Development of plant pots to mitigate mosquito populations

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Abstract

This project, **Development of plant pots to mitigate mosquito populations**, aims to develop a plant pot capable of trapping mosquitoes and reducing water usage while studying the effect of different light colors on mosquito attraction. The team designed the mosquito-trapping plant pot based on mosquito oviposition behavior, where mosquitoes typically lay eggs on water surfaces. The pot was designed with a water reservoir at the bottom and a mosquito trap on the side, consisting of rectangular slots lined with black felt fabric, mimicking the damp black surfaces that mosquitoes are naturally attracted to. Once mosquitoes enter, they cannot escape. When mosquitoes lay eggs on the water surface, the larvae develop as usual, but adult mosquitoes cannot exit the trap. Additionally, a sturdy cotton rope was placed between the soil and the water reservoir, allowing water absorption to sustain plant growth in drought or high-temperature conditions. To evaluate the effect of light color on mosquito attraction, three mosquito-trapping plant pots illuminated with different light colors, including blue, purple, and green, were placed in the same area. Humidity was measured daily over two weeks, and the number of mosquitoes in each pot was recorded and monitored through different life cycle stages. Among the three versions tested, Version 2 showed the highest number of pupae and adult mosquitoes, indicating superior trapping efficiency. Both tested versions of the mosquito-trapping plant pot were also designed to enhance soil moisture using cotton rope. However, the soil moisture levels did not significantly differ at the 0.05 significance level. Regarding the effectiveness of different light colors in attracting mosquitoes in Version 2, the results showed a significant difference at the 0.05 level, with purple light being the most attractive to mosquitoes. This innovation is expected to contribute to mosquito population control while promoting plant growth, providing useful data for developing control measures and monitoring strategies in areas at risk of mosquito-borne diseases.

Keywords: Mosquito trap; Plant pot; Mosquitoes.

Research Questions

1. Can the developed innovation effectively trap or attract mosquitoes to lay eggs?
2. Can the developed innovation reduce water consumption for plant irrigation?

Hypothesis

1. The mosquito-trapping plant pot can effectively trap Aedes mosquitoes and help prevent their spread.
2. The mosquito-trapping plant pot and the color of light influence mosquito attraction.
3. The mosquito-trapping plant pot can reduce water usage for plant irrigation.

Introduction

GLOBE (Global Learning and Observations to Benefit the Environment) is an international program that encourages young people and scientists around the world to engage in environmental studies through the collection and analysis of real-world data, involving students, researchers, and the general public. For over 30 years, the program has promoted learning through observation and citizen science to gain a deeper understanding of local environmental issues. One of GLOBE's key areas of focus is the study and monitoring of mosquito populations, which are vectors of diseases, particularly dengue fever, malaria, and Zika virus. The GLOBE Mosquito Habitat Mapper is a tool that helps people identify and record mosquito breeding sites in their communities. The data can be used to study and analyze trends in the spread of mosquito-borne diseases, which can help to develop effective disease control and prevention measures. Thailand, located in a tropical region, faces a high risk of mosquito-borne diseases, including dengue fever, which is transmitted by Aedes mosquitoes. The life cycle of mosquitoes consists of four stages: egg, larva, pupa, and adult. Aedes mosquitoes lay eggs on the inner walls of water containers just above the water surface. The larvae hatch when submerged in water, develop into pupae, and eventually emerge as adult mosquitoes. Male mosquitoes feed on nectar, whereas females require blood meals from humans or warm-blooded animals to obtain protein for egg production. A single female mosquito can lay approximately 100 eggs per cycle and reproduce up to seven times in its lifetime (Usawadee, 2010).

A field study conducted in Trang Province (Kanyakorn, 2023) investigated Aedes larval prevalence in two districts, Hat Samran and Mueang Trang, by collecting data from 24 households. The study identified three mosquito larvae species: Aedes (dengue vector), Culex (nuisance mosquitoes), and Toxorhynchites (predatory mosquitoes). The most common mosquito breeding site was plant pot saucers, followed by plastic containers and discarded waste. The Aedes larval index values (House Index (HI) at 83.33%, Container Index (CI) at 62.58%, and Breteau Index (BI) at 510.00) were all significantly higher than the World Health Organization (WHO, 2009) threshold, indicating a high risk of dengue outbreak in the province.

In response to this issue, the research team aimed to develop an innovation that can attract mosquitoes to lay eggs while conserving water and supporting plant growth in drought-prone environments. The mosquito-trapping plant pot serves a dual purpose: as a household decoration and as a tool to reduce mosquito populations. Previous research explored mosquito-trapping mechanisms based on the mosquito's natural oviposition behavior, particularly their tendency to lay eggs in water-containing plant saucers. The innovation was further enhanced by integrating light to attract mosquitoes into the trap.

This project was inspired by the Lethal Ovitrap developed by the Department of Medical Sciences, which utilizes a black, small jar-like container with a covered top and openings that allow mosquitoes to enter and lay eggs. The trap also includes drainage holes to maintain water levels (Public Health Science Research Institute, 2018). A study conducted in Florida, USA, and Australia found that Aedes mosquitoes are most attracted to black surfaces (Hoel DF, 2011). Therefore, the mosquito-trapping plant pot was designed using black plastic to maximize its effectiveness in attracting mosquitoes.

Materials

Materials for the Creation and Development of the Innovation

1. SketchUp software
2. 3D Printer
3. Ultimaker PC (Polycarbonate) 2.85 mm
4. Black canvas fabric
5. Stiff round cotton rope/ Stiff cotton rope
6. 3mm LED GB light

Equipment for Testing and Data Collection

1. Microscope with 40x magnification
2. 70% Alcohol
3. Dropper
4. Slide glass
5. Thermometer
6. Hygrometer
7. Lux meter
8. Soil moisture meter

Methods

1. Mosquito data collection

Explore the mosquito breeding sites in different areas. Especially in areas with high humidity, both indoors and outdoors, and in shaded areas under trees or in the garden at the study site. Collect mosquito larvae data using Mosquito habitat mapper App, to determine the prevalence of *Aedes* mosquitoes and find an area for trapping mosquito eggs.

Data are collected by conducting Land Cover to take photos of the landscape, identify types of land cover (such as trees, grass, etc.), and compare their observations with satellite data.

2. Design and Development of the Mosquito-Trapping Plant Pot

1) Survey mosquito breeding sites in various areas, focusing on locations with high humidity, both indoors and outdoors, as well as shaded areas under trees or in gardens within the study area, to determine the prevalence of Aedes mosquitoes and identify potential areas for egg trapping.
2) Study the structure of the prototype plant pot to be developed.
3) Research methods and solutions for addressing the mosquito issue.
4) Design the initial draft of the mosquito-trapping plant pot using SketchUp software (Version 1 of the mosquito-trapping plant pot).

3. Testing the Effectiveness of Mosquito-Trapping Plant Pot Version 1

Place three mosquito-trapping plant pots (Version 1) from Experiment 1 in the school area, each planted with the same type of plant, for a duration of 2 weeks. Measure soil moisture, temperature, relative humidity, and light in the experimental area daily.

Count the number of mosquitoes in each pot and examine them at different stages of the mosquito life cycle using a microscope with 40x magnification.

4. Analyze Test Results and Improve the Mosquito-Trapping Plant Pot

Identify weaknesses in Version 1 and make improvements to develop Version 2 of the mosquito-trapping plant pot.

5. Testing the Effectiveness and Soil Moisture of Mosquito-Trapping Plant Pot Version 1 and 2

Place three mosquito-trapping plant pots of both Version 1 and Version 2 in the school area, each planted with the same type of plant, for a duration of 2 weeks. Measure soil moisture, temperature, relative humidity, and light in the experimental area daily. Count the number of mosquitoes in each pot and examine them at different stages of the mosquito life cycle using a microscope with 40x magnification.

6. Studying the Effectiveness of Light Color in Attracting Mosquitoes

Place three of the most effective mosquito trapping plant pots, each with a different light color including purple, green, and blue, in the same location. Plant the same type of plant in each pot and leave them for 2 weeks. Count the number of mosquitoes in each pot and observe the growth stages of the mosquitoes using a microscope with 40x magnification.

7. Analysis of Experimental Results

Analyze the collected data and present the results in tables and graphs using Microsoft Excel for data analysis, as follows:

1. Analyze the effectiveness of different light colors on mosquito attraction using ANOVA.
2. Analyze the soil moisture levels using ANOVA.

Results

Section 1: Development and Innovation Creation

1. **Results of the Creation and Effectiveness Testing of the Mosquito-Trapping Plant Pot Version 1**

The study on the creation and testing of the mosquito-trapping plant pot version 1 revealed that one key factor that could enhance the effectiveness of the pot is increasing the mosquito egg-laying area. By removing the mesh in the mosquito-trapping section, as mosquitoes tend to lay their eggs on the water surface, this change facilitated more egg-laying. Additionally, a drainage area was designed on the side to increase the water surface area.

The mosquito-trapping plant pot consists of two sections: the upper part for planting and the lower part for trapping mosquitoes. The mosquito entry points were designed as cone-shaped openings, each with a diameter of 1.5 cm, placed in four locations around the pot. A rectangular drainage hole, measuring 0.5x1 cm, was positioned below the mosquito entry points. Additionally, a hole with a diameter of 0.8 cm was made between the upper planting section and the lower mosquito-trapping section. A 10 cm long cotton rope was inserted to act as a water-absorbing material.

The pot was created using a 3D printer with PLA plastic to ensure durability. Its effectiveness was then tested by placing it in the school area for two weeks, with a pineapple plant grown inside. Pineapple plants thrive in humid but not overly wet conditions, and the pot must be able to retain moisture effectively.

Furthermore, this version of the mosquito-trapping pot was improved by adding stiff cotton rope between the soil in the plant section and the water in the mosquito-trapping section. This modification helped the water to be absorbed via the rope, improving water retention and promoting the plant's growth. This feature also enabled water conservation, supporting plant growth even in environments with water scarcity or high temperatures.

The images below (Figures 1 and 2) illustrate the design and structure of the mosquito-trapping plant pot.

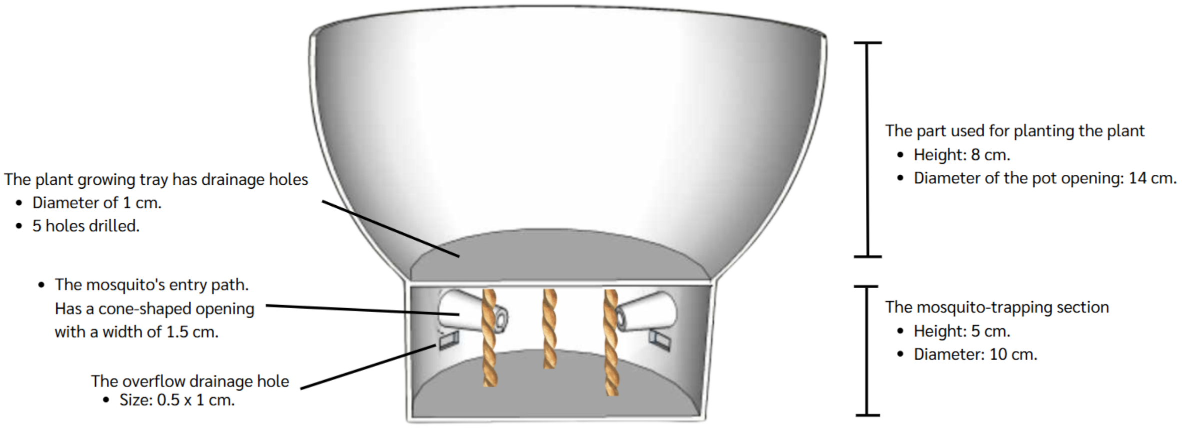

Figure 1 shows the draft design of the mosquito-trapping plant pot Version 1.

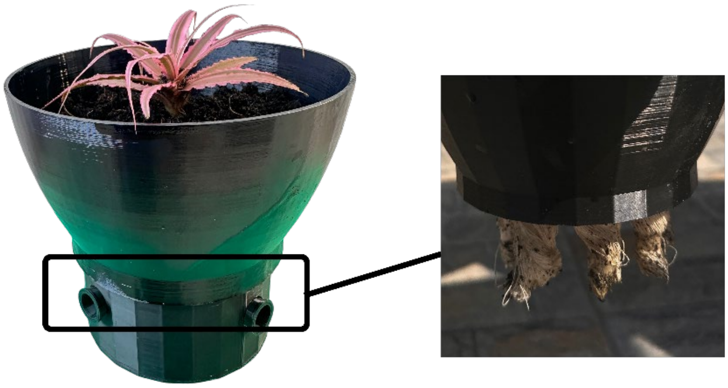

Figure 2 shows the mosquito-trapping plant pot Version 1.

2. Results of the Development and Effectiveness Testing of the Mosquito-Trapping Plant Pot Version 2

Based on the findings from the previous version, improvements were made as follows: it was observed that mosquitoes, particularly Aedes mosquitoes, are attracted to black fabric and moist surfaces. Therefore, the mosquito entry points were redesigned as rectangular openings, each measuring 3.5x1 cm, with 6 entry points in total. Black canvas fabric was attached around these entry points to further attract mosquitoes. A rectangular drainage hole, measuring 0.5x1 cm, was placed below the mosquito entry points.

After the modifications, the new version of the mosquito-trapping plant pot was tested for its effectiveness by placing it in the school area for 2 weeks. The same type of plant, a pineapple plant, was used in this test, just as in the previous test with version 1. The following images (Figures 3 and 4) illustrate the design and structure of the improved mosquito-trapping plant pot version 2.

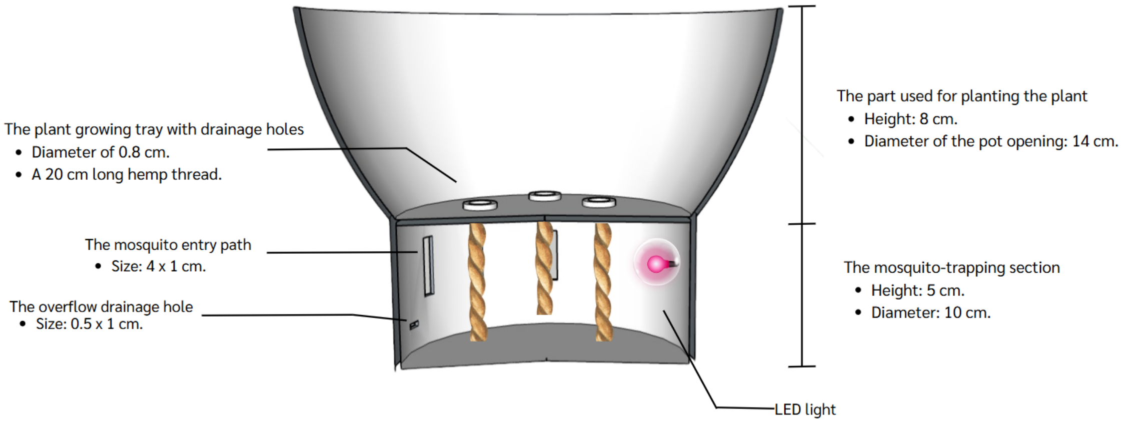

Figure 3 shows the design of the mosquito-trapping plant pot Version 2.

Figure 4 shows the mosquito-trapping plant pot Version 2.

3. Comparative results of the effectiveness of mosquito trapping plant pots

1. Results of the Comparison of Mosquito-Trapping Plant Pot Effectiveness

The comparison of the effectiveness of the mosquito-trapping plant pots was conducted by placing each version of the plant pot in the school area for 2 weeks, from December 2024 to January 2025. The results of the number of mosquitoes found at different life stages in each version of the plant pot are presented in Table 1 below.

Table 1: Number of Aedes Mosquitoes Found at Different Life Stages in Each Version of the Mosquito-Trapping Plant Pot

Pot Version	**Mosquito Count**			
	Eggs	Larvae	Pupae	Adults
Prototype	0	27	8	3
version 1	0	33.33 ± 1.25	10.67 ± 2.05	4 ± 0.82
version 2	0	36.33 ± 2.87	12.67 ± 2.50	6.67 ± 1.25

Section 2: Results of Weather Study

The weather study results between December 2024 and January 2025 at the school, which could affect the factors influencing mosquito breeding, are shown in Table 2.

Table 2: Weather Data for December 2024 - January 2025

Weather Data	December 2024	January 2025
Air Temperature (°C)	34 ± 0.35	32 ± 0.67
Relative Humidity (%)	77 ± 1.23	89 ± 0.84
Light Intensity (Lux)	100 ± 35	100 ± 38

Section 3: Results of Soil Moisture Study

The results of the analysis of soil moisture over a 2-week period, during which mosquito life cycle data were collected, showed that the soil moisture values in both Version 1 and Version 2 of the mosquito-catching pots did not significantly differ at the 0.05 level. This is illustrated in Figure 5.

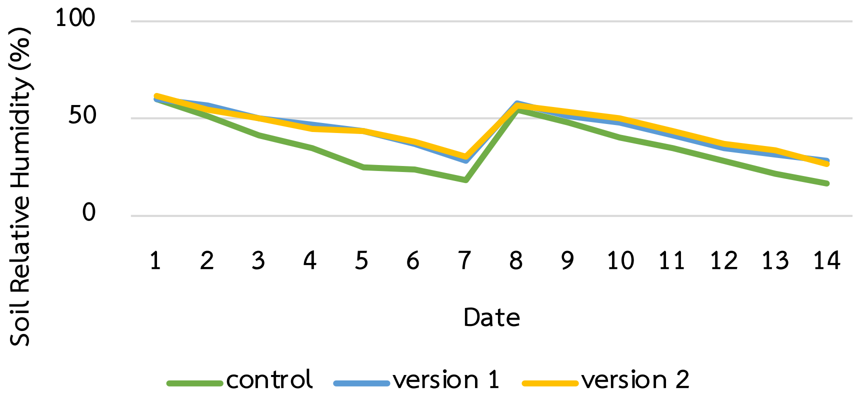

Figure 5 Graph showing the soil moisture in the pots of version 1 and version 2.

Section 4: Study of Light Color Effectiveness in Attracting Mosquitoes

The study on the effectiveness of light colors in attracting mosquitoes in Version 2 of the mosquito-catching plant pots over a 2-week period, during which mosquito life cycle data were collected, showed that the effectiveness of each light color significantly differed at the 0.05 level. This is illustrated in Figure 6.

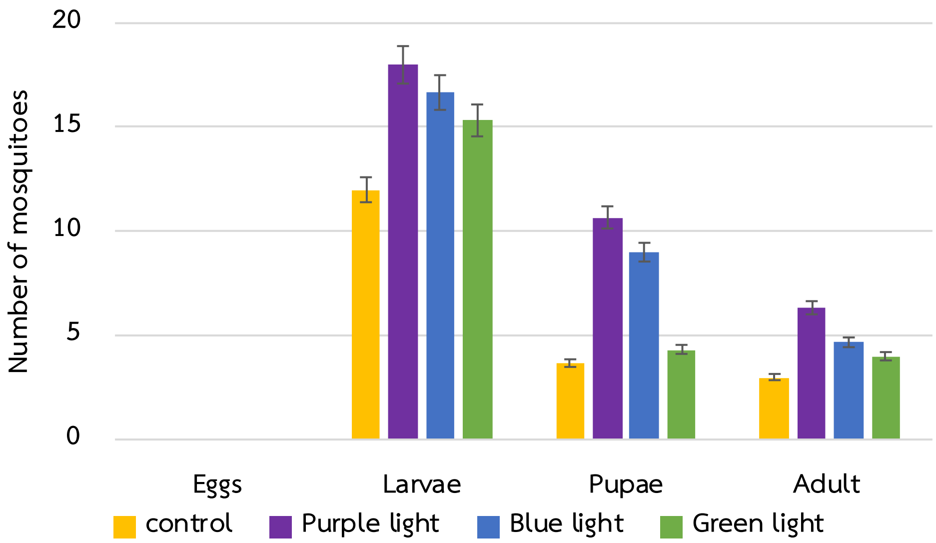

Figure 6: A graph showing the effect of light color on mosquito attraction.

Discussion and Conclusions

Summary of Experimental Results

The study and evaluation of the effectiveness of the mosquito-trapping plant pots revealed that the development of each version impacted both mosquito trapping and the increase in mosquito populations during the experimental periods. Initially, the prototype pot was able to trap 27 mosquito larvae, 8 pupae, and 3 adult mosquitoes. The results obtained from this trial provided critical data that contributed to the refinement and enhancement of the mosquito-trapping plant pot in subsequent versions. This process involved considering various factors, such as the egg-laying rate of mosquitoes, the structural design of the pot to increase trapping efficiency, and other elements that might influence mosquito behavior, including egg-laying and larval development.

In version 1 of the mosquito-trapping plant pot, the design aimed to improve mosquito trapping efficiency by eliminating the mesh to expand the water surface area for egg-laying. Additionally, mosquito entry points were modified to be cone-shaped openings, with four openings arranged around the pot. Drainage holes were positioned at the bottom of the pot to facilitate water flow. After a two-week testing period, the number of mosquito larvae increased to 33, accompanied by 11 pupae and 4 adult mosquitoes. These findings demonstrated that the design modifications had a positive impact on the rate of mosquito egg-laying and subsequent trapping efficiency.

In version 2 of the mosquito-trapping plant pot underwent further refinement, where the mosquito entry points were expanded to larger rectangular openings. Additionally, black burlap was added around the entry points to attract mosquitoes, as studies have shown that Aedes mosquitoes are particularly attracted to the color black and environments with high humidity. The performance of this version was tested for two weeks, during which it trapped 36 mosquito larvae, 13 pupae, and 7 adult mosquitoes. These results indicated a significant improvement in mosquito trapping efficiency, with a statistically significant difference at the 0.05 significance level. Moreover, the study on the impact of different light colors on mosquito attraction over a two-week period revealed that purple and blue lights attracted more mosquitoes compared to the control group and green light. There was a noticeable increase in the number of mosquito larvae, pupae, and adult mosquitoes when purple and blue lights were used. Furthermore, upon monitoring the growth stages of mosquitoes, it was observed that the purple light group yielded the highest number of mosquito larvae, followed by the blue and green light groups, respectively. This trend persisted through the pupae and adult mosquito stages, suggesting that purple and blue light were more effective in attracting mosquitoes than green light or no light at all. These findings underscore the efficacy of purple and blue light in mosquito attraction, providing valuable insight for future mosquito control strategies.

Upon comparing all three versions, version 2 demonstrated the highest number of pupae and adult mosquitoes, indicating its superior ability to trap mosquitoes. However, version 1 exhibited a higher number of mosquito larvae compared to the other versions, which may be attributed to its design, which facilitated a larger surface area for mosquito egg-laying. Thus, combining the advantages from both versions could further enhance the efficiency of the mosquito-trapping plant pot.

Both versions of the mosquito-trapping plant pot were designed to optimize soil moisture retention through the use of cotton rope. However, no significant difference in soil moisture levels was observed between the two versions at the 0.05 significance level.

Discussion of the Experimental Results

The development of the mosquito-trapping plant pot in each version reflects efforts to improve mosquito trapping efficiency based on an understanding of the behavior of Aedes aegypti mosquitoes. Studies show that *Aedes aegypti* mosquitoes tend to lay eggs in calm and clean water sources. The modification of version 1 by removing the mesh to increase the water surface area for egg-laying aligns with this behavior, which may explain the increase in mosquito larvae compared to the prototype pot.

In version 2, further improvements were made by adding mosquito entry points and attaching black cloth around the entry areas. This is consistent with research by Ursula Benz in 2024, which found that mosquitoes, particularly under nighttime conditions with light, are more attracted to black targets than white ones. This research suggests that *Aedes aegypti* mosquitoes are drawn to black and high-humidity areas. Therefore, the use of black cloth with moisture may have contributed to attracting more mosquitoes to lay eggs, resulting in a higher number of pupae and adult mosquitoes.

After completing the experiment, the mosquito-trapping plant pots were distributed to 20 local residents for real-world use, and feedback was gathered as follows:

1. Location of the plant pots : 15% used the pots indoors, 65% used them outdoors, and 20% used them both indoors and outdoors.

2. Usage Frequency: 80% of users used the mosquito-trapping plant pots daily, 35% used them weekly, and 5% used them monthly.

3. Convenience : 70% rated the ease of use as excellent, 20% rated it as good, and 10% rated it as average.

4. Effectiveness: 75% rated the effectiveness as excellent, 20% rated it as good, and 5% rated it as average.

The survey results show that both the convenience and effectiveness of the plant pots were rated positively, indicating high satisfaction from actual users.

However, the addition of more mosquito entry points and the use of mosquito-attracting materials may increase the complexity of production and the associated costs. Additionally, all three versions of the mosquito-trapping plant pot were designed to enhance soil moisture retention through the use of cotton rope, allowing water to be absorbed into the soil. This is consistent with the 2015 study by Victoria Vitale, which indicated that wicks release water into the soil at an appropriate rate according to the soil's moisture level and stop releasing water when the soil becomes sufficiently moist. This ensures that the plant receives a consistent water supply without requiring frequent watering. The fish trap is a local innovation that is widely used in catching fish. Once the fish swim into the trap, they cannot swim out. It is similar to and works in accordance with the function of the mosquito entrance funnel, which means that once the mosquitoes enter, they cannot fly out.

Therefore, future developments of mosquito-trapping plant pots should strike a balance between mosquito trapping efficiency and production cost-effectiveness, as well as consider the potential environmental impact and safety for humans.

Recommendation

Combining the advantages of version 1 and version 2 may enhance the effectiveness of the mosquito-trapping plant pot in the future.

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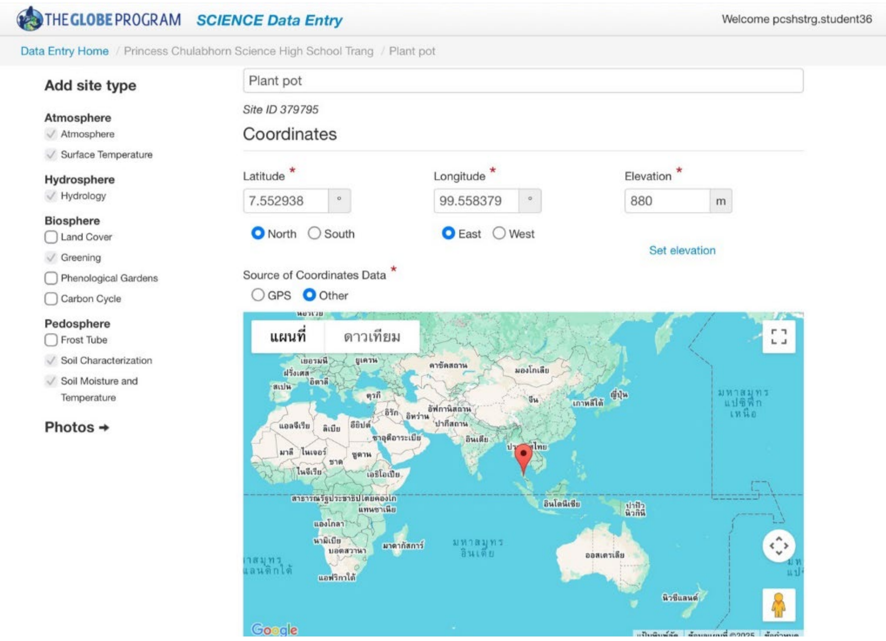
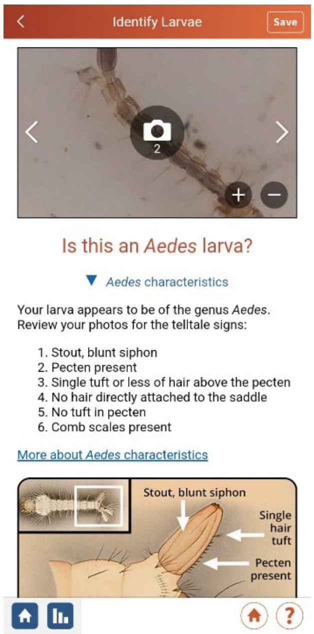
GLOBE's databases





(Optional) Badges (3 Badges)

1) I AM A DATA SCIENTIST

The Development of plant pots to mitigate mosquito populations project and the GLOBE program both focus on using data collection and analysis to address environmental issues. In the plant pot project, data on mosquito attraction and trap effectiveness was gathered, revealing that purple light attracted the most mosquitoes. There are encourages to collect and analyze environmental data, organize it into clear tables and graphs, and use statistical analysis to draw conclusions. This project emphasizes discussing results, identifying data limitations, and suggesting future research directions. Ultimately, it demonstrates how citizen science can contribute to solving real-world problems, such as controlling mosquito populations and understanding environmental impacts.

2) I AM AN ENGINEER

The Development of plant pots to mitigate mosquito populations project aligns well with the requirement of evidence to address an engineering problem, explore solutions, and describe the potential impact on the environment. In this project, the problem of mosquito-borne diseases is tackled by developing a plant pot that traps mosquitoes while reducing water usage. The design is based on mosquito oviposition behavior and includes features such as a water reservoir and a trap lined with black felt fabric, mimicking conditions that attract mosquitoes. The project focuses on optimizing the design of the plant pot to trap mosquitoes effectively, which is a direct engineering solution to a real-world problem. The study of how light colors (blue, purple, and green) affect mosquito attraction also explores a potential improvement to the design, with purple light proving to be the most attractive to mosquitoes. Additionally, the project contributes to the environment by promoting plant growth while simultaneously controlling mosquito populations. The design enhances soil moisture using a cotton rope, allowing for water absorption that sustains plant growth in drought or high-temperature conditions. This innovation supports environmental sustainability by reducing water usage and mitigating the spread of mosquito-borne diseases, demonstrating the positive impact of engineering principles on both health and the environment.

3) I MAKE AN IMPACT

The Development of plant pots to mitigate mosquito populations project directly addresses a local issue—mosquito-borne diseases like dengue fever, which are a significant concern in many regions, particularly in areas with warm and humid climates. The research begins by focusing on the behavior of mosquitoes, specifically their tendency to lay eggs in standing water, which is commonly found in household environments. This local issue led to the development of the mosquito-trapping plant pot, which serves as an innovative solution to control mosquito populations while simultaneously promoting plant growth. The findings of the research, particularly the effectiveness of purple light in attracting mosquitoes, offer actionable insights that can have a direct, positive impact on local communities. By reducing mosquito populations, the project contributes to disease prevention and enhances public health. Furthermore, the innovative design of the plant pot, which minimizes water wastage and supports plant growth, provides a sustainable solution to common problems faced in households. This project also highlights the connection between local and global impacts, as mosquito-borne diseases are a global concern. The approach taken by the students can be scaled and adapted to other regions at risk of these diseases. The research, based on local observations and testing, can contribute to broader strategies for controlling mosquito populations in communities worldwide. Thus, the project not only addresses a local problem but also provides valuable recommendations from a survey of villagers in communities who have actually tried using this innovation for improving mosquito control measures on a larger scale.