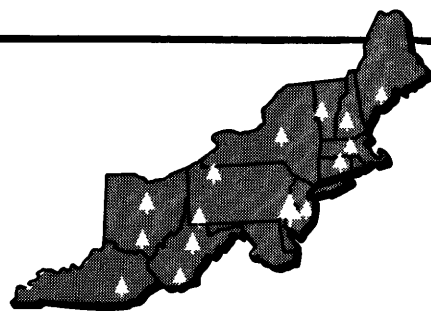


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THE COMPOSTING OPTION FOR HUMAN WASTE DISPOSAL IN THE BACKCOUNTRY

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Abstract.—The disposal of human waste by composting at backcountry recreation areas is a possible alternative to methods that are considered unsafe. The literature indicates that aerobic, thermophilic composting is a reliable disposal method that can be low in cost and in maintenance. A bark-sewage mixture can be composted to produce a pathogen-free substance that might be used in site rehabilitation. Composting in a leakproof bin is odorless, and is largely independent of site conditions.

In the last few years, there has been a significant increase in the number of visitors to backcountry recreation areas. This growth has created several problems for the manager, including the difficulty of disposing of human waste safely at remote shelter sites.

The pit privy was the universal method for disposing of human waste at these remote sites. Privies were located on sites where the soil was deepest. But because of the larger number of visitors to backcountry recreation areas, and the fact that privies must be moved when they are full, there are more privies on sites where the soil is shallow or poorly drained. Managers are increasingly aware that environmental and health hazards might result from placing privies on inadequate sites.

The composting of human waste at backcountry shelter sites might offer some advantages over conventional methods of waste disposal.

The Compost Process

The main concern about using composting for waste disposal in the backcountry has been whether the process produces a pathogen-free substance that can be disposed of easily. Studies show that aerobic, thermophilic (45 to 70°C) composting produces substances that have few, if any, pathogens. In a windrow composting operation where a mixture of raw sewage and ground hardwood bark was used, *Escherichia coli*, *Candida albicans*, and *Salmonella heidelberg* were added to the raw sewage. There was no evidence of these human pathogen indicator organisms after 36 hours of composting at temperatures above 60°C (Walke 1975). Similar results were obtained when *Salmonella*

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newport, *Ascaris lumbricoides*, *Candida albicans*, and poliovirus type 1 were added to raw sewage under similar conditions (Wiley and Westerberg 1969). Other studies have shown that pathogenic microorganisms that may be harmful to man are destroyed during composting (Gotaas 1956; Knoll 1959; Wiley 1962; Straub 1962).

Most of the information on the destruction of pathogens concerns the effect of heat generated during the composting process on microorganisms. These organisms also are killed during composting by antibiosis, the destruction of pathogens through antagonistic relationships among microorganisms or by substances produced by certain microbes (Knoll 1959). *Salmonella typhimurion*, *S. cairo*, *S. infantis*, *S. typhi*, and *S. paratyphi* B. were killed at a sustained temperature of 50°C as long as the pathogens were exposed to the composting material. The same microorganisms encapsulated in gelatin were not destroyed at that temperature.

This indicates the importance of an active composting process in eliminating health hazards. Good composting conditions directly affect the activity of microorganisms; and it is this activity that generates sufficient heat and antibiotic conditions to destroy pathogens. The difficulty is ensuring that good composting conditions are created.

Microorganisms are controlled to a large extent by the appropriate carbon/nitrogen ratio and moisture content of the compost material. Carbon/nitrogen ratios of from 20:1 to 30:1 are desirable because the organisms use these elements in those proportions (Nell and Krige 1971; Goleuke 1972; Poincelot 1974). A higher ratio slows the composting process because nitrogen may become limiting, while a lower ratio may result in a loss of nitrogen in the form of ammonia.

Desirable moisture levels for composting range from 40 to 70 percent (Poincelot 1974; Kochtitzky et al. 1969; Schulze 1961; Snell 1957; Wiley 1957; Gray et al. 1971; Nell and Krige 1971). The lower end of this range generally applies to windrow or heap composting where maintenance may be infrequent; the upper end applies to aerated systems where the material is agitated mechanically. We can assume that when moisture content is less than 40 percent, the activity of microorganisms is reduced to un-

desirably low levels; when the moisture content is greater than 70 percent, composting conditions become anaerobic.

For composting in backcountry areas, human waste must be mixed with a material that will adjust the moisture content to an acceptable level and help produce the proper C/N ratio. One of the best mixing agents is ground hardwood bark (Walke 1975). This material is highly absorbent, is a good source of nutrients, helps eliminate odors, has a desirable C/N ratio, and is easy to handle.

Unfortunately, there is no material already on the site that could be used; the available soil usually does not have an appropriate C/N ratio, and it does not absorb enough liquids unless used in large amounts. And soil is not easily obtained on shallow or rocky sites. The same is true for fresh litter.

So despite the inconvenience of physically carrying ground hardwood bark to a remote site, composting with this material seems to be a satisfactory alternative when other waste disposal methods cannot be used. Noncomposting methods are often far more expensive; in some areas, the only alternative to composting is closing the site.

Other Considerations

Other considerations in composting are the texture of the material, aeration, and the size of the pile. A finely textured material is desirable (Snell 1957; Poincelot 1974), particularly for composting raw sewage and hardwood bark.¹ A fine-textured material is more susceptible to invasion by microbes, is more easily moistened, and increases the rate of decomposition. A distribution of particle sizes ranging from 1.2 cm in diameter for materials that are being aerated and mechanically mixed to 5.0 cm in diameter for mixtures that are managed infrequently has been suggested (Gray et al. 1971).

Aeration by the "natural chimney effect" is not adequate for maintaining enough oxygen in the pile at times of peak demand for oxygen (Snell 1957). Thus it is sometimes necessary to turn even a well-managed pile. The oxygen content in the pile is the best indicator of turning

¹Included in report by Gregory MacDonald to Environmental Protection Agency on a 1974 composting study in North Stratford, N.H.

time, but unusual odors or declining temperatures also are useful indicators.

Aeration also might be improved by driving perforated tubes through the compost heap (Wolf and Dunn 1953) or by composting in wire mesh bins (Maier et al. 1957). These methods might be helpful at remote sites where the pile is turned infrequently.

The size of a compost pile also is important at remote sites where the volume of human waste may be relatively small. There is a minimum size below which the surface area to volume ratio results in a loss of heat that is greater than the amount of heat that is produced. Our pilot study in 1976 showed that a bin that is 3 feet (.91 m) by 4 feet (1.2 m) by 2 feet (.61 m) and that is filled with a bark-sewage mixture can maintain temperatures greater than 60°C. This is one indication of the minimum size for a compost pile. It also has been reported that a 27 ft³ (0.75 m³) pile is effective for aerobic composting (Dunn and Emery 1959).

Conclusion

Composting of human waste seems to have strong potential at shelter sites accommodating as many as 50 people—even where soils are shallow—because it can be done in a leakproof bin. This process is safe and odorless, and produces a substance that might be used in site rehabilitation. Composting in a bin also can be low in cost and in maintenance, and the process is largely independent of site conditions. This alternative would be particularly useful at sites where other methods are impractical. A mixture of human waste and ground hardwood bark adjusted to about 50 percent moisture, and that is at least 27 ft³ in volume, should promote activity by microorganisms that will destroy most pathogens. The destruction process would require that all portions of the pile be exposed to a temperature of at least 60°C for 36 hours.

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