

Analysis of the Willingness of Tempe Home Industry Business Actors to Implement Phytoremediation Methods Using Water Spinach (*Ipomoea aquatica* Forsk) in Pliken Village, Kembaran District, Banyumas Regency

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ABSTRACT

The purpose of this study was to analyze the willingness of the community, namely tempe home industry business actors and the constraints faced in the application of phytoremediation methods using water spinach (*Ipomoea aquatica*) for the treatment of tempe liquid waste. Data collection was carried out through interview methods and distributing questionnaires with Likert scale calculations to 30 tempe business respondents. The results showed that the average home industry tempeh factory business actors in Pliken Village partially agreed with the implementation of the phytoremediation program in the management of tempeh liquid waste using water spinach plants (*Ipomoea aquatica*). The obstacles faced in implementing the research results of the phytoremediation program in the community in Pliken Village are: (I) Time factor; (II) Economic factor, (III) Mindset factor, (IV) Lack of knowledge factor.

INTRODUCTION

The increase in the food industry, especially the tempeh industry in Indonesia, is dominated by micro-scale industries (home industries) and small industries. According to the Central Statistics Agency (2024), the number of micro-scale industries in Central Java province reached 811,039 units, which is greater than the number of small-scale industries, which is 51,887 units. Home industry is an industry that carries out production at home with limited capital and the use of simple tools so that it does not have a waste processing installation (Ayuni and Putri, 2022). The tempeh industry in Pliken Village can be an example of a home industry that has experienced a lot of development because the majority of its population has a home tempeh industry so that it is nicknamed the center of the tempeh industry. According to the Banyumas Regency Industry Service (2023), the number of home tempeh industries in Kembaran District, especially in Pliken Village, is the largest compared to other villages, namely 463 units. The high activity of the tempeh industry can have a negative impact on changes in river water quality because wastewater from production is discharged directly into the river.

The role of the community to participate independently is very necessary in the management of industrial waste. The development of awareness and positive attitudes towards the environment needs to be increased in order to reduce the potential for environmental pollution and minimize the negative impacts caused. Environmental sustainability can be realized if someone has a high environmental awareness so that they can consider the impacts that can occur from actions taken on their environment (Munawar et al., 2019). The creation of high environmental awareness will encourage the community, especially tempeh craftsmen in Pliken Village, to make efforts to manage liquid waste so that they can help in the utilization of natural resources more efficiently and sustainably (Haifa et al., 2024).

The strategy for efficient utilization of natural resources can be done through phytoremediation. The application of the phytoremediation method in the management of tempeh liquid waste, especially in Pliken Village, has never been done before. The management of tempeh liquid waste in Pliken Village can be applied with phytoremediation as an effort to prevent potential environmental pollution. Remediation technology through phytoremediation has several advantages, namely being environmentally friendly, relatively affordable, easy to do, and improving water quality (As'ari et al., 2022). Phytoremediation is the cleaning of pollutants or pollutants by utilizing the capabilities of plants. The use of phytoremediation agents of water spinach (*Ipomoea aquatica*) in the processing of tempeh liquid waste, especially in Pliken Village, has also never been done. Water spinach plants can be used as phytoremediation agents because they have the ability to adapt to habitats containing pollutants, grow quickly, and have hyperaccumulator properties so that they can accumulate contaminants into plant tissue (Maslinda, 2021). This study aims to analyze the willingness or participation of the community and the constraints that can hinder the implementation of phytoremediation programs using water spinach (*Ipomoea aquatica*).

LITERATURE REVIEW

Environmental Awareness

Environmental awareness is a state of knowing about the importance of a healthy and clean environment and can be seen through the behavior and actions of each individual so that they can improve the quality of the environment in order to meet human needs properly. Environmental awareness is influenced by four factors, namely (Gabriella and Sugiarto, 2020):

a) Ignorance factor

Someone who does not have knowledge about a healthy environment can be said to be unaware, so a person's ignorance can influence environmental awareness.

b) Poverty factor

Poverty becomes one of the sources of social problems in realizing environmental awareness if population growth is not accompanied by economic growth. This results in fulfilling needs becoming the main focus compared to responding to environmental issues.

c) Human factor

A person with a high sense of humanity will be more environmentally aware and will not take actions that could harm others.

d) Lifestyle factors

An environmentally conscious lifestyle can affect a person's level of awareness of the environment. The person's view will also focus on everything related to being environmentally friendly.

Environmental knowledge is needed before creating environmental awareness. This knowledge can be obtained through formal or informal education. Someone who has knowledge about environmental pollution such as the causes and impacts can influence that person to think critically so as to encourage solving environmental problems that occur. In addition, the knowledge gained can make someone have environmental insight so that it allows for the emergence of adaptive solutions to environmental problems (Vivanti et al., 2017). Community participation in solving environmental problems can occur if someone has knowledge so that it encourages the creation of behavioral changes to protect the environment. According to research conducted by Dariyatmo et al., (2024) added that knowledge is a foundation in changing a person's behavior so that behavior that is based on knowledge can last longer than behavior that is not based on knowledge.

Level of Education

Education is an effort to increase understanding, experience, and knowledge according to a person's needs so that they have good behavioral changes through teaching and training. The level of education and knowledge are correlated in influencing a person's attitudes and behavior. Increasing knowledge is an indicator that education is said to be successful so that with higher education it is hoped that they can have knowledge that can influence positive behavioral changes. Increasing knowledge can be obtained through informal education and is not always absolute and can only be obtained from formal education (Dariyatmo et al., 2024).

Age

The level of participation of each individual in something is related to age. According to research conducted by Sukmaningrum (2017) explains that the population is divided into three groups, namely:

- a) Residents aged under 15 years
Residents who are considered unable to produce goods or services in the production process
- b) Residents aged 15 – 64 years
Residents who are considered to be able to produce goods or services in the production process
- c) Residents are over 64 years old
Residents who are considered no longer capable of producing goods or services and whose livelihood is supported by residents of productive age.

The level of knowledge possessed by a person can be influenced by age. The older a person is, the more knowledge they have because this knowledge can be obtained through formal education or informally, namely through personal experience or that of others (Lewen et al., 2020). However, the older a person is at a productive age does not guarantee that a person has active awareness in participating in something if it is not accompanied by increased knowledge through training, learning, socialization, and experience (Cahyani et al., 2014).

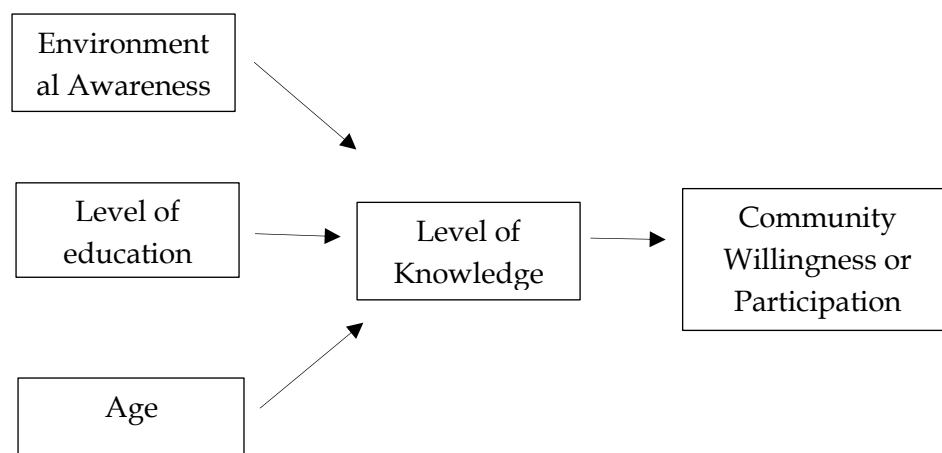


Figure 1. Conceptual Framework

METHODOLOGY

Data collection was carried out using questionnaire distribution and interview methods. The interview method was conducted with local village officials in Pliken Village such as at the village hall and sub-district. In-depth interviews were conducted with competent sources in their fields such as in the field of service at the Pliken Village Hall and the sub-district head at the Kembaran District Office. Meanwhile, the distribution of questionnaires was given to tempeh industry business actors in Pliken Village with a total of 30 respondents (Cohen et al., 2020).

The questionnaire method is carried out by calculating on a Likert scale. Measuring attitudes, opinions, and perceptions of both an individual and a group of people towards the level of public awareness of tempeh liquid waste

can use a Likert scale (Sugiyono, 2018). Each statement provided in the questionnaire column has an answer ranging from very positive to very negative and the score can be calculated in Table 1.

Table 1. Scale Based on Likert Scale

Statement	Positive Score	Negative Score
Strongly agree	5	1
Agree	4	2
Neutral	3	3
Don't agree	2	4
Strongly Disagree	1	5

The questionnaire data was analyzed descriptively and the values were interpreted using the following formula equation (Erinsyah et al., 2024):

- a. Calculation of the total number of responses in responding to statements in the questionnaire can be done using the following equation:

$$\text{Frequency of each statement} = T \times P_n \quad \dots\dots\dots (1)$$

Information :

T = Total number of respondents who chose

P_n = Likert score number options

- b. Calculation of the highest (Y) and lowest (X) values

Y: Highest Likert score x number of respondents

X : Lowest Likert score x number of respondents

- c. The interval formula can be found using the following formula:

$$I = \dots\dots\dots \frac{100}{\text{Total skor (likert)}} \quad (2)$$

- d. Calculation of intervals (distance ranges) and interpretation of percentages used to search for score intervals (I) in the following equation:

$$\text{Index formula (\%)} = x 100 \frac{\text{Total Skor}}{Y} \quad \dots\dots\dots (3)$$

Based on the interval value sought, the score interpretation criteria are obtained, namely:

Table 2. Criteria Based on Interval Scores

Category	Positive Statement Score	Negative Statement Score
Strongly Disagree (STS)	0% - 20%	81% - 100%
Disagree (TS)	21% - 40%	61% - 80%
Neutral (N)	41% - 60%	41% - 60%
Agree (S)	61% - 80%	21% - 40%
Strongly Agree (SS)	81% - 100%	0% - 20%

Source: Research data processing (2024)

Data analysis of respondents' answers to each statement is carried out by interpreting the data through formula equations and criteria based on the

interval scores that have been searched. Meanwhile, data on the number of frequencies in the aspects of education level and age are explained descriptively with crosstabs analysis. This analysis is used as a summary of data presentation on the frequency and percentage of each category of the variables analyzed.

RESEARCH RESULT AND DISCUSSION

Respondents' Answer Results

Measurement of responses from respondents, namely tempeh entrepreneurs, in the form of attitudes and opinions from each individual. This test was conducted using a questionnaire based on a Likert scale. Likert scale testing is used to determine if the implementation of the phytoremediation program for managing tempeh liquid waste using water spinach (*Ipomoea aquatica*) obtained many responses of agreement or disagreement. The score criteria obtained were interpreted based on the intervals that had been entered into the interval formula equation. The Likert scale test obtained the following results:

Table 3. Respondents' Answers Based on Interval Score Categories on the Likert Scale

No	Statement	Percentage Value	Respondents' Answers
1	Tempeh liquid waste contains pollutants that can be cleaned using water spinach (<i>Ipomoea aquatica</i>)	80.67%	Agree
2	Water spinach plants (<i>Ipomoea aquatica</i>) can absorb pollutants in liquid tempeh waste which can cause water pollution.	68.67%	Agree
3	Water spinach (<i>Ipomoea aquatica</i>) has the ability to adapt because it can grow in polluted environments.	76.67%	Agree
4	The roots of the water spinach plant (<i>Ipomoea aquatica</i>) have a high absorption capacity for pollutants in water.	82.67%	Strongly agree
5	Water spinach (<i>Ipomoea aquatica</i>) has an important role in aquatic ecosystems, namely as a regulator of water quality.	82%	Strongly agree
6	The estimated investment cost using the phytoremediation method (cleaning pollutants using plants) is estimated at IDR 1,500,000 - 2,000,000 and the estimated investment cost of the conventional method using a simple IPAL (Wastewater Treatment Plant) is estimated at IDR 55,000,000 - 60,000,000.	66.67%	Agree
7	The operational costs of using phytoremediation (cleaning pollutants using plants) are cheaper, namely around IDR 500,000 compared to the conventional method using chemicals, namely IPAL, which is IDR 1,000,000.	66.67%	Agree

8	Management of liquid tempeh waste using phytoremediation is a method that is relatively affordable and environmentally friendly.	80%	Agree
9	Phytoremediation methods can be carried out in-situ (pollutant cleaning can be done directly by planting water spinach plants at polluted locations) or ex-situ (taking tempeh liquid waste from the original location and processing it outside the original location by planting water spinach plants).	72%	Agree
10	The phytoremediation method has the advantage of reducing pollutants in liquid tempeh waste in large quantities.	80%	Agree
11	The process of cleaning pollutants using plants takes a relatively long time.	50%	Neutral
12	Phytoremediation methods using plants depend on how often the plants are exposed to sunlight which is useful for their growth process.	46.67%	Neutral
13	Tempeh liquid waste can be carried away by river flows so there is no need to manage liquid waste before it is disposed of into the environment.	46.67%	Neutral
14	Water spinach (<i>Ipomoea aquatica</i>) is used in the phytoremediation method (cleaning pollutants) in liquid tempeh waste. If consumed by animals or humans, it can harm health.	47.33%	Neutral
15	Incompatibility of plants used in the application of phytoremediation methods to tempeh liquid waste	47.33%	Neutral
16	The greater the amount of liquid tempeh waste absorbed by water spinach plants (<i>Ipomoea aquatica</i>), the more it can inhibit plant growth.	50.67%	Neutral
17	Supervision from the community is important to monitor the liquid tempeh waste produced in case it can cause river water to become polluted.	44%	Neutral
18	Managing liquid tempeh waste before it is disposed of into the environment is an important activity in preserving the environment.	42.67%	Neutral
19	There are no costs for managing tempeh liquid waste because the proceeds from tempeh product sales are only sufficient to meet daily living needs.	37.33%	Agree
20	Tempeh business actors are not aware of the government regulations in the Provisions of Article 16 of Banyumas Regency Regional Regulation Number 8 of 2018 which regulates liquid waste management permits for business actors due to the lack of direction between the government and tempeh industry business actors.	37.33%	Agree

Respondents gave the answer that home industry tempeh factory business actors in Pliken Village do not clearly understand phytoremediation technology

in managing liquid tempeh waste produced. Respondents' responses partly agreed with the statement given regarding the application of phytoremediation using water spinach (*Ipomoea aquatica*). Business actors generally know that water spinach can grow wild in rice fields, swamps, and even ditches, so they assume that water spinach can absorb pollutants in their environment. However, the lack of knowledge caused the respondents' answers to be neutral.

Based on the interview results, it is explained that economic factors are an obstacle for each individual to have environmental awareness. Low environmental awareness results in business actors assuming that handling the management of tempeh liquid waste is the responsibility of the government. In addition, economic factors can also be an obstacle in the management of tempeh liquid waste. This is due to the limited income of business actors and the allocation of profits that are focused on meeting daily living needs. Limited income is also related to the low level of education of business actors, especially as seen in statements 6, 7, 8, and 19. The unstable economic situation causes business actors to prefer to choose a method of managing tempeh liquid waste with relatively affordable costs. The main focus on meeting living needs in seeking large profits results in business actors being less concerned about the impact of losses that can be caused by the absence of tempeh liquid waste management for the surrounding environment.

Education Level Aspect

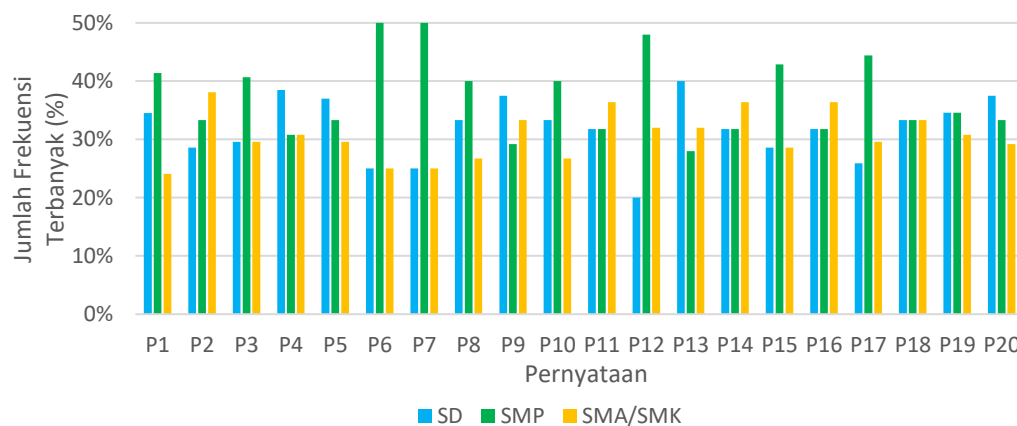


Figure 2. Highest Frequency Amount in the Education Level Aspect

The level of education does not necessarily state that respondents with an elementary school education background are respondents with very little knowledge compared to respondents with a final education level of junior high school or high school. The highest frequency of respondents with high school education level is only shown in statements 2, 11, 14, and 16 so that respondents with a high school background cannot be considered to have all the knowledge related to environmental aspects, namely phytoremediation, both technically and from a legal perspective on wastewater management permits for tempeh industry business actors. This can also be caused by knowledge that is not only obtained from formal education, but can also be obtained from informal education.

Informal education is education obtained from daily experiences both in the family environment and the surrounding environment (Syaadah et al., 2022). A low level of education does not always absolutely affect the level of knowledge possessed. Low education affects the knowledge possessed, which in turn affects changes in behavior. However, in reality, even though business actors agree with this statement, it is undeniable that environmental awareness is still low. The higher the education, the more individuals will receive information and knowledge openly and be more aware of environmental aspects (Munawar, 2019).

Habits in the family environment and the surrounding environment in acting in a disciplined manner to protect the environment can affect the environmental awareness of each individual. The lack of information obtained affects the respondents' answers so that the number obtained shows a neutral answer to statements 13, 14, and 18. Environmental education at an early age, especially in the Golden Age, is very necessary considering that it plays a role in forming a person's behavior and responsibility towards the environment (Adawiah et al., 2022). In addition, based on the results of the interview, it was found that the lack of socialization regarding the management of tempeh liquid waste in Pliken Village could be the cause of the lack of environmental awareness among tempeh business actors.

The lack of a sense of ownership of the environment among business actors and the surrounding community has resulted in many violations that often occur by disposing of tempeh liquid waste directly, especially into the Jelalang River. This can be seen from the results of interviews and statement 17 which states that the absence of regular supervision has caused respondents to be indifferent regarding the potential for river water to be polluted due to the disposal of liquid tempeh waste, so that they do not consider supervision and monitoring to be an important thing to do. The mindset of the community that has been formed for a long time and assumes that liquid tempeh waste can be carried away by river flows makes it difficult to increase environmental awareness.

Age Aspect

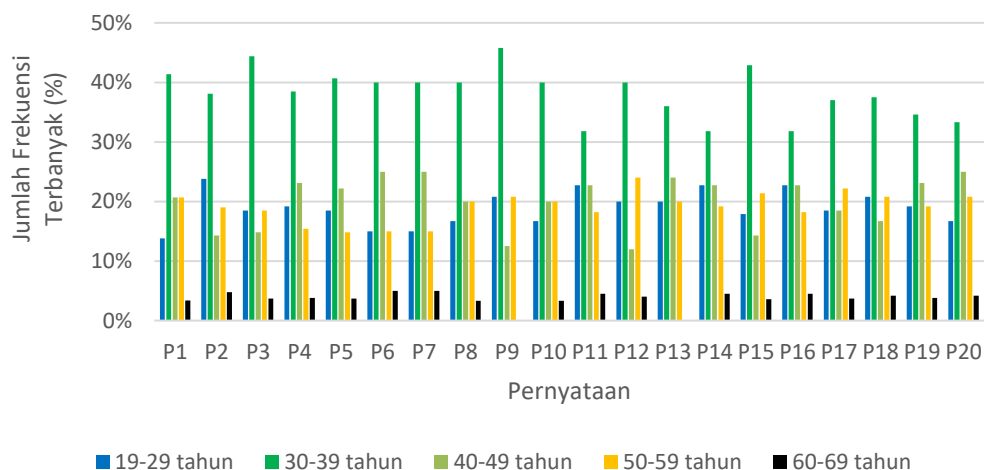


Figure 3. Highest Frequency in Age Aspect

Information acceptance when viewed in terms of age shows that the age range of 30-39 years has the ability to understand and absorb information the fastest because they are at a productive age (Sumekar et al., 2021). This is evidenced by statements 1 to 20 that the highest number of respondents aged 30-39 years. According to research by Ryan et al., (2018) stated that the percentage with the highest understanding of information is obtained at the age of 30-59 years. The low percentage of ability to understand information is shown in people under 30 years of age and over 60 years of age. The respondents' answers on average agreed to statements 1-10 and were neutral to statements 11-20 with the highest number of respondents aged 30-39 years. This neutral answer states that even though the respondents are in their productive age, the lack of knowledge possessed by the respondents causes low environmental awareness.

The lack of knowledge possessed by respondents can be shown through statement 20 related to ignorance of government regulations governing wastewater management permits for each industry to be required to have an IPAL (Wastewater Treatment Plant). As a result of this ignorance, many violations occurred so that legal policies could not be implemented effectively. In addition, the limited time owned by business actors can affect the constraints of tempeh wastewater management. This is because the process of making tempeh products takes a relatively long time and limited human resources so that it is only carried out by family members. According to research conducted by Mu'adib & Subajo (2024), it is stated that the preparation of strict village regulations regarding the management of tempeh liquid waste and administrative sanctions need to be carried out for perpetrators who commit violations. The Pliken Village Government needs to work together with related agencies to coordinate the socialization of tempeh liquid waste management programs and activities.

CONCLUSIONS AND RECOMMENDATIONS

On average, most of the home industry tempeh factory business actors in Pliken Village agreed with the implementation of the tempeh liquid waste management technology program using water spinach (*Ipomoea aquatica*). The obstacles faced in implementing the results of the phytoremediation program research in the community, especially in Pliken Village, are: (I) Time factor, namely the dense working hours in the tempeh making process and the work is only done by families without employees so that it takes time, (II) Economic factor, namely home industry tempeh factory business actors focus on profit so that they do not pay attention to environmental aspects by managing tempeh liquid waste, (III) Mindset factor, namely the habit of business actors to dispose of tempeh liquid waste directly into the river has become a hereditary tradition so that they have low environmental awareness, (IV) Lack of knowledge factor, namely the attitude of being less able to accept information openly and focusing on practical matters so that they tend to be afraid of taking risks.

ADVANCED RESEARCH

This study has limitations in the number of samples involving only 30 respondents so that the results cannot be generalized to describe the respondents' answers as a whole so that the results of the study are only relevant to the small

group being investigated. This study is far from perfect, so in further research it is expected to be better than before.

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