Investigation of the pollution status and the waste reusing ability in trade village Duong Lieu, Hoai Duc, Hanoi

Khảo sát tình trạng ô nhiễm và tiềm năng tái sử dụng chất thải ở làng nghề Dương Liễu, Hoài Đức, Hà Nội

Short communication

Nguyen, Phuong Hanh*; Chu, Thi Thu Ha

Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Hanoi, Vietnam

Vietnam has about 2,000 trade villages locating mainly in the north. Duong Lieu village in Hoai Duc, Hanoi, is one of the key areas of agricultural production and food processing. However, this area is affected by serious environmental pollution, particularly caused by solid waste and wastewater. Solid wastes of the starch production process from arrowroot are disposed in large amounts and represent the main reason for environmental pollution in Duong Lieu village. These wastes are present anywhere in this village, for example on the main road, in gardens, event fill in ponds and ditches. The components of the dried arrowroot waste are mainly carbon-rich substances such as starch (5%), cellulose (90%) and N, P, K (0.5%; 0.11%; 0.16%, respectively). The fresh arrowroot waste has humidity of up to 80%. This substrate is suitable for culture of straw mushroom and oyster mushroom. The mushrooms use cellulose as carbon source for their growth. Therefore, waste from arrowroot that can be recycled efficiently by the biological method for culturing mushrooms. This treatment method is suitable to the conditions of Vietnam because it does not only reduce waste residues but also is environmentally friendly.

Keywords: solid wastes, mushroom, arrowroot, biological method

1. Introduction

Vietnam is a developing country and has about 2,000 trade villages mainly concentrated in Northern regions (Dang Kim Chi, 2005; www.langnghe.org.vn). The activities of these trade villages lead to a noticeable degradation of environmental quality. Duong Lieu, located about 20 km west of Hanoi city centre, is a village famous in Hanoi for its agricultural products processing. The advantage of trade village development is the economic benefit but the activities of this kind cause serious environmental pollution.

Processing of agricultural products is a traditional occupation here mainly practiced at household scale. There are about 65-75% of households in the commune engaging in this kind of work (Committee of Hoai Duc district, 2007). In this area, the two main concerned issues of pollution are related to food hygiene and to the...
management of waste, both being still not thoroughly solved. Figures 1, 2, 3 and 4 show the solid waste piled up on the main road, gardens and filled pond, drains.

In the past, with the small production scale, waste residues were usually transported to landfill. Nowadays, with expanded scale of production, the large amount of waste residue is about 400-500 tons/day (Committee of Hoai Duc district, 2007). The landfill method is no longer appropriate because of the land limitation and the soil and groundwater pollution by leachate from the landfill.

Many countries worldwide use waste materials as renewable resources (Dang Kim Chi, 2005; Vietnam Environment Administration, 2008). Waste of certain process can be the input source of other sectors in order to reduce environmental pollution.

2. Objectives and methods

2.1. Objectives

• Solid wastes from the starch production process from arrowroot.
• Straw mushroom (*Volvariella volvacea*), oyster mushrooms (*Pleurotus*) and Cinnamon worm (*Perionyx excavates*)

2.2 Methods

• Field Survey.
• Quick interview method
• Determination of total N by Kieldahl method, P by colorimetric method, K by flame photometer and atomic absorption, NO₃ by disulphophenic acid method
• Mushroom yield is calculated by ratio between weights of fresh mushrooms and of dry substrate.

3. Results

3.1 Assessing the status of solid waste management from starch processing

The Duong Lieu traditional village produces throughout the whole year, but the production concentrates mainly from October of previous year to April of next year (about six months). The materials used in processing cycle are cassava and arrowroot, amounting for tens of tons. The consequence is that a large amount of solid waste is disposed untreated into the environment (Table 1).
Table 1 indicates that starch processing in Duong Lieu villages disposed of thousands of tons of wastes per year, and the amount increased about 5% - 10% after each year. In the production process, approximately 13m$^3$ per 1 ton of arrowroot is discharged into surrounding environment. The wastewater is characterized by a high organic content, expressed through BOD and COD concentrations much higher than the standards (Table 2).

Table 3 indicates that cassava waste is mostly reused, whereas arrowroot waste is not reused but wasted. The local challenge is to manage and treat this waste in order for economic benefit and to reduce its impact on the surrounding environment.

3.3. Prospects for reuse and treatment of arrowroot residues from starch processing

3.3.1 Reuse capabilities of arrowroot wastes

The utilisation flow can be: Arrowroot solid wastes $\rightarrow$ Cultivation of mushrooms $\rightarrow$ mushroom harvest and residues (which after culture of mushrooms are used as fertilizer). The sources of arrowroot waste used in the above process should be carefully treated.

3.3.2 Chemical composition of arrowroot waste

Components of the dried arrowroot waste are mainly carbon-rich substances such as starch (5%), cellulose (90%) and N, P, K (0.5%; 0.11%; 0.16%, respectively). The fresh arrowroot waste has humidity up to 80%. This kind of waste is suitable for culture of straw mushrooms and oyster mushroom. These mushroom species use cellulose as carbon source for their growth. Therefore,
waste from arrowroot can be recycled efficiently by this biological method.

3.3.3 Treatment of the arrowroot waste to produce the substrate for culturing mushrooms
Analyses have shown that starch and cellulose are the main components of this waste whereas N, P and K are found in small amount, making the waste a suitable source of nutrients for many organisms such as fungi and other microorganisms. It is therefore assumed that the arrowroot waste can be treated by biological methods.

The production of oyster mushroom and straw mushroom cultivated on arrowroot waste are very low in comparison with the ones cultivated on rice straw and sawdust (Table 4). The solution for improvement of the mushroom yield can be to add some essential nutrients into the arrowroot waste before being used as the growth medium.

Table 4. Yield of mushrooms growing on the tradition substrate and on the arrowroot waste

<table>
<thead>
<tr>
<th>Mushroom</th>
<th>On the arrowroot waste</th>
<th>On the straw and sawdust (tradition substrate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw mushroom</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Oyster mushroom</td>
<td>20</td>
<td>60</td>
</tr>
</tbody>
</table>

The yield (%) is calculate as ratio between mushroom fresh weight and dry weight of arrowroot waste.

Substrates for culturing mushroom must be treated strictly and have enough nutrients. The required conditions for the growing of mushroom should ensure: pH values of 7-8, 65-70% humidity, N 2.0-2.5%, P 1.2-1.5%. Compared with these requirements, the arrowroot waste is not suitable and should be amended with nutrients before being used as the growing medium for the mushroom. For this, the starch shall be eliminated and dried to reduce the moisture, then soaked with diluted lime solution (1-2%) to adjust pH to 7-8. Adding 1-3% bran and an amount of N, P and K will help to increase the content in nutrients.

Waste residues from arrowroot can be thus packed into bags and wet sterilized at a temperature range of 120-150 °C for 3-4 hours. After cooling down at room temperature, they can used as substrates to cultivate the mushrooms. For straw mushroom, piles of substrates weighing about 20 kg/pile are made, and for oyster mushroom, substrates are packed into plastic bags weighing 1.5-2.0 kg/bag.

The process of cultivation of straw mushroom and oyster mushroom on waste residue from the arrowroot starch processing is described as follows:

Dry arrowroot wastes → material pre-treatment → heap or bags → wet sterilization → seed implantation → care, watering → harvest → process.

Each species of mushroom was grown from two to five crops. On arrowroot wastes, oyster mushroom can be grown two crops, such as autumn-spring and summer. Growing productivity reached 60-100% in autumn-spring with harvest time lasts about a month. But in the summer it produced much lower yield (only 10-25%) with short harvest time (10-15 days). In contrast with oyster mushroom, yield of straw mushroom is high in summer, and very low in autumn - spring season (5% -12%).

The results of cultivating mushroom are shown in the following Table 5, Figure 5 and Figure 6.

Table 5. Time duration, pH, temperature optimum, harvesting and productivity of two species of mushrooms growing on the waste from arrowroot

<table>
<thead>
<tr>
<th>Mushroom species</th>
<th>Time of culture (month in year)</th>
<th>Time of harvest (days)</th>
<th>Yield (%)</th>
<th>Optimum temperature (°C)</th>
<th>Optimum pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Volvariella volvaceae)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Pleurotus)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. Oyster mushroom (Pleurotus)

Figure 6. Straw mushroom (Volvariella volvaceae)

Besides factors such as temperature and pH, the intensity of light and the seed quality of mushrooms also have great influences on harvested yields.
3.4 Producing vermicompost fertilizer from arrowroot waste residues by using blueworm (*Perionyx excavatus*)

Arrowroot wastes after cultivation of mushroom were treated to produce vermicompost fertilizer. By using a blueworm species (*Perionyx excavatus*) the organic materials in the arrowroot waste residues were decomposed into humus without odour to fertilize the agriculture soil.

The experimental formulas were conducted as follows:

<table>
<thead>
<tr>
<th>Experimental formula</th>
<th>N total (%)</th>
<th>N available (mg/100g)</th>
<th>P total (%)</th>
<th>P available (mg/100g)</th>
<th>K total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control 1</td>
<td>0.91</td>
<td>38.7</td>
<td>0.18</td>
<td>33.3</td>
<td>0.18</td>
</tr>
<tr>
<td>Experiment 1</td>
<td>1.30</td>
<td>44.9</td>
<td>0.20</td>
<td>62.4</td>
<td>0.22</td>
</tr>
<tr>
<td>Formula 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control 2</td>
<td>1.17</td>
<td>41.2</td>
<td>0.19</td>
<td>15.6</td>
<td>0.23</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>1.62</td>
<td>45.5</td>
<td>0.21</td>
<td>29.8</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Solid wastes of arrowroot after cultivating the blueworms have contents of N, P and K levels higher than control samples. This tendency was similar in the two experiment formulas, for example total nitrogen content increased from 0.91% to 1.30% in formula 1 and increased from 1.17% to 1.62% in the formula 2. The content of nitrogen and phosphorus in available forms significantly increased, especially high in case of phosphorus. In Formula 1: available phosphorus increased from 33.3 mg/100 g to 62.4 mg/100 g; and in formula 2: from 15.6 mg/100 g to 29.8 mg/100 g.

Thus, the blueworms had an important contribution in the treatment of organic matter of arrowroot solid wastes in which the materials were decomposed from persistent forms into available forms. In addition, we also gained the blueworms, which are also a good source of protein food for livestock and poultry.

4. Conclusion

Duong Lieu village is an agricultural product processing area in Hanoi. This village disposed of about 400-500 tons of solid wastes per day. About 95% of the waste residues from arrowroot were not reused, and were the main cause of environmental pollution that needs to be researched and solved. Compositions of dried solid wastes of arrowroot were mainly carbon-rich substances and small amounts of N, P and K. These are the nutrients needed for living organisms; that means these substances are easily biodegradable. So, we can treat solid wastes of arrowroot by biological methods.

Finding a process to treat solid wastes of arrowroot on the laboratory scale, like reusing them as raw materials for mushroom cultivation, raising blue worms (*Perionyx excavatus*) and producing vermicompost fertilizer as well. Gained productions of arrowroot waste treatment process are the kind of nutritious foods for human such as straw mushroom and oyster mushroom. Besides, vermicompost fertilizer for crop plants and the blueworm production are also economic benefits.

5. Reference


