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The Effects of Emulsified Neem Oil as an Alternative Disinfectant Compared with Chlorine in Disinfecting Coliform Bacteria on Water Samples from Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga

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Abstract:

The purpose of this study is to evaluate the effectiveness of emulsified neem oil as an alternative disinfectant to chlorine in reducing coliform bacteria in water samples from Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga. This area suffers from significant water quality issues, with high levels of total coliform and fecal coliform bacteria posing serious health risks to the local population. The study aims to address this problem by investigating whether emulsified neem oil can serve as a safer, yet effective, alternative to chlorine for water disinfection. The study utilized a comparative experimental design, with water samples collected from river. These samples were analyzed for coliform bacteria using the SMEWW 9221 B standards. Initial antimicrobial tests confirmed that emulsified neem oil and chlorine were effective against Escherichia coli, a coliform bacteria indicator. However, while chlorine effectively disinfected the water samples, emulsified neem oil alone did not meet the disinfection standards. To explore a more effective solution, the researchers came up with a new disinfectant that combined emulsified neem oil and chlorine in varying ratios (C-1, C-2, and C-3). Multiple tube fermentation tests (MTFT) showed that the combined disinfectant at a dosage of 1 mL was effective in reducing coliform bacteria to acceptable levels, which was consistent with the successful chlorine dosage of CL-1. The study's primary finding is that, while emulsified neem oil alone is insufficient for effective water disinfection, its combination with chlorine shows significant potential as a viable water treatment solution. This combined approach improves both safety and practicality, providing a potential alternative to high chlorine dosages, which can be dangerous. In conclusion, the combination of emulsified neem oil and chlorine shows potential for improving water quality in Sitio Camachile. Further study is needed to optimize the dosage ratios and ensure the method's scalability and sustainability for broader application, resulting in improved public health outcomes and water safety in communities facing similar challenges.

Keywords — **Emulsified Neem Oil, Chlorine, Disinfection, Water Quality**

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I. INTRODUCTION

The water treatment industry is driven by the need for sustainable and eco-friendly solutions to ensure the safety and quality of drinking water. The use of disinfectants, such as chlorine, has been a cornerstone of water treatment, but concerns about environmental and health impacts have led to a search for alternative approaches. Neem oil, derived from the neem tree (Azadirachta indica), has a rich history of medical use and is known for its natural antibacterial properties, making it a promising alternative to chlorine. This study aims to investigate whether emulsified neem oil can serve

as a viable alternative to chlorine in the context of disinfection of coliform bacteria on a selected community. The importance of water treatment cannot be overstated, as microbes in raw water can cause a range of illnesses, from self-limiting diarrhea to more serious conditions like meningitis and even fatalities. Public health may be at risk if human enteric viral viruses are found in sources of drinking water, highlighting the need for effective disinfection methods. The use of disinfectants, such as chlorine, has been a cornerstone of water treatment, but concerns about environmental and health impacts have led to a search for alternative approaches. This study aims to investigate whether emulsified neem oil can serve as a viable alternative to chlorine in the context of disinfection of coliform bacteria on a selected community.

A. Review of Related Literature and Studies

The water treatment industry is driven by evolving environmental and health regulations, necessitating the development of decision support systems. These systems play a crucial role in guiding the selection of appropriate treatment processes. A methodical approach for crafting decision support systems involves analyzing treatment challenges, knowledge acquisition and representation, and identifying and assessing criteria for optimal treatment system choice. [1]

Chlorine is the most commonly used disinfectant in water supply systems in the United States. Chlorine disinfection can achieve a bacterial annihilation rate higher than 99.9%, depending on the specific chlorine species present. UV/chlorine disinfection stands out for its improved effectiveness and energy savings, but its usefulness is limited by the generation of potentially hazardous byproducts. [2]

Neem (Azadirachta indica) is an evergreen tree with incredible health-promoting properties. It has been used for centuries in traditional medicine and has been found to have antioxidant, anti-inflammatory, and antimicrobial properties. Neem oil is used as an insecticide, fungicide, and antifertility agent, and is also used in water treatment and purification due to its ability to remove impurities and contaminants. [3]

Escherichia coli (E. coli) is a common bacterium that is frequently used as a sentinel in research on antibiotic resistance. E. coli is a gram-negative, oxygen-negative, and non-sporulating bacterium that can ferment lactose to produce acid and gas within a certain temperature range. It is often used as an indicator of contamination in fresh and marine water quality. [4]

Plant extracts can be applied as a bacterial infection treatment. Plants contain various molecules that can protect the human body from infections, making them potential sources of antioxidant and antimicrobial properties. The agar disk diffusion method was used to determine the potential of various plant species as a substitute antibacterial agent. [5]

A two-year monitoring study of two drinking water reservoirs found a significant increase in coliform bacteria during summer months, reaching up to 2.4 × 104 bacteria per 100 ml. The dominant species were Enterobacter asburiae and Lelliottia spp. The study concluded that the surge in coliform bacteria is an autochthonous process, resembling a "coliform bloom" within the reservoir. [6]

Untreated water can contain various bacteria, including fecal indicator bacteria. The effect of chlorine disinfection on different groups of bacteria, including fecal indicator bacteria, was determined. The results suggest that disinfected water would pass current regulatory standards for drinking water microbial quality. [7]

The study highlights the widespread occurrence of health-based violations in drinking water quality across the United States, posing a risk to public health. The absence of a systematic procedure for selecting systems for additional inspection and monitoring is identified as a challenge for state enforcement agencies. The study recommends strategies for improving national drinking water quality and addressing clustered violations in certain regions. [8]

B. Gap Analysis

The water treatment industry is undergoing significant changes in response to evolving environmental and health regulations, necessitating the development of decision support systems to

guide treatment selection and design. These systems must be integrated, user-friendly, and technologically advanced to effectively address the challenges posed by wastewater discharge and the need for safe drinking water. Various treatment methods, including UV/chlorine disinfection and activated sludge systems, have their benefits and limitations. The use of neem tree extracts in water purification may offer health benefits. A study explores the potential of neem oil as an environmentally friendly alternative to chlorine for disinfecting coliform bacteria, aligning with the imperative for sustainable water treatment solutions. The study aims to determine the effectiveness of emulsified neem oil in disinfecting coliform bacteria, providing a thorough analysis of current water treatment techniques and highlighting the risks associated with wastewater release. The historical background of water treatment and the dangers of waterborne illnesses are also discussed, with neem oil emerging as a promising substitute for conventional disinfection methods.

C. Statement of Problem

The study aims to investigate the specific impact of emulsified neem oil and chlorine as disinfectants in water, focusing on three main research questions. It seeks to determine whether emulsified neem oil is effective against Escherichia coli when tested using the agar disk diffusion method, if emulsified neem oil requires a lesser dose than chlorine to disinfect coliform bacteria, and whether the combined agents meet disinfection standards if it does not. Additionally, the study evaluates the effectiveness of emulsified neem oil in disinfecting water samples from Barangay Nabuclod compared to chlorine alone, using the Water Coliform Count as a measure.

D. Objectives

The general objective of the study is to test the effectiveness of emulsified neem oil as an alternative disinfectant compared with chlorine in disinfection of coliform bacteria. The specific objectives of the study are:

1. To determine if the emulsified neem oil is effective against Coliform bacteria such as Escherichia coli on agar disk diffusion method;
2. To determine the optimal dosage of emulsified neem oil on a specific volume of water needed to disinfect Coliform bacteria if emulsified neem oil failed then to determine if combined agents at different concentrations can pass the standards; and
3. To determine the effects of emulsified neem oil as a disinfectant on water sample from Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga.

E. Scope and Limitations

This study aims to assess the antimicrobial efficacy of Emulsified Neem oil in comparison to Chlorine, specifically targeting Coliform Bacteria. The scope involves controlled laboratory experiments that imitate water treatment conditions in order to evaluate the disinfectant properties of emulsified neem oil, considering factors such as microbial reduction. However, this study is delimited to the selected pathogens and does not encompass a comprehensive analysis of all waterborne microorganisms. It is also delimited to testing using agar disk diffusion method in which the test results only consider if the Emulsified Neem oil is effective against Escherichia coli. The outcome of the Escherichia coli test will be considered as the comprehensive result for the presence of antibacterial of the emulsified neem oil. Also, it does not include the testing regarding the color, odor, taste, safety for ingestion, and pH level of Emulsified Neem oil added on water. For the disinfection of the water sample brought from Nabuclod, it will only undergo Water Coliform Count to obtain if the said emulsified neem oil is effective as an alternative disinfectant.

II. METHODS

F. Data Collection

The researchers of the study collected 175 grams of Neem leaves from Dizon Estate, San Agustin, City of San Fernando, Pampanga. The collected leaves were brought to the Bureau of Plant Industry in 3M75+P6M, Diosdado Macapagal Gov. Center,

San Fernando 2000, Pampanga for verification and authentication. The researchers bought chlorine and emulsifying agents such as soy lecithin obtained from commercial stores. Water samples were obtained from Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga. In making neem oil, the first step is gathering fresh neem leaves from the neem tree, second step is spread the neem leaves in a sunny and dry spot and let them dry completely, third step is pulverized the neem leaves using electric blender, it should be finely grind to increase its potential and to harness its antibacterial activity, fourth step is heat the coconut oil with low fire before adding the dry fine neem leaves to help optimize the extraction process, fifth step is weigh the dry neem leaves, specifically, 175 grams to ensure accuracy in the extraction process, sixth step is put the fine neem leaves along with the coconut oil with a rough ratio of 1:3, to ensure that the concentration of neem leaves is high, seventh step is stir the mixture to ensure thorough mixing of dry fine neem leaves with the preheated coconut oil, eighth step is weigh the emulsifying agent, specifically, soy lecithin, its amount should be based on the 3% of the coconut oil used because it is a good starting point for creating a stable emulsion, ninth step is put the emulsifying agent which is the soy lecithin in the mixture and give it a nice stir to combine all the components and to avoid burn, tenth step is simmer the neem oil, with low heat, wait for about 30 minutes to enhance the infusion and enhance extraction efficiency, after that let it cool, eleventh step is filtered the residue, using a strainer or cloth, pour the extracted neem oil to remove the remaining solid, ensuring purity, twelfth step is store the extracted neem oil, put the neem oil in a clean, dry, and airtight container ensuring that it will not be exposed to sunlight to prevent degradation and keep it in a cool and dry place. For the collection of water samples, the first step is the preparation of sampling equipment, visit the testing laboratory and acquire sterilized 100 mL sampling bottles. These bottles should be made of high- quality, non-reactive plastic, or glass, with secure, leak-proof caps. Each bottle should be labeled for sample identification and have a capacity of exactly 100 mL to ensure accurate measurements. The second step is, identify sampling locations, determine the specific location in Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga, where water samples will be collected. Third step is the collection of water samples, simply submerge the bottle below the water surface and fill the bottle to the 100 mL mark, ensuring no bubbles are trapped inside. Fourth step is, apply water treatment, divide water samples into groups with emulsified neem oil treatment and chlorine treatment, combined emulsified neem oil and chlorine treatment, and without treatment. Fifth step is, label each bottle immediately after collection and treatment. Tightly seal the bottle with its cap to prevent contamination. Sixth step is transport samples to laboratory, place the collected samples in a cooler with ice packs to maintain a temperature during transport. For the last step, submit samples for analysis, upon arrival at the laboratory, submit the samples and ensure the

laboratory personnel are informed of the specific test to be conducted, such as coliform and fecal coliform analysis following the SMEWW 9221 B

standard.

G. Data Analysis

The results of an antimicrobial test from the laboratory of a study were used and adopted to determine the effectiveness of the Emulsified Neem oil against Escherichia coli where it was shown that 10% concentration on the said method effectively inhibited the bacterial growth of E. coli [28]. The researchers can use the emulsified neem oil as a treatment for water for microbiological tests, which will be compared to chlorine containing 10% concentration that was tested through the laboratory of F.A.S.T Laboratories found in Angeles, Pampanga. The test result will be in qualitative form, either Positive or Negative. To determine the optimal dosage of treatment, the researchers will be using three dosages of treatment for chlorine and emulsified neem oil. The three dosages in terms of mL are 1 mL, 5 mL, and 10 mL. From these dosages, the optimal dosage will be analyzed by observation of the results on the water coliform count, and the least dosage will be the optimal dosage. If the optimal dosage for emulsified neem

oil is deemed to be unidentified then the researchers will combine the emulsified neem oil and chlorine in different concentrations which will be based on the optimal dosage of the passed chlorine sample. In DAO 2016-08 or DENR Administrative Order No. 2016-08, the researchers can also determine what water body classification it has [30]. The test results from the water coliform count will be analyzed based on the "Philippine National Standards for Drinking Water of 2017" [31]. The purpose of the water sample from Barangay Nabuclod is for public water supply and since Escherichia coli is an indicator for fecal contamination for freshwater, the water sample must have less than 1.1 MPN per 100 mL to assume that it can be potable water using multiple tube fermentation test based on the Philippine National Standards for Drinking Water of 2017.

III. RESULTS AND DISCUSSION

Based on the study adopted, the emulsified neem oil had a 10% concentration on the disk diffusion method 10.2 mm inhibition zones while from the laboratory test, chlorine having the same concentration resulted in 13mm inhibition zones.

TABLE 4. AGAR DISK DIFFUSION METHOD

Sample Description	Antimicrobial Property Determination		
	Test Organism	Zone of Inhibition	Antimicrobial Property
Emulsified Neem Oil	*E. coli*	10.2 mm	Positive
Chlorine	*E. coli*	13mm	Positive
Test Method	Disk Diffusion Method		

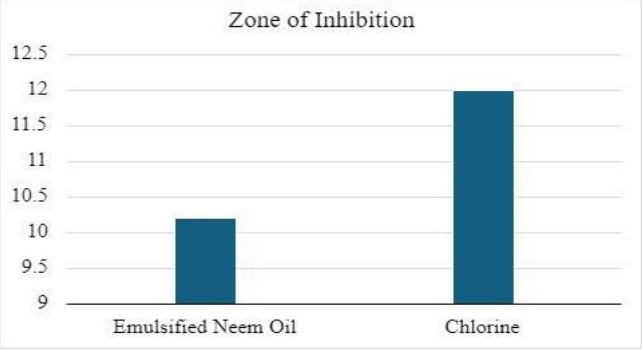

Fig. 1 Agar Disk Diffusion Method

From the laboratory test result obtained in Aqua laboratory for the control group no treatment, the analysis of raw water obtained from Sitio Camachile, Barangay Nabuclod, Floridablanca resulted in 79,000 MPN/100mL for the Total Coliform Count while the analysis of the sample in the Fecal Coliform Count resulted in a 49,000 MPN/100mL.

Table 5. Analysis of Raw Water

Parameters	Method Reference	Unit	Results
Total Coliform	SMEWW 9221 B	MPN/100mL	79,000
Fecal Coliform	SMEWW 9221 B	MPN/100mL	49,000

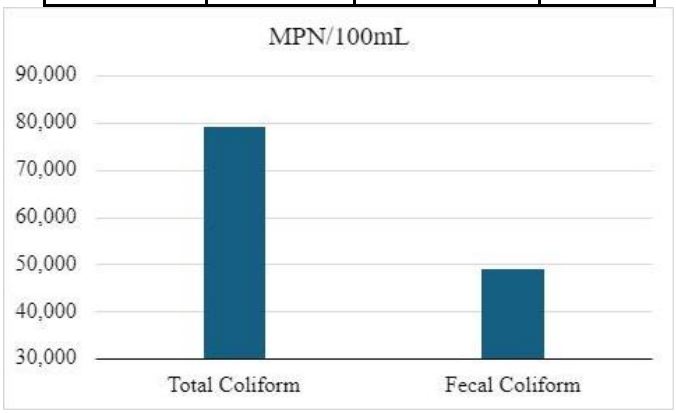

Fig. 2 Analysis of Raw Water

From the laboratorytest result in Aqualab for the experimental group of Emulsified Neem Oil and Chlorine, the total water coliform count resulted in terms of MPN/100mL, >8.0 for ENO-1, ENO-2, and ENO-3 while <1.1 on CL-1, CL-2 and CL-3.

Table 6. Total Water Coliform Count Using Multiple Tube Fermentation

Sample Name	Dosage	Unit	Standards	Results	Remarks
ENO-1	1Ml	MPN/100mL	< 1.1	> 8.0	FAILED
ENO-2	5Ml	MPN/100mL	< 1.1	> 8.0	FAILED
ENO-3	10mL	MPN/100mL	< 1.1	> 8.0	FAILED
CL-1	1mL	MPN/100mL	< 1.1	< 1.1	PASSED
CL-2	5Ml	MPN/100mL	< 1.1	< 1.1	PASSED
CL-3	10Ml	MPN/100mL	< 1.1	< 1.1	PASSED

From the laboratory test result in Aqualab for the experimental group of Emulsified Neem Oil and Chlorine, the thermotolerant (fecal) coliform count resultedin terms of MPN/100mL, >8.0 for ENO-1, ENO-2, and ENO-3 while <1.1 on CL-1, CL-2 and CL-3.

Table 7. Thermotolerant Coliform Count Using Multiple Tube Fermentation

Sample Name	Dosage	Unit	Standards	Results	Remarks
ENO-1	1mL	MPN/100mL	< 1.1	> 8.0	FAILED
ENO-2	5mL	MPN/100mL	< 1.1	> 8.0	FAILED
ENO-3	10mL	MPN/100mL	< 1.1	> 8.0	FAILED
CL-1	1mL	MPN/100mL	< 1.1	< 1.1	PASSED
CL-2	5mL	MPN/100mL	< 1.1	< 1.1	PASSED
CL-3	10mL	MPN/100mL	< 1.1	< 1.1	PASSED

For the added new samples combining emulsified neem oil and chlorine which is also an experimental group, the total water coliform and thermotolerant coliform count resulted <1.1 in terms of MPN/100 mL on C-1, C-2 and C-3.

Table 8. Total Water Coliform and Thermotolerant Coliform Count Using MTFT

Sample Name	Dosage		Parameters	Unit	Standards	Results	Remarks
	ENO	CL					
C-1	0.1mL	0.9mL	Total Coliform	MPN/100mL	< 1.1	< 1.1	PASSED
			Thermotolerant Coliform	MPN/100mL	< 1.1	< 1.1	PASSED
C-2	0.2mL	0.8mL	Total Coliform	MPN/100mL	< 1.1	< 1.1	PASSED
			Thermotolerant Coliform	MPN/100mL	< 1.1	< 1.1	PASSED
C-3	0.3mL	0.7mL	Total Coliform	MPN/100mL	< 1.1	< 1.1	PASSED
			Thermotolerant Coliform	MPN/100mL	< 1.1	< 1.1	PASSED

On Table 4, the antimicrobial test which is the agar disk diffusion method of emulsified neem oil with 10% concentration resulted in 10.2 mm inhibition zones indicating an effective inhibition of bacterial growth. While the antimicrobial activity of chlorine containing 10% concentration resulted in a 13 mm inhibition zone which indicates a Positive for antibacterial property against Escherichia coli. This means that both disinfectant agents which are the emulsified neem oil and chlorine are effective against E. coli indicating that they are effective in disinfecting those specific bacteria.

The analysis of raw water in Table 6, one water sample without containing any disinfectant was tested in the Aqua laboratory located in the City of San Fernando, Pampanga. The water sample were analyzed into two specific parameters, Total Coliform and Fecal Coliform. The sample resulted in 79,000 MPN/100mL in total coliform indicating a high amount of total coliform count in the water. Also, it resulted in a 49,000 MPN/100mL in fecal coliform indicating a high amount of fecal coliform present in the water. This means that the classification of the water sample obtained in Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga is under Class D. Class D refers to navigable water, specifically river water. It is also identified as an environmental water and wastewater. Since the water samples are tested thru water potability standard, the method reference used was SMEWW 9221 B having a <1.1 MPN/100mL standard for total coliform and thermotolerant coliform in multiple tube fermentation tests.

The MTFT of total coliform and thermotolerant coliform in Table 7 & 8 of ENO- 1, ENO-2, ENO-3 resulted >8.0 MPN/100mL which indicates that the disinfectant agent failed while for CL-1, CL-2, and CL-3 resulted <1.1 MPN/100mL which indicates that the it has passed the standards. Therefore, the emulsified neem oil failed to be an effective disinfectant compared to chlorine and the optimal dosage also failed to be determined since more than 10mL dosage on a 100mL is already unrealistic and can harm the safety of a person.

In line with this, a new sample type of disinfectant was added, combining emulsified neem

oil and chlorine in a ratio of 1:9, 2:8, 3:7 in 1mL, naming them C-1, C-2 and C-3 respectively. The choice of a 1 mL total volume for these new formulations was based on the successful results obtained from the existing disinfectant, CL-1. This existing solution utilized a dosage of 1 mL of chlorine diluted in 100 mL of water and met the established standards for efficacy.

The total coliform and thermotolerant coliform count using multiple tube fermentation test in Table 9 of C-1, C-2 and C-3 resulted in <1.1 MPN/100 mL which indicates that the combined disinfectant agent passed the standards. Therefore, combining emulsified neem oil and chlorine is effective in disinfection of coliform bacteria present in the water sample brought from Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga.

Despite the emulsified neem oil not meeting the established standards for disinfecting water, it still demonstrated a notable decrease in bacterial presence. This outcome highlights the potential of neem oil as a supplementary antimicrobial agent. While it may not be sufficient as a standalone disinfectant, its ability to reduce bacterial levels suggests that it can contribute to overall water hygiene when used in conjunction with other disinfectants, such as chlorine.

The reduction in bacteria observed with neem oil indicates its inherent antimicrobial properties, which can play a crucial role in enhancing the effectiveness of primary disinfectants. By combining neem oil with chlorine, as seen in formulations C-1, C-2, and C-3, we can leverage the strengths of both agents to achieve better disinfection outcomes. This synergistic approach not only improves the overall quality of treated water but also reduces the reliance on chemical disinfectants, potentially minimizing their associated risks and side effects.

Moreover, neem oil's natural origin makes it an attractive option for sustainable and eco-friendly disinfection practices. Its partial efficacy against bacteria underscores the importance of continuing research to optimize its formulation and combination with other disinfectants. In conclusion, while emulsified neem oil alone may not fully meet disinfection standards, its ability to decrease bacterial levels signifies its valuable contribution to improving water quality and warrants further exploration and integration into disinfection strategies.

Neem oil plays a significant role in disinfecting the water, not solely because it is combined with chlorine, but due to its inherent antibacterial and antiviral properties. Neem oil contains active compounds such as azadirachtin, nimbin, and nimbidin, which are known for their antimicrobial efficacy. These compounds work by disrupting the cell membranes of bacteria and viruses, thereby enhancing the overall disinfecting power of the mixture. When emulsified and combined with chlorine in varying ratios (1:9, 2:8, and 3:7), named C-1, C-2, and C-3 respectively, the neem oil boosts the chlorine's effectiveness, resulting in a more potent and comprehensive disinfection process. This combination not only ensures the elimination of a broader spectrum of pathogens but also contributes to a more sustainable and eco-friendly approach to water treatment.

In terms of cost efficiency of combined disinfection agent and chlorine, chlorine cost is much cheaper than the combined. Chlorine has a 1mL dosage cost for Php 0.097 while the C-1 sample cost for Php 0.18, C-2 sample cost for Php 0.264 and lastly C-3 sample cost for Php 0.96. This means that Chlorine is much cheaper than the combined disinfection agent at any ratio. Also it is the most economical way to disinfect microorganisms. Even though the combined disinfection cost much higher than the normal, it may exhibit much more potential for safety since it limits the harmful effect of chlorine by having a much eco-friendlier substance present in the disinfectant.

IV. CONCLUSIONS AND RECOMMENDATIONS

The study examined the efficacy of emulsified neem oil and chlorine as disinfectants to address water quality issues in Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga, through testing and innovative approaches, highlighting the potential and limitations of the disinfection methods

investigated. The main conclusions of the study are as follows:

Efficacy of Individual Disinfectants:

- Emulsified neem oil, despite its known antibacterial properties, failed to meet the standards and optimal dosages for effective water disinfection. Its use is also limited due to safety concerns.
- Chlorine effectively disinfected the water samples, demonstrating its efficacy as a water treatment agent. However, dosages above 10 mL/100 mL were found to be impractical and potentially hazardous.

Introduction of Combined Disinfectant:

- To address the limitations of using emulsified neem oil alone, a new approach combining emulsified neem oil and chlorine in different ratios was introduced.
- The combined disinfectant, at a dosage of 1 mL, proved effective in reducing coliform bacteria to acceptable levels, as indicated by results from Multiple Tube Fermentation Tests (MTFT).

This study contributes to the development of innovative water treatment solutions and underscores the importance of ongoing research to refine and implement effective disinfection methods for improving water quality and public health in communities facing similar community challenges.

Given the results of the study showing that emulsified neem oil was less effective than chlorine in disinfecting coliform bacteria in water samples from Sitio Camachile, Barangay Nabuclod, Floridablanca, Pampanga, the following recommendations are:

1. Optimize formulations of neem oil, including higher concentrations and other emulsifiers, to improve its disinfectant efficacy.

2. Test various contact times between the neem oil and water to identify whether longer exposure improves its ability to disinfect.

3. Additional tests are needed for other water quality standards aside from microbiological aspects.

4. Identify the most efficient concentrations of emulsified neem oil and chlorine to achieve effective disinfection while maintaining safety.

5. Expand the scope of water samples analyzed to include samples from different sources or locations within the study area to assess the generalizability of the findings.

6. Build a monitoring program that regularly checks the water quality after treatment to make sure a combination of emulsified neem oil and chlorine meets the safety requirements and efficacy over time.

7. To consider other water classification standards such as class B on water samples obtained in Sitio Camachile since it can't reach the standard of <1.1 MPN/100mL.

8. To test the emulsified neem oil if it is suitable for secondary disinfection on water since it was already tested in primary disinfection.

9. Although it is not advisable to test for combined emulsified neem oil and chlorine due to its cost, this combined disinfection agent might provide a potential for a much safer disinfectant than chlorine since chlorine can also cause some harmful effects such as what we call chlorination byproducts or CBPs.

10. To test other ways to use emulsified neem oil in disinfection like in the form of tablets which is similar in chlorine tablets.

11. To do a particle tracing or contaminant tracing around the vicinity to create a mitigation or a way to decrease the contamination of the river water.

These recommendations aim to advance our understanding of emulsified neem oil's potential as a water treatment solution and its applicability in addressing water quality issues

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