RECYCLING OF SPENT OYSTER MUSHROOM SUBSTRATE

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Spent Mushroom Substrate (SMS) needs heat treatment before being removed from the growing chamber. But it takes extra cost, and thus, some mushroom growers want to throw away the contaminated SMS far from the farm in order to prevent re-contamination (Fig. 1). Without proper treatment, contaminated SMS can cause re-contamination. In opposition, recycle of SMS can increase sustainability and also help farm economy.

This article is excerpted from “Spent mushroom substrate around the world” (Danny Lee Rinker) and “Project report” (ZERI Foundation), and edited by Seung Woo Kang.

A Brief Description of Spent Oyster Mushroom Substrate

At the end of several mushroom harvests, the growing material is considered spent. SMS contains enough digestible nutrition, primarily decomposed by mushroom, to be fed livestock (Table 1, 2). It will increase growers’ income and protect environment to recycle SMS for feeding livestock or soil for other plants. As you can see in Table 2, \textit{Pleurotus} compost contains high percentage of three primary nutrients (nitrogen, N; phosphorus, P or P\textsubscript{2}O\textsubscript{5}; potassium, K or K\textsubscript{2}O) as a fertilizer.

Table 1. Characteristics of spent oyster mushroom substrate

<table>
<thead>
<tr>
<th></th>
<th>Ash (%)</th>
<th>TSS* (%)</th>
<th>C (%)</th>
<th>H (%)</th>
<th>N (%)</th>
<th>Mg (mg/L)</th>
<th>Ca</th>
<th>Na</th>
<th>K</th>
<th>Mn</th>
<th>Ni</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>72.92</td>
<td>830</td>
<td>23.6</td>
<td>4.06</td>
<td>5.99</td>
<td>7.72</td>
<td>30.13</td>
<td>1.32</td>
<td>4.47</td>
<td>2.2</td>
<td>nil</td>
<td>2.34</td>
</tr>
</tbody>
</table>

* TSS: Total Soluble Solids

(Source: Chiu \textit{et al.}, 1998)
Part II. Oyster Mushrooms

Chapter 9. Post-harvest Management

Table 2. Analysis of the fertilizer value of compost from the edible *Pleurotus ostreatus*

<table>
<thead>
<tr>
<th></th>
<th>N (%)</th>
<th>P$_2$O$_5$ (%)</th>
<th>K$_2$O (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pleurotus</em> compost</td>
<td>1.70</td>
<td>0.61</td>
<td>1.13</td>
</tr>
<tr>
<td>Human manure and urine</td>
<td>0.30</td>
<td>0.16</td>
<td>0.30</td>
</tr>
<tr>
<td>Pig manure</td>
<td>0.60</td>
<td>0.60</td>
<td>0.50</td>
</tr>
<tr>
<td>Cow manure</td>
<td>0.59</td>
<td>0.28</td>
<td>0.14</td>
</tr>
</tbody>
</table>

(Source: Zheng et al., 2002)

For instance, a Thai mushroom grower recycles his spent substrate as a soil for other plants (Fig. 4, 5). He put the spent substrate for over one year under outdoor condition before reuse.

**SMS Recycling Cases in ZERI Projects**

**Colombia: spent coffee-substrate for feeding cattle and pigs**

The organic wastes from a coffee farm contain biochemicals, which do not permit their reuse as cattle feed. Therefore, they could at best be used for earthworm farming. However, enzymes of the tropical mushrooms are capable of neutralizing these biochemicals. Even better, the mushroom mycelia (roots) are rich in protein (up to 38%). This means that the waste from the coffee farm-after mushroom farming - becomes an excellent additive to cattle and pig feed.
4kg of vegetable or fungal protein produces 1kg of pig meat. In the case of cattle farming, the ratio is 7 : 1. Many consider this to be a very inefficient way for us to get protein. However, we usually do not consider the volume of energy pig or cow manure can produce in a digester. 100 pigs produce enough manure each day to generate a calorific energy value equivalent to 10L of petroleum. Manure energy (biogas), should be used first and foremost by the coffee farmer for the preparation of the substrate for mushroom farming. The coffee bush waste needs to be pasteurized, and for specific types of mushrooms sterilized, before being used as a mushroom growing substrate. And since this requires a continuous flow of energy, it is best to use a locally available renewable energy source - and pigs always produce waste.

**Africa: spent substrate of water hyacinth weed for cattle feeding and vermiculture**

The Southern African region has an abundance of the waterweed commonly known as water hyacinth (*Eichhornia crassipes*). This aquatic weed has become a serious problem because it grows very fast and in the process chokes up waterways, blocks navigable waterways, reduces fishing points, and in some cases blocks water pumps. The adverse impact of the excessive growth of the water hyacinth is being felt in the economies of all lake districts of Africa: Zimbabwe, Malawi, Zambia, Tanzania, Kenya, and Uganda. Then, scientific research initiated by the ZERI Foundation demonstrated that dried water hyacinth is the best substrate for farming mushrooms and that the spent substrate after fungi harvesting is rich in protein from the mycelia of the mushrooms and is excellent feed for earthworms, which convert it all into humus and can be fed to chickens, ducks and pigs.

After only 30 days, the dried substrate from water hyacinth produced a variety of mushrooms. Once harvested, it did not take more than 10 days to harvest a second and even a third flush. 1 ton of dried water hyacinth substrate generated 1.1 tons of mushrooms, thus generating more mushrooms than base material and out-performing traditional substrates such as sawdust. The residual substrate of water hyacinth after mushroom farming, is a rich food-base for cattle. Since nearly all the lingo-cellulose has been broken down by the enzymes of the mushroom, the rest of the material can also be used to farm earthworms, which will convert the material into a humus. The humus that is produced in the process would then be reapplied to the soils, recovering and replenishing some of the lost topsoil. Earthworms are also an excellent chicken feed.

**Some Studies on SOMS* Recycling**

**Bioremediation**

many mushroom mycelia in removing the biocide pentachlorophenol. *Mycological Research* 102(12): 1553-1562.

**Crop production**

**Re-use in the cultivation of mushrooms**

**Food for animals and fish**
- Kakkar and Dhanda. 1998; Bakshi, *et al.* 1985. Adult and young buffaloes fed spent wheat or rice straw from *Pleurotus* cultivation.
- Kakkar, *et al.* 1990; Adamovia, *et al.* 1998; C. Jaramillo. 2001; Cattle feed from spent wheat straw compost (pers. comm.).

**Pest management**


**Miscellaneous uses**