PennState Extension

Impact of the Mushroom Industry on the Environment

Growers must use the mushroom's ability to consume organic materials discarded by man, to help control pollution in modern society.

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The Situation

The industry of composting urban waste for disposal differs from our mushroom composting goals. Urban composters promote slow temperature composting (110-130 °F) in small piles that support very active thermophilic fungi, bacteria, and actinomycetes. Their procedures are designed to replenish organic matter and humus in the soil by rapidly reducing carbohydrates and organic matter by 50% in one week. Whereas our high temperature (160-180 °F) or thermogenic composting process prevents such degradation, and conserves carbon so that the 50% reduction of organic matter occurs during the cropping process. Mushroom substrate preparation will change carbon into specific carbohydrates that the mushroom can use. These differences must be emphasized for any reference or comparison with composting waste materials for disposal.

Our role in waste disposal and recycling should be reexamined. The mushroom farm's image as one of waste recycling must be maintained or enhanced. It is important that mushroom researchers understand the problems of urban waste composting. A future possibility is to build a mushroom farm to use previously composted urban waste. Fibrous material such as hay and straw may not be replaced, but the search for other products that can be combined to produce a productive compost should be continued.

The industry should reflect upon itself by asking these questions: Can any polluting be eliminated and can farms become totally conserving? How can mushroom farming fight pollution and garbage accumulation? Growers have been making tremendous strides in these areas for several years, yet farms still have an impact on the environment.

The End Result Post (Spent) Mushroom Substrate

When the mushroom takes up where the thermophilic organisms stop in recycling the carbon of green plants it uses part of the compost as nutrient in producing its fruiting bodies. Most of the compost is left behind as a residue called spent compost, spent mushroom substrate or more recently proposed "post mushroom substrate." This material is ready to be further attacked by a new set of organisms. The growers must now dispose of this substrate or encourage these other organisms to decompose this organic matter further. Fortunately, post mushroom substrate is not spent and has many uses.

Have we fully investigated the requirements for using post mushroom substrate in the gardening market? It is not simply a matter of making it available, but growers must think of the removal of this substrate as a marketing opportunity: adapting the material to that of the gardeners' needs, further decomposing of the substrate or mixing other ingredients into it to enhance or dilute nutrients. Although this will dispose of material but is not recycling per se.

In the areas where many mushroom farms are concentrated near an urban area, the disposal of spent compost is still a problem for most growers. Piles of spent substrate in all parts of the landscape are no longer ignored by neighbors or environmental regulatory agencies. The piles may become anaerobic and give off offensive odors. Runoff from piles may be allowed to drain into nearby water sources. An urgent situation is approaching in some areas and disposal of the post mushroom substrate is essential for the mushroom farmers' survival.

The mushroom substrate we spread on the ground does not appear to pose a pollution problem. Since compost is already nearly 75% inorganic matter, it decomposes to an unobjectionable soil like residues. Studies at the Stroud Water Research Center suggest that the impact to the ground water under post mushroom substrate pile is minimal. Nevertheless, this type of substrate disposal does not seem sensible in a world where humus rich materials should be in high demand.

One hope is that gardeners, municipal parks and landscape will buy it, but that has not happened to the expected demand required for complete disposal. The mushroom industry must try to educate not only the community but all possible users about the value of post mushroom substrate. Local garden centers should be telling their customers to use post mushroom substrate as a mulch around newly planted shrubs and add it to their garden soil. The floriculture research done at Vineland, Ontario and other places should be widely distributed as educational material to promote the use of post mushroom substrate in container crops.

One type of disposal is to recycle it back onto the fields for other agricultural crops. Although the quantity, storage, handling, and trucking cost are higher than with chemical fertilizers, the long term benefits of the material need to be highlighted. Research at Penn State and around the world continues to show the value of post mushroom substrate as source of nutrients for many crops and plants. This research has confirmed what some farmers and gardeners have known for years. Spent compost is a source of nutrients and water holding properties for such crops such as corn and other vegetables. The corn farmers of Lancaster have a pollution problem when they add the quantity of manure necessary to produce some of the highest corn yields per acre in the country. The corn plant is unable to use all the nitrates because of another limiting factor, possibly the organic carbon compounds that hold water. These excess nitrates leach into the ground and end up in the Chesapeake Bay. Therefore, corn farmers have to reduce fertilization rates and accept lower yields to avoid increasing nitrate levels in the ground water. It is possible that spent compost would be an ideal source of organic carbon material to retain the nitrate rich water in the soils. Post mushroom substrate, possibly mixed

with the fresh animal manure, would allow corn farmers to add the quantity of manure required, without the fear of excess nitrates or nutrients leaching into the ground.

Other environmental, agricultural and industrial uses of post mushroom substrate were summarized in the proceeding from the SMS Symposium of 1994. Most of these uses were recently reviewed by Michael Dann (Mushroom News August 1996) and will only briefly be mentioned here. Bioremediation of soils contaminated with wood preservatives and pesticides has been documented. Spent mushroom substrate is the material of choice for creating wetlands for passive treatment of coal mine drainage. Compost teas from post mushroom substrate have been somewhat effective in controlling apple scab and late blight of tomatoes. Preliminary results by Wuest, Anton and Kelly suggested that treated spent as a casing material may even reduce the incidence of Verticillium disease on mushrooms. These areas of research are just beginning to be explored and with a concentrated research effort may result in a variety of demands for post mushroom substrate, not to mention the environmentally friendly connotations the results may bring.

The practice of recycling spent compost back into Phase I composting is not economically feasible because as it adds little nutritional value. However, producing a second crop of mushrooms by supplementing spent mushroom substrate with certain additives may be possible. During the first crop the mushroom uses most of the cellulose, lignin, and other carbohydrates. In the early 60's Sinden and Schisler showed that specific forms of nitrogen limited mushroom yields. However, nitrogen as a limiting factor can be overcome by the addition of delayed released protein-lipid rich materials at spawning, such as that developed by Schisler and Carroll in the mid-70's. My research has shown that once the requirement for nitrogen is satisfied, phosphorus becomes a limiting factor. The addition of rock phosphate to heavily supplemented compost at spawning will further increases later break yields. Furthermore, the addition of chelating agents to compost at spawning has shown that later break yields can be improved. These studies at Penn State have suggested that phosphorus availability may be a limiting factor. By controlling the ionic activity of calcium and potassium in the compost solution, phosphorus availability is increased and later break yields can be improved. At first glance longer harvesting periods or re-spawning spent substrate does not seem economical. Using the existing space available it seems most unlikely that a grower would reach profitable yields from the remaining nutrients for a second crop. However development of the mechanism involved in increasing phosphorus nutrition, availability or uptake may increase the amount of substrate consumed by the mushroom and reduce the quantity of post mushroom substrate remaining after harvesting 3-4 breaks.

The Other By-Products

Nuisance odors continue to be discharged from our composting operations. These odors or their concentrations are not harmful, but can be annoying to neighbors downwind from composting wharves. Community complaints have resulted in demands for legislation to limit or ban mushroom composting operations. So do mushroom growers need deodorants sprayed around their compost wharves? Some composting ingredients have been suggested by Sinden and others, to reduce these offensive odors. Sinden suggested materials such as grape pumice, coffee grounds and cocoa beans, licorice root, sugar cane bagasse and sugar beet pulp could be used. However, good composting management that reduces or eliminates anaerobic compost will greatly reduce odors. Anaerobic cores can be avoided by keeping piles smaller and the center drier. Compromises such as not reaching the maximum "inbound" moisture in compost as early as desired or accepting a little drier compost in the pre-wetting stages made be needed to avoid the offensive anaerobic odors. Hydration technology embraces the notion of achieving early inbound moisture without the need for large pre-wet piles that easily go sour. Forced aeration and controlled environment composting eliminate anaerobic composting. Unfortunately, all these technologies are not often affordable in an industry that has small profit margins that are easily reduced by lowering market prices. Other lower cost solutions need to be developed before regulations force composters into expensive solutions.

Covered compost yards to keep rain and snow out assist in preventing anaerobic compost. Catch basins, lagoons and holding tanks should be the primary targets for odor sources. Offensive odors from improperly managed drainage catch basins and from the practice of pumping anaerobic water back onto the raw ingredients is often the source of neighbor complaints. Reusing water drained from the compost during Phase I is not as good of a solution as practicing composting procedures that avoid runoff. When runoff is unavoidable, then pumping it back onto the pile is an acceptable solution and should be considered as another example of effective recycling. Maintaining this recycled water well aerated will help reduce neighbors' concern. Roofs also help alleviate water runoff from the piles contaminating ground water.

Drainage from compost yards is being more closely regulated. Water that drains from composting yards and mushroom houses that may pollute the local water supplies has been reduced or most often eliminated. Eventually all composting operations may have to use plans similar to those suggested by the Soil and Water Conservation Agencies. These agencies have helped several farms in the installation of water runoff containment sites for their composting wharves or spent substrate storage areas.

Stems and other mushroom tissue removed from the beds during harvesting are other waste products. Some growers incorporate the stumps and trash back into the compost at Phase I. It solves the disposal problem and adds a useful supplement to the compost nutrition.

A thorough and complete pasteurization of the compost during Phase II is important to prevent the spread of disease. In fact, this practice may be quite dangerous with crops heavily infested with virus or Trichoderma. Much of the harvesting leftovers go to land fills or is mixed with the post mushroom substrate dumped on the land to decompose slowly. It may be possible that municipal waste composting operations could use mushroom stems as a source of moisture and/or carbohydrates.

Pesticides and Biological Control

Over the past decade or more the registration for many pesticides used to control mushroom pests have been discontinued. Several times farms have been scrutinized for pest control practices, pesticide residues and worker protection standards. The new EPA workers' protection standards have helped farms become aware of many of these health concerns. Although these regulations require more work and cost to train employees, they should prevent unwanted accidents and pesticide poisoning. Overall, the potential problem of pesticide residues and worker exposure to them is being removed by the improved pesticide safety practices at farms and by the unwelcome banishment of registered pesticides for the industry. The AMI continues to lobby the government and chemical companies to keep the remaining pesticides available. Fortunately, growers have improved control of the insect pest that once ravaged our crops. Because physical sealing of the mushroom houses is environmentally friendly, it has become the most important control method on farms today. As farmers, we ought to be thankful we have such an option.

Many composting operations use parasitic wasps to control the pesky house fly populations around the composting wharves biologically. This control reduces the annoyance of these pests to employees and neighbors. Besides parasitic wasps, other biological control products are available for the growers to use. Widely used, growth hormone regulators are effective and less toxic to humans. However, since these compounds are more toxic to aquatic insects, it is extremely important they do not reach local streams or water supplies. Biological control products like Bacillus thuringiensis (Bt), parasitic nematodes and plant products are being tested and used on crops to control the mushroom fly and some fungal diseases. Better control of the mushroom flies not only helps yield and quality, but it also reduces the intolerable numbers of irritating flies that invade neighboring homes. The clean up of organic matter around the farms not only reduce the breeding grounds for pests and diseases, but also create a more pleasant appearance of the farms to neighbors and passing motorist. Out of sight out of mind?

Helping with Waste Disposal

If left alone, all organisms will perish in their own waste. In the days of the horse and buggy, the mushroom industry provided a valuable way to dispose of a waste commodity. Today the

mushroom industry supplies the same service for race tracks and boarding stables, who cannot simply throw the material away or pile it on unused land. Unfortunately, the mushroom business grew faster than the horse racing business, so their waste is now inadequate for our industries' needs and horse manure has become a costly ingredient. In addition, other materials that are more consistent incoming to the farm are preferred to the inconsistencies associated with horse manure coming from different sources. Mushroom farms use tons of second grade hay grown on thousands of acres. Which incidentally provides additional income for farmers whose land might otherwise be idle.

Another waste product mushroom farms help to dispose of is poultry manure. The disposal of its manure is a difficult problem for the poultry industry. Does the community realize how many nuisance odors and pests are produced by an old storage pile of poultry manure? Poultry manure is one of the most commonly available nitrogen sources across all areas of the country. In some areas the chicken and egg industries are threatened by the accumulation of manure. It would be more advantageous for both industries if mushroom growers could use more poultry manure in their formulas. Unfortunately the mushroom industry uses relatively small amounts of poultry manure.

To maintain compost structure for aeration during composting requires a base of organic fibrous material to keep the piles loose and provide carbohydrates for the nutrition of the mushroom. One Pennsylvania farm has worked with their local municipality to use the leaves collected in the township during the fall. They have successfully used the leaves in their composting process and now are considering improved ways to store and handled larger quantities. Paper waste will add cellulose to the compost, but only added at a low amount per ton of dry material. More research into this area may be valuable to find a use for the tremendous amount of junk mail and paper waste.

Summary

Sure, if more people understood where food comes from, they would consider agriculture and mushroom farming friendly to the environment. Rapidly developing communities may begin to tolerate our farms and agricultural. Promoting mushroom farming as environmentally friendly should be a long term educational goal of the industry.

As growers we tend to only see composting from a mushroom's point of view. More importantly the environmentalist, municipal governments and communities should look to mushroom farms as a disposal agent. Researchers should be more interested in testing and using agricultural and industrial waste products for mushroom compost. Growers must use the mushroom's ability to consume organic materials discarded by man, to help control pollution in modern society.

A worst case scenario is the expansion of municipal waste composting facilities to use more organic waste products for the sole purpose of disposing of urban and industry waste. These waste disposal facilities will be designed for a fast, complete and efficient reduction of organic materials. The productivity of their operations may not be as important as having a high volume capacity to use municipal waste. Mushroom farms will not compete well with these industries for the organic materials required by our crop.

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