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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.

Việt nam có khoảng 2000 làng nghề và tập trung chủ yếu ở miền Bắc. Dương Liễu là một trong những vùng trọng điểm chế biến nông sản thực phẩm. Song hiện tại khu vực này đang bị ô nhiễm môi trường nghiêm trọng,đặc biệt ô nhiễm rác thải và nước thải. Chất thải rắn của quá trình chế biến tinh bột từ củ dong là rất lớn. Nó có mặt khắp nơi từ trong nhà ra ngoài ngõ thậm chí lấp đầy cống rãnh, ao hồ. Đây chính là nguyên nhân gây nên ô nhiễm môi trường vùng làng nghề. Thành phần của bã dong rất giàu cellulose (90%), tinh bột (5%) và có cả nitơ, photpho, kali tương với 0,5%, 0,11% và 0,16%; độ ẩm của bã dong tươi lên tới 80%. Cơ chất này thích hợp để trồng nấm rơm và nấm sò. Bởi các loại nấm này sử dụng cellulose là nguồn cung cấp cacbon chính để sinh trưởng. Do vậy, bã thải từ củ dong có thể được tái sử dụng hiệu quả bằng phương pháp sinh học như là dùng trồng nấm. Đây là một sự lựa chọn phù hợp với điều kiện Việt Nam, vừa giảm thiểu chất thải dư thừa vừa thân thiện với môi trường.

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

* Corresponding author
E-mail: hanhiebr@gmail.com

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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.

Figure 1. Waste disposal on the main road

Figure 2. Pond filled with waste

Figure 3. Waste deposited in garden

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.

Figure 4. Filled drains

In Duong Lieu village today there are more and more solid wastes, but only very small amount of those are recycled. So, the threatening of environmental pressure to public health is very serious. The methods considered for the treatment of solid waste are biogas tanks or processing to make animal feed and fertilizer, however, they did not perform well. An alterative approach is growing mushrooms on waste residues from agricultural processing. This is regarded as an environmental friendly solution with potential economical benefit.

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, NO_3 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. Input materials and solid wastes (output) of starch production in Duong Lieu village

Material	Input material (tons)				Solid waste (output), (tons)			
	Time (year)				Time (year)			
	2000	2001	2008	2010	2000	2001	2008	2010
Cassava	116,000	125,000	150,000	171,000	47,000	48,000	51,000	57,000
Arrowroot	31,000	52,000	66,000	82,000	10,000	16,000	22,000	25,600
Total	146,000	172,000	216,000	253,000	56,000	64,000	73,000	82,600

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 2. Water quality in some places in starch production village Duong Lieu

Samples	Parameters							
	pH	Temperature (^{0}C)	SS (mg/l)	BOD_5 (mg/l)	COD (mg/l)	Coliform total (MPN/100ml)	N total (mg/l)	P total (mg/l)
N1	6.26	27.5	474	5506	6,406	900×10^3	154.02	29.93
N2	5.47	32.4	394	5656	8,666	22×10^3	85.12	16.19
N3	6.59	27.7	55	3473	5,010	8×10^3	39.76	8.48
N4	5.1	26.1	17	63	232	13×10^3	5.6	0.05
Vietnam standard 5945: 2005 (column B)	**5.5-9**	**40**	**100**	**50**	**80**	**5,000**	**30**	**6**

where:

Samples	Place	Samples	Place
N1	Wastewater of production of arrowroot starch in the household in Dong hamlet	N3	Wastewater of production of cassava starch in the household in Dong Phu hamlet
N2	Wastewater of production of arrowroot starch in the household in Doan Ket hamlet	N4	Irrigation ditch between fields

3.2 The use of waste residue from starch processing

People reuse the waste generated from starch processing for different purposes. The survey showed that the wastes from cassava tubers were reused 90% as feed for cattle, poultry or as fertilizer. In this rural area, wastes from arrowroot were sometimes dried and used as fuel. However, today several fuel types are available such as gas, electricity, coal, and the fertilizer applied for agriculture is mainly micro-organic-based fertilizer. Hence, the direct reuse of waste residue as fuel and fertilizer is no longer of interest, so about 95% of wastes are disposed in environment without any treatment (Table 3).

Table 3. Status use of the waste residues of starch production process in Duong Lieu village

Solid waste	Solid Waste is use (%)			Solid waste not be reused (%)
	animal feed	fuel	fertilizer	
Cassava waste	30	0	60	10
Arrowroot waste	0	5	0	95

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 → Cultivation of mushrooms → 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

Mushroom	Yield (%)	
	On the arrowroot waste	On the straw and sawdust (tradition substrate)
Straw mushroom	5	10
Oyster mushroom	20	60

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 ^{0}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

Mushroom species	Time of culture (month in year)	Time of harvest (days)	Yield (%)	Optimum temperature (^{0}C)	Optimum pH
Straw mushroom (*Volvariella volvaceae*)	Jun., Jul., Aug.	15-25	25-30	24-30	8
Oyster mushroom (*Pleurotus*)	Feb., Mar. and Sep., Oct., Nov	25-30	60-100	15-20	7-8

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 excavates*) 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:

Formula 1: Solid wastes of arrowroot being not used for cultivating mushroom and not decomposed by blueworms (control 1); solid wastes of arrowroot being used for cultivating mushroom and decomposed by blueworms (experiment 1).

Formula 2: Solid wastes of arrowroot being used for cultivating mushroom and not decomposed by blueworms (control 2); solid wastes of arrowroot being used for cultivating mushroom and decomposed by blueworms. Two experiments were performed after 2 months of raising blueworms. The experiment results are shown in Table 6.

Table 6. Composition of arrowroot solid wastes after raising blueworms

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

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 blueworms (*Perionyx excavates*) 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.

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