

DRY TOILET 2018

6th International Dry Toilet Conference



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Title: Composting as a Sanitation Solution in Nicaragua

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Abstract: A “compost toilet” functions as a collection receptacle. Therein urine, faecal material, other bodily excretions, and toilet paper, are collected with a carbon-based “cover material” such as sawdust, rice hulls, sugar cane bagasse, etc. The cover material prevents odors, blocks flies, inhibits vermin, and provides a carbon/nitrogen balance that promotes composting. The toilet material is composted in a separate bin system. The compost bins can also collect and process food scraps, animal mortalities, garden residues, etc.

Compost toilets were introduced in Nicaragua in May of 2015 by GiveLove.org, a U.S. NGO. The initial project was at a school in Villa Japon near Tipitapa, with 300 students. The school had a pit latrine system beforehand. The pit, located adjacent to the schools drinking water well, was closed and replaced with compost toilets. The program was organized and managed by a local woman’s cooperative, *Sweet Progress*, a Nicaraguan non-profit organization, whose “Eco-Girls” set up “Eco-Banos” throughout the community.

Much of the surrounding community in Tipitapa, Nicaragua, had practiced open defecation due to the lack of a sanitation system, the high cost of pit latrines, and the lack of water. Sweet Progress trained community members how to use compost toilets. They also built the compost toilets and the compost bins, and integrated the systems into households, 50 at a time, at 1/10 the cost of pit latrines. This program is ongoing as of 2018.

Compost toilets can be located indoors where they are more comfortable and secure. The toilets are self-managed, using rice hulls as the cover material. Despite a 70% rate of open defecation before the GiveLove.org project started, the households employing compost toilets have nearly a zero open defecation rate. The resulting compost is being used to grow food.

THREE TO FIVE KEYWORDS: *Sweet Progress, Nicaragua, thermophilic composting, compost toilet, ecological sanitation*

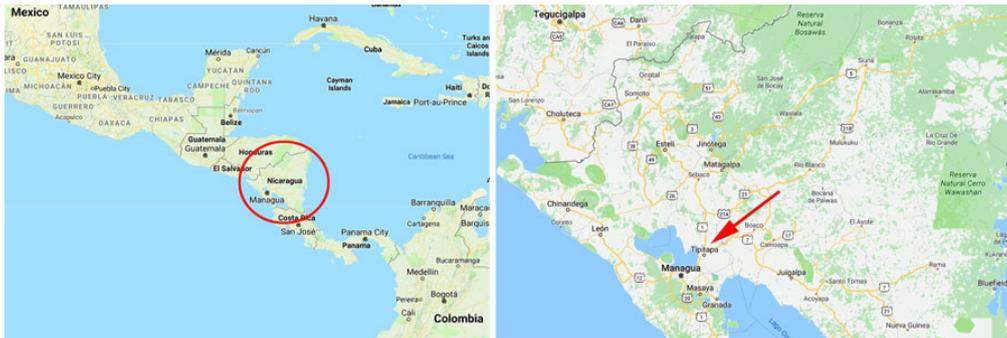
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1.0 INTRODUCTION

In the Tipitapa area of Nicaragua, Central America, north of the capital city Managua (Figure 1), a women’s cooperative called “Sweet Progress” has developed a compost toilet enterprise that is providing compost toilets, compost bins, cover material, and compost training to the local community.

Figure 1—Tipitapa, Nicaragua is just northeast of Managua:



Sweet Progress manufactures the compost toilets from local and recycled materials (Figure 2). Some of the toilets are made from laminated cardboard. The women’s cooperative (Figure 3) also raises honeybees and collects honey.

Figure 2—The Sweet Progress women’s cooperative in Tipitapa, Nicaragua manufactures compost toilets, or “Eco-Banos”:



Figure 3: The Sweet Progress women’s cooperative, with two American guests, this paper’s author, Joe Jenkins, and GiveLove’s Program Director Alisa Keesey (in sunglasses):



2.0 COMPOST TOILETS

A “compost toilet” is a dry toilet designed to collect toilet material so it can be composted in a separate compost bin. This is different from a dry toilet designed to dehydrate the toilet material by means of urine diversion, external heat sources, and venting.

2.1 Compost Definition

Composting, by definition, has three requirements: 1) human management; 2) aerobic conditions; and 3) the generation of internal biological heat. If these three requirements are not met, “composting” is not taking place and the end result cannot be called “compost.” According to the U.S. Composting Council on February 27, 2018, *“The American Association of Plant and Food Control Officials (AAPFCO) has approved a new definition for compost that emphasizes the pathogen-removing thermophilic process, differentiating it from many products often confused with compost. This more completely defines what our products are so that people out there wanting to call their products compost cannot do that without meeting this definition.”* The new definition states that compost is *“the product manufactured through the controlled aerobic, biological decomposition of biodegradable materials. The product has undergone mesophilic and thermophilic temperatures, which significantly reduces the viability of pathogens and weed seeds and stabilizes the carbon such that it is beneficial to plant growth. Compost is typically used as a soil amendment but may also contribute plant nutrients.”*

Most devices referred to as “composting toilets” do not compost and should be referred to as “dry toilets” or “biological toilets,” but not composting toilets. They do not compost because the toilet contents do not generate internal biological heat, primarily because of small organic masses and organic material that is too dry. When organic material is subjected to a true composting environment, it is converted into humus by microorganisms while human pathogens are eliminated or significantly reduced. Dehydration toilets do not achieve composting, although their contents can later be added to a true composting system and presumably thereby processed for pathogen removal.

Compost toilets collect the “toilet material,” which can include fecal material, urine, toilet paper, cleaning water, other human excretions such as vomit and menstrual discharges, and whatever carbon-based cover material is being used in the toilet. Cover materials can include sawdust, rice hulls, sugar cane bagasse, grasses, leaves, coco coir, coffee grounds, and other semi-dry, finely grained materials derived from plants or plant byproducts such as paper and cardboard. Correct toilet cover material with a degree of moisture in it will completely block all odor and flies, allowing compost toilets to be located almost anywhere, including, for example, right next to a bed.

Compost toilets, to function correctly, require four elements: 1) the toilet receptacle; 2) the cover material; 3) a compost bin; and 4) human management. Like a flush toilet not being able to function without water, drains, and pipes, a compost toilet will not function without cover material, compost bins, and someone to manage the system.

2.2 Toilet Receptacles

The compost toilet’s primary element is an internal collection receptacle that is rigid, stable, durable, and water proof. The receptacle collects toilet material before it contacts the environment, thereby eliminating environmental pollution. No drainage is allowed from the toilet into the environment. The toilet receptacle doesn’t need to be vented because the cover material blocks the odors. A correctly equipped compost toilet setup includes the toilet itself, plus an empty replacement toilet receptacle, plus an adequate container of cover material (Figure 4), all with lids. The receptacles should be color

coded or labeled to prevent cross-usage. The toilet in Figure 4 is at the Police Barracks School in Moroto, northern Uganda. The 55-liter toilet receptacles simply slide in and out the front of the toilet. These toilets cost approximately \$25 USD to build.

Figure 4—Toilet setups should include the toilet, a spare receptacle, and cover material:



2.3 Cover Material

Access to cover material is the primary limiting factor in the adoption of compost toilet systems. The cover material must be carbon or cellulose based to promote the composting process. Cellulose, an important component of plant cell walls, is an organic compound with the formula (C₆ H₁₀ O₅) and is the most abundant organic polymer on Earth, according to Wikipedia³.

Mineral based materials such as ashes or lime do not contain carbon, do not promote composting, and should not be used as cover material in compost toilets. Alkaline substances such as wood ashes and lime raise the pH of organic material and thereby inhibit bacterial growth, which is counter-productive to composting⁴. Composting is a process that encourages the growth of bacteria, which may seem counter-intuitive to sanitation professionals, but it's the beneficial bacteria in compost that eliminate pathogens by predation, competition, and the creation of an environment hostile to disease organisms.

Some locations have large amounts of post-industrial byproducts such as sawdust, sugar cane bagasse, coco coir, and rice hulls (husks). Other locations have little or none of these, but may be rich in natural grasses, weeds, leaves, plants, and local agricultural byproducts that may make suitable cover material, especially if ground or chopped to the correct consistency. In Nicaragua, the primary source of cover material was from a local rice factory where rice hulls were made available to Sweet Progress, who then provided them to the compost toilet users (Figure 5). Note that the rice husks are stored outside and exposed to the rain to allow for hydration and an increase in biological activity.

Figure 5— Rice husks in Nicaragua stockpiled for toilet cover material:



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The cover material *inside the toilet* should be of a fairly fine consistency and should have a degree of moisture rather than be completely dry. If these conditions exist, the toilet cover material will block odor completely, as plant cellulose makes a very effective “biofilter” to prevent odors from escaping a toilet. The cover materials *in the compost bins* can be bulky and can include dry or green grasses, hay, weeds, leaves, straw, green plants, bagasse, and other organic materials. The main immediate purpose for the compost bin cover material is to block odors, but the cover material in the bin can also protect the compost from waterlogging and leaching due to excess rain, from drying due to hot arid conditions, from freezing in cold climates, and from attracting vermin.

Some cover materials work better than others. For example, sugarcane bagasse contains sugar residues which help feed bacteria. Bagasse may have an inorganic silica content of approximately 9.78%¹ while rice husks may contain up to 20% by weight of silica². The higher inorganic component of rice husks may be one reason why rice husks seem to be slower to compost than sugarcane bagasse, based on our field trials. When cover materials with a higher inorganic component are used, it may be necessary to increase the amount of food scraps and green feedstocks in the compost to achieve higher compost temperatures, as indicated by our field trials.

Likewise, particle size in toilet cover material is important. For example, wood and lumber byproducts usually include three materials: 1) sawdust; 2) wood shavings; and 3) wood chips. Sawdust is a fine textured material made from sawing logs into boards or sawing larger boards into smaller boards (Figure 6). It is a good cover material due to its small particle size which allows for a maximum surface area on which to allow microorganisms to thrive, especially when there is a degree of moisture in the material, such as when sawdust is made from logs with residual sap. The moisture creates biofilms around the wood particles where bacteria and other microorganisms can multiply. Bacteria don’t have legs; they don’t walk, they swim, which is why moisture is so important in a compost environment. Sawdust made from kiln-dried lumber lacks moisture and therefore should be exposed to rainfall when in storage to allow for rehydration, or water should be added to it to replace the moisture lost in the kiln drying process.

Figure 6—Slightly moist “sawdust” is a good material for making compost:



Wood “shavings,” on the other hand, are made by wood-planing machines and consist of particles of wood significantly larger than sawdust particles (Figure 7). These larger particles have less surface area and are less accessible to bacteria. They can inhibit compost enough to suppress the compost temperatures in smaller backyard compost piles. When temperatures are suppressed due to larger wood particles, more green material and food scraps may help the compost temperatures increase, as suggested by our field trials.

Figure 7—Wood “shavings” are not as good in compost piles as sawdust:



Wood “chips” are produced by chipper-shredder machines (Figure 8). They have even larger particle sizes and are least likely to benefit compost piles. They should not be used in smaller compost bins such as backyard bins. Even in large municipal compost operations wood chips may not compost and may have to be screened out of finished compost before marketing.

“Sawdust,” “wood shavings,” and “wood chips” are mentioned here because many people don’t understand that there is a distinct difference between the three and the terms are being incorrectly used interchangeably. For example, a compost toilet user should not be looking for “wood chips” as a cover material.

Figure 8: Wood “chips” are not recommended for composting:



2.4—The Compost Bins

The toilet receptacle is removed from the toilet when full, or when convenient to remove. If a full receptacle is too heavy to handle, the receptacle should be removed before it becomes too heavy. Once removed, the toilet is immediately re-fitted with an empty receptacle to remain in service. Empty receptacles should have a few centimeters of cover material in the bottom to make cleaning of the receptacle easier. Once the full receptacle is removed, it can simply be set aside with a lid on it, to be composted later. The composting can be done by the user, or by a trained compost manager who collects the receptacles and transports them to compost bins. The compost bins can be located near the toilets to minimize transport. When properly managed, the compost bins will have no odor.

The compost bins used by Sweet Progress in Nicaragua were primarily made from wood pallets (Figure 9). Wood pallets are a byproduct of the shipping industry and are readily available at a low cost in many locations. They can easily be assembled into a quick compost bin by setting the pallets

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on edge and fastening them together, either by tying, nailing, or screwing. Once the pallets are available and on-site, a family-size bin can be constructed in 10 minutes.

Figure 9—The Japon School in Nicaragua used pallets to construct compost bins. The school's compost management crew, members of the Sweet Progress woman's cooperative, is shown at left.



Bins can also be made using wire mesh. The mesh size should be small enough to prevent entry by rodents. If the wire mesh is rigid enough, a round wire compost bin can be free-standing (Figure 10). Sticks driven into the ground can provide support if needed (Figure 11). Bins can also be constructed using only sticks (Figure 12). However, one concern is rodent access or rat-proofing of the bins, which may be needed in some locations. The wire may need to be buried in the ground a few centimeters to prevent digging underneath. The compost bins may need to be completely enveloped in rat-proof wire mesh, and a rat-proof lid may need to be included when located in rat infested areas. A wood framed wire bin is shown in Figure 13.

Figure 10—Free standing wire compost bin in Nairobi, Kenya:



Figure 11—Wire bin supported by sticks, in Dongobesh, Tanzania:



Figure 12—Wire bin made only from sticks, in a Karamojong Village, northern Uganda:



Figure 13—A wood-frame wire mesh compost bin in the USA:



3.0 COMPOST TOILET USAGE AND MANAGEMENT

A compost toilet system requires four essential components: 1) the toilet; 2) the cover material; 3) the compost bin; and 4) management. Management is key to the successful use of any compost toilet system.

3.1—Compost Toilet Usage

A great many people are unfamiliar with compost or composting, nor do they realize that composting can be used as a sanitation solution. This is true in both developing countries where composting is often unheard of, and in developed countries where flush toilets are common, and composting is uncommon. People therefore need education and training about composting and especially about compost toilets, their function, operation, and management.

When presented with composting as a sanitation solution, acceptance has been very good among people who open defecate or who use pit latrines. Of the billions of people who currently have no toilet other than an open field or a hole in the ground, the vast majority of them will never have a flush toilet due to lack of water, lack of infrastructure such as pipes, drains, pumps, and water treatment facilities, and due to the high expense of a water toilet system. Their options for safe, sanitary, ecological, and convenient toilets are very limited. Compost toilets can provide a solution for many.

Using a compost toilet is simple. After depositing odorous excretions into a toilet, either by sitting or squatting, the toilet contents are covered with the cover material. The toilet lid is then closed, and the toilet user washes her hands (Figure 14). The toilet is used like any flush toilet in that all excretions are included into the toilet and no urine diversion is needed or recommended. Urine is essential for the composting process because its moisture and nitrogen help compensate for the dryness and the carbon of the cover materials. Also, toilet paper should be included in the compost toilet, as well as any wash water for those who squat and don't use toilet paper. When wash water is used, more cover material may be needed to balance the excess liquid in the toilet, and the toilet may reach its functional capacity sooner.

Figure 14—Toilet instructions should be prominently displayed inside each toilet room:



The toilet should never be filled to the top when in use. A 55-liter toilet receptacle may have a functional capacity of approximately 40 liters. A 20-liter toilet receptacle may have a functional capacity of 15 liters. When the toilet receptacle has reached its functional capacity, it is removed from the toilet and replaced with an empty receptacle to which a few centimeters of cover material has been first added in the bottom. Compost toilets should be equipped with several receptacles, so the toilet may remain in service even as receptacles fill up.

Compost toilet receptacles can be a variety of sizes, shapes, and materials. The smallest recommended size for adult usage is 20 liters, although smaller receptacles can be used in children's toilets. Larger receptacles, such as 200-liter drums, may require pallet jacks, skid loaders, or fork lifts for handling. Receptacles with narrow mouths should be designed to fit through the toilet top and come into contact with the toilet seat ring (Figure 15). This may require a hinged top on the toilet cabinet, but it ensures that all excretions will go into the toilet. Receptacles with wide mouths can simply slide underneath the toilet cabinet as in Figure 4. Plastic compost toilets may be designed for mass-production (Figure 16). A good management practice is to keep the toilet receptacle lid inside the toilet cabinet behind the receptacle. Then, when the full receptacle is removed, the lid is easily placed on top of it before removal.

Figure 15—Small-mouthed toilet receptacles should protrude through the top of the toilet cabinet:



Figure 16—Plastic compost toilets may be well-suited for mass production:



Any compost toilet system should have a dedicated manager(s), otherwise the system is likely to fail. The manager makes sure there are clean, empty receptacles available to replace the full ones. She also makes sure there is adequate cover material. She checks the toilet receptacles and removes any that are full, replacing them with empty ones. The full ones are set aside with lids, their contents to be composted when convenient. The toilet space is regularly monitored for cleanliness, and toilet paper or wash water is restocked as needed. The compost manager makes sure the contents of the full receptacles are correctly deposited into a compost bin, then the receptacles are cleaned and returned to use. All cleaning water is deposited into the compost bins. Ideally a compost manager is someone who wants to use the compost and therefore has a vested interest in the success of the toilet system.

In Tipitapa, the compost toilets were equipped with 20-liter plastic receptacles which lifted out the top of a hinged toilet cabinet. Figures 17-22 are photos of the compost toilets provided to some of the 25 households during the first phase of the compost toilet project. Figure 23 shows an 80-year-old man who lives in a very small, crude dwelling near Tipitapa. He located his compost toilet immediately adjacent to his bed for convenience (Figure 24).

Figures 17, 18, and 19 (l to r)—New compost toilets at various homes:



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Figures 20, 21, and 22 (l to r)—New compost toilets at various homes:



Figures 23 and 24 (l to r)—Eighty-year-old man with compost toilet beside bed:



Before the families had the compost toilets, they engaged in open defecation or they used pit latrines. Some photos of the pit latrines in use are shown in Figures 25-27. Note that the pit latrine holes present a danger to small children, who can fall in. Bad odors are abundant.

Figures 25, 26, and 27 (l to r)—Some of the pit latrines in use before the compost toilets:



The compost toilets used in the Villa Japon school were of the same 20-liter style but were housed in stalls (Figures 28 and 29).

Figure 28—Villa Japon school compost toilet stalls:



Figure 29—Villa Japon school compost toilet stalls, with an “Eco-Girl” monitoring the toilets:



3.2—Use of Cover Material

The cover material falls into two functional categories: 1) toilet cover material; and 2) compost bin cover material.

The toilet cover material is used inside the toilet receptacle. It should be fine-grained, carbon-based, and have some degree of moisture, but not be wet. When the correct cover material is used in adequate

quantities, all odor from the toilet will be blocked, allowing the toilet to be located almost anywhere, including inside a bedroom, office, home, tent, or even a vehicle. The advantage of such a toilet should be obvious when considering people with mobility issues, the elderly, the handicapped, cold or harsh climates, even people dealing with young children who don't want to have to go outside in the rain or snow at night to find a pit latrine. Pit latrines are located away from the living area because of their foul odors and fly breeding. Compost toilets don't have these characteristics when properly managed and can instead be located wherever convenient.

The general rule when using cover material inside a toilet is that if there is a bad odor, or if there are flies attracted to the toilet, more cover material is needed. If more cover material doesn't stop the problems, then the wrong cover material is being used. The advantage to this management approach is that one needs only to rely on one's nose and eyes to determine whether the toilet is being correctly managed.

The cover material *in the compost bins* does not have to be fine grained, nor does it have to contain moisture. It can consist of grasses (green or dry), weeds, leaves, hay, straw, bagasse, coco coir, etc. It can be fresh and green, dry, or in a state of decay. Whatever cover material is used, it should not have a foul odor because its primary purpose is to block odor from the toilet material, rotting food scraps, or animal carcasses in the compost pile. This is also why animal manures are not best suited for cover material—because they have odors. Animal manures can be used inside compost bins, however.

3.3—Using the Compost Bins

Proper management of compost bins requires three main considerations: 1) correct construction of the bin; 2) correct feeding of the compost pile; and 3) correct usage of the cover material.

3.3.1 Bin Construction

Bin construction must be above ground, not underground in “pits.” Composting is an aerobic process and when organic material is piled above ground, interstitial air spaces in the material provide adequate oxygen for the composting process to take place. No turning or mechanical agitation is needed. Many people believe that compost must be “turned” to keep it aerated, but this is not true, as proven by our field trials. The biological activity in a compost pile can be monitored with a compost thermometer. If the temperatures are adequate, then the compost is progressing successfully. The U.S. Environmental Protection Agency requires that static, contained compost piles reach temperatures of 55C and maintain them for three days to ensure acceptable pathogen reduction. Our field trials have shown 55C maintained for months in static, completely undisturbed piles consisting primarily of toilet material and sugar cane bagasse.

Turning, digging, or agitating compost piles can create significant problems. One obvious issue is the cost of equipment to turn compost, or the cost of labor to manually turn the piles—costs that are not encountered when the piles are left undisturbed. Another significant issue is the release of vapors, spores, odors, gasses, organic material, and heat when turning piles. None of this is released in undisturbed piles. This is particularly important when composting toilet material, animal carcasses, and food scraps because of the significant odors produced by these feedstocks. Such materials can be composted without the need to turn, dig, or agitate the piles, so the odor issue does not exist. Furthermore, the aerial release of gasses, molds, spores, vapors, and organic compounds can pose a health risk for people who may inhale these things.

Therefore, our model for composting requires an above-ground container or compost bin, plus specific loading techniques and specific use of cover material. When the directions are followed, a compost bin is filled, covered, then left undisturbed for a period of time, usually 9-12 months. Nothing is released from the compost and no odors are emitted. Labor costs are minimal. The heat inside the pile is not released into the air as is done by turning compost but remains contained in the pile to maintain the hot environment created and desired by the compost organisms. The compost ages to maturity based on monitoring the biological activity using a compost thermometer. When the internal temperature of the compost drops to ambient and seed germination tests are successful, then the compost can be used for agricultural purposes, but not before.

Rice husk compost seems to generate less heat than bagasse compost. Our rice husk/toilet material compost piles at the Villa Japon school in Nicaragua were only reaching temperatures of 48C (Figure 30) at the time of this documentation, whereas our bagasse/toilet material compost in other countries typically exceeded 55C and sometimes much higher. Lower internal compost bin temperatures require longer retention times (time spent inside the compost bin) for adequate pathogen reduction and agricultural conversion before the compost should be used.

The compost bins should be vermin proof. Dogs, goats, chickens and other nuisances should not be able to access the compost. This can be achieved by placing a wire lid over the piles, laying a piece of wire fencing on top of the piles, or making the bins high enough that animals can't climb in. At the Villa Japon school, the compost managers simply laid thorny branches on top of the compost piles to prevent horses from eating the cover material (Figure 31). When rats are a problem, the compost bins should be completely enveloped in rat-proof wire mesh, including underneath, or else the compost bin should be constructed of a rat-proof material such as blocks, bricks, concrete, metal, or something similar, again with a rat-proof wire mesh underneath and on top. Flies are kept out by the cover material.

Figure 30—Rice husks can depress compost temperatures:



Figure 31—Thorny branches on top of the compost can be an effective barrier to animals:



The bins should be situated on a soil base, not a concrete base. The soil acts as a buffer for excess liquid, which is absorbed by the top few inches of soil. The soil also provides an interface between the compost and the earth, creating a conduit for soil organisms to enter the compost pile. The soil in the bottom of the compost bin should be dished out like a shallow bowl, with the soil that is dug out of the bowl piled around the edges of the bin. This creates a bermed depression in the bottom of the bin that prevents excess liquid from leaching out from under the pile (Figure 32). Excess liquid underneath a compost pile doesn't hurt anything, but if it leaks out underneath the sides of the pile, contamination can occur by people or animals walking in it, and by flies breeding in it.

Once the compost bin base has been dished out, a “biological sponge” is created on the bottom of the bin (Figure 33). This is a layer of organic material approximately a half meter thick, composed of grasses, hay, straw, weeds, leaves, bagasse, or whatever clean, somewhat absorbent organic materials are available to use. The biological sponge creates the base for the compost pile. Once the sponge is created, toilet material and other feedstocks can be added.

Figure 32—Start the compost bin with a bermed, concave bottom:



Figure 33—Make sure there is a biological sponge in the bottom of the compost bin:



3.3.2 Bin Feeding

When organic materials are being added to a compost pile, they should always be added into the center of the pile. The rule is to never put feedstocks “on” a compost pile, always put feedstocks “in” a compost pile. A heavy layer of cover material is always kept on top of the compost (Figure 34). This keeps out flies and keeps in odors. When adding new feedstock to a pile, pull the cover material open to expose the compost in the center of the bin (Figure 35). Or, when starting a new pile, pull the biological sponge open. Then dig into the existing compost (if any) to form a hole. Then deposit the new material into the hole, cover it with the existing compost, then pull the cover material back over the compost. Add additional cover material as needed.

Figure 34—Make sure there is a heavy cover material on the bin contents at all times:



Figure 35—Open the cover material, then create a hole in the compost when adding new material.



This important management procedure is facilitated by limiting the height of the compost bin to a little over a meter and the width of a compost bin to approximately two meters, so the center can be reached from either side with a shovel or fork. The length of the compost bin doesn't need to be limited. The bin should be accessible from at least two sides to make it easier to pull the cover material off and create a depression in the center of the pile.

When feeding the compost bin in a center depression, the cover material is pulled to the outer edges of the bin. This causes the cover material to form a layer around the *outside* of the compost and not just on top. This outer layer of cover material aids in odor containment and fly prevention. It also insulates the compost in cold climates, keeps compost from falling out the sides of bins when wire or pallets are used, and the porous mass encourages oxygen to be available around the edges of the compost. This management technique eliminates exposed edges of the compost and encourages hot temperatures throughout the compost mass. When this technique is used, the compost bin walls can be made of

impervious materials such as metal, plastic, block, bricks, or mud. There is no need to allow for air penetration through the side walls of the bin.

In some cases, a roof over the compost may be desired. Although the cover material itself acts as a roof of sorts, protecting the compost from heavy rains and from drying, a secondary roof can be utilized. It can be as simple as some branches propped over the compost bins (Figure 36).

Figure 36—A simple roof over the compost bins may be desired in some cases. This is in Nicaragua:



3.4—Using the Compost

The compost must be fully aged and mature before it can be used agriculturally. Immature compost is “phytotoxic,” meaning it kills plants. Trying to rush compost is a mistake. The compost will be finished when the microorganisms convert the organic material into humus. This can be gauged by monitoring the compost temperature. The compost temperature must drop to ambient temperature, then an additional “retention time” is needed to allow for aging or curing, and for the decomposition of residual woody materials.

The thermophilic or hot phase of the compost tends to occur during the initial decomposition of the organic material. The lower temperature stages follow the thermophilic stage and allow for fungi and macroorganisms such as earthworms to further digest the organic materials, resulting in a fully mature, agriculturally valuable compost. The finished compost can be tested for germination by taking a sample and planting seeds such as squash, watermelon, cucumber, or pumpkin. Fully mature compost will germinate healthy seedlings. Also, compost samples can be sent to a compost testing lab for analysis. It is extremely important when collecting samples for laboratory analysis that the samples are not contaminated by improper handling or by collecting with contaminated tools or utensils.

The finished compost can be used in a variety of ways. It can be placed into holes in which seeds, seedlings, shrubs, climbing vines, or trees are planted. It can be used as a mulch, or it can be dug, plowed, or roto-tilled into agricultural soil. If there is a concern about the hygienic safety of the compost, such as when high compost temperatures have not been achieved, the compost can be used where it does not come directly into contact with edible crops.

Most human toilet practices produce waste, sewage, water pollution, soil pollution, odor, fly breeding and disease. Properly managed compost toilets produce agriculturally valuable compost without waste, sewage, pollution, flies, or dangers associated with open defecation and pit latrines. People who

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currently rely on pit latrines and/or open defecation see compost toilets as a revolutionary approach to sanitation. However, proper use of compost toilet systems requires education and training. Figures 37 and 38 illustrate some of the education and training that took place in Tipitapa.

The people who most need this toilet solution tend to be people who have little or no money. Despite the low cost of compost toilets, many people who want them still need financial assistance.

Figure 37—The Eco-Girls participate in a training seminar:



Figure 38—The Eco-Girls conduct a community training seminar:



¹*Analysis of Chemical Composition in Sugarcane Bagasse and Rice Straw for their Suitability Using in Paper Production*; Suhardy Daud, Siti Shuhadah Md Salleh, Mohd Nazry Salleh, Farizul Hafiz Kasim and Saiful Azhar Saad; School of Materials, Bioprocess and Environmental Engineering, Universiti Malaysia Perlis (UniMAP), Jejawi 02600 Arau, Perlis; 2007

²*Lignin Isolation Process from Rice Husk by Alkaline Hydrogen Peroxide: Lignin and Silica Extracted*; Anwar Ma'ruf1, Bambang Pramudono, Nita Aryanti; Chemical Engineering Department of Muhammadiyah University of Purwokerto, Indonesia; Chemical Engineering Department of Diponegoro University, Indonesia; International Conference on Chemistry, Chemical Process and Engineering (IC3PE) 2017; AIP Conf. Proc. 1823, 020013-1–020013-5; doi: 10.1063/1.4978086; Published by AIP Publishing. 978-0-7354-1491-4

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