Appalachia-Science in the Public Interest
50 Lair St., Mt. Vernon, KY 40456

ASPI TECHNICAL SERIES TP 58

SOLVING KENTUCKY'S WATER PROBLEMS

Introduction

Kentucky's waters are polluted. Thirty-one percent of all rivers, creeks, and streams in Kentucky have fecal coliform pollution (13). This pollution results from untreated sewage reaching the waterways due to "straight pipe" discharge and malfunctioning septic tanks. This sewage can contaminate drinking water, irrigation water, fishing water, and cause the spread of disease. This contamination can reduce the recreational uses of our waterways. If we do not make changes now, more waterways will close like Boonesboro Beach on the Kentucky River. Boonesboro Beach was closed due to fecal coliform pollution from untreated sewage. This report proposes that dry composting toilets and constructed wetlands are a viable, efficient, environmentally sound and cost-effective solution to the pollution caused by "straight pipes" and malfunctioning septic tanks.

"Straight Pipes"

A "straight pipe" is an illegal sewer pipe that goes directly from a toilet to an exterior creek, stream or river. This is untreated sewage released directly into our waterways. State officials have estimated that there are as many as 100,000 "straight pipes" in the State of Kentucky. The headwater counties of the Kentucky River Basin in Eastern Kentucky (Letcher, Knott, and Perry Counties) have no sewer collection and treatment facilities. While some of the residences have septic tanks, the majority have straight pipes. Letcher County has the largest concentration of straight pipes where there are estimated up to 3000 straight pipes. These straight pipes contribute to pollution of our streams since they dump raw untreated sewage into our water (12).

Septic Tanks

Even though septic tanks are considered the solution to straight pipes, they, in fact, contribute to water pollution. Septic tanks are the source of two types of groundwater and surface water pollution: nutrient pollution, and fecal coliform pollution (3). Septic tanks are especially risky in heavy clay soils or poorly drained soils because the leachfields will overflow above the surface, especially during rain and snow melt. Once the soil is saturated, it cannot hold any more water and the excess liquid rises to the surface. This then spreads the discharge from the house out into the environment, into the groundwater, and surface water (6). This discharge is full of nutrients which can cause eutrophication in the streams and creeks; and pathogens that can cause disease.

Compost Toilets and Constructed Wetlands

In a technical paper about compost toilets, the Environmental Protection Agency (EPA) says that compost toilets are "well-suited for remote areas where water is scarce or areas with low percolation, high water tables, shallow soil or rough terrain" (4). In the same report, the EPA also says, "as they require little or no water, compost toilet systems can provide a solution to sanitation and environmental problems in unsewered, rural, and suburban areas"(4). Both of these suitable areas for compost toilets describe rural Kentucky, and especially Appalachia. The rough terrain and high clay and rock content soil contribute to the difficult task of dealing with the waste. The area is not suitable for either a municipal sewage system or for a septic tank system. The viable option is dry compost toilets and constructed wetlands.

Compost toilets and constructed wetlands: promote water conservation; reduce water pollution; are inexpensive and easy to build; and are especially suitable for rocky, steep, rural areas. Conventional flush toilets use excessive amounts of drinking water. A dry composting toilet can reduce the use of domestic water by as much as 50%. Using constructed wetlands also eliminates waste water as it reuses the household graywater and releases it through evapotranspiration. While conserving water, a dry compost toilet produces no waste emissions. The artificial wetlands remove sediment and dissolve nutrients to produce clean and unpolluted water. Also, dry composting toilets and constructed wetlands do not release methane as wastewater treatment facilities do. Methane gas contributes to global warming.

Compost toilets and artificial wetlands can be built very inexpensively by local people. Since many of the "straight pipes" and malfunctioning septic tanks are located in rural and poorer areas of Kentucky, it is essential that the solution be inexpensive and easily built. Septic tanks and sewage treatment systems are very expensive. While Personal Responsibility in a Desirable Environment (PRIDE) is offering loans to these poor rural residents, these sizable loans must be paid back. There must be a lower cost solution that these residents can afford. To install a sewage treatment system costs millions of dollars (paid to outside contractors) - money that many of these poorer counties do not have.

Finally, much of rural Kentucky and Appalachia is rocky, mountainous, and steep-sloped with poorly drained soils. In these areas it is very difficult to install a septic tank because of the slope of the land, the soil content, and/or the small size of the property. A septic tank system needs a considerable amount of flat land with well drained soil. Compost toilets can be built in the home and do not need any flat land. Constructed wetlands can be built in a variety of different settings, and can be terraced on steep slopes.

Currently, compost toilets and constructed wetlands are regulated as on-site sewage disposal systems. The Kentucky on-site sewage disposal regulations include include 902 KAR 10:140. On-site sewage disposal system installer certification program standards; 902 KAR 10:085. Kentucky on-site sewage disposal systems; 902 KAR 10:110. Issuance of on-site sewage disposal system permits (2). The state of Kentucky is one of only seven states that gives specific approval of compost toilets. This is an important step, the next step is to begin to recognize and promote compost toilets and constructed wetlands as the solution to Kentucky's water pollution problems.

Dry Composting Toilets

Dry compost toilets (DCT) were first developed in Sweden in the 1930's. The extremely rocky Swedish countryside prevented the installation of typical sewage systems such as sewage transport or septic tanks. Sweden faces a similar dilemma that the Commonwealth of Kentucky faces - how to handle human waste without a septic tank or sewage system. DCTs are the solution to this dilemma because they are easy and inexpensive to build and maintain; reduce waste and pollution; are especially suited for rural and mountainous areas; and create a safe usable compost.

Dry Compost Toilets

DCTs are well-ventilated chambers that promote aerobic decomposition through the use of bacteria and fungi. Aerobic decomposition is the decomposition of the organic waste by means of oxygen using bacteria and fungi (4,3,1). The system works by maintaining a proper aeration, moisture, temperature and carbon:nitrogen balance to support the aerobic bacteria and fungi. These bacteria and fungi break the matter down to 10-30% its original volume (4,3,1). It is important to distinguish a dry composting toilet from an outhouse. An outhouse uses anaerobic decomposition which means that bacteria without oxygen begin to work and produce offensive odors.

Reduces waste and pollution

Outhouses, septic tanks, and sewage treatment plants, which use aerobic decomposition, can create methane and anaerobic decomposition, and may pollute ground and surface waters. Outhouses can leach into the groundwater; septic tanks can overflow; and sewage treatment plants can become backed up in residents' homes. Dry compost toilets are contained in a concrete chamber and do not leach into the soil and pollute the groundwater. Since DCTs promote aerobic decomposition, they do not create methane. Instead they only release carbon dioxide (CO_2) and water vapor, released through a vent as the waste composts. The humus or compost that remains in the chamber can then be reused as a soil amendment without any waste or pollution.

Inexpensive installation and maintenance

While septic tank systems and sewage treatment plants are expensive, the dry compost toilet can be built for as little as $500 (not including labor). It is a simple procedure that the home owner or local contractor could do (see Appendix I). The other option is to purchase one of the many varieties of pre-made containers and install them into the home. The pre-made containers vary in price from $1000 to $7000 (see Appendix I).

All maintenance of the dry composting toilet focuses on promoting aerobic decomposition. This means maintaining: **1)** aeration, **2)** moisture content, **3)** temperature, and **4)** carbon-nitrogen ratio.

> **1.** One must maintain the *proper aeration* to keep the decomposition aerobic. Aeration ensures that oxygen infiltrates the compost pile to support the aerobic bacteria and fungi. Designing a system that draws air into the compost pile through a vent, with or without a fan, ensures the aeration of the compost. If the DCT is not properly ventilated, then anaerobic decomposition will begin (3).
>
> **2.** The *proper moisture* content is also important to maintain the aerobic decomposition. If the pile becomes too wet, it becomes too tight and reduces the amount of oxygen available to the aerobic bacteria and fungi. If the pile is too dry, the bacteria and fungi cannot function. The pile needs about 45% to 70% moisture content. One simple way to prevent too much moisture is to have a pipe to drain extra liquids which are often called compost tea. There are also toilets that separate urine and feces (1,3,16).
>
> **3.** The *ideal compost temperature* is between 78 Fahrenheit and 160 Fahrenheit. If the temperature is too low, then decomposition will slow and even stop. The higher the temperature, the faster the pathogens will die. There are many ways to maintain this temperature: building thick insulation around the chamber; locating chamber in a heated room; installing an electric heater; or using solar heat (3,16).
>
> **4.** As with any compost pile, the proper *carbon-nitrogen ratio* must be maintained. The C:N ratio must be about 25:1. Since human waste, especially urine, has a higher nitrogen content, it is important to add carbonaceous material such as peat or sawdust (3,16).

All of these maintenance needs are easily solved in the construction of the DCT and the careful attention of the owner. They are much simpler than conventional flush toilets to maintain because the user has control. If a difficulty with the DCT develops, the homeowner can fix the problem. With sewage systems and septic tanks, the owner has to pay someone to fix the problem and wait for that person to come. Dry compost toilets are designed durably and to last a long time, unlike flush toilets which can break. ASPI has only had to make some minor repairs to their units and replace fans in the 20 years it has had seven types of DCT's on its property.

Along with ensuring the conditions most conducive for aerobic bacteria, one must also be aware of sanitary issues. One concern with any composting operation is flies and other insects, since flies can spread disease from the DCT to the kitchen area. Flies and other insects should not be a problem if the toilet is operating properly. Some other ways to keep flies away: do not put fruit, dairy or meat products into the toilet; patch any cracks in the toilet that a flying insect could crawl through; and always keep the lid down on the toilet to prevent entrance from the top (3,6). The toilet can be cleaned just as a flush toilet. The only difference is that nothing toxic or antibacterial can be used (since the bacteria are what decomposes the waste). It can be cleaned using biodegradable soap and water (3).

Most dry composting toilets only need to be emptied about once or twice a year. By this time the waste is a dark sawdust type material. It is generally pathogen free, but the user should use gloves as a precaution. It is ready then to be used as a soil amendment. To remove the waste, the user simply opens the access door, shovels the waste into a wheelbarrow or bucket and takes it to the outside compost pile or applies it directly to trees, shrubs, or flower beds.

Create a safe and usable compost

Human waste is only safe if it is composted - *human waste, uncomposted, cannot be used directly on gardens because it may contain pathogens*. The composted waste, called humus, is a safe and very good soil amendment for non-food gardens such as trees, flowers, shrubs, plants for bird and other feed, fiber crops (hemp, cotton, etc), berry bushes, wildscape and lawns. If specific safety precautions are followed, the compost will also be safe for edible crops. ASPI spent one year extensively testing its compost and food crops to ensure the complete destruction of pathogens and found that the pathogens were destroyed within a year or more of composting (see Appendix III).

The pathogens that can exist in human waste before it composts include viruses, bacteria, protozoa, and parasitic worms. Each pathogen has its own tolerance and life span in a compost pile. All pathogens can be destroyed in a compost pile within a year except the ova of the parasitic worms. The ova of the parasitic worm have tough skin and a much higher tolerance. Temperature, competition between the different microorganisms for food, and consumption by other microorganisms help destroy the pathogens (3, 6, 9, 10). This is why it is important to maintain the four major conditions for composting in the toilet chamber.

There are two ways to compost: slow composting or thermophilic composting. Slow composting, at 70-95 Fahrenheit, will eliminate most pathogens and diseases in a few months. Thermophilic composting, at 110 - 150 Fahrenheit, cultivates microorganisms which produce heat that helps destroy the pathogens within a few hours (3, 6, 9, 10). Most dry compost toilets use slow composting methods. However, to ensure that all pathogens, especially the ova of the parasitic worms, are destroyed, it is recommended to utilize thermophilic composting for several days in an outside pile. For extra safety, the user should solarize a two inch layer of the compost outside under a clear plastic cover, in the sun, for a few hours to several days. It is important to let it heat long enough to reach 120 - 140 Fahrenheit for three to five consecutive hours. This ensures that any remaining pathogens are killed (6, 9,10). (It is vital that thermophilic and/or solarizing methods are followed if using the compost on edible crops. We want to ensure that the compost is safe so that composting toilets have a perfect safety record.)

Constructed Wetlands

Once a house has a dry composting toilet, a constructed wetland is the perfect solution to handle the household graywater. Graywater, generally described as washing water, comes from bathtubs, showers, washing machines, kitchen and bathroom sinks, and dishwashers (3). The average water conservative person produces about 30 gallons of graywater per day (6). A wetland recycles a household's many gallons of water and purifies it without the need of an expensive septic tank or sewage system. These wetlands are especially useful in the rural mountainous areas in Kentucky where it is difficult and expensive to build septic tanks or sewage systems. Constructed wetlands can be built easily and inexpensively in rocky, steep, or mountainous rural areas and can reduce water waste and pollution.

Constructed wetlands

Constructed wetlands are based on the model of wetlands in nature. Natural wetlands filter sediment and the plants use the dissolved nutrients before releasing the water into the streams, lakes or rivers. Constructed wetlands are created to similarly filter the graywater from a household. The wetland should be sized to 120 square feet per bedroom. The one foot deep constructed wetland is lined with a PVC, polyethylene or comparable material liner of at least 24 milliliter thickness, to prevent leaking possible chemicals or pathogens into the groundwater. While one foot of gravel covers the liner, two inches of wood chips or peat moss or similar material cover the gravel. The plants are planted in the wood chips. (8, 10).

Pipes bring the graywater from the house into the wetland. The water passes through the wetland slowly. The plants wrap their roots around the gravel at the bottom of the wetlands. Bacteria and other microorganisms live around the gravel and the plants' roots. Within the wetland microorganisms and plants work together to clean the water as it passes through the gravel and plant roots. The sediment and other organic material settles out, while the dissolved nutrients are taken up by the plant roots. Through this symbiotic relationship, the plants and the microorganisms use up all of the dissolved materials in the graywater (3, 6, 9, 10). In specially designed wetlands, aquatic microorganisms can metabolize benzene, naphthalene, toluene, chlorinated aromatics, hydrocarbons, and pesticides. The aquatic plants can take up insecticides, benzene, lead, fecal coliforms, mercury, and algae (6).

Another pipe then removes the water from the other end of the wetland. Since the pathogens, chemicals, and other nutrients are settled out or are used by the wetland vegetation and bacteria, the water that exits the other end of the wetland is purified water. However, in ASPI's experience, very little water exits the wetland since it is used by the plants and the rest is released through evapotranspiration (the loss of moisture from plants through natural evaporation).

Inexpensive and easy installation and maintenance

Constructed wetlands are very easy to build and can be finished in a few days. The materials needed are basic and can be found easily by the average homeowner (see Appendix II). There are two common types of constructed wetlands: subsurface flow wetlands and surface flow wetlands. However, the more common for treatment of graywater is the subsurface flow wetland. Subsurface wetlands are a closed system, therefore there is no standing water that might contain pathogens. Even though these wetlands do not have any standing water, subsurface wetlands require a steady flow of water. (Surface flow wetlands require more water and have standing water).

It is important to evaluate the slope, type of soil, and weather conditions before deciding what type of wetland to use. These conditions are also important to decide what type of plants to use in the wetland. Generally, any water loving plants that are suitable to the area will be successful. Sun-loving plants recommended for Kentucky include: Common cattail, Canes or wild reed, Soft stem bulrush, Marsh milkweed, Pickerelweed, Blue water iris, and Sweet flag. For a shaded wetlands recommended plants include: river cane, jewel weed, and wild iris.

Constructed wetland maintenance is as easy as watching what goes down the drain. As long as no large food particles, grease, or toxic chemicals are poured down the drain, then the wetland should function properly. Again, the homeowner can easily fix any problems that do develop. In ASPI's experience, the most common problems have been fixed by clearing the drain of clogged food particles that were sent down the drain. The wetlands will work wonderfully if they are properly maintained.

Conclusion

ASPI has worked to educate the citizens of Kentucky about dry composting toilets and constructed wetlands in a number of ways through the following: USEPA funded workshops; six USEPA funded television shows over the past two years; talks to professional groups; technical papers; and demonstrations at our Center. ASPI has used both dry composting toilets and artificial wetlands for over 20 years with great satisfaction and success.

Human waste is an uncomfortable subject for many people, and for that reason the current crisis faced by the Commonwealth of Kentucky has not been publicized and adequately discussed in a positive manner. Dry composting toilets are a wholesome and practical approach to saving water and reusing natural resources while preventing water pollution. It is time to face the problem head on and promote cost effective and environmentally sound solutions to the fecal coliform pollution problem in Kentucky.

References

1. Arnold, Robyn, ed. "Compost Toilets." ASPI Technical Series #2. Livingston, KY: ASPI Publications, 1990.

2. Cabinet for Human Resources, Department of Health Services Kentucky On-site Sewage Disposal Systems Regulations 902 KAR 10:081, 902 KAR 10:085. Rev. Sept 9, 1989.

3. Del Porto, David and Carol Steinfeld. The Composting Toilet System Book. Concord: The Center for Ecological Pollution Prevention, 1999.

4. EPA "Water Efficiency Technology Fact Sheet: Composting Toilets." September 1999.

5. EPA www.epa.gov/owow/tmdl/states/kymap.html June 28, 2000.

6. Jenkins, Joseph. The Humanure Handbook. Grove City: Jenkins Publishing, 1999.

7. Kentucky Division of Water. "Cumberland River Basin and Four Rivers Region Status Report." March 2000.

8. Kieffer, Jack. "Artificial or Constructed Wetlands," ASPI Technical Series #20. Livingston, KY: ASPI Publications, 1994.

9. Kieffer, Jack. "Preparation of Compost from the Toilet for Use in the Garden." ASPI Technical Series #41. Mt. Vernon, KY: ASPI Publications, 1998.

10. Personal Interview. Jack Kieffer, SJ. July 2000.

11. Steinfield, Carol. "Compost Toilets Reconsidered." Biocycle: Journal of Composting and Recycling. 38:3, March 1997.

12. State of Kentucky. http://water.nr.state.ky.us/dow/fac/sec105.html

13. State of Kentucky. www.nr.state.ky.us/305b/#strms

14. State of Kentucky. www.nr.state.ky.us/nrepc/kra/straight.html June 27, 2000.

15. Van Der Ryn, Sim. The Toilet Papers. Santa Barbara: Capra Press, 1978.

16. www.envmgmt.com.au/ctoilet.html June 28, 2000.

Funding for this report was provided by a US EPA 319(h) grant & through the Kentucky Division of Water to the Kentucky Waterways Alliance, Inc.

Author/Project Director - **Al Fritsch,S.J.**

Printed on Recycled ♻ Paper