The utilization of water hyacinth (*Eichhornia crassipes*) for the development of sludge worm (*Tubifex sp.*) cultivation

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Abstract. Sludge worms (*Tubifex sp.*) is one of the important components of fish cultures. Sludge worms contain high protein as nutrition for fish foods. The worm grows fast and relatively smaller size that is suitable with the small size of the fish mouth. Intensification of sludge worm production through cultivation needs to be done in order to meet the growing needs of fish food. Water hyacinth (*Eichhornia crassipes*) is a weed that lends the ecosystem and is not utilized in the community. In fact, water hyacinth has a high protein content to become feed nutrition. This research supports the conversion of water hyacinth into optimal cultivation media.

is the experimental design used four media variations namely treatment-I, treatment-II and treatment-III. Fermentation was used to breakdown the fibre of water hyacinth. The water system used a recirculation system. The parameters tested are water quality, water flow rate & dissolved oxygen. The pH showed range from 7.0–7.6. DO showed range from 1.2−1.4 mg/L. The temperature showed range 25.6–28.2 °C.

Keywords: Cultivation, fermentation, sludge worm, water hyacinth

1. Introduction

One of the important phases of the fish cultivation is juvenile development. The juvenile time is around 10 days from egg. Juvenile fish instinctively prefer to accept food items which are easily detected and captured while moving, swimming or having any type of motility in water. Larval stage is believed to be suitable criteria for feed. The movement of larvae (living food) is likely stimulated by larval feeding responses [1]. Larvae are believed to be visual feeders adapted to capture moving prey. Moreover, living food for fish are needed as a high-protein component of their diet and needed food with a relatively small size suitable with small mouth of fish. Among living forage organisms that are appropriate to be used in fish farming is representatives from subclass of *Oligochaeta* worms, one of them is *Tubifex sp.* [2]. This worms contain high food value (5,575 cal g⁻¹ dry weigh) [3].

Sludge worms are small aquatic invertebrates measuring usually 3–4 cm long. Sludge worms form large clusters in silt of rich in organic reservoir, but also occurs on sandy and rocky soils in small quantities. In the event of danger, the body is instantly hidden in a burrow. The front end of the body is constantly in soil of 5–10 cm [3]. Sludge worms consume organic matter from silt, and it excrete simple minerals, that contribute to the mineralization of the soil [4]. Mostly, sludge worms are distributed and is one of abundant groups of Annelids in freshwater [5]. They are found forming reddish colonies in the mud. Usually, the worm food comes from sediment and ingested by selectively digesting bacteria therein and absorbing molecules through the body wall [6]. Sludge worms have a high protein content that can
be sufficient as fish food. However, majority of sludge worms are obtained from nature. The sludge worm catch is still unstable and depend on environmental conditions. So is it still not enough to fulfill market demands.

Sludge worm cultivation needs to be improved to meet the sludge worm market needs. Research on the components that support cultivation is continuing. One of them is the development of sludge worm cultivation media. Processing the potential of organic material that is around for the development of cultivation media that can support the growth of sludge worm. One of the organic ingredients that has the potential is water hyacinth.

The existence of water hyacinth (Eichhornia crassipes) in nature are frequently realized as weeds in the waters [7]. Furthermore, water hyacinth often become a problem in nature because utilization is not optimal. Research about plants that have organic matter like water hyacinth has already been done in mustard groves, ruminant feed, compost and so on [8, 9]. However, research has never been done on water hyacinth. Therefore, this study aims to develop quality sludge worm using water hyacinth as growing media. This indirectly will improve fish quality.

2. Materials and method

2.1. Location

This study was conducted in the Gudang 37, Kramat Jati, East Jakarta, Indonesia and Integrated Multidisciplinary Laboratory, Universitas Indonesia, Depok.

2.2. Preparation of culture unit

The experiment was conducted to found suitable medium form for water hyacinth because this can affect sludge worm growing. The sludge worms were cultured for 20 days in plastic container (52 × 38 × 15 cm³) culvert system under a rooftop to protect the worm from over light and rain intensity. In order to provide good drainage, the culverts were arranged above ground level. Continuous water flow through the culvert was maintained that is aimed to get the best circulation for worms. Twenty-four culvert were used to conduct 3 × 5 factorial design (3 treatments each with 5 replications). The media combination is shown in table 1.

2.3. Collection of Ingredients

The water hyacinths used are available in Depok. Water hyacinth were collected from Jalan Baru Lake in Margonda site in Depok, Indonesia. Water hyacinth collected from lake that will be used for fermentation will be acclimated before. Pre-treatment involves soaking water hyacinth in water in laboratory for 5 days. This step aimed to reduce heavy metal content or other compounds. Water hyacinths are chopped using a grinding machine (Honda GX 200). The result is a 0.2–0.5 cm leaf cut. The copping aims to facilitate microorganisms to degrade water hyacinth fibers easily. The mud was collected from soil in research location. The water temperature where water hyacinth collected is 28 °C and pH is 6.8 using pH Meter (IONIX +). Previously, water hyacinths were dried out in field before fermentation during 15 days.

| Table 1. Design of treatment |
|-----------------------------|
| **Treatment**   | Mud (%) | Water hyacinth (%) |
| Control         | 100     | 0                  |
| Treatment I     | 90      | 10                 |
| Treatment II    | 80      | 20                 |
| Treatment III   | 70      | 30                 |
2.4. Fermentation
The first phase consisted of the preparation of fermented water hyacinth, molasses, water, and probiotic treatment with Effective Microorganism (EM4). By using the optimum composition of 15 % EM4 (per grams of water hyacinth) it influences the activity of microorganisms for degradation of organic material [10, 11]. Fermentation was done in a water drum (HDPE) with 60 L capacity (figure 1). Fermented water hyacinth become easily ingested by worms [12]. Moreover, the fermentation has been proven to be effective in increasing the nutrient in culture media. Zahidah et al. research stated that fermentation refers to a process of breaking the organic compound involving a microorganism and produce a product that has a longer storage time and better organoleptic characteristic and nutritional component [13].

2.5. Media preparation
Proximate composition of water hyacinth was determined following research given by Oyeyemi et al. (table 2) [14].

2.6. Collection of Tubifex sp.
Wild sludge worms were collected from fish farmer in Bumi Kepanduan Sentul (BKS), Bogor, West Java, Indonesia. The sludge worms were cleaned over 24 hours before inoculation into the culverts by using continuous water flow [15].

![Fermentation of water hyacinth.](image)

**Figure 1.** Fermentation of water hyacinth.

| Nutrient     | Concentrate (%) |
|--------------|-----------------|
| Crude protein| 56.38 ± 2.15    |
| Fat          | 4.11 ± 0.55     |
| Ash          | 4.88 ± 0.24     |
| Crude fibre  | 1.02 ± 0.05     |
| Carbohydrate | 56.38 ± 1.55    |

**Table 2.** Proximate composition of water hyacinth leaf protein concentrate.
2.7. Inoculation of sludge worms
The sludge worms were inoculated at the rate 1.25 mg cm\(^{-2}\) used by recirculation system. However, water rate will observe every 10 days. The circulation system supported by water pump (DABAQUA Q 2007). The water flow rate was using research Ahmad et al. that is maintained by stop cork of pipes (PVC). Also, the periodic supply of culture media was started form 10\(^{th}\) days with 10 days interval. Water temperature and pH of the culture was recorded with digital pH meter (IONIX+).

Air temperature was recorded by digital thermometer in Handphone (Xioumi MI Play) that included recording of coordinates. Dissolved Oxygen (DO) and pH were determined using DO meter (Seven GoPro and MW 600 DO).

2.8. Sampling
The sampling of sludge worms started after 10 days from inoculation. Sampling was conducted in the evening. The worms collected by glass tube and using a filter. The sludge worms were separated, dried with tissue and weighed using a balance (KrisChef EK9150) [13]. Sludge worms harvested after 30 days cultivation period before dawn or after dusk [16].

3. Results and discussion
The fermentation of water hyacinth showed black-like green color & mushy texture. The fermentation process included hydrolysis, acidogenesis, acetogenesis and methanogenesis. Hydrolysis was under anaerobic fermentation conditions. Dissolved organic matter such macromolecules were transformed into micro molecules such as amino acids, monosaccharides, fatty acids and so on. Acidogenesis converted dissolved organic matter into short chain fatty acids. Acetogenesis converted the product of acidogenesis into hydrogen, carbon dioxide and acetic acid (Verma). Hydrolysis help worms to break down the carbohydrate and protein. The WHLPC result from Adeyemi et al. showed water hyacinth contains essential amino acids. The data suggest water hyacinth can used as source of vegetables protein for aquafeed supplement [14].

The sludge worm growth is closely related with environmental conditions. The water quality such as water temperature, pH and dissolved oxygen have affects on sludge worms [17]. So, measurement of environmental conditions is needed. The environmental condition in cultures is present in table 3. The data is obtained from cultivated habitat of sludge worms.

Table 3 showed that water temperature in the cultivation has a range 25.6–28.2 °C. Meanwhile, in Agathis lake in UI where is sludge worm found also (table 4). The water temperatures have range 28.7–29.8 °C. That temperatures are measured at 14.30 WIB. Research by Lou et al. showed the 22 °C is optimum temperature for respiration of sludge worm. The sludge worm can tolerate 20–27 °C and avoids temperatures over 30 °C [17]. So, the cultivation temperature can use for growing sludge worms. Results show treatment I (27.7 °C) or II (27.6 °C) are good temperatures for sludge worm cultivation compared to other temperatures.

| Treatment    | Air temperature (°C) | Water temperature (°C) | pH  | DO (mg/l) |
|--------------|-----------------------|------------------------|-----|-----------|
| Control      | 31                    | 28.2                   | 7.6 | 5.8       |
| Treatment I  | 31                    | 27.7                   | 7.0 | 1.4       |
| Treatment II | 31                    | 27.6                   | 7.0 | 1.2       |
| Treatment III| 31                    | 25.6                   | 7.2 | 1.2       |
Table 4. Environmental conditions in Situ Agathis UI.

| Coordinates                  | Air temperature (°C) | Water temperature (°C) | pH water | DO (mg/L) |
|------------------------------|----------------------|------------------------|----------|-----------|
| 6°22'6" S 106°49'30" E      | 31                   | 29.1                   | 7.1      | 6.8       |
| 6°22'11" S 106°49'26" T     | 31                   | 29.8                   | 6.9      | 6.7       |
| 6°22.135' S 106°49.493 E    | 31                   | 28.7                   | 7.9      | 3.9       |
| 6°22'2" S 106°49'31" T      | 31                   | 29.5                   | 8.0      | 9.6       |
| 6°22'3" S 106°49'82" T      | 31                   | 29                     | 8.5      | 9.2       |

The cultivation pH ranged from 7.0 to 7.6. Meanwhile, in natural habitat the water pH are 6.9–8.5. The best pH range for good respiration of sludge worms are 6–8. Neutral pH approaching alkaline were beneficial for sludge worm. Furthermore, pH range is also suitable for microorganisms such as nitrifying bacteria. All of the treatments are good pH for worm cultivation [17].

Table 3 also showed the DO of the treatments as follows: 1.4 mg/L, 1.2 mg/L and 1.2 mg/L. Meanwhile, DO contained in the natural habitat show the highest DO is 9.6 mg/L and lowest is 3.9 mg/l. Research showed the 3.5 mg/L till 4.5 mg/l were beneficial for respiration rate of worms. However, 4 mg/L is the suitable DO for worm cultivation in aerobic tank [17]. The cultivation treatments showed lower DO than the optimum DO. So, improvement of the water system is needed to solve the problem before the worms are cultivated.

4. Conclusion
The environmental conditions of the sludge worm habitat were investigated and compared with previous cultivation studies. The suitable treatments for cultivations are treatment I or II. However, increasing the DO value is necessary. In the future, the biomass of sludge worms should be measured.

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