

BEST ENVIRONMENTAL MANAGEMENT PRACTICES

FOR MUSHROOM GROWERS IN CANADA




CANADIAN MUSHROOM GROWERS' ASSOCIATION
DES CHAMPIGNONNISTES DU CANADA




In December 2000, the Canadian Mushroom Growers' Association (CMGA) established an Environmental Task Force to address the increasing need for environmental stewardship and best environmental management practices. As part of that commitment, the Task Force has developed this Best Environmental Management Practices (BEMP) Guide for Mushroom Growers in Canada. The result of months of exhaustive research and study, it is intended to provide mushroom growers, their surrounding communities and mushroom consumers at large, with a better understanding of the environmental issues facing this sector of agriculture and some guidelines to resolve those challenges.

The CMGA welcomes contributions to this Guide.

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This Guide has been written in cooperation with the University of Guelph. The contents have been reviewed by the Ontario Ministry of Agriculture and Food [OMAF] and Agriculture and Agri-food Canada [AAFC]. The integrity of the information remains the responsibility of the Canadian Mushroom Growers' Association.

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"The Canadian Mushroom Growers Association has a commitment to the environment and to the continuation of successful business under increasingly stringent environmental controls."

– CMGA Policy Statement on the Environment

ABOUT THE CMGA BEST ENVIRONMENTAL MANAGEMENT PRACTICES GUIDE

A summary of the current knowledge on the cultivation of mushrooms as it relates to environmental practices is included. Published literature and work in-progress, from around the world, were reviewed in preparation of this document. Farm sites were visited in Canada, the United States and Europe and an extensive survey of Canadian mushroom growers was conducted.

The practices described in this document apply to the cultivation of *Agaricus bisporus* (white button) mushrooms, which represent ninety-nine per cent (99%) of the mushrooms grown in Canada. Although culture techniques for non-Agaricus mushrooms differ from *Agaricus*, most environmental management practices apply to all mushroom facilities.

The main objectives for the BEMP Guide are:

- To provide Canadian mushroom growers with practical guidelines for managing their farms in an environmentally responsible manner.
- To inform provincial and municipal governments on the current guidelines for standard environmental practices on mushroom farms.
- To demonstrate to consumers that Canadian mushroom growers are using environmentally sound agricultural techniques.

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INTRODUCTION

Over the past fifty years, Canadian agriculture has evolved from a small, mixed-farm culture to large, highly specialized enterprises - while, in many cases, retaining family ownership and management. This trend to intensive agriculture has been driven, in many instances, by forces outside agriculture such as population growth, rapid urbanization, global markets, genetic improvement of plants and animals, demographics, consumer demands for predictable quality and food safety, and consolidation within the food processing, distribution and marketing system. Canadian consumers spend only thirteen percent of their disposable incomes on food.

Currently, fewer than three percent of Canadians are engaged in agriculture. Those professional farmers must be, not only experts in raising their crops and livestock, but also must balance the benefits of efficient food production with environmental sustainability.

Modern mushroom farms illustrate these challenges. Consumers demand a reliable supply of excellent mushrooms. Those demands can be met only by utilizing modern techniques, equipment and resources.

Fortunately, mushroom farms have the capacity to respond to these challenges. They utilize the expertise of engineers, research scientists, chemists, technical consultants and a host of other professionals to analyse the opportunities and design solutions. Mushroom growers sponsor research on new technologies and use innovative practices from around the world. In short, modern mushroom farms are pro-active in developing environmental solutions in a practical and responsible manner.

Better knowledge regarding health and nutrition, on behalf of Canadian consumers, has substantially increased the demand for mushrooms, and other fresh vegetables. Along with the demand for healthy, safe foods comes the demand for a sustainable environment. Mushroom growers are constantly vigilant of their responsibility to ensure that water, land and air resources are protected.

MUSHROOM FARMING IN CANADA

Mushrooms are the second largest horticultural crop in Canada, second only to potatoes, by farm gate value. In 2001, approximately 190,000,000 pounds (86,000,000 kg.) of mushrooms were grown, with a value of $274,000,000. Ontario produced approximately 50% of the national total, while British Columbia accounted for 32%, the Prairie Provinces 13%, and Quebec and the Maritimes provided the remaining 5%.

Fig. 1 **Mushroom Sales**

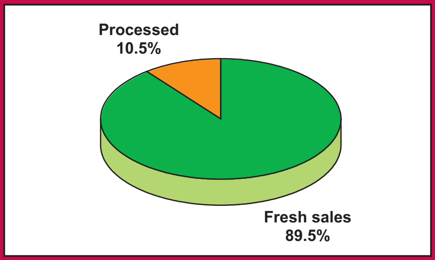
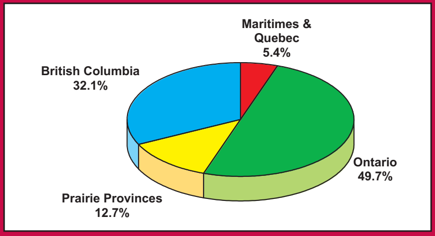
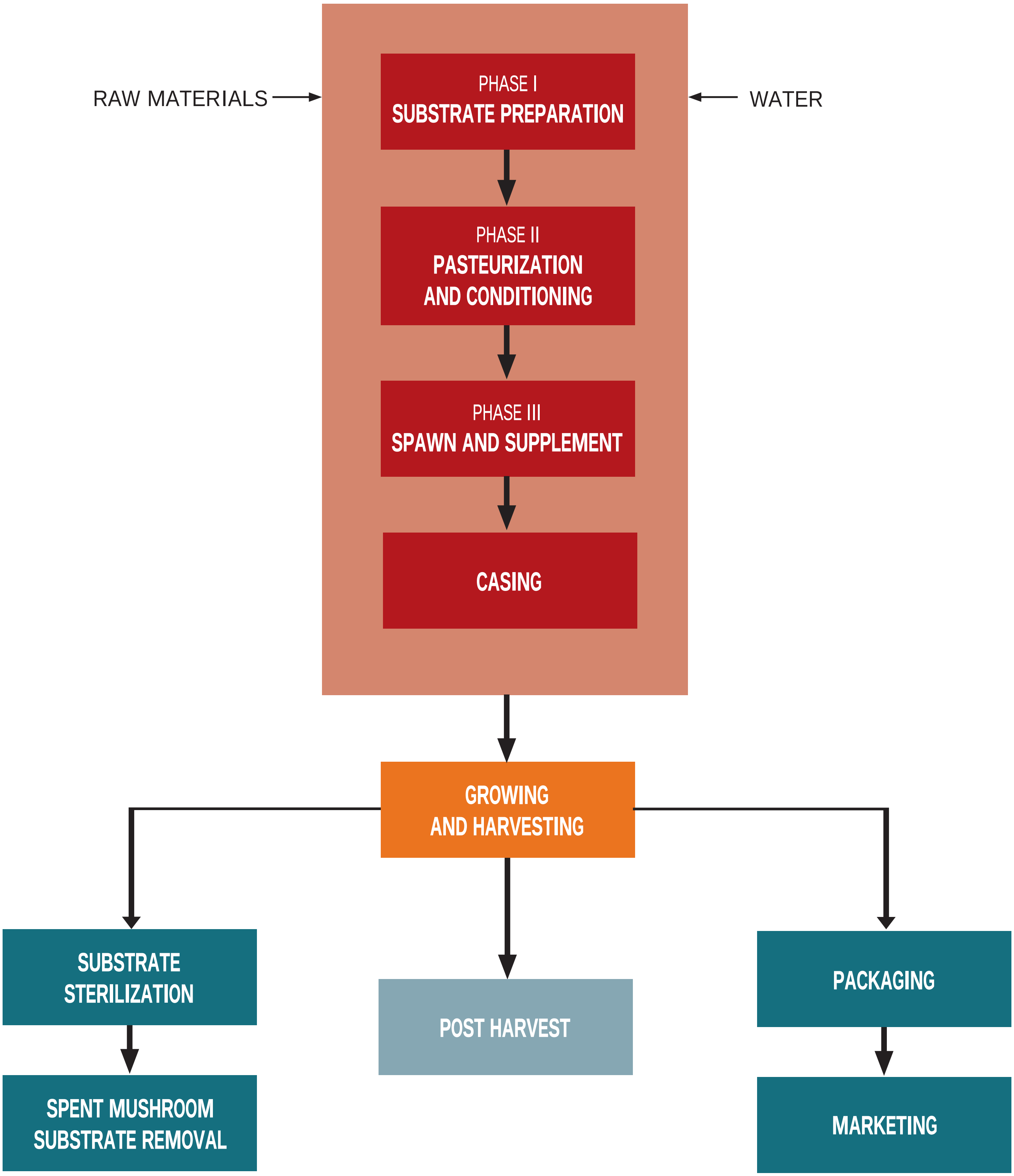


Fig. 2 **Regions of Mushroom Production**



THIS MANUAL OUTLINES THE BEST MANAGEMENT PRACTICES FOR DEALING WITH ENVIRONMENTAL ISSUES ASSOCIATED WITH EACH STEP OF MUSHROOM FARMING.

Figure 3: **Mushroom Growing Flow Chart**



SECTION

1

SUBSTRATE PREPARATION TO CASING

PHASE I: Raw Materials

The most common ingredients of mushroom substrate in Canada are: straw and hay, horse stable bedding, poultry litter, and gypsum.

Many mushroom growers have developed unique formulations for mushroom substrate, the material in which the mushroom mycelia actually grow. These formulations are based on availability and cost of raw materials, and individual farming practices.

The most common ingredients of mushroom substrate in Canada are:

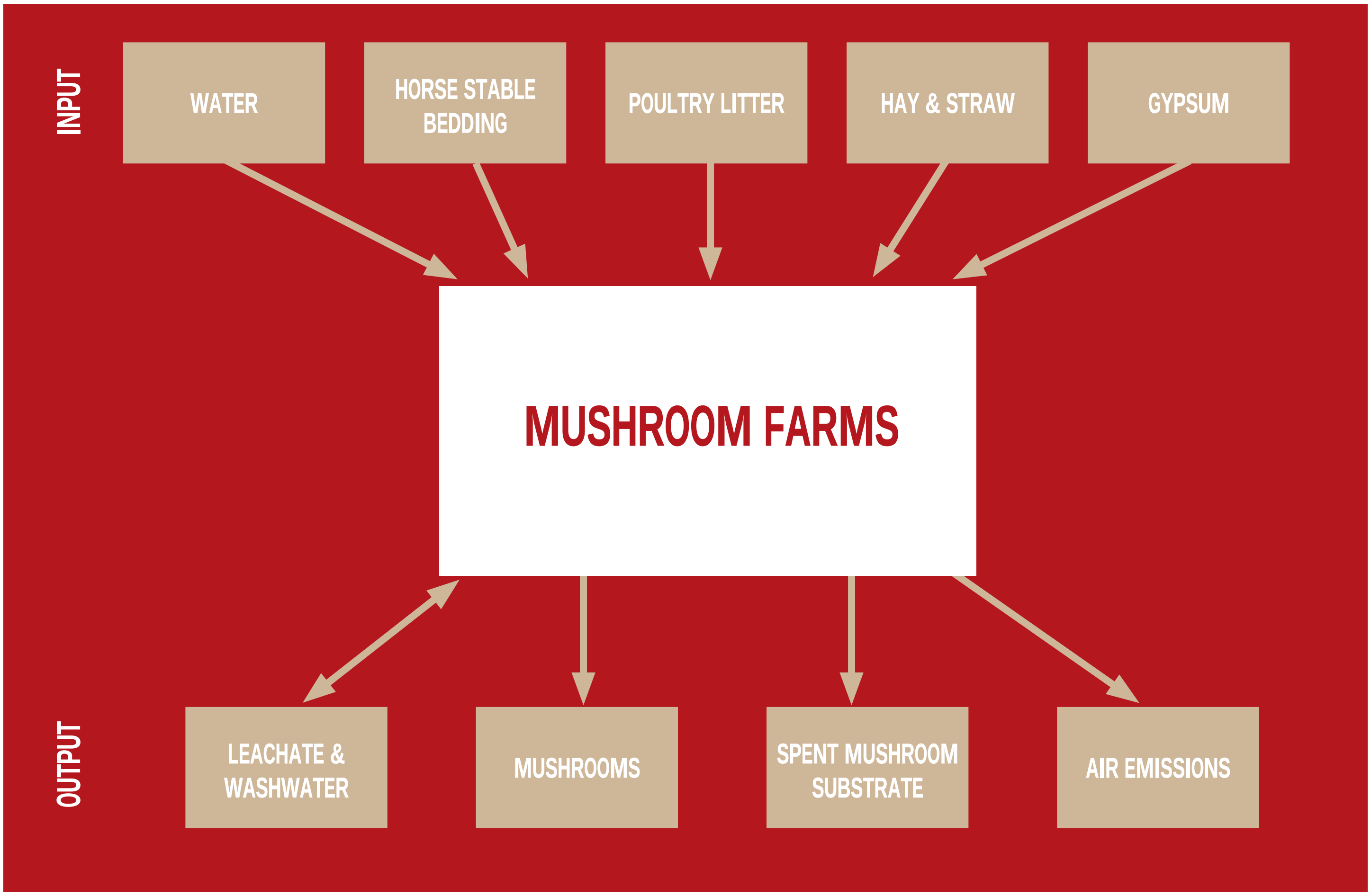
- wheat, straw and hay
- horse stable bedding
- poultry litter
- gypsum

A variety of other ingredients may be added to improve the nutrient analysis and structure of the substrate, including ground corncobs and stalks, oilseed meals such as soybean or canola meal, mustard seed, as well as inorganic fertilizers such as urea and ammonium nitrate.

Mushroom farms offer a valuable service to the livestock and poultry sectors by transforming their agricultural by-products into a healthy food crop and a valuable soil conditioner, known as Spent Mushroom Substrate [SMS]. In the future, mushroom growers will play an even greater role in helping Canadian agriculture meet the nutrient management requirements of each province.

Although mushroom farms play a vital role in the cycle of nutrient management, mushroom growers face substantial challenges in the storage and handling of raw materials and washwater.

Figure 4: **Process Flow Diagram**



BEST PRACTICE:

Raw Materials, Substrate, and Leachate Control

Raw Materials Management

Concrete wharfs should be of sufficient size to receive raw materials, accommodate pre-wet piles and ricks, and facilitate the general handling of substrate. Placement of raw materials and ricks should be optimized to reduce unnecessary traffic and tracking of materials off the wharf.

For those materials that do not generate leachate, such as clean, baled straw, hay or ground corncobs, bare ground storage is acceptable. [Local and provincial regulations may apply to set-backs from waterways, etc.]

In the selection of storage locations, mushroom growers consider the concentrations of soluble nutrients in the raw materials and environmental concerns surrounding the material's potential to generate leachate. While storage of raw materials on concrete wharfs (slabs) is the preferred management practice, alternatives can be considered for raw materials that have minimal or no potential to leach nutrients or other elements.

The wharf should be designed and constructed of concrete, which prevents the infiltration of leachate into the soil. The wharf should be graded to prevent the pooling of water and to channel the leachate into a storage system.

Uses of Leachate

In general, any runoff from substrate and other organic materials should be:

- Recycled into Phase I substrate, if substrate is produced on the farm, or
- Applied to the land, in compliance with local or provincial regulations

Collected leachate can be reused in the substrate preparation process. Leachate from the wharf and washwater from the growing rooms can be added to the mix of raw materials in the early stages of substrate preparation. This recycling practice adds moisture, valuable nutrients and microorganisms to the mix and reduces the need for excess storage and treatment systems. The recycled liquid should be kept aerated to reduce anaerobic activity and odours. The recycled liquid should be agitated to prevent solids from settling in the collection basins, and facilitate the return of these solids to the substrate.


Ricks in various states of substrate preparation

LEACHATE

Leachate, originates as run-off from the storage and preparation of mushroom substrate. While piles of wet organic materials normally generate some leachate, higher run-off volumes are generated when the piles are subjected to heavy rainfall or snowmelt. Leachate may contain dissolved and particulate organic matter, microorganisms and/or chemical residues. Leachate from raw materials must be properly collected, stored and handled to avoid contamination of surface and groundwater. Provincial and federal regulations do not allow direct discharge of leachate into streams, ditches or tile drains that will enter streams. Thus, all liquid leachate must be stored, treated or handled through other methods, as outlined in this section.

Planning a Leachate Storage System

A leachate storage system must be large enough to safely contain stormwater and runoff resulting from extreme rainfall or snowmelt events. Local regulations will apply. Hire an environmental engineer to design the leachate storage system. Types of storage systems include:


Concrete, steel or plastic tanks


Clay or plastic-lined lagoons or ponds

ODOURS


Compost wharf

Odours from raw materials, as well as those stemming from the preparation of mushroom substrate, pose an environmental challenge. Bacteria and other microorganisms, in some raw materials, create gases when little or no oxygen is present. These gases include hydrogen sulphide, which produces a strong odour often described as smelling like "rotten eggs."

Growers should understand the complex relationships among temperature, oxygen levels, substrate density and time, with respect to odour generation and intensity. Fundamentally, since odours are generated by anaerobic microorganisms, the objective is to minimize anaerobic activity and maximize aerobic activity. The key is a sufficient supply of oxygen, distributed uniformly throughout the rick or bunker. High temperatures, between 60ºC and 80ºC [140ºF and 176ºF] during Phase I, not only reduce microbial metabolism but also lead to higher yields of mushrooms. Also, dense substrate structure and clumps preclude oxygen, and harbour anaerobic bacteria that generate malodours. [Pecchia et al., 2000]

The types of chemical compounds and their concentration levels vary during the different stages of Phase I. Levels of sulphide compounds are highest in air samples taken at the end of the Phase I cycle, or fill turn. According to Duns et al. [1997], odorous compounds associated with Phase I composting are: dimethyl disulphide, dimethyl sulphide, carbon disulphide, butyric acid, acetic acid, methenamine and cresol. According to Hendriks [1997], places where smells occur in composting facilities are:- transport and storage of horse stable bedding and poultry litter, pre-wet piles, stacking and mixing into ricks, storage of goody water and transport of substrate to Phase II.

This issue is complicated by the fact the human sense of smell is complex. Odours evoke a wide range of physiological and emotional responses and different people can have very different reactions to the same odour. Continuous exposure to an odour can cause a person's sense of smell to become less sensitive, referred to as odour fatigue. It is difficult to describe odours consistently and objectively, and to establish acceptable threshold levels for odours. Ref. Livestock and Poultry Odors, University of Minnesota, 2001.

BEST PRACTICE:

Factors to Promote Aerobic Conditions and Reduce Odours

- The temperature profile of the Phase I substrate may be a guide to the level of aerobic activity.
- Do not over-water, thereby creating anaerobic conditions and nutrient washout.
- Make sure the initial mix of ingredients is thorough, especially avoid anaerobic clumps of poultry litter in the substrate.
- Prevent standing water and poor drainage areas on the wharf and around raw material storage areas.
- Trap solids before they enter the collection basin. If solids are already present in the basin, remove them regularly.
- Aerate and agitate stormwater runoff in collection basins, tanks and ponds.
- Maintain maximum setback distances between the substrate preparation operation and other land uses or residences.
- Screening (fences, trees, landscaping, berms) may be helpful in shielding the substrate preparation operation from the view of adjoining property owners, and to dissipate the odour-carrying air.
- In situations where extremely strict environmental regulations are in place, remedial treatment of exhaust air, using systems such as straw filters, scrubbers, etc. may result in further odour reduction.

BIOFILTRATION: A biofilter is a bed of organic matter where aerobic microflora convert odorous gases into non-odorous microbial biomass. Biofilter systems are only partially effective, requiring more research to make the systems completely efficient and cost effective.


Biofilter

BEST PRACTICE:
Phase I Odour Control

Aeration

Aeration allows substrate preparation to proceed aerobically, reducing the potential for the formation of odorous sulphur compounds. Aeration of pre-wet materials during Phase I can be achieved in a number of ways, including multiple flips of piles or forcing air through plenum systems or spigot floors.

Generally, within the Canadian mushroom sector, spigot floors are used for aerating Phase I materials. A series of lateral pipes are embedded in the floor of the wharf, bunker or tunnel. Air is forced through the pipes by an air pump or fan. The lateral pipes are fitted with a series of nozzles or spigots, which supply a uniform airflow to the substrate. Potential nozzle damage is avoided by constructing grooves in the concrete floor, which coincide with the rows of nozzle openings.

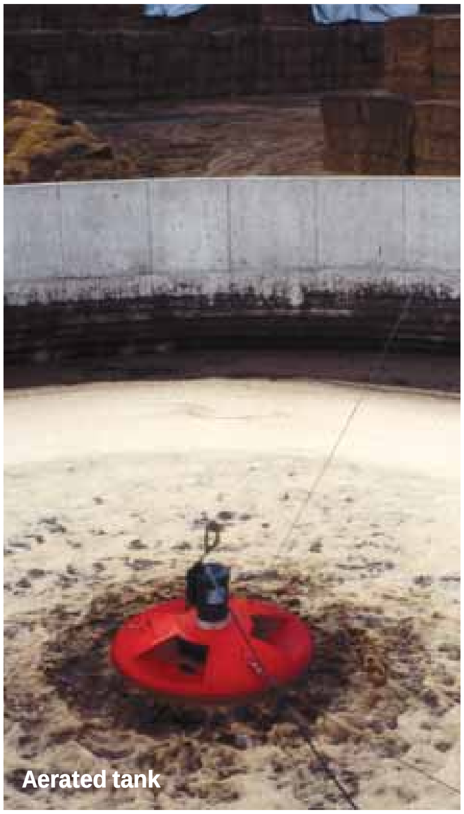

Prewet operation

Bunkers and Tunnels

Several substrate preparation facilities around the world have constructed bunkers or tunnels with aerated floors to reduce odours during Phase I. While aerated bunkers or tunnels are not a cure-all for odour problems, it is generally accepted that the use of these systems results in a reduction in malodorous gases.

Most bunkers in use today are uncovered or have a partial roof. The air emitted from the substrate is dispersed into the atmosphere. In most bunker systems, a computer constantly monitors temperatures in the substrate, and may have the capacity to monitor oxygen (O_2) levels.

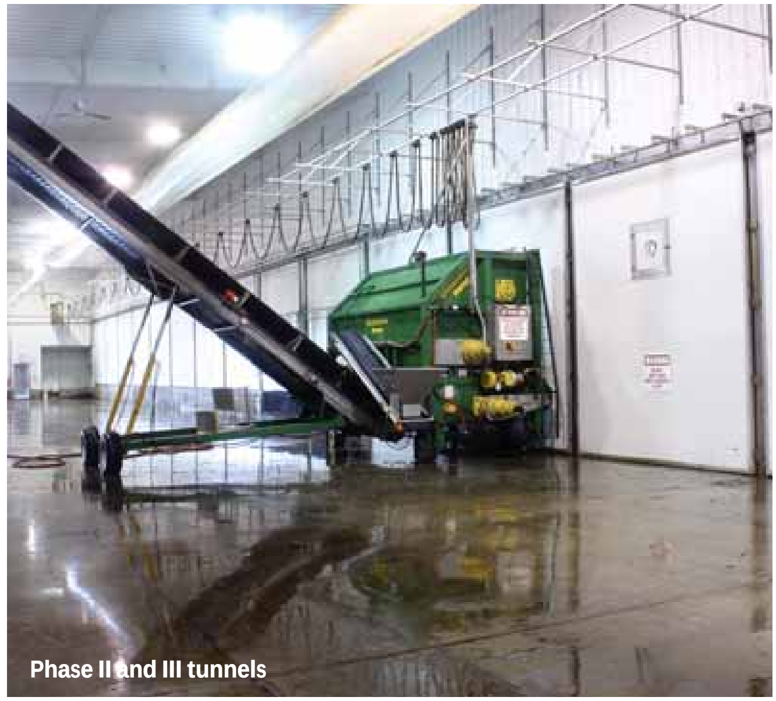
A Phase I tunnel or totally enclosed bunker, with a forced-air system built into the floor provides the greatest potential for odour reduction. After the air has percolated through the substrate, the grower may capture and re-circulate the air, exhaust it to the atmosphere, or treat it prior to exhaust. Some methods of treatment are (i) ozone (O_3), (ii) pH adjusted water wash tanks, and/or (iii) biofilter beds, often filled with straw, bark, roots or wood chips.


Aerated tank


Bunker


Phase 1 tunnel forced air system

PHASE II: Pasteurization and Conditioning


Phase II and III tunnels

Pasteurization is a critical stage in the preparation of mushroom substrate. It is designed to eliminate the presence of various pests in the substrate. In the conditioning stage, ammonia is converted to microbial protein or biomass, which later becomes a food source for the mushrooms.

Phase II takes 4-6 days. It is divided into several stages from time of filling. They are (i) leveling, (ii) heat up to the critical pasteurization temperatures of 58ºC (136ºF) for 6 to 9 hours, (iii) lowering the temperatures to 45-48ºC (113-118 ºF) for the rest of the time, for conditioning, prior to (iv) cool-down for spawning, i.e. the addition of mushroom mycelium.

Phase II conditioning is a temperature-dependent, ecological process for the growth and reproduction of de-ammonifying organisms. The growth of these thermophilic (heat-loving) organisms is dependent on (i) a source of nitrogen, some of which is in the form of ammonia, and (ii) freely-available carbohydrates, which come from incompletely composted ingredients. The end result is a selective growing medium for mushrooms. Phase II conditioning does not generate malodours.

In Canada, mushroom growers achieve Phase II pasteurization by four different procedures.

(1) The traditional method has been to move the substrate directly from the Phase I wharf or bunker into the shelves, beds or trays in the growing rooms, seal the rooms, and conduct Phase II pasteurization and conditioning.
(2) Many growers, particularly in BC, purchase Phase I substrate from independent, substrate-preparation farms, load it directly into shelves, beds or trays in the growing rooms, and conduct Phase II pasteurization and conditioning.
(3) The majority of the farms surveyed had on-site tunnels in which Phase II pasteurization was conducted in a bulk form rather than in trays or beds.
(4) In multiple-zone growing systems, substrate is packed into stackable trays that are moved into an environmentally controlled Phase II room. Thereafter, the trays are moved to standard growing rooms.

BEST PRACTICE:
Water Management During Pasteurization & Conditioning

Water condensate from Phase II tunnels should be recycled. Boiler blowdown water could be added to washwater, depending on disposal method and treatment chemicals used. It is advisable to check with your chemical supplier. [See Section 2, Growing & Harvesting]


Boiler

PHASE III: Spawn and Supplement

Spawning is the mushroom culture equivalent to planting seeds for a field crop. Mushrooms are "planted" using fungal mycelia rather than seeds. Fungal mycelia, grown vegetatively, are known as spawn. Spawn-making requires biosecure laboratory facilities to prevent the mushroom mycelia from mixing with mycelia of other fungi. Spawn-making starts with sterilized mixtures of cereal grains such as rye, wheat, millet, and other small grains, plus water and lime. Particles of mycelia are added to the sterilized grain, and the mixture is incubated to promote colonization. Mushroom farmers purchase spawn from specialized commercial laboratories.

During Phase III, either in tunnels or growing rooms, spawn is mixed thoroughly into the complete Phase II substrate using specialized machinery. The temperature and relative humidity are managed to optimize mycelial growth from the spawn, i.e 25-26ºC (78ºF) and >98% Relative Humidity (Rh). The mycelia grow in all directions from a spawn grain. The time needed for spawn to fully colonize the substrate depends on the amount of spawn added, its distribution, the substrate moisture and temperature, and the nature/quality of the substrate. A complete spawn run usually requires 15 days.


Spawning

Immediately after spawning in beds/trays or shelves, a cover, such as polyethylene, may be placed over the spawned substrate to preserve water in the substrate and manage carbon dioxide (CO_2) concentrations. In Phase III tunnel systems, spawn is added and mixed with the substrate as the tunnels are being filled. Supplements may be added either at the time of filling or during removal.

BEST PRACTICE: Disposal of Spawn and Supplement Packaging


Spawn packaging

Spawn packaging (paper or plastic bags) should be either recycled or placed in an approved refuse container. Polyethylene and other tray-cover materials are generally not reusable and should be discarded into an approved refuse container without delay. If pesticides have been used, the soiled plastic should be shielded from rain to eliminate the potential for runoff of low-level pesticide residues from the plastic surface.

Casing

Casing is a top-dressing layer, approximately 5 cm. (2 in.) deep, applied to the surface of the spawn-run substrate. Materials such as peat moss, deep dug sedge peat, spent sugarbeet lime, limestone, clay-loam field soil or weathered, reclaimed, spent mushroom substrate (SMS) can be used as casing.

Casing acts as a water reservoir and provides a place where the mushroom mycelia form thick white rhizomorphs. Rhizomorphs form when the very fine mycelia grow together. They look like thick strings. Moisture is essential for the development of firm mushrooms. Therefore, during the period following casing, water must be applied intermittently to raise the moisture level to maximum water-holding capacity of the casing layer.

BEST PRACTICE: Casing

Spawn and casing clean up

All spilled substrate, spawn and/or casing materials should be cleaned-up from the floor and utilized like spent mushroom substrate [SMS].

Water run-off from casing

Low concentrations of minerals or pesticides may be added to the water used to moisten the casing soil. In those cases, multiple small waterings should be used to avoid exceeding the absorption rate of the casing. Pesticide runoff from the casing should be minimized. Runoff water from casing should be treated as washwater (see Section 2, Best Practices: Washwater Collection and Storage).

A dedicated tank and pump system should be used for watering beds, trays or shelves. Mix only sufficient chemicals for a specific growing area, thereby eliminating the need for storage and disposal of leftover chemicals. For recommendations to minimize the use of pesticides see OMAF, Publication 367, Ontario Mushroom Pesticide Recommendations. To minimize use of other chemicals follow directions on the labels.

SECTION

2

GROWING AND HARVESTING

Growing

The commercial cultivation of mushrooms requires a highly controlled, delicate environment in which fresh air, carbon dioxide, temperature and moisture work in harmony to turn mushroom mycelia into mature, edible mushrooms. Each mushroom grower has developed his/her own set of cultural practices that work for him or her.


Mushrooms ready for harvest

BEST PRACTICE:

Washwater Collection and Storage

Collection

Growing room washwater should be collected in floor drains connected to storage tanks or sedimentation ponds. It should not be discharged directly into streams or ditches. Washwater should be tested periodically to identify its components . A storage tank or collection basin may be necessary to allow testing and subsequent treatment of washwater. On farms where substrate is prepared, this water may be stored on-site for recycling into the Phase I substrate preparation process.

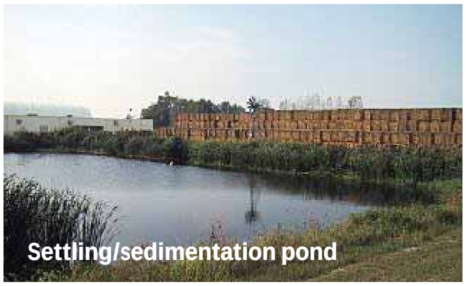
Settling/Sedimentation Ponds

The terms sedimentation and settling are used interchangeably. Sedimentation or gravitational settling is the process of separating suspended particles from water. Sedimentation ponds may be used for clarifying mushroom washwater. A professional engineer should design the storage system. Groundwater investigations may be necessary prior to siting such a facility. A provincial Wastewater Management Permit may be required. [Local and provincial regulations may apply.]

Storage of Washwater in Tanks

Storage tanks should be constructed of impervious material, such as plastic, concrete, steel or fiberglass. They must have sufficient structural strength to ensure that they do not collapse or rupture. No washwater can be placed in a tank if it would cause the tank to rupture, leak, corrode or otherwise fail. Storage tanks should be not only designed by a qualified engineer, but also inspected annually for uniformity, damage and imperfections.

Subsurface tanks used for washwater storage should be examined annually, for evidence of leakage. Visual inspection is possible where subsurface tanks are constructed inside other structures that provide sufficient space for physical observation. For new installations, consideration should be given to installing a weeping tile, outside and around the tank, running to a collection point for sampling the water. A depth measurement, during a period of inactivity, will help determine if any leaks occur. Leaks should be repaired promptly.


Settling/sedimentation pond


Storage of washwater in tank

WASHWATER

Drainage from mushroom growing rooms may include wash-down water, condensate from steam pasteurization, and excess irrigation water that leaks through the beds. This drainage water may contain residues of organic supplements and pesticides that cannot be discharged directly into ditches or streams. The types and concentrations of these compounds are dependent on application rate, location, climate, time of year, and the characteristics of the washwater handling system. If handled inappropriately, washwater may be a potential pollutant of surface waters. The possible presence of pesticide residues may preclude it from discharge to municipal sanitary sewer systems, as well. [Local and provincial regulations may apply.]


Washwater

BEST PRACTICE:

Treatment and Disposal of Washwater

Mushroom growing room washwater may be applied to soil or vegetated land. The application rate must be low enough to prevent runoff to streams, ditches or ponds. Check local and provincial regulations before application.

Minimizing Volume, Organic Matter and Pesticide Residues

The organic content of growing room washwater can be reduced or eliminated by following good housekeeping practices. The following guidelines for housekeeping and water conservation apply:

- Do not over-water the crop;
- Remove (sweep, pick-up, etc) spilled compost and casing soil, stumps, and other debris from floors before wash-down;
- Provide screening for floor drains to collect organic debris that may be picked-up by the washwater;
- Condensate from air conditioning units may be discharged safely outside the building, since air conditioner condensate is clean water;
- Steam pasteurize each room with substrate at the end of each crop. This should reduce excessive washing, runoff and the need for chemical disinfection.


Floor squeegee


Clean growing room

Washwater: Application Methods and Timing

Washwater may be used to irrigate and fertilize existing perennial crops, such as sod, hay, or seasonal field crops. It can be applied to the ground and vegetation, or incorporated into the soil. Seasonal application, timing and site selection are important considerations for washwater application. [Local and provincial regulations may apply]

NEVER MIX CHLORINE BLEACH WITH FORMALDEHYDE AS THIS CAN PRODUCE A POTENT CARCINOGEN.

In general, spring application before seeding is best for conserving nutrients, as the crop will utilize these. Summer application may be suitable for grain stubble, non-crop fields or little-used pastures. Fall application of washwater, after harvest, generally results in greater nutrient loss since the potential for leaching is higher without crop roots to extract nutrients. Winter application should be avoided to prevent nutrient loss and pollution through runoff from snowmelt on frozen ground. Application of washwater must not cause surface water pollution. [Local and provincial regulations may apply]

Consider the following practices to reduce or eliminate pesticide residues in washwater:

- Use pesticides with short degradation times, and store for the natural degradation period, whenever feasible;
- Use correct application rates;
- Clean up or neutralize spills immediately;
- Eliminate or minimize the use of disinfectants (e.g., formaldehyde) by pasteurizing the growing room before removing spent mushroom substrate;
- Install constructed wetlands or vegetated filterstrips to clarify washwater; and
- Follow Integrated Pest Management (IPM) practices to minimize the amounts of pesticides used. For (IPM) recommendations see OMAF, Publication 367, Ontario Mushroom Pesticide Recommendations.

Chemical storage

CHEMICALS AND PESTICIDES

Though the use of chemicals and pesticides is a necessary part of mushroom farming, steps must be taken to ensure compliance with regulations that are intended to protect the workers at the farm, the environment and consumers. Minimizing the use of pesticides is the best way to ensure human and environmental safety. Make sure that chemicals are applied according to label directions when needed to control a specific problem.

Mushroom growers should complete a Pesticide Handling Course. Consult your chemical supplier for local regulations.

Pesticides and chemicals used on mushroom farms should not be allowed to enter surface water, groundwater, or drinking water. Direct routes to surface water may include (i) careless handling, (ii) accidental spills or (iii) excess spraying. Indirect routes include spray drift, evaporation and subsequent deposition.

Chemical guides

BEST PRACTICE:

Storage and Handling of Pesticides

Pesticides should be stored and mixed a safe distance from the nearest surface water and water well. Employees should be trained, and provided with protective clothing. Grower Pesticide Safety Courses are offered to farmers in most provinces. Containers should be clearly labeled.

Containers for liquid pesticides must be triple-rinsed and punctured prior to disposal. Emptied bags for powdered pesticides, protective clothing, disinfectant mats, footwear, filters, etc. must be managed in accordance with the pesticide or disinfectant label and existing regulations. Be sure to place unclean items in an approved container to prevent chemicals from being washed-off by rain and snow.


Handling chemicals

Materials, equipment and a written emergency plan for dealing with chemical spills should be checked regularly. It should include clean-up procedures and emergency phone numbers. Spill containment materials, such as oil-containment socks, oil-dry litter and spill-mats to cover drains, should be on hand. These materials should be kept in an enclosed, easily accessible cabinet, along with a checklist of materials and contact numbers for a spill-response team. Spill containment materials should be located wherever needed, such as truck filling stations, maintenance shops and chemical storage/usage areas.

Detoxification of washwater

When washwater is recycled to Phase I substrate preparation, it is not necessary to detoxify pesticide residues. Otherwise, pesticide residues in washwater should be detoxified. Some pesticides will degrade under the correct conditions. Other types of pesticides may be neutralized with chlorine bleach. Check with the manufacturer for degradation times, pH requirements, and other considerations.

For additional information on pesticides, see OMAF [Ontario Ministry of Agriculture and Food] Publication 367, Mushroom Pesticide Recommendations. This publication can be obtained from the Canadian Mushroom Growers' Association.


Chemical storage cabinet

Harvesting

The terms "flush" or "break" are terms commonly used by mushroom growers to describe multiple harvests of a single crop. Growers often harvest two or three "breaks" in each crop, 7 to 10 days between each "break", with yields decreasing with each "break". Most *Agaricus* mushroom growers harvest for 16 to 35 days. Air and bed temperatures, relative humidity and ventilation are critical parameters monitored and controlled throughout the growing period. Refer to OMAF Publication 350 on Mushroom Production for more details.

Mushrooms are generally harvested by hand, at market maturity. After picking the mushroom, the harvester trims off the base of the mushroom. These are called stumps. Unmarketable and misshapen mushrooms that have no commercial value are called culls. The stumps and culls should be placed in a discard container along with small amounts of dislodged casing material, for removal from the growing area.

Harvesting mushrooms

BEST PRACTICE:

Disposal of Stumps, Culls and Debris

All of the harvesting debris, including stumps, culls and dislodged casing or substrate should be collected from the floor and placed in the discard container. It is advisable to wet the floor prior to sweeping, in order to prevent dust and the spread of Dry Bubble (Verticillium) throughout the room. The debris may be added to the Phase I ricks to become part of future substrate or mixed with Spent Mushroom Substrate [SMS]. These materials should not be left in piles near mushroom growing rooms, because they degrade rapidly, attract flies and generate odours.

Stumps

BEST PRACTICE:

Recyclable Materials and Trash

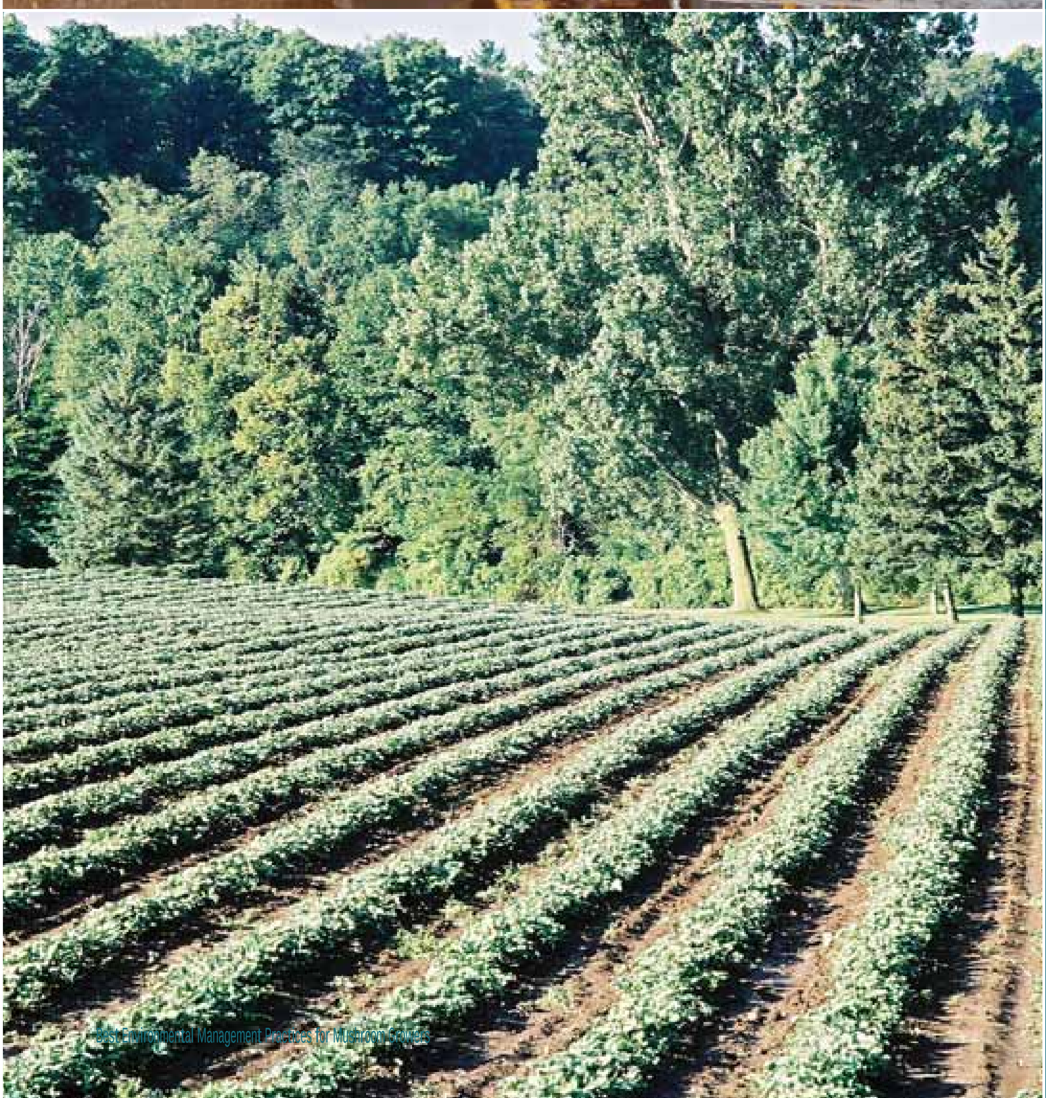
On mushroom farms, trash and refuse include items not only from farming activities, but also from employees. The by-products of farming activities may include discarded wood from trays, beds and shelves, pesticide containers, petroleum-based products [oils and greases] and damaged harvesting containers. Trash generated by employees may include newspapers, magazines, printout paper, lunch containers, beverage cans, etc.

A proper disposal system should be set up that enables trash and debris to be sorted to maximize recycling. Debris should be stored in approved, labeled, easily accessible containers.

Special care should be taken in the disposal of fluorescent light bulbs, lumber and other material that pose safety risks. Empty pesticide and supplement containers should be stored and disposed of in a manner to ensure no movement of chemicals to the environment with rain or snow.

Compaction of recycled cardboard

Collected trash should be disposed of in a timely and responsible manner. Those materials that cannot be recycled should be directed to regulated landfill locations.



SECTION

3

POST HARVEST

Spent Mushroom Substrate (SMS)

Spent Mushroom Substrate

After mushrooms have been harvested, the substrate is considered "spent" and mushroom growing is terminated. The growing material, consisting of substrate, casing and mycelia is called spent mushroom substrate (SMS). All mushroom farms have SMS after the harvesting of mushrooms is complete.

Spent mushroom substrate is a uniform, easily crumbled mixture of organic materials. Nutrients do not leach from SMS as readily as from fresh or non-composted organic wastes. Since SMS has a moisture holding capacity, it will absorb some water before leaching during rainfall events.

BEST PRACTICE:

Treatment of SMS

Disinfecting SMS

After the last picking, it is good practice to disinfect the substrate and the interior surfaces of growing rooms or houses by injecting live steam. The objective is to raise the substrate temperature to 70ºC (158ºF) for 12 hours. That is not always possible in older growing rooms. This practice, when done correctly, significantly reduces the spread of diseases and eliminates insects prior to removing the substrate from the growing room. After the heat treatment, the SMS is removed from the trays/beds/shelves.

Storage of SMS

Many mushroom growers have arranged for SMS to be removed from the farm, daily, as it is produced. For those farms, there is no need for a permanent storage facility. On farms where SMS is stored, a permanent storage facility should have sufficient capacity to store all the SMS produced on the mushroom farm. Check provincial Nutrient Management Plans, where applicable, for storage-time regulations. SMS should be stored away from the mushroom growing rooms to minimize the potential for transfer of insects and diseases. SMS should not be stored (i) on saturated soils, (ii) in depressions that may accumulate water during rainstorms, (iii) in natural drainage ways, (iv) in locations subject to flooding, or (v) where runoff will access waterways.

The main environmental concerns about storage of spent mushroom substrate are surface runoff during heavy rainfall events and leaching of salts from the piles. Storage must be conducted in a manner that prevents groundwater degradation and surface water pollution. Berms or other structures should be constructed to divert runoff away from SMS piles, to prevent any contaminated runoff from entering surface waters. Runoff that has contacted SMS should be collected, stored and reused.

Limiting Odours from SMS

Volatile sulphur compounds and cresol are the principal odour compounds in SMS. To reduce malodours, SMS may be placed in ricks and turned periodically. That will significantly increase the rate of microbial decomposition. Aeration of SMS may decrease offensive odours by reducing anaerobic fermentation. [see Section I, Odours and Odour Control, pages 10 & 11]

Since the potential for malodours is greatest when SMS piles are opened or moved, care should be taken in handling SMS. Relatively little research has been conducted on odours from SMS, at this time.

Cropland enrichment

BEST PRACTICE:

Uses of SMS

Soil conditioner

Spent mushroom substrate is most commonly blended with soil, for use as a soil conditioner in landscaping. The factors, which determine potential uses for SMS, include: nutrient and salt content, water-holding capacity, substrate maturity, and the presence of weed seeds, insects, pathogens or pesticides. Spent substrate's high water-holding capacity and its slow release of nutrients makes it an excellent soil conditioner. Since the nutrients in SMS are bound in organic compounds, they are released slowly over several years. Application rates will be a function of the existing levels of nutrients in the soil, the crop to be grown, past additions to the soil, and time of application.

Nutrient Content of SMS

Since nutrients and other chemicals in SMS may vary according to the different substrate formulations, analysis of SMS should be conducted to determine its N:P:K contents. In the event that substrate formulations change, additional nutrient and chemical testing may be necessary.

SMS can be applied as a top dressing to a standing crop (i.e. hay), as a mulch or as a fertilizer. Due to the physical characteristics of SMS, its nutrients are more stable than those in manures. Therefore, it poses less threat to surface water when reasonable care is taken to avoid application to areas where water erosion is likely (e.g. bare sloping land).

Since SMS has a high percentage of plant fibre and is very lightweight when dry, it is susceptible to being easily wind blown. When not used as mulch, it should be worked into the soil as soon as possible.

SMS piles ready for shipment to soil blenders

An average N:P:K analysis for fresh and weathered SMS might be 1.9: 0.4: 2.4 and 1.9: 0.6: 1.0, respectively, based on dry weight.

The carbon to nitrogen (C:N) ratio of SMS usually ranges from 14 to 17. At the upper end of this range, spent substrate, with a high C:N ratio, may cause a reduction in plant available nitrogen. This should be taken into consideration when determining use, as supplementary N may be required.

The high level of soluble salts in fresh SMS, the release of ammonia after incorporation into soil, and the resulting changes in pH during weathering are the main limiting factors when deciding on the use of spent substrate. These factors are gradually reduced in significance after the spent substrate is mixed with soil or has weathered.

SECTION

4

OTHER TOPICS

BEST PRACTICE:

Controlling Stormwater

Each mushroom farm should have a planned water management system to handle clean stormwater. The water management system must be adequate to divert, collect and reuse or dispose of all the stormwater received.

Stormwater management should be designed to minimize the amount of contaminated water that must be handled on site. It is critical to minimize the amount of rain or stormwater runoff that comes in contact with manure, substrate, straw or other organic materials. There should be separate containment and diversion systems to direct any runoff contaminated with organic materials, into a recycling or treatment system. Roofs should slope away from substrate and other organic materials. Otherwise, they should be fitted with eavestroughs and downspouts to channel the water away. Buildings should have perimeter gravel splash pads, drains and gutters.

The natural flow pattern of the site should be considered when locating stormwater storage areas. Use natural topography, curbing and/or berms (earthworks) to exclude storm water from substrate and/or storage areas. Uncovered storage areas should be sloped or graded to direct runoff to the collection system. Grassed or vegetated waterways are recommended to minimize erosion.

Stormwater can be discharged to ditches or streams, only if the stormwater is not likely to pollute, and the volume does not cause flooding downstream.

To determine if a water contamination problem from stormwater exists, timely tests of the runoff should be done. Compare laboratory test results with records of chemicals used. [Local and provincial regulations may apply]

Collection basins must be sized to contain runoff from significant rainfall such as the 25-year, 24-hour storm (local regulations vary by region), plus additional volume to contain all runoff until it can be recycled or applied to the land.

A settling basin, screen or rock (riprap) filter can be used to separate substrate, straw and other large solids from runoff entering the collection basin. Debris must be removed frequently to prevent runoff from overflowing the collection channel.

STORMWATER

With large buildings and wharf areas, mushroom farms may collect large volumes of water from rain and snow. Some municipalities may require that clean runoff from roofs and paved areas be retained in ponds, on roofs or on grassed fields to prevent flooding during significant storms.

Wharf runoff, generated by storm events, differs from normal leachate production as it is very dilute, and the mushroom farmer has less opportunity to control its rate, volume and frequency. Nevertheless, good practices and environmental laws dictate that there be no discharge of untreated stormwater from the wharf into surface water or groundwater. Provisions must be made to ensure control of storm water and contaminated runoff in a collection basin for reuse or treatment.

Water storage tank


Downspouts

BEST PRACTICE:

Community Relations

Due to the nature of mushroom farming and the materials used, it is important that every effort be made to establish and maintain good relationships with neighbours.

Community Relations

A good policy is to make your neighbours familiar with your farming operation. A yearly farm tour for the neighbours can clear up misconceptions and diminish mistrust. It is important to emphasize that farmers operating modern farms are far more aware of their environmental responsibilities than their predecessors.

When planning to build or remodel an existing facility, consider the neighbours. Allow as much separation space as possible, consider the direction of prevailing winds when permitting or locating farm severances.

While there may be unavoidable periods when the practices of mushroom farming infringe on the neighbours, every effort should be made to minimize the frequency and length of those periods. A phone call to neighbours advising them when such periods will start and finish, may help defuse complaints.

Tree barriers

Conflict Resolution

In spite of the best preventative efforts, there may still be some concerns raised by neighbours. A timely response, inviting discussion of the issue, may have a significant impact on whether or not they escalate. When both the farmer and complainant discuss solutions, the prospects for agreement are increased.

Regardless of the method adopted for resolving a complaint, it is important that there be timely follow-up to questions, concerns and solutions. A Complaint Form may be useful to document complaints [see figure 5].

Third Party Involvement in Disputes

In some cases, neighbours may complain to various levels of government. Depending on the province, the ministries of agriculture and/or environment may visit the farm.

If the complaint is warranted and does not represent a violation of existing environmental legislation, a voluntary abatement program may be recommended, or it may be referred to the respective Farm Practices Review Board depending on the province.

Figure 5: **Standard Complaint Form**

COMPLAINT FORM

DATE: ____________ NAME OF CALLER: ________________________________ TELEPHONE NUMBER: ______________________

LOCATION OF CALLER: ____

WEATHER CONDITIONS AT TIME OF COMPLAINT: ____

DETAILS OF COMPLAINT: ____

____

____

FOLLOW-UP ACTION: ____

____

____

Appendix 1:
Glossary and Definitions

Berm: a mound of earth constructed to divert or contain runoff water. A berm is often built to limit eyesight of facilities and operational activities giving a more pleasant public view of the property.

Biofilter: a bed of organic matter, i.e. straw, bark, roots or wood chips, where microflora convert odorous gases into non-odorous microbial biomass.

Blow-Down Water: water, containing dissolved or suspended solids, removed from a boilers or cooling towers.

Bunker (Horizontal Silo): an uncovered or partially covered structure with an aerated floor, designed to ensure the Phase I mushroom substrate is maintained in an aerobic condition.

Casing: a layer of top-dressing material, applied to the surface of the spawn-run substrate. Casing acts as a water reservoir and provides a place for the mushroom mycelia to form thick white rhizomorphs. The most commonly used casing material is peat moss.

Conditioning: a stage in Phase II of substrate preparation. Conditioning is a temperature-dependent, ecological process in which ammonia is converted to microbial protein or biomass, by de-ammonifying organisms. The biomass becomes a food source for the mushroom mycelium.

Constructed Wetlands: a Wetland Biofilter System [WBS] consists of constructed ponds (cells), layered with gravel and sand, in which plants such as cattails are planted.

Culls: unmarketable, discarded mushrooms that have no commercial value.

Fill-turn: the final turning of a Rick, at the end of the Phase I cycle, prior to moving the substrate to Phase II rooms or tunnels.

Goody Water: [see Leachate]

Groundwater: water within the earth that supplies wells and springs.

Leachate: the water that runs-off raw materials, substrate and Spent Mushroom Substrate. Leachate may contain dissolved and particulate organic matter, microbes and/or chemical residues. Leachate is non-potable.

Limestone: a rock that is formed chiefly by accumulation of organic remains, such as shells or coral, consisting mainly of calcium carbonate. Limestone is used to raise or buffer the pH of peat moss (see Casing).

N:P:K: the ratio of Nitrogen, Phosphorus and Potassium This is a standard rating for commercial fertilizers.

Pasteurization: a controlled temperature process by which objectionable organisms such as specific insects, fungi and nematodes are selectively minimized or eliminated, without major chemical alteration of the substance. Pasteurization is a stage in Phase II of substrate preparation, in order to eliminate the presence of various pests. In Phase II tunnels, the desired temperature and time can be achieved without supplemental heat. In conventional tray/shelf systems, steam is applied to the substrate.

pH: a measure of the concentration of hydrogen ions [H+] in a solution. 7 = neutral, below 7 = acidic, above 7 = basic.

Phases I, II, III: stages of preparing mushroom substrate from the earliest mixing and wetting of the raw ingredients – Phase I, to the pasteurization and conditioning of the substrate – Phase II, to the addition of spawn and the colonization of the substrate with mushroom mycelium-Phase III.

Pre-wet Piles: the initial blending and wetting of the various substrate raw materials.

Rhizomorphs: thick strands of mushroom mycelium growing into and throughout the casing.

Rick: a machine-formed, rectangular pile of Phase I substrate.

Spawn: a pure culture of mycelium, colonized within a grain kernel carrier such as rye, wheat or millet.

Spawning: the mushroom culture equivalent of planting seeds for a field crop. Spawn is mixed thoroughly into the Phase II substrate, after it is pasteurized and conditioned.

Spawn Run: after the spawn has been mixed throughout the substrate, the mycelia grow in all directions from the spawn grains colonizing the substrate.

Stumps [roots, trimmings]: a waste by-product of mushroom harvesting, produced when harvesters trim the base off each mushroom.

Substrate: a growing medium for mushrooms produced through the biological decomposition of organic materials under controlled conditions. Mushroom substrate is a highly specific product that is prepared for the sole purpose of producing mushrooms.

Sugar beet lime: a by-product of the sugar extraction from sugarbeet pulp consisting of calcium carbonate and used as an ingredient of casing.

SMS (Spent Mushroom Substrate): the material, in the beds, shelves or trays, that remains after a mushroom harvest cycle has been completed. SMS material consists of substrate, casing and mycelia.

SMS Sterilization: the complete kill of organisms under a selected high temperature and time regime.

Stormwater: a large volume of water resulting from a heavy fall of rain, snow or hail. When captured without contamination, stormwater does not contain chemical or microbial impurities.

Supplement: a protein/nitrogen rich material applied either after Phases II or III to provide additional nutrients for increased mushroom yields.

Surface Water: water that exists on the surface of the earth, such as rivers, lakes and reservoirs.

Tunnel: a totally enclosed room with an aerated or forced-air system built into the floor. In most substrate tunnels, the exhaust air is usually captured and treated before it is exhausted to the atmosphere.

Washwater (Wash-down Water): originates from the cleaning and sanitizing of mushroom growing rooms and equipment. Washwater may contain organic matter and chemical residues. It may be recycled to Phase I substrate preparation or decontaminated before being released.

Wharf: a concrete slab used to store raw materials where substrate materials are pre-wetted and where ricks can be watered and turned.

Appendix 2:
Legislation and Regulations

GOVERNMENT OF CANADA

Canadian Environmental Protection Act 1999:
http://laws.justice.gc.ca/en/C-15.31/text.html
and description
http://www.ec.gc.ca/EnviroRegs/Eng/SearchDetail.cfm?intAct=1001

Canadian Water Act:
http://www.ec.gc.ca/EnviroRegs/Eng/SearchDetail.cfm?intAct=1003

Fisheries Act:
http://laws.justice.gc.ca/en/F-14/text.html

BRITISH COLUMBIA

Ministry of Agriculture Food and Fisheries:
http://www.gov.bc.ca/agf/

Ministry of Water, Land and Air Protection:
http://www.gov.bc.ca/wlap/

Farming and Fishing Industries Development Act:
http://www.qp.gov.bc.ca/statreg/stat/F/96134_01.htm

Fish Protection Act:
http://wlapwww.gov.bc.ca/habitat/fish_protection_act/

Ministry of Sustainable Resource Management:
http://www.gov.bc.ca/srm/

Environment and Land Use Act:
http://www.qp.gov.bc.ca/statreg/stat/E/96117_01.htm

Environment Management Act:
http://www.qp.gov.bc.ca/statreg/stat/E/96118_01.htm#section4

Environmental Assessment Act:
http://www.qp.gov.bc.ca/statreg/stat/E/96119_01.htm#section2

Farm Practices Protection Act (right to farm):
http://www.qp.gov.bc.ca/statreg/stat/F/96131_01.htm

Pesticide Control Act:
http://www.qp.gov.bc.ca/statreg/stat/P/96360_01.htm

Soil Conservation Act:
http://www.qp.gov.bc.ca/statreg/stat/S/96434_01.htm

Waste Management Act:
http://www.qp.gov.bc.ca/statreg/stat/W/96482_01.htm *(Mushroom composting pollution prevention regulation 431/98)*

Water Act:
http://www.qp.gov.bc.ca/statreg/stat/W/96483_01.htm

ALBERTA

Environmental Protection and Enhancement Act (EPEA) 1992:
http://www3.gov.ab.ca/env/protenf/approvals/factsheets/enhanact.html
In one streamlined package, the Act consolidates the following Acts: the Agricultural Chemicals Act, Beverage Container Act, Clean Air Act, Clean Water Act, Ground Water Development Act, Hazardous Chemicals Act, Land Surface Conservation and Reclamation Act, Litter Act and some sections of the Department of the Environment Act.

Water Act:
http://www3.gov.ab.ca/env/water/legislation/WaterAct.html

SASKATCHEWAN

http://www.se.gov.sk.ca/legislation.htm

The Clean Air Act:
http://www.qp.gov.sk.ca/index.cfm?fuseaction=publications.details&p=410

Environmental Assessment Act:
http://www.qp.gov.sk.ca/index.cfm?fuseaction=publications.details&p=488

Environment Management and Protection Act
http://www.qp.gov.sk.ca/index.cfm?fuseaction=publications.details&p=1657

The Water Appeal Board Act:
http://www.qp.gov.sk.ca/index.cfm?fuseaction=publications.details&p=946

ONTARIO

http://www.e-laws.gov.on.ca/

Agricultural and Horticultural Organizations Act:
http://192.75.156.68/DBLaws/Statutes/English/90a09_e.htm

Agricultural Tile Drainage Installation Act 1990:
http://192.75.156.68/DBLaws/Statutes/English/90a14_e.htm

Drainage Act:
http://192.75.156.68/DBLaws/Statutes/English/90d17_e.htm

Environment Protection Act:
http://192.75.156.68/DBLaws/Statutes/English/90e19_e.htm

Farm Implements Act:
http://192.75.156.68/DBLaws/Statutes/English/90f04_e.htm

Farm Products Container Act:
http://192.75.156.68/DBLaws/Statutes/English/90f07_e.htm

Nutrient Management Act:
http://www.gov.on.ca/OMAFRA/english/nm/act.html

Waste Management Act:
http://192.75.156.68/DBLaws/Statutes/English/92w01_e.htm

Water Resource Act:
http://192.75.156.68/DBLaws/Statutes/English/90o40_e.htm#TOC

Water Management Policies and Guidelines Provincial Water Quality Objectives.1994
http://www.ene.gov.on.ca/envision/gp/3303e.pdf

QUEBEC

Acts:
http://www.menv.gouv.qc.ca/publications/lois-reglem-en.htm
Environmental Quality Act
Pesticides Act
Watercourses Act

NEW BRUNSWICK

Overview of Environmental Legislation:
http://www.gnb.ca/0009/0355/0005/0029-e.html

The Clean Air Act:
http://www.gnb.ca/0062/acts/acts/c-05-2.htm

Clean Environment Act:
http://www.gnb.ca/0062/acts/acts/c-06.htm

Petroleum Product Storage and Handling Reg:
http://www.gnb.ca/0062/regs/87-97.htm

Clean Water Act:
http://www.gnb.ca/0062/acts/acts/c-06-1.htm

Water Well Regulation:
http://www.gnb.ca/0062/regs/90-79.htm

Pesticides Control Act:
http://www.gnb.ca/0062/acts/acts/p-08.htm

NOVA SCOTIA

Environment Act:
http://www.gov.ns.ca/legi/legc/statutes/environ1.htm

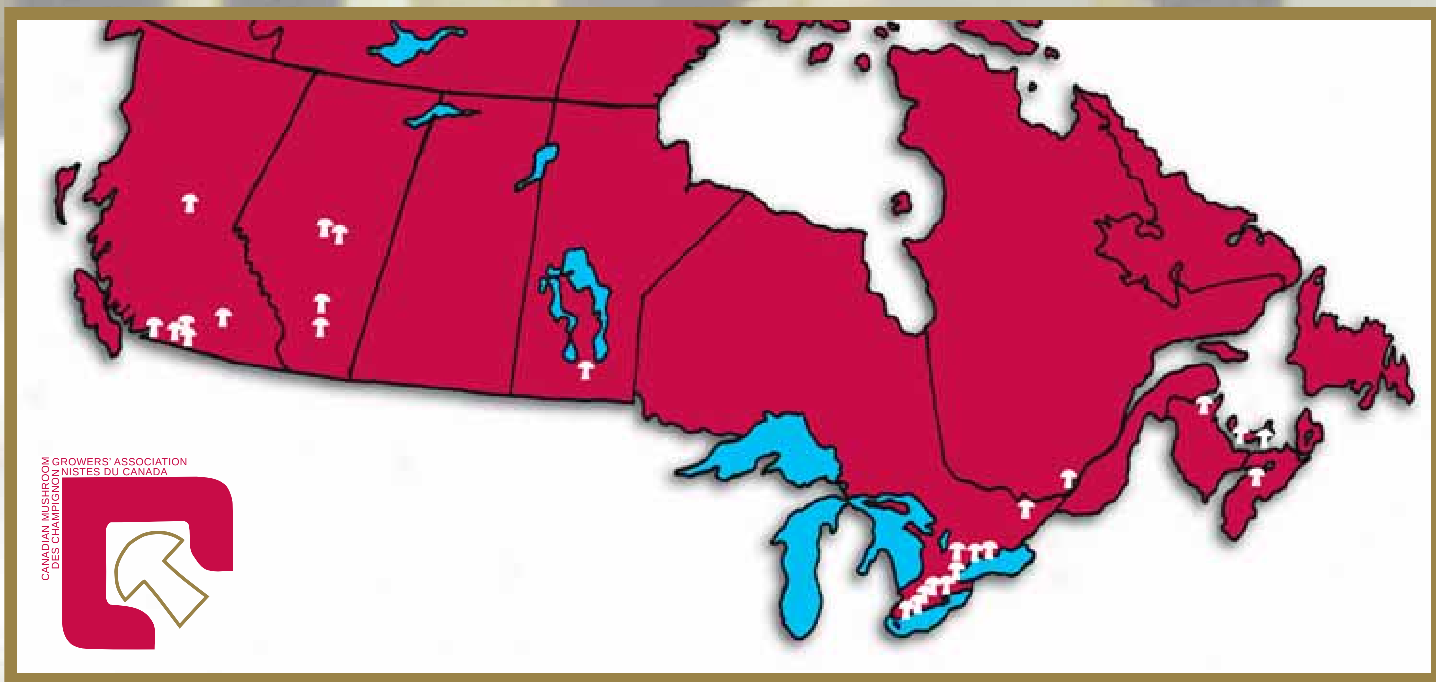
Water Resource Protection Act:
http://www.gov.ns.ca/legi/legc/bills/58th_1st/3rd_read/b032.htm

OTHER REFERENCES

An evaluation of watershed management in Ontario:
http://www.ene.gov.on.ca/programs/3513e.pdf

Watershed management on a watershed basis – Implementing an ecosystem approach:
http://www.ene.gov.on.ca/programs/3109e.pdf

MUSHROOM FARMING IN CANADA



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