrass and lime peel, plants that can be used as raw materials for natural insecticides include red onion peel.

Red onion peel is the outer layer of red onions, which is typically discarded or unused. However, it has the ability to control pests and vectors. Red onion peel contains saponin, flavonoids, tannins, and alkaloids. The saponin compound has toxic properties and can damage the digestive tract of insects, leading to reduced

nutrient absorption and ultimately resulting in insect or insect death.³⁴ In addition, the tannins contained in red onion peel are able to induce a numbing sensation on the mosquito's or insect's tongue and constrict their throat.³⁵ Red onion peel, which is commonly discarded and considered valueless, is expected to be utilized by the community as a raw material for the production of natural insecticides.

The Corporate Social Responsibility (CSR) program conducted by the Gas and Steam Power Plant (PLTGU) Unit Keramasan is expected to serve as a platform for innovative and sustainable economic opportunities through the development of natural insecticide products. The main raw materials for insecticide production, which are natural and easily accessible, support the effectiveness of the manufacturing process. Ongoing guidance and support from the institution will continue to be provided through the Corporate Social Responsibility (CSR) program. After the Corporate Social Responsibility (CSR) program has been implemented and the community has acquired the ability to produce natural insecticides and carry out independent vector control, this activity is considered successful in reducing the incidence of dengue hemorrhagic fever in the operational area of the Gas and Steam Power Plant (PLTGU) Unit Keramasan, namely Kertapati District, Palembang, Indonesia.

Conclusion

The Corporate Social Responsibility (CSR) program of the Gas and Steam Power Plant (PLTGU) Unit Keramasan, through community empowerment activities involving counseling and training in the production of natural ingredient-based insecticides, has generated positive impacts on both the health and economic sectors. Through this activity, participants in the counseling and training, who are residents of Kertapati District, can transform natural materials that previously had no practical value into beneficial products. The natural ingredients used as raw materials to produce natural insecticides in this program have been proven effective in eliminating insects, as supported by various studies that have been conducted.

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