Logistical Considerations for Spent Mushroom Compost Utilisation

Considérations logistiques pour l'utilisation du compost de champignonnières.

W. Magette, S. Smyth and V. Dodd
Agricultural and Food Engineering Department, University College Dublin
Earlsfort Terrace, Dublin 2, Ireland.
E-mail : william.magette@ucd.ie

Abstract

Intensive agricultural enterprises such as mushroom producers generate volumes of organic wastes that generally exceed the capacity of land resources under their direct control to safely assimilate. In the case of Ireland's mushroom industry, the fact that producers are concentrated into distinct geographic locations amplifies the problem of safely utilising a by-product of production: spent mushroom compost. This paper presents a preliminary evaluation of the logistical constraints and possible alternatives for both agricultural and non-agricultural uses of spent mushroom compost. Considered are problems of transport, production techniques, regulatory controls, citizen opposition, economics, and inertia against change within the mushroom industry.

Keywords *: waste management, sustainable development, spent mushroom compost.*

Résumé

Les entreprises agricoles intensives, comme les producteurs de champignons, engendrent des volumes d'ordures organiques qui dépassent, généralement, la capacité des ressources du terrain, sur leur contrôle direct, d'assimiler les ordures sans risques.

Dans le cas de l'industrie des champignons en Irlande, le fait que les producteurs soient concentrés dans des emplacements géographiques distincts amplifie le problème d'utilisation prudente des dérivés de production. Cet article présente une évaluation préliminaire des contraintes logistiques et les autres possibilités pour l'usage agricole et non agricole du compost vide des champignons. Nous avons considéré les problèmes de transport, les techniques du production, la législation, l'opposition des citoyens, l'économie et l'inertie contre le changement dans l'industrie des champignons.

Mots-clés : gestion déchets, développement durable, compost champignonnières.

1. Introduction

One of the great success stories within Irish agriculture is the mushroom industry that has developed over the last 20 - 30 years. The industry now produces product valued at approximately IR£60 million. Most of this production is exported to the U.K. and other European countries, where Irish mushrooms are renowned for their uniform, high quality and long shelf life. Irish mushrooms are grown at competitive prices due to a unique production system based upon 1) a pre-packaged compost growth medium, 2) relatively simple and inexpensive production facilities (*i.e.* polyethylene tunnels), and 3) a meticulous level of quality control.

An inevitable by-product of mushroom production is compost that can no longer sustain an economically viable yield of mushrooms. This so-called "spent" mushroom compost (SMC) is rich in organic matter; fairly high in the macro-nutrients nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca); and has a high electrical conductivity (Table 1). Like most other organic sources of nutrients, SMC would be considered an unbalanced fertiliser because the macro nutrients are not in the correct proportions to each other for normal plant nutrition.

Large quantities of SMC are produced by the industry. A typical production cycle in the Irish mushroom industry is 10 - 12 weeks in duration. When production facilities are emptied of the spent compost at the end of this cycle, a single, typically-sized facility generates approximately 18 t of SMC, resulting in an annual load of 260,000 t per annum for the entire industry. Applying the average values for

	Total analysis		Available nutrients[1]	
	% of DM	Fresh material	(mg L^{-1})	
Bulk Density (kg/m^3)		329	pH	6.6
Dry Matter (%)		31.5	EC (µS/cm)	7,500
Organic Matter	65.0		Nitrate-N	63
N	2.55	8.0 kg/t	Ammonium-N	50
P	1.24	3.9 kg/t	P	32
K	2.50	7.9 kg/t	K	2,130
Ca	7.25	22.8 kg/t		
Mg	0.67	2.1 kg/t		

[1] Availability analysis was carried out on a water extract from a 1:1.5 volumetric (SMC:water) mixture and the results expressed as mg L^{-1} of extract.

Table 1
Mean composition of spent mushroom compost in Ireland
(from Maher and Magette, 1997).

N and P content of SMC as given in Table 1, the industry "generates" 2,080 t of N and 1,014 t of P per annum that must be managed.

2. Key Obstacles to SMC Management

Physical characteristics of the Irish mushroom industry

Like other organic waste by-products that derive from agricultural production, management of SMC by returning it to the land is, ostensibly, the most logical alternative. However, like virtually every other type of intensive agricultural enterprise (*e.g.*, pig and poultry rearing), mushroom production can take place independently of whatever land base is necessary to produce the inputs it uses. Economically, this permits small entrepreneurs with limited capital and land resources to become successful mushroom producers. Unfortunately, it also facilitates concentrations of producers, often in regions that are unsuitable for other types of agriculture. This combination of factors has caused severe environmental problems in Ireland in the recent past with the pig industry (Dodd and Champ, 1983). While being concentrated in distinct regions, individual producers are relatively dispersed within the regions.

The primary input for mushroom production is fresh compost, which is a special-purpose blend of straw (from wheat or barley) and a nutrient source (typically poultry manure) that has undergone controlled biological degradation.

Lack of Waste Management Oversight

Heretofore, mushroom producers have not had to be directly involved in the *ultimate* management of SMC. Instead, many producers have simply hired specialist contractors to remove the compost at the end of a production cycle.

In short, the ultimate management of SMC has been unsupervised; contractors have been left to their own devices for disposing of the material by whatever mechanism yields them the biggest profit. In some cases, farmers have used SMC judiciously for its nutrient value. However, such responsible uses have been overshadowed by the widespread occurrence of the unsustainable disposal practices. Except for large producers that are required to obtain an Integrated Pollution Control (IPC) license from the Environmental Protection Agency, it is not clear that Irish waste management laws apply directly to SMC.

Packaging

Pre-packaged compost is one factor in the success of the Irish mushroom industry. At the manufacturing plant, fresh compost made to specification is mechanically filled into plastic bags, which are loaded onto flatbed (or enclosed) articulated lorries for distribution to mushroom producers. At destination, the bags of compost are off-loaded and placed in the mushroom tunnels, at which time they are shaped

into cylinders and trimmed to remove excess plastic from around the tops of the bags. Casing material is placed on the surface of the compost and the production cycle begins. Thus, the bags which originally facilitated compost transport continue service as containers for mushroom production. To this extent, the plastic bags are convenient and utilitarian.

However, at the end of the production cycle, the plastic bags add to the SMC management problem. On the one hand, the bags themselves represent a waste by-product that requires management. In cases where bags are separated from the SMC, "management" includes incineration and landfilling, neither of which is in keeping with a "recycling" ethos. In other cases, no attempt is made to separate the bags from the SMC they contain, and the bags are co-disposed with the SMC in landfills, sink holes, bogs, fields, and along roadsides. Recycling at a proper plastic recycling facility is not viable at present due to the fact that even after they are emptied, the bags still contain a significant amount of SMC adhering to the bag surface. Even if producers were inclined toward recycling, the fact that they are relatively dispersed would preclude the practice until "regional" recycling facilities become available, until an economically viable collection system is established, or both.

Hygiene

Most mushroom producers are extremely careful about maintaining a high standard of hygiene in and around the production facilities.
Concerns about hygiene also constrain how SMC might be transported from its point of origin to its ultimate point of use. For example, a logical mechanism for returning SMC to where raw materials for the fresh compost originated would be to use the same lorries that transported the fresh compost. However, this practice would introduce the possibility that the compost production facility could become contaminated with organisms pathogenic to mushrooms. This would have a disastrous impact on a large number of producers.

Competition for Spreadlands

The application to land of organic by-products from any intensive agricultural enterprise must follow a mass balance principle (Dodd, 1991). In general, nutrients (or more specifically N and P) are the controlling elements of concern when land applying organic wastes.
However, the same constraint pertains to other intensive enterprises desiring to use land as a waste management option. In addition, government programmes to encourage environmentally friendly farming practices (DAFF, 1996) will further restrict the availability of land for use by intensive producers. Restrictions on soil test phosphorus levels remove additional land from the available pool. In combination, these constraints have a significant influence on the location of new intensive agricultural enterprises (Magette, Carton and Power; 1997) and on the distances that existing producers may have to travel to find suitable agricultural spreadlands. In reality, agricultural land may not always be readily available as a management option for every mushroom producer.

User Demands

As just outlined, when the ultimate management site for SMC is agricultural land, the needs of users (*i.e.* farmers) are fairly easy to estimate. In general, farmers want an inexpensive, yet reliable source of nutrients in a form that is easy to handle and apply uniformly. If, however, the ultimate destination of SMC were not agricultural land, other users could have quite different demands.

The landscaping industry is seen to be one potential user of SMC. Leonard (1998) surveyed landscape contractors in the northwest region of Ireland to determine their attitudes about and demands for SMC as a product in their businesses. Respondents indicated they would prefer a product delivered to them (in bales) at a cost not exceeding IR£10 m^{-3}. Home gardeners have been suggested as a possible end user of SMC that has been further composted (Leonard, 1998; Teagasc, 1993), but no market survey to identify demand (in terms of SMC volume and characteristics) has yet been performed.

Incineration also has been suggested as a potential SMC management alternative (Teagasc, 1993). However, on it's own, SMC has a rather low calorific value (Smyth, Magette and Dodd, 1998) and is not, therefore, a suitable fuel source. SMC might well be appropriate for co-incineration with other wastes. While incineration would facilitate pathogen destruction and dramatically reduce the volume of material to be handled, it would do nothing to alter the mass of P that must be managed. Incineration as a technique for SMC management alone is probably not economically viable; nor is there much public support for incineration of any type.

3. Preliminary Analysis and Potential Management Solutions

Our preliminary assessment of the SMC management problem, together with our experience in addressing similar organic waste management problems, has led us to the following "conclusions". These are shaping our thinking toward developing a long-term problem solution.

1. SMC management must be organised and coordinated; *i.e.*, individual growers should participate in a group solution rather than trying to solve only their own SMC management concerns.
2. SMC management must be based primarily on land application, although other management alternatives (*e.g.*, commercial markets, incineration) may have a role in a total solution.

Group Solution

The chaotic and environmentally unfriendly manner in which much SMC management is currently taking place is illustrative of the failure of individual attempts at SMC "management". Likewise, the current variety of unsound (*i.e.*, unsustainable) *disposal* practices (as opposed to *management* practices) is

reflective of 1) economic pressures that force cheap solutions and 2) lack of specific regulatory controls over most SMC uses.

A group (or coordinated) solution would spread the costs of SMC management over many "users" and could also keep costs down through the realisation of economies of scale. In addition, a group solution would facilitate a higher level of quality management in all aspects of the management operation, though the employment of trained personnel with dedicated job responsibilities. Lastly, a coordinated solution would facilitate sustained growth of the mushroom industry.

Given that a group SMC management approach should be adopted, several organisational models could be suggested. At one end of the spectrum, the scheme could be totally privatised, being operated by a commercial entity that may have no connection whatsoever with the mushroom industry. Alternatively, a co-operative approach – quite familiar in agri-business – could be formed, in which individual mushroom producers are members and decide the operational rules for the scheme. The option we favour involves a marriage of these two models in which the producers of fresh compost and marketers of mushrooms are integral participants in the management of the spent compost.

Land Based Application

The nutrients and organic matter in SMC give it value as a soil amendment for crop production. As for other waste by-products from the agricultural industry, land application is a natural, low cost, sustainable management option for SMC.

Unfortunately, SMC suffers from the same drawbacks as most organic wastes: variability in quality, unbalanced nutrient content, handling problems, and continuous supply but only occasional need. In the Irish mushroom industry SMC also suffers from being encased in a plastic wrapper that has no inherent end-value and represents a management problem by itself. Further, SMC poses a hazard to hygiene in and around active production facilities and must be handled very carefully.
These facts all suggest the need for a management scheme based on centralised « processing » of SMC, if land application is to be a successful ultimate management option. Such a facility would facilitate :

- the removal of plastics using specialised machinery;
- further composting to reduce volume, enhance stability and improve handling characteristics;
- the killing of mushroom pathogens;
- possible blending of additional nutrients to end product to improve nutrient balance;
- bulk storage to span time frames unsuitable for land application;
- possible co-composting of other wastes (*e. g*. MSW).

Even if this is the model were adopted logistical problems would remain. Siting of such a facility must take into account both location of producers and location of

spreadlands. To protect hygiene around production tunnels, SMC should not be stored or disposed within 2 km of tunnels. Yet, a centrally located SMC processing facility facilitates cost-effective transport. In principle, the collection of SMC from dispersed sources is identical to the collection of solid wastes from domestic households. The techniques for successfully accomplishing this task are widely available.

Determining whether, in fact, re-composted SMC can be transported back to tillage areas is less straightforward. This is difficult to ascertain as most tillage crops in Ireland are grown on contract with specific fertiliser inputs; in order to use SMC the nutrient levels would have to be consistent, or a specially blended commercial fertiliser would need to be developed to correct the nutrient deficiencies inherent with SMC.

Other Considerations

It is difficult to envision a solution to Ireland's SMC management problem that does not also address the plastics issue associated with SMC. At least one marketing group is exploring the feasibility of using biodegradable plastic bags instead of the currently used polyethylene bags. Our group is examining the possibility of using natural fibre bags. Either of these alternative bags, if economically and technically viable, would solve the plastics recycling dilemma that faces mushroom growers using the "bag and tunnel" system commonplace in Ireland today.

4. Conclusions

4.1. While we are confident that a solution to the SMC management issue in Ireland must be coordinated among many mushroom growers, must involve fresh compost producers/mushroom marketers, and must utilise land as the ultimate receptor for the SMC, we have yet to complete our analysis of the logistical problems that preclude such a solution. We have no reservations that these obstacles can be addressed successfully.

4.2. A key question will be, however, at what cost a solution can be obtained. Clearly, with narrow profit margins and a relative inability to pass costs on to consumers, producers will be sceptical of any solution, no matter how technically sound, if it significantly increases production costs.

4.3. On the other hand, it can no longer be argued that the current *laissez faire* approach to SMC management is sustainable. We hope that a regulatory approach to solving this issue can be avoided. To do so, however, will require a significant attitudinal change among growers and marketing groups. It also may require both internal changes (*e.g.*, alterations in production technique) and external changes within the industry. Lastly, there may need to be coordination at the highest levels of Irish government to assure that land is a viable treatment medium for both extensive and intensive producers of organic and nutrient rich waste by-products.

5. Acknowledgements

This work was part funded by EU Structural Funds via the Irish Department of Agriculture and Food Research Stimulus Fund. The authors also appreciate the thoughtful input of Mr. Michael Maher, Teagasc, who is the project leader for the overall research project

6. References

DAFF. 1996. Rural Environment Protection Scheme Agri-Environment Specifications. 15 May 1996 Revision., Department of Agriculture, Food and Forestry Dublin, Ireland. 74 pp.

Dodd, V. A. 1991. Planning for intensive livestock production units. IN: J. Feehan (ed.) Environment and Development in Ireland. The Environment Institute, University College Dublin, Clonskeagh, Dublin, Ireland. pp. 358-367.

Dodd, V. A. and W. S. T. Champ. 1983. Environmental problems associated with intensive animal production units, with reference to the catchment area of Lough Sheelin. IN: J. Blackwell and F. J. Convery (eds.). Promise and Performance - Irish Environmental Policies Analysed. Resource and Environmental Policy Centre, University College Dublin, Ireland. pg. 111-129.

Leonard, P. 1998. The Use of Spent Mushroom Compost in Landscaping. Teagasc, Dublin, Ireland. 8 pp.

Magette, W. L., O. T. Carton and V. Power. 1997. Implications of the Irish EPA's new licensing requirement. IN: T. Matsunaka (ed.) Environmentally Friendly Management of Farm Animal Waste. Rakuno Gakuen, University, Ebetsu, Japan. pg. 23-26.

Maher, M. J. and W. L. Magette. 1997. Solving the spent mushroom compost problem. IN: L. Staunton and J. Grant (eds.) Advances in Mushroom Production, Proceedings, 12th Teagasc National Mushroom Conference and Trade Show. Teagasc, Kinsealy Research Centre, Dublin, Ireland. pg. 73-82.

Smyth, S., W. L. Magette and V. A. Dodd. 1998. A national strategy for SMC management. Agricultural and Food Engineering Research 1997-98. Agricultural and Food Engineering Department, University College Dublin, Earlsfort Terrace, Dublin, Ireland (in press).

Teagasc. 1993. Monaghan Agricultural Waste Management Study. Teagasc, Johnstown Castle Research Centre, Wexford, Ireland. 201 pp.