HUMANURE HANDBOOK

A GUIDE TO COMPOSTING HUMAN MANURE

(Emphasizing Minimum Technology and Maximum Hygienic Safety)

Third Printing

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The Humanure Handbook

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A word of appreciation is in order for the Slippery Rock University Master of Science in Sustainable Systems program, Slippery Rock, PA 16057 USA, which played a significant role in encouraging the author to focus his attention on the subject at hand.

A note of appreciation must be added for the international permaculture, organic agriculture, and sustainable gardening communities, whose existence and support has been inspirational.

Finally, a *special* note of recognition must be added in behalf of the author's wife, Jeanine, whose assistance at every stage in the creation of this work was tremendously beneficial.

Photographs, design and graphics are by the author unless otherwise indicated. Some of the graphics include clip art, or modified clip art, and any advertisements or segments of advertisements came from very old magazines found in a barn.

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Third Printing Notes from the Author

When first published, I wondered whether this book would sink or swim, suspecting that not many people would want to read about *"humanure"*. But I should have known - this book neither sinks nor swims. It *floats.* And like a turd that won't flush, the Humanure Handbook keeps coming back. This is surprising, considering the humor throughout this book is execrable, and there is plenty to be offended or annoyed by if you have a mind for it. Worse, there are two prerequisites to reading this book: you must be able to read, and you must be able to defecate. Apparently there are still *some* people who fit into this category, and for the most part, their comments have been encouraging. Here's a sampling:

"Your discovery of the proper small scale of the operation is world shaking." F. A., Delaware

"I enjoyed the book immensely, but my mother is appalled. Pleasing me and irritating my mother - you score big in my two favorite categories." K. L., Indiana

"Your book is pure gold, just what I needed to give to my County Health Department." M. T., Missouri

"Your book was carefully handed to me in a brown paper bag at church last spring. Great research, clear writing and terrific humor." L. U., West Virginia

"I showed a review of your book to my dad and he almost gagged! Would you mail me one in a plain wrapper? I live with my parents." M. C., Colorado

"If you could claim credit for engineering the thermophilic decomposers, you would probably win the Nobel Peace Prize." T. C., Arizona

"We started using our 'system' the day after receiving the book. It took about two hours to put together. I wish more problems that at first seemed complicated and expensive could be solved as simply as this." J. F., New York

"I've been composting and using my own waste for the past 20 years. Most of my friends think it odd. I counter that not even barbarians piss and shit in their drinking water!" E. S., Washington

"Fascinating! We are indebted to you for your book Humanure Handbook." R. L., New York

"I'm sure you've probably heard it all before, but I really appreciate the fact that someone finally did their research and put it together in a pleasant readable form." S. C., Wisconsin

"For 22 years I have used scarab beetle/larvae . . . they eat my shit in five minutes flat." C. M., South Carolina

"I live and work in an international youth hostel and we're using your saw-dust toilets." B. S., Georgia

"This wonderful book fits right into my compost = redemption religious philosophy. You have answered questions I have held open since childhood." R., Massachusetts

"Just finished reading your book and I'm glad. Seeing Mr. Turdly dancing around the compost pile wasn't my ideal dream." E. S., Washington

"I'm wracking my brain, trying to find a compelling way to tell you how great I think your book is." K. W., Wisconsin

"I've spent my whole life recycling, reducing, reusing everything but my own shit and I'm ecstatically grateful to have your directions reach my lap." W., Maine

"I found your book entertaining, informative, and a great motivating force compelling us to start recycling our "humanure" immediately." B. W., Texas

"It is the shittiest book I've ever read, but it's great!" D. H., Wyoming

"I liked your book. Putting back nutrients after taking them away makes sense as well as the image of dropping a turd in a 5 gallon toilet filled with pure drinking water seems crazy." T. O., New Hampshire

"As parasites attached to the earth, it would seem that the only conscious thing we do that isn't killing the host, is manuring in the woods, fields or a compost toilet." D. G., Minnesota

"Two things you might be interested in: A more natural way to eliminate is in the squatting position. [and] Urine is not a waste product. Taking urine internally has been going on for some time (1000's of years) and by many is considered a wonderful medicine. I take my first urine daily. Also, urine is used today in ear wax removal, hand creams, and other. Now is that full of crap . . . or is it?" W. E., Ohio

"Your book (Humanure) saved my butt at a town council meeting yesterday. Thank you for writing it." D. W., Colorado

"My 74 year old father thinks human waste should not be used in a garden, and I want to prove him wrong." A. M., Washington

"I had to call my dear heart long distance immediately to read her what may be the most hopeful environmental news I've read in my 35 years, that something can transmute horrible toxins. Why aren't all the environmentalists raving about this?" C., Vermont

There have been enough written comments about the Humanure Handbook to fill an entire book. The first two printings have been read in every state in the USA including Puerto Rico, and in at least nine other countries (Canada, Australia, Japan, England, Mexico, Guatemala, Spain, Wales, and Malaysia), by people of all ages (teens to nonagenarians). Perhaps the time has come to make *humanure* a household word. And with enough brown paper bags, perhaps the book will even get passed around a bit!

JCJ - Spring, 1996

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INTRODUCTORY INFORMATION

"It is more important to tell the simple, blunt truth than it is to say things that sound good."
John Heider

America is a land of waste. Much of what we waste consists of organic material which would prove very valuable if we would recycle it for agricultural purposes. That organic material includes food wastes, municipal leaves and other yard wastes, agricultural residues, and human waste in the form of digestive refuse material, otherwise known as fecal material and urine. The simple blunt truth is that we shit every day and we should be returning that organic material back to the soil.

Each of us is responsible for the byproducts of our digestive systems, namely feces and urine. Feces and urine are not waste. They are natural, organic refuse materials discarded by our bodies after completing the digestive processes. We choose to make these organic materials either waste materials or resource materials depending on what we do with them. When we discard them, we waste them. When we recycle them, we recover a natural resource.

Recycled refuse is not waste. It is a common misuse of semantics to say that waste is, can be, or should be recycled. Resource materials are recycled. Refuse is recycled. But waste is never recycled. That's why it's called "waste". This may seem like a trifling point to some, however it's actually quite important. Those of you who take the responsibility for recycling your refuse materials are not creating waste, and the term "waste" should not be associated with you. If you are composting all of your body's organic refuse and returning it to the soil and someone asks you, *"What do you do with your human waste?"* the correct response would be, *"What waste?"*

So let's define some terms. Feces and urine are byproducts of the human digestive system. They are refuse materials. When discarded, they're known as human *waste*. When recycled for agricultural purposes they're known by various names, including night soil (in Asia) and human manure or ***humanure.*** *Humanure is not human waste. Humanure is not waste - it is an agricultural resource.*

Humanure is a valuable organic resource material, in contrast to human waste, which is a dangerous pollutant. Humanure originated from the soil and can be quite readily returned to the soil, especially if properly composted. Human waste (discarded feces and urine), on the other hand, creates significant environmental problems, provides a route of transmission for disease, and deprives humanity of important soil nutrients. It's also one of the primary ingredients in sewage, and is largely responsible for much of the world's water pollution.

When crops of any sort are produced from soil, it is imperative that the organic residues - the refuse materials resulting from those crops, including animal excrements - are returned to the soil from which the crops originated. *This recycling of all organic residues for agricultural purposes should be* <u>*axiomatic*</u> *to sustainable agriculture.* Yet, spokespersons for the sustainable agriculture movement in the West remain silent about using humanure for agricultural purposes. Why?

In the 1970's I played around with the idea of composting my own manure for a few years, but I didn't get into it seriously until I settled down on my own homestead in 1979. At that time, I began composting humanure, proceeding through the process instinctively, altering my procedures when necessary, but always maintaining an emphasis on simplicity. Now, fifteen years later, I've decided to write about my experiences for the sake of those who are interested.

In the process of creating this book, I engaged in an extensive review of the literature related to the topic of composting humanure. I have carefully listed all of my references at the end of each chapter, and I encourage the reader to look to those references for verification or for additional information. In that review, I was surprised and even shocked to find that a) there is very little in print on the subject of composting humanure, and b) the information that is available is inconsistent with and sometimes diametrically opposed to the information which I gleaned from my own experiences. For example, current literature still lists humanure as a taboo and dangerous compost ingredient. (I don't. In fact, I would describe it more as an *essential* compost ingredient.) It recommends turning compost piles. (I don't. In fact, turning compost piles can do more harm than good.) It recommends liming compost, using other rock dusts in compost, or covering it with wood ashes (I don't. Rock dusts have no place in a compost pile.) It recommends segregating urine from feces when humanure is composted (I don't, and I can't imagine anything more undesirable than segregating urine from fecal material.) And the list goes on.

Before I continue, I want to make it perfectly clear that I do not consider myself an agricultural or scientific expert in any professional sense of the word. I am simply a layperson with twenty years of gardening experience who has done research and gained experiences on composting humanure which others may find valuable. Nobody has paid me in any way to write this book, and all expenses incurred have come out of my own pocket.

It has not been my intent or goal, nor will it ever be, to profit financially from this book, although I'd be happy if my production expenses are one day eventually reimbursed. My intent has been to provide helpful information to those who want it, and to stimulate discussion about neglected topics including composting, humanure, the human nutrient cycle, waste, sustainable gardening, sustainable agriculture, etc. I'd roughly estimate that one in a million Americans have an interest in composting humanure. If I manage to find all of them and they read this book, I'll need a total of about 250 copies available in print. If that. On the other hand, there are millions of people throughout the developing world who could benefit from the information in this book. These are people who live simple lives with minimal resources and who are more apt to understand the increasing need to hygienically recycle organic refuse as the human population continues to swell upon an ever-shrinking planet.

I approach this topic (composting humanure) with a certain bias in favor of simplicity; or perhaps *sustainability* would be a more appropriate word. Therefore, most of the practical information that I present in this book reflects a sustainable approach. I don't encourage energy intensive or resource consumptive approaches to humanure composting. The methods I encourage are ones requiring little, if any, technology, and no electricity. They focus on the single family level, and not on the municipal level. The information I present is ideal for people who cannot or do not want to use running water or electricity for organic resource recycling, either by choice, culture, or emergency circumstances, or who have meager material resources at their disposal and can't afford expensive waste disposal systems or the loss of soil nutrients that would result from such systems. It is also ideal for anyone wanting to gain a basic understanding of humanure composting, no matter how complicated a recycling system they want to use for themselves, if any at all.

Composting humanure involves a simple process of microbial digestion. Like anything, the process can be made as difficult or complicated as one wants. It's the *process* itself that's important, not to mention interesting. For example, few people realize that there are reportedly 100 billion bacteria *per gram* of humanure, or that bacteria can digest diesel fuel and TNT, or chemically alter uranium. Some say that microorganisms in a compost pile can even produce enough heat to cook an egg (so far I haven't tried this).

Let's face it- everybody shits. It's one of those basic functions of the human body. We breathe, we eat, we copulate, we defecate, not necessarily in that order. Yet, few people know anything about what happens to their excrement after it's been flushed down a toilet, or about the value of humanure as agricultural fertilizer, or about how to render it hygienically safe for recycling. Must our topsoil become depleted of nutrients and our agricultural petrochemicals that currently replace those nutrients become scarce, and our water supplies polluted before the art of composting humanure will be taken seriously by the human race?

In a nutshell, the purpose of this book is to explain why we Westerners aren't composting our humanure, why we should be, and how it can be done. Much of the discussion about why we're not doing it is philosophical, with a bit of delving into history and (god forbid) religion. The discussion of why we should be composting humanure focuses on the environmental problems associated with current waste disposal systems, as well as on the loss of agricultural nutrients that is the legacy of such systems. Chapter six focuses on "worms and disease", the often repeated cry of warning from those humans who equate the recycling of humanure with barbaric and unsanitary foolishness. There is no greater barrier to the recycling of humanure than this ignorance of the Western populace. And that ignorance is pervasive, deeply rooted, and tenacious. Granted, the warnings of "worms and disease" certainly bear some merit, however, such warnings tend to be exaggerated, sensational, and rooted in ignorance or fear. It is possibly for this reason more than any other that I have been goaded into writing this book.

The observant reader may notice that there are some apparent inconsistencies in the information presented in this book. In cases where various sources present inconsistent data about specific topics, I have simply reported the data as presented and left the reader to draw his or her own conclusions. Such inconsistencies are infrequent and of little consequence, nevertheless their existence should not be ignored (for example, one source reports that roundworm eggs will die in two hours when subjected to a temperature of 55°C, while another source reports that the eggs will die in ten minutes at the same temperature). Furthermore, don't be surprised if some information is repeated within this book. This is not by accident, as some information is worth repeating, especially as this book may end up on a shelf to be used for later reference by many readers who may tend to refer to only one chapter or another, in which case the repetition of material may be to the reader's long-term advantage.

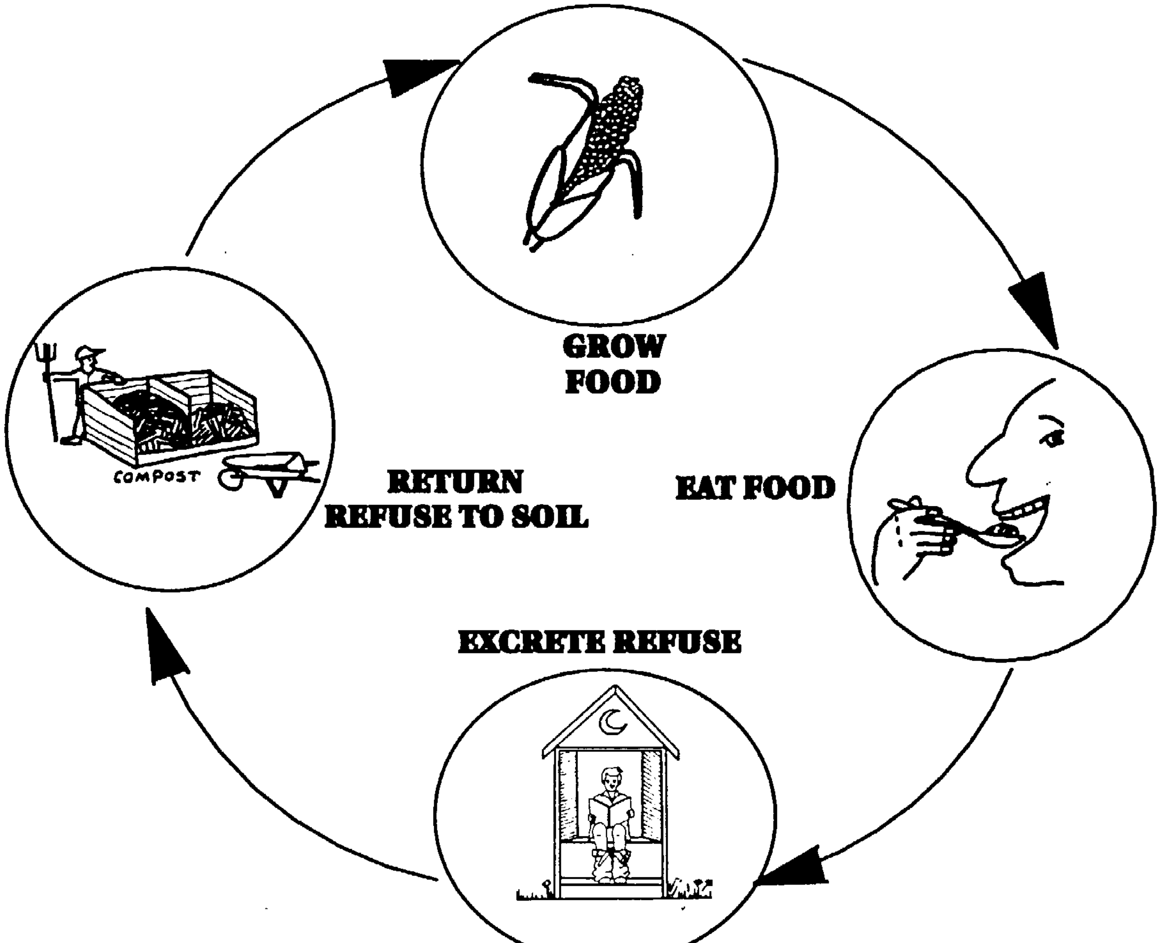
If you're only interested in composting humanure, and want to skip the philosophy and other extraneous information, go straight to chapter seven. However, I'd encourage the reader to start at the beginning. The story of humanure is an interesting one. It begins with witches, travels to the Far East, and ends up in one's backyard. Not in my backyard you say? Ha! Read on.

J. C. J.

FIGURE A

THE HUMAN NUTRIENT CYCLE

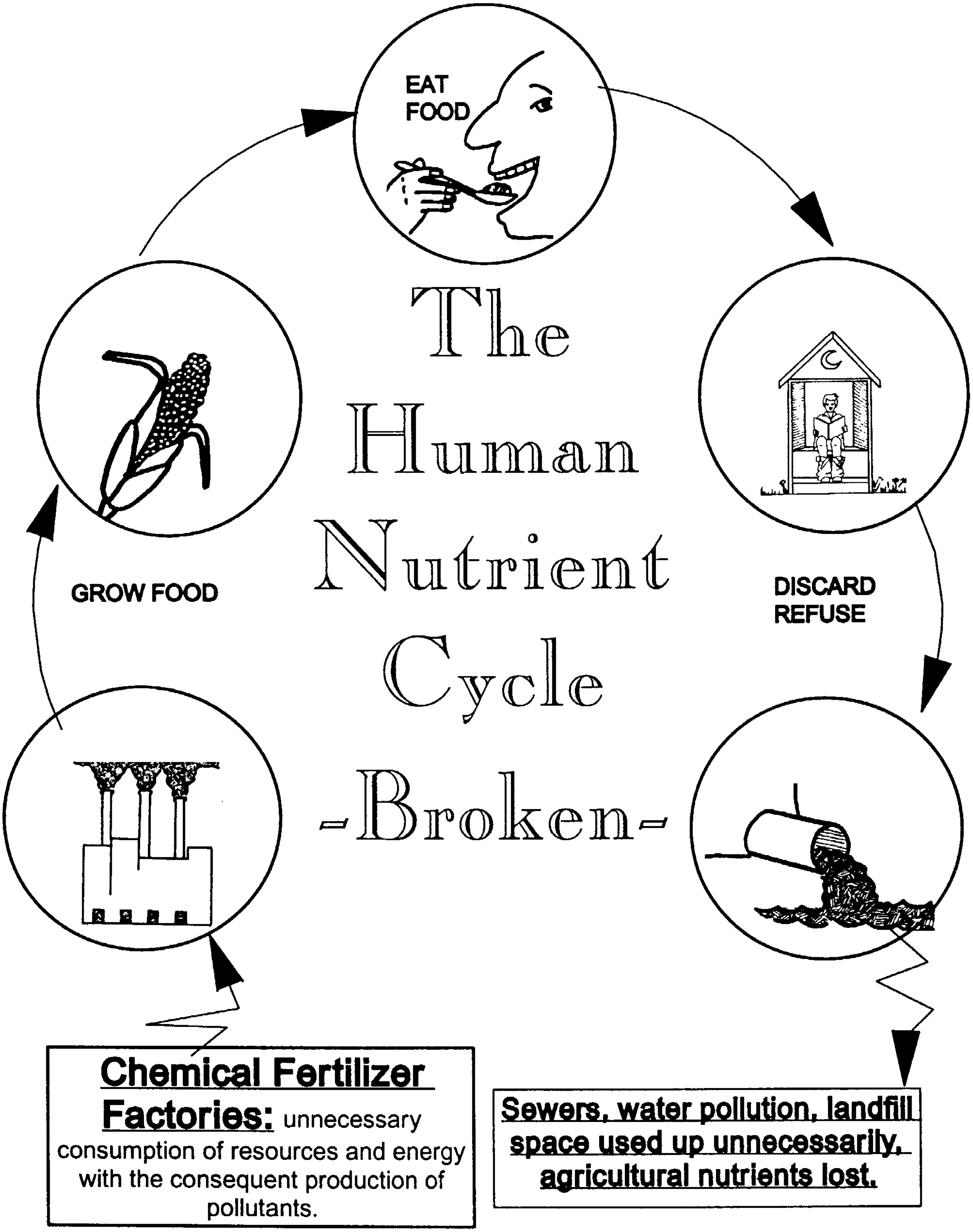
- INTACT -



<u>THE HUMAN NUTRIENT CYCLE IS AN ENDLESS NATURAL CYCLE.</u>

IN ORDER TO KEEP THE CYCLE INTACT, FOOD FOR HUMANS MUST BE GROWN ON SOIL THAT IS ENRICHED BY THE CONTINUOUS ADDITION OF ORGANIC REFUSE MATERIALS DISCARDED BY HUMANS, SUCH AS HUMANURE, FOOD SCRAPS, AGRICULTURAL RESIDUES, AND THE LIKE. BY RESPECTING THIS CYCLE OF NATURE, HUMANS CAN MAINTAIN THE FERTILITY OF THEIR AGRICULTURAL SOILS INDEFINITELY, INSTEAD OF DEPLETING THEM OF NUTRIENTS AS IS COMMON TODAY. FOOD-PRODUCING SOILS MUST BE LEFT MORE FERTILE AFTER EACH HARVEST, DUE TO THE EVER-INCREASING HUMAN POPULATION AND THE NEED TO PRODUCE MORE FOOD WITH EACH PASSING YEAR.

FIGURE B


The Human Nutrient Cycle
-Broken-
EAT FOOD
DISCARD REFUSE
GROW FOOD
Chemical Fertilizer Factories: unnecessary consumption of resources and energy with the consequent production of pollutants.
Sewers, water pollution, landfill space used up unnecessarily, agricultural nutrients lost.

CRAP HAPPENS

"Anyone starting out from scratch to plan a civilization would hardly have designed such a monster as our collective sewage system. Its existence gives additional point to the sometimes asked question, Is there any evidence of intelligent life on the planet Earth?"
G. R. Stewart

The world is divided into two categories of people: those who shit in drinking water and those who don't. We in the Western world are in the former class. We defecate in water, usually purified drinking water. After polluting the water with our body's digestive system byproducts, we flush the once pure but now polluted water "away". Away to where? Good question.

This ritual of defecating in water may be useful for maintaining a good standing within Western culture. If you don't deposit your feces into a bowl of drinking water on a regular basis, you may be considered a miscreant of sorts, perhaps uncivilized or dirty or poverty stricken. You may be seen as a non-conformist or a radical. However, these perspectives are based upon ignorance. There is currently a profound lack of knowledge and understanding among Westerners about what is referred to as the "human nutrient cycle" and the need to keep the cycle intact.

The human nutrient cycle goes like this: a) grow food, b) eat it, c) collect and process the food refuse (feces, urine, food scraps and agricultural residues), and d) return the processed refuse to the soil, thereby enriching the soil and enabling more food to be grown. Then the cycle is repeated, endlessly. When our food refuse is instead discarded as waste, the natural human nutrient cycle is broken and all manner of problems can result. Those problems can be summed up in two convenient words: waste and pollution.

Crap happens. However, it's interesting to note that the creation of human waste is a matter of human choice. We *choose* to throw things away rather than recycle them. We *choose* to create waste rather than recycle useful resources, because it's more convenient to discard things than to reuse them. Even though those resources may be refuse materials with little *apparent* value, such as the refuse of our digestive systems, when recycled, they can prove to be both useful and valuable.

It's common to refer to human fecal material and human urine as "human waste". However, such a term is misleading at best. Human waste actually consists of a huge number of items and substances (cigarette butts for example), and human digestive system refuse is only waste when it's discarded. When it's recycled for agricultural purposes it's called, among other things, human manure or ***humanure*** for short.

All humans create fecal material and urine. However, some people create human waste, or sewage, while others create humanure, an agricultural resource, depending on whether the material is wasted or recycled. We in the United States each waste about a thousand pounds of humanure every year, which is discarded into sewers and septic systems throughout the land. Much of the discarded humanure finds its final resting place in a landfill along with the other solid waste we Americans discard, which, coincidentally, also amounts to about a thousand pounds per person per year. For a population of 250 million people, that adds up to nearly *250 million tons of solid waste discarded every year, at least half of which is valuable as an agricultural resource.*

This is not to suggest that *sewage* should be used to produce food crops. In my opinion, it should not. Sewage consists of human digestive-system refuse collected along with other hazardous materials such as industrial, medical and chemical wastes, all carried in a common water-borne waste stream. Humanure, on the other hand, when kept out of the sewers, collected as a resource material, and properly

FUN FACTS

WASTE NOT - WANT NOT

America is a land of waste. Of the top fifty municipal solid waste producers in the world, America is fifth in line, being outranked only by Australia, New Zealand, France and Canada. Although the U.S. population increased by 18% between 1970 and 1986, its trash output increased by 25% during that time period, indicating that as time passes, we become more wasteful as a nation. Today, every individual in America produces about four pounds of trash daily, which will add up to 216 million tons per year by the year 2000, almost ten percent more than in 1988. If this sounds like a lot, sit down for a minute: municipal solid waste (the 216 million tons per year just mentioned) make up only one percent of the total solid waste created annually in the United States. The rest comes from industry, mining, utilities and other sources.[1]

processed (composted), makes for a fine agricultural resource material suitable for food crops. Granted, there are certain hygiene considerations involved in the processing of humanure for food purposes, and these will be discussed at length later in this book.

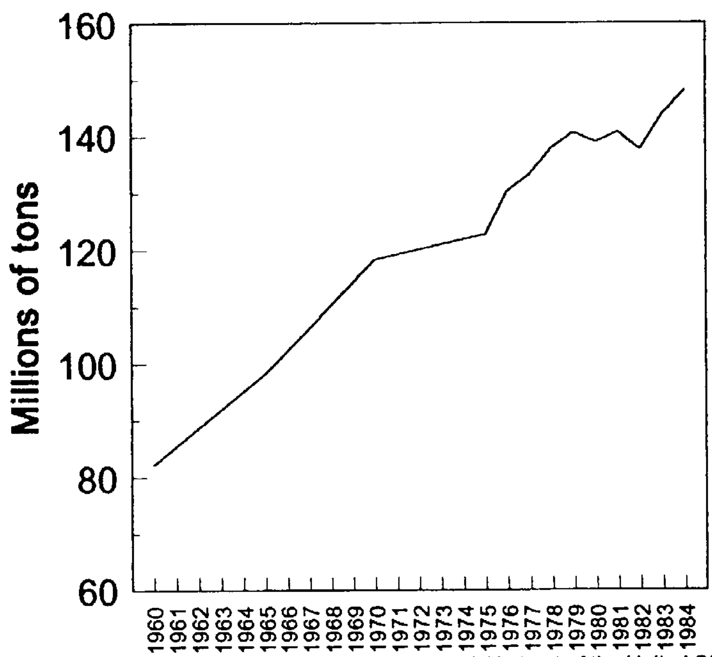
The United States Environmental Protection Agency estimates that 13.2 million tons of food refuse are produced in American cities alone every year. That food refuse would make great organic material for composting, especially if mixed with humanure. If we composted the food refuse, we would be recycling a *resource* instead of creating *waste.* Instead, much of that food waste is buried in landfills. as is most of our discarded feces and urine. Yet, it is becoming more and more obvious that it is unwise to rely on landfills to dispose of recyclable materials. Landfills fill up, and new ones need to be built to replace them. The estimated cost of building and maintaining an EPA approved landfill is now nearly $125 million. In fact, the 8,000 operating landfills we had in the United States in 1988 had dwindled to 5,812 by the end of 1991. Slowly, we're catching on to the fact that this trend has to be turned around. We can't continue to throw "away" usable resources in a wasteful fashion by burying them in disappearing landfills.

As a result, recycling is slowly becoming more widespread in the U.S.. Between 1989 and 1992 recycling increased from 9 to 14% and the amount of U.S. municipal solid waste sent to landfills decreased by 8%.[2] This is a welcome trend, however it doesn't adequately address a subject sorely in need of attention: what to do with humanure, which is not being recycled.

If we had scraped up all the human excrement in the world and piled it on the world's tillable land in 1950, we'd have applied nearly 200 metric tons per square mile at that time (roughly 690 pounds per acre). In the year 2000 we'll be collecting significantly more than *double* that amount because the global population is increasing, but the global land mass isn't. In fact, the global area of agricultural land is steadily *decreasing* as the world loses, for farming and grazing, an

Figure 1.1

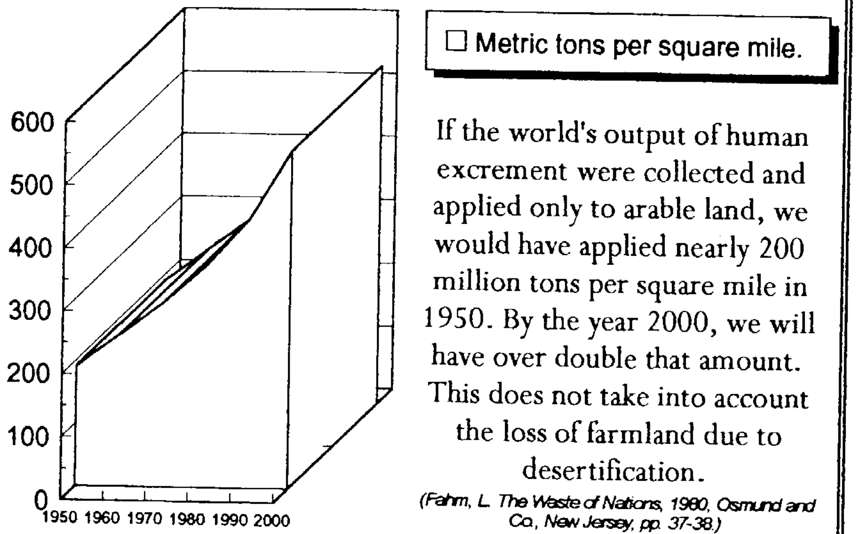
Gross Solid Waste Generated in the USA, Not Including Sewage



Source: US Dept. Of Commerce, 1987 Statistical Abstract of the United States

Figure 1.2

Amount of humanure available worldwide per square mile of tillable land.



If the world's output of human excrement were collected and applied only to arable land, we would have applied nearly 200 million tons per square mile in 1950. By the year 2000, we will have over double that amount. This does not take into account the loss of farmland due to desertification.

(Fahm, L. The Waste of Nations, 1980, Osmund and Co, New Jersey, pp. 37-38.)

area the size of Kansas each year.[3] The world's burgeoning human population is producing a ballooning amount of organic refuse which will eventually have to be dealt with responsibly and constructively. It's not too soon to begin to understand human organic refuse materials as valuable resource materials begging to be recycled.

In 1950 the dollar value of the agricultural nutrients in the world's gargantuan pile of humanure was 6.93 billion dollars. In 2000 it will be worth 18.67 billion dollars (calculated in *1975* prices).[4] This is money currently being flushed down the drain and out somewhere into the environment where it shows up as pollution, and/or landfill material. Every pipe line has an outlet somewhere; everything thrown "away" just moves from one place to another. Humanure and other organic refuse materials are no exception. Not only are we flushing "money" away, we're paying through the nose to do so. And the cost is not only economic, it's environmental.

A cursory review at the local library of sewage pollution incidents in the United States yielded the following: More than 2,000 beaches and bays in twelve states were closed in 1991 because of bacterial levels deemed excessive by health authorities. The elevated bacteria levels were primarily caused by storm-water runoff, raw sewage, and animal wastes entering the oceans. The sources of the pollution included inadequate and overloaded sewage treatment plants, sewage overflows from sanitary sewers and combined sewers, faulty septic systems, boating wastes, and polluted storm water from city streets and agricultural areas.[5]

Also in 1991, the city of Honolulu faced penalties of about $150 million for some 9000 alleged sewage discharge violations that were recorded since 1985[6]. That same year, Ohio Environmental Protection Agency fined Cincinnati's Metropolitan Sewer District $170,000, the largest fine ever levied against an Ohio municipality, for failure to enforce its wastewater treatment program.[7] In 1992, the U.S. EPA sued the Los Angeles County Sanitation Districts for failing to install secondary sewage treatment at a plant which discharges wastewater into the Pacific Ocean, and for fourteen years of raw sewage spills and other discharges that have violated California Ocean Plan bacteria standards.[8]

When humanure is composted with other organic refuse, it is converted into a sweet-smelling soil building material. Here it is applied to a garden.

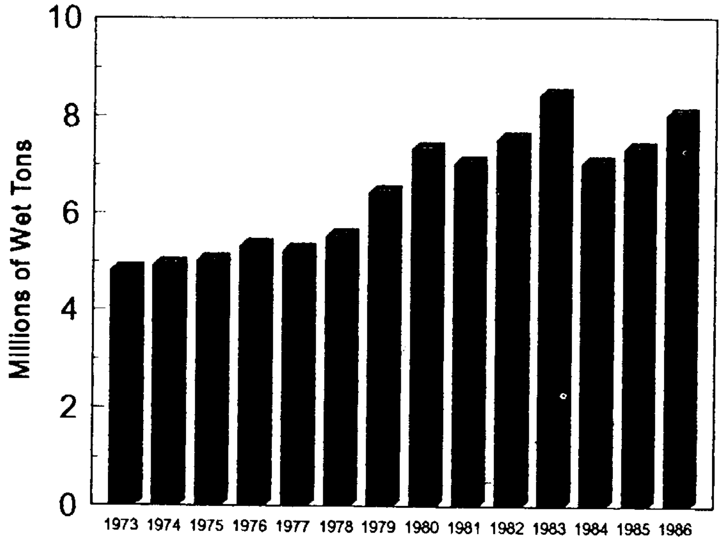
That same year California was required to spend $10 million to repair a leaking sewer pipeline that had forced the closure of twenty miles of southern California beaches. The broken pipeline was spilling up to 180 million gallons of sewage per day into the Pacific Ocean less than one mile offshore, resulting in a state of emergency in San Diego County. This situation was compounded by the fact that a recent heavy storm had caused millions of gallons of raw sewage from Mexico to enter the ocean from the Tijuana River.[9]

Environmental advocates in Portland, Oregon sued the city in 1991 for allegedly discharging untreated sewage up to 3,800 times annually into the Willamette River and the Colombia Slough.[10] In April of 1992, national environmental groups announced that billions of gallons of raw waste pour into lakes, rivers, and coastal areas each year when combined sewers, which carry storm water and wastewater in the same pipe, overflow during heavy rains, also causing many cities to suffer from discharges of completely untreated sewage.[11]

Much of the sewage sludge along coastal cities in the United States has simply been dumped into the ocean. However, dumping of sewage sludge in the ocean was banned as of December 31, 1991. Nevertheless, the city of New York was unable to meet that deadline and was forced to pay $600 per dry ton to dump its sludge at the Deepwater Municipal Sludge Dump Site 106 miles off the coast of New Jersey. Illegal dumping of sewage into the sea also continues to be a problem.[12] A bigger problem may be what to do with sewage sludge now that landfill space is

Figure 1.3

Sewage Sludge Dumped in US Ocean Waters 1973-1986



Source: US EPA, 1988, Report to Congress on Administration of the Marine Protection, Research, and Sanctuaries Act of 1972, EPA-503/8-88/002.

diminishing and it can no longer be dumped into the ocean. We'll get into that later.

SOILED WATER

The discarding of human waste adversely affects the quality of our planet's water supplies. First, by defecating directly into water, we pollute the water. Every time we flush a toilet, we launch five or six gallons of polluted water out into the world.[13] Secondly, even after the polluted water is treated in waste-water treatment plants, it may still be polluted with excessive levels of nitrates, chlorine, and other pollutants. This treated water is discharged directly into the environment. Also, by discarding organic human refuse materials as waste, we deprive ourselves of valuable soil nutrients. We should be returning the organic material back to the land in order to keep the human nutrient cycle intact.

Instead of using humanure to replenish the soil depleted by agriculture, we manufacture and use chemical fertilizers. From 1950 to 1980 the global consumption

FUN FACTS about water

- If all the world's drinking water were put into one cubical tank, the tank would measure only 95 miles on each side.
- Number of people currently lacking access to clean drinking water: 1.2 billion.
- Percent of the world's households that must fetch water from outside their homes: 67%.
- Percent increase of the world's population by the middle of the next century: 100%.
- Percent increase in drinking water supplies by the middle of the next century: 0%.
- Amount of water Americans use every day: 340 billion gallons.
- Number of gallons of water needed to produce a car: 100,000.
- Number of cars produced every year: 50 million.
- Amount of water required by a nuclear reactor every year: 1.9 cubic miles.
- Amount of water used by U.S. nuclear reactors every year: the equivalent of one and a third lake Eries.
- Sources: Der Spiegel, May 25, 1992; and Annals of Earth, Vol. 8, No. 2, 1990, Ocean Arks International, One Locust St., Falmouth, MA 02540.

of artificial fertilizers rose by 900%[14], and in 1988, U.S. farmers used almost 19 million tons of synthetic fertilizers.[15] All the while, hundreds of millions of tons of organic wastes are generated in the U.S. each year, including humanure, then buried in landfills when they could instead be composted and returned to the soil in place of artificial fertilizers.

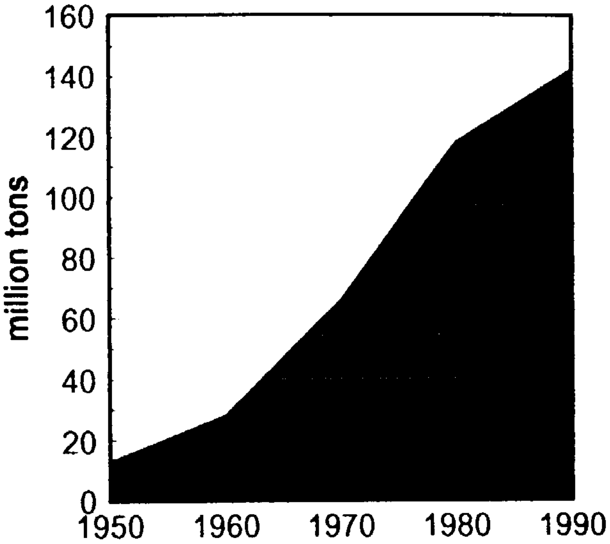
Today, pollution from agriculture is said to be a main reason for poor water quality in our rivers, lakes and streams, the pollution being caused by both siltation (erosion) and nutrient runoff due to excessive or incorrect use of fertilizers.[16] For example, in 1992 the state of Florida was required, through litigation, to build some 35,000 acres of marshlands to filter farm-related runoff that was polluting the Everglades with nutrients such as phosphorous.[17] Nitrates from fertilizers are also causing pollution, seeping into ground water, lakes, rivers and streams. A 1984 U.S. EPA survey indicated that out of 124,000 water wells sampled, 24,000 had elevated levels of nitrates and 8,000 were polluted above health limits.[18]

Chemical fertilizers provide a quick fix of nitrogen, phosphorous, and potassium for impoverished soils. However, it's estimated that 25-85% of chemical nitrogen applied to soil and 15-20% of the phosphorous and potassium are lost to leaching, much of which can pollute groundwater.[19] Much of this pollution shows up in small ponds which become choked with algae as a result of the unnatural influx of nutrients.

Not only are we polluting our water with agricultural runoff and sewage, we're

Figure 1.5

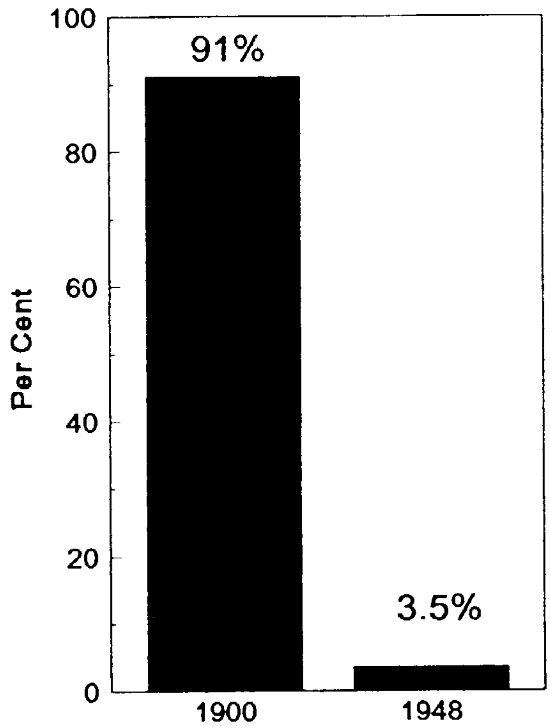
Use of Fertilizer Worldwide Since 1950:



[Source: Brown, et. al., Vital Signs, Norton and Co., Scranton, PA, 1992]

Figure 1.6

AMOUNT OF NITROGEN USED IN FERTILIZERS IN THE USA DERIVED FROM ORGANIC SOURCES (1900 - 1948)

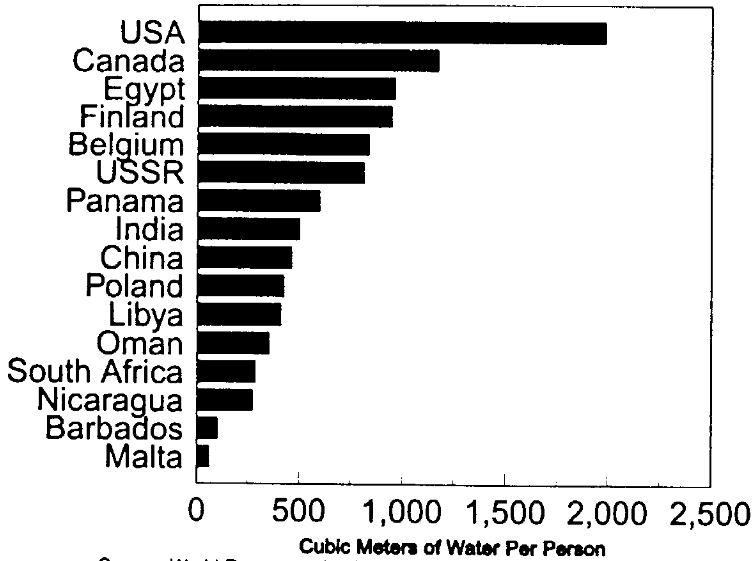


Source: Markham, Jesse W. (1958). The Fertilizer Industry Greenwood Press (p 96)

In 1900 in the USA, natural organics supplied 91% of all the nitrogen used in commercial fertilizers; in 1948 the same sources supplied only 3.5%, the remainder coming primarily from chemical ammonia compounds.

Figure 1.4

Average Annual Per Capita Water Use In Selected Countries



Source: World Resources Institute, 1986, World Resources 1986.
As seen in The Water Encyclopedia, van der Leeden et.al.

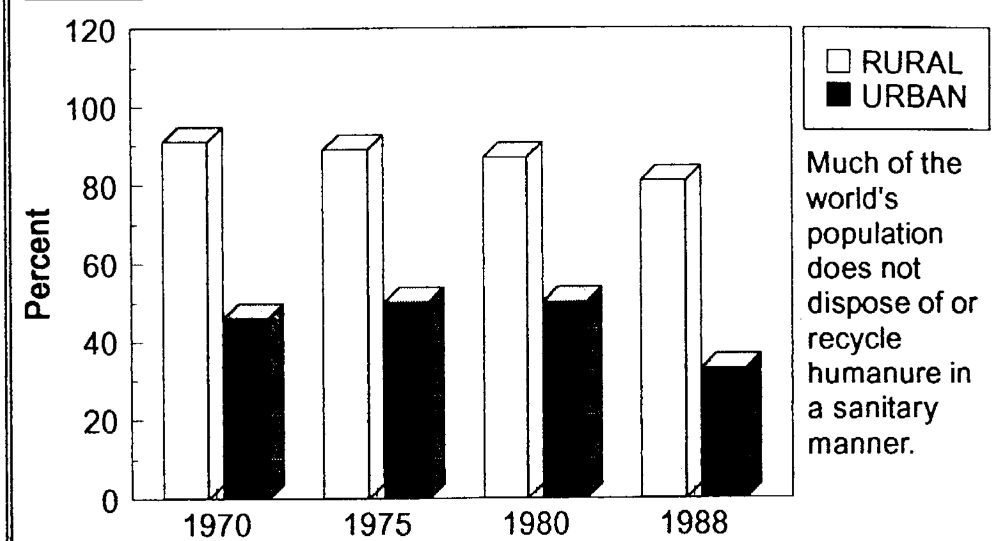
using it up, and flushing toilets is one way it's being wasted. Of 143 countries ranked for per capita water usage by the World Resources Institute, America came in at #2 using *188 gallons per person per day* (Bahrain was #1).[20] The use of groundwater in the United States exceeds replacement rates by 21 billion gallons a day[21]. It takes one to two thousand tons of water to flush one ton of human waste (see chapter 4, reference # 43).

The impacts of polluted water are far ranging, causing the deaths of 25 million people each year, three fifths of them children.[22] Diarrhea, a disease associated with polluted water, kills 6 million children each year in developing countries, and it contributes to the death of up to 18 million people.[23] It's not necessarily the flushing of toilets that's polluting drinking water in developing countries, yet it's still, to a large extent, fecal contamination of water supplies, a problem that could be avoided by composting humanure instead of neglecting to do so. The object is to keep fecal material out of the environment and out of streams, rivers, wells and underground water sources, thereby eliminating the transmission of various diseases. Thermophilic (heat producing) composting will effectively convert fecal material into a hygienically safe humus, yet composting humanure has not become widespread in the West. Instead, human waste continues to pollute the world around us.

But in the United States haven't we solved the problem of water borne diseases? Largely yes, but not entirely. Illness related to polluted water afflicted 85,875 Americans from 1971-82. Forty-nine percent of these were caused by water treatment deficiencies.[24] Several American cities have suffered from outbreaks of cryptosporidia since 1984, cryptosporidia being protozoa which cause severe diarrhea. These protozoa enter people when they drink water contaminated by infected feces from humans and animals. Outbreaks occurred in Braun Station, Texas in 1984; in Carrollton, Georgia, in 1987; in Medford and Talent, Oregon in 1992; and in Milwaukee in 1993. Hundreds of thousands of people have been afflicted by the bug, for which there is no treatment. The illness runs its course in about fourteen days in healthy people, but can kill people who have weak immune systems.[25]

Pollution from sewage and synthetic fertilizers results in part from the belief that humanure and food refuse are waste materials rather than recyclable natural resources. There is, however, an alternative. Humanure and food refuse can be composted and thereby rendered hygienically safe for agricultural or garden use.

Figure 1.8



Much of the world's population does not dispose of or recycle humanure in a sanitary manner.

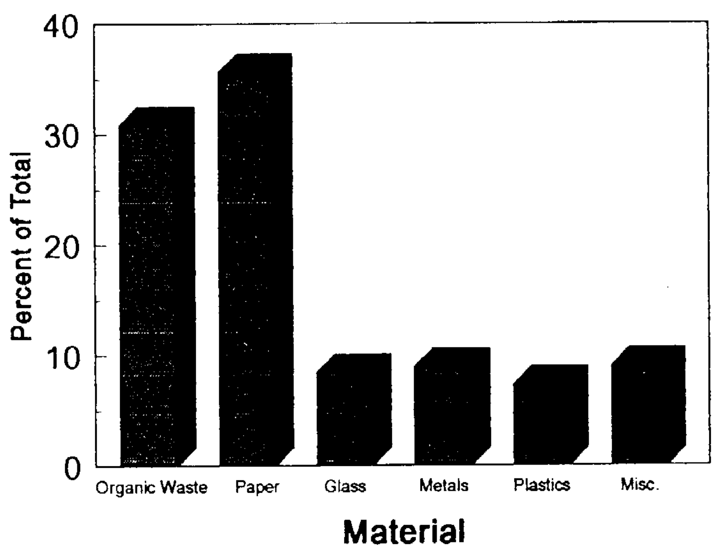
Source: Franceys, R., et. al. (1992). A Guide to the Development of On-Site Sanitation. World Health Organization, Geneva. (p. 5).

Much of the Eastern world recycles humanure. Those parts of the world have known for millennia that humanure is a valuable resource which should be returned to the land, as any animal manure should. The West has yet to arrive at that conclusion.

WASTE REDUCTION-RESOURCE RECOVERY

According to Sandra Postel (1992), *"The protective ozone shield in heavily populated latitudes of the northern hemisphere is thinning twice as fast as scientists thought just a few years ago. A minimum of 140 plant and animal species are condemned to extinction each day. Atmospheric levels of heat-trapping carbon dioxide are now 26 percent higher than the preindustrial concentration, and continue to climb. The Earth's surface was warmer in 1990 than in any year since record keeping began in*

Figure 1.9



Source: van der Leeden, et. al. (1990). The Water Encyclopedia. Lewis Publishers, Mich. 48118 (p.570).

Much of the municipal waste in the United States is compostable. The above graph does not include humanure.

the mid-nineteenth century; six of the seven warmest years on record have occurred since 1980. Forests are vanishing at a rate of some 17 million hectares per year, an area about half the size of Finland. World population is growing by 92 million people annually, roughly equal to adding another Mexico each year; of this total, 88 million people are being added in the developing world."[26]

Mr. Lester Brown adds that we're losing 24 billion tons of topsoil each year worldwide, and that areas of global farmland, grassland, and forestland are shrinking and being replaced by wasteland.[27]

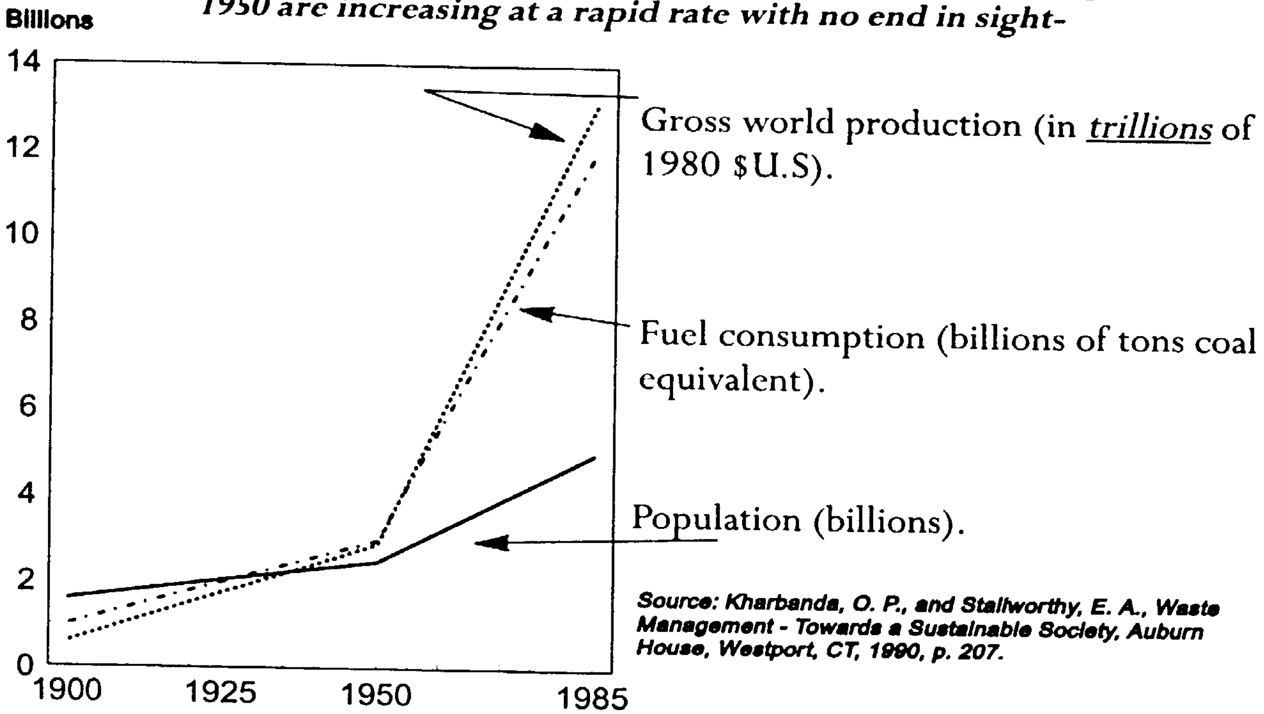
It should be added that CO2 levels are on the increase because of air pollution from the burning of fossil fuels such as coal and petroleum, and that CO2 and other gaseous pollutants bring us acid rain, acid fog, acid snow, and smog.

Crap happens. However, we don't inherit the earth, as the saying goes, we borrow it from our children, and we should be stewarding it for our future progeny. That's the sane thing to do. Most humans are sane, and they care about the future, about their children, their own health and their planet's health. The social and environmental problems we're faced with today are caused by poor leadership, lack of political foresight, and fear, greed and corruption caused by power and wealth, or a lack of it. If what Sandra Postel and Lester Brown are saying is true, our resources are dwindling and our ability to support life is slowly but steadily deteriorating. We

Figure 1.10

Our increasing impact on planet Earth:

World population growth, world production, and world fuel consumption since 1950 are increasing at a rapid rate with no end in sight-



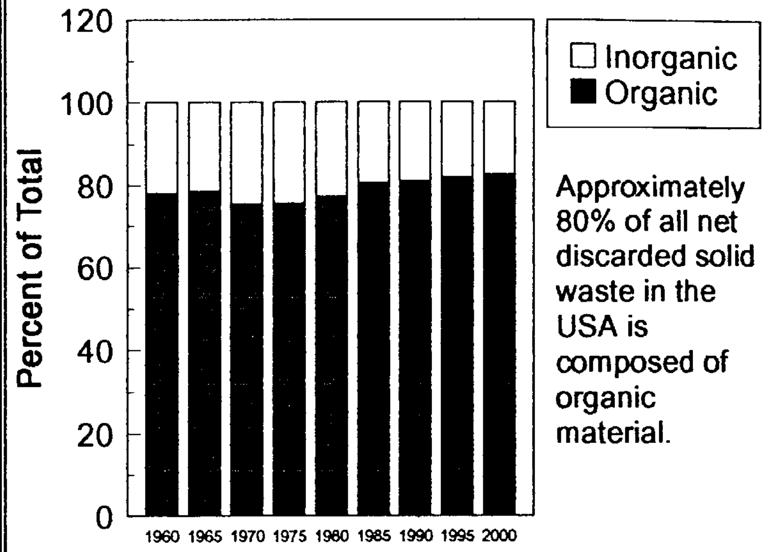
***Source:* Kharbanda, O. P., and Stallworthy, E. A., *Waste Management - Towards a Sustainable Society,* Auburn House, Westport, CT, 1990, p. 207.**

should do something about that, and we can start with ourselves. What can we do? We can change our *minds.*

What we should be discarding is our throw-away *mentality.* Would it be so difficult to replace such a mentality with one which emphasizes ***waste reduction and resource recovery***? "Waste reduction - resource recovery" is a worthy motto to lead us toward a sustainable future. A throw-away society eventually strangles itself in its own waste, while squandering valuable natural resources and energy in the process.

Figure 1.7

Composition of Unrecycled Discarded Solid Waste in the USA 1960-2000



Source: US EPA, 1988 Characterization of Municipal Solid Waste in the United States 1960-2000, PB88-232780.

Ironically, the majority of the unrecycled solid waste discarded in the United States is organic waste and could be composted and thereby converted into one of the necessities of life: food.

Our refusal, as humans, to take intelligent responsibility for the recycling of our own nutrients, our own manure and food refuse, indicates a very significant blind spot in our understanding of natural processes.

WASTE VS. MANURE

Human digestive-system refuse is only waste if it's not recycled. Otherwise, it's manure, and a valuable resource and soil amendment material at that. Farmers never speak of "cow waste", they speak of cow manure. Nor does one hear of "horse waste" or "pig waste" or "chicken waste", instead they are all "manures" and for good reason. They aren't wasted. They're returned to the soil as they should be, thereby completing a natural cycle. These manures are valuable fertilizers for the soil, preventing the soil from becoming depleted of nutrients and inoculating the soil with bacteria and microorganisms which give the soil life and vitality.

Let's take a look at the process. Crops are grown, say oats; the oats are harvested and fed to animals, say cows. Now we stand back and wait. Eventually, the oats, which entered the cow's mouth, go through the cow's digestive system and the

Properly composted humanure yields a rich, loamy, pleasant-smelling soil-building material, here being applied to spring garden beds.

cow's body takes what it needs from them. What it doesn't need or can't use goes out the other end and plummets to the barn floor as a " cow patty".

Now farmers know that cow manure is valuable. They also know that those cow patties are digested crops, and that crops are soil, water and sunshine converted into food, and the best way to get rid of those patties is to put them back in the field from where they originated. So the farmer loads up the manure spreader and flings the manure back into the fields, thereby cleaning up his barn, saving himself lots of money on fertilizers, and keeping his soil healthy. Sounds reasonable enough. But what about *human* manure?

Humanure is a little bit different. It shouldn't simply be flung around in a fresh and repulsive state. It should undergo a process of bacterial digestion first, usually known as *composting*, in order to destroy possible pathogens. This is the missing link in the human nutrient recycling process. The process is similar to a cow's: A human grows food for itself on a field, or in a garden. The food enters the human's mouth and continues on into the digestive system where the body extracts what it needs, rejecting what it doesn't need at the time, or what it can't use. The body then excretes the rejected material.

At that moment the body is no longer responsible for the excretion. The body did its share of the work, now it's time for the mind to go to work. Thinking must now happen. The human mind now has basically two choices - consider the excretion to be waste and try to get rid of it, or consider the excretion to be a resource which must be recycled. Either way, the body's refuse must be collected. As waste, the human waste must be dispensed with in a manner that is safe to human health and to the environment; as a resource, the humanure must be conscientiously composted to ensure the destruction of potential pathogens, then returned to the soil.

Much of the humanure (also known as "night soil") recycled in Asia is not composted. It's simply applied raw to the fields. *That is not what this book is about.* Raw humanure carries with it a significant element of danger in the form of disease pathogens. Those diseases, such as intestinal parasites, hepatitis, and others, are destroyed by composting, *when the composting process generates heat.* Raw applications of humanure to fields, on the other hand, are not hygienically safe and can assist in the spread of various diseases which may be endemic to areas of Asia where raw humanure is used. Americans who have traveled to Asia tell of the "horrible stench" of raw humanure that wafts through the air when such a material is applied to fields. For these reasons it is imperative that humanure always be composted before agricultural applications. Proper thermophilic (heat producing) composting destroys possible pathogens and results in a pleasant smelling material.

On the other hand, raw night soil applications to fields in Asia return humanure to the land and thereby do recover a valuable resource which is used to produce human food. *Composted* humanure is used in Asia as well. Cities in China, South Korea and Japan recycle humanure where it's returned to the land around the cities in greenbelts where vegetables are grown. Shanghai (China), a city which had a population of nearly 11 million people in 1970[28], produces an exportable surplus of vegetables in this manner.

Humanure can also be used to feed algae which can in turn feed fish for aquacultural enterprises. In Calcutta, such an aquaculture system produces 20,000 kilograms of fresh fish daily.[29] The city of Tainan, Taiwan, is well known for its fish, which are farmed in over 6,000 hectares of fish farms fertilized by humanure. Here humanure is so valuable that it's sold on the black market.[30]

Furthermore, humanure can be mixed with other organic refuse from human activity such as kitchen and food scraps, grass clippings, leaves, garden refuse, and sawdust. When composted, this blend of nutrients can yield a balanced, loamy, rich, pleasant-smelling and hygienically safe soil additive suitable for food gardens as well as for agriculture.

The following chapters discuss the roots of the cultural bias against the recycling of humanure that we Westerners are burdened with. The amazing phenomenon of compost is also discussed, as it is the obvious alternative to organic waste disposal. Various conventional waste disposal systems currently in use, such as sewers and septic systems, are looked at, and a more detailed analysis of their environmental shortcomings is given. Common composting toilets, including home-made as well as store-bought ones, are also looked at, as are simple humanure composting systems (which focus more on the composting and less on the toilet). The issue of human pathogens associated with humanure is closely scrutinized. Finally, a low-impact, largely technology-free system of humanure composting (the sawdust toilet) is discussed in detail.

EXPERIENCE HELPS

Allow me to interject here that I'm not advocating the composting of humanure based on theory. In fact, I have composted all of my family's humanure since 1979 (fifteen continuous years at the time of this writing) on our rural homestead using a very simple, low-impact, low-technology system (a *sawdust toilet).* The resulting compost has always been used in our food garden.

I've had an unusual opportunity to experiment with the composting of humanure, and this experience has yielded for me an abundance of empirical data. My experiences have made me confident that humanure can be easily and safely composted using only the simplest methods, yielding a valuable soil additive from what would otherwise be putrid and dangerous waste. By no means do I claim to have all the answers. But I do hope to at least be able to provide a *starting point* for those of you who seek information about composting humanure. Perhaps this book will shed a small ray of light onto what is otherwise a vacuum of information.

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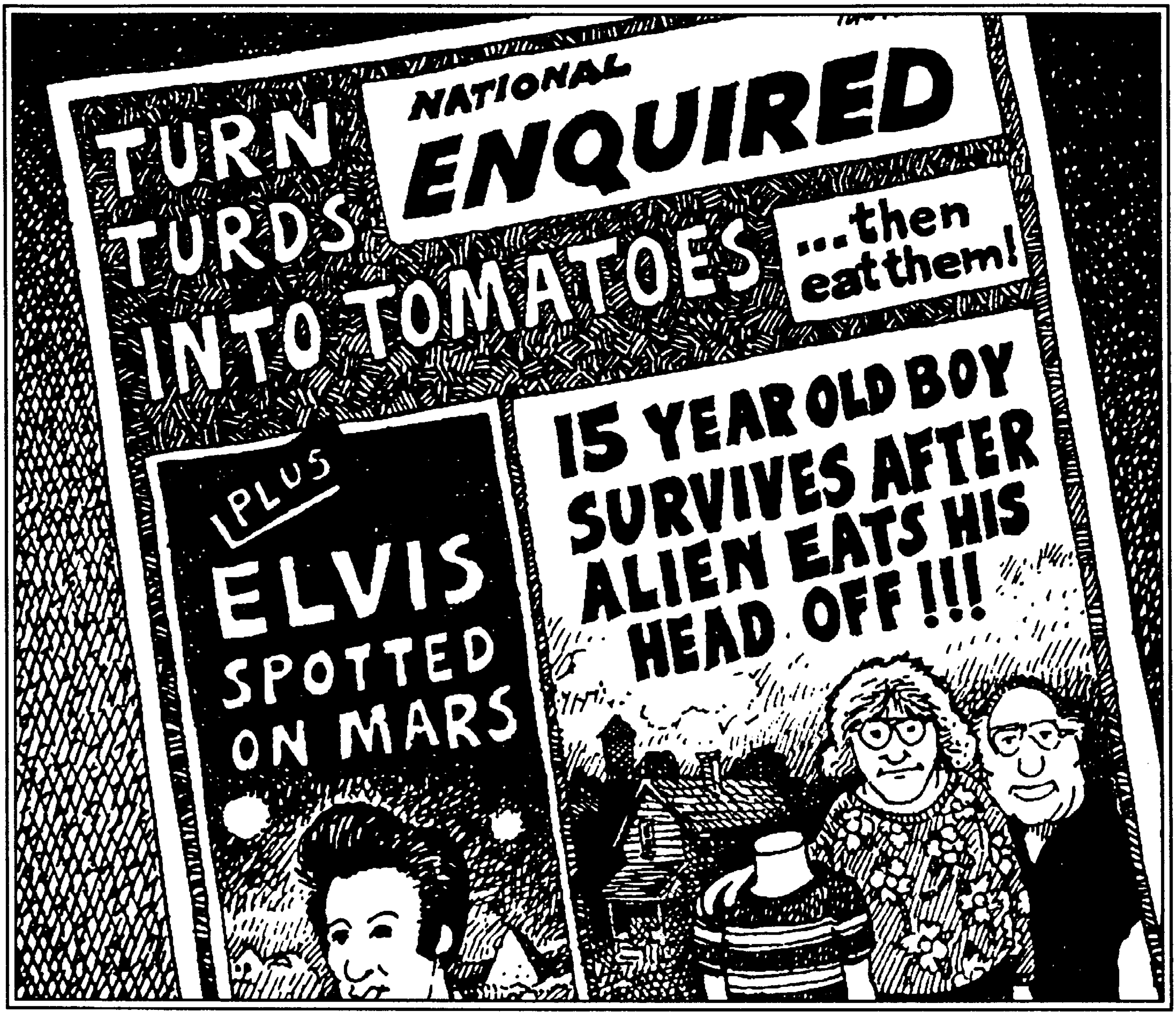

NATIONAL ENQUIRED
TURN TURDS INTO TOMATOES
...then eat them!
PLUS
ELVIS SPOTTED ON MARS
15 YEAR OLD BOY SURVIVES AFTER ALIEN EATS HIS HEAD OFF !!!

MICROHUSBANDRY

Harnessing the Power of Microscopic Organisms

"Making compost is an art rather than a science. To go about it mechanically, merely following rules, not only will not yield the best results, but the work will not be as enjoyable."
J. I. Rodale

There are essentially four ways to deal with human excrement. The first is to *dispose of it.* People do this by defecating in water, or in outhouses or latrines. Most of this excrement ends up wasted, buried in the ground, or becomes a source of pollution. The second way to deal with human excrement is to *apply it raw to agricultural land.* This is popular in Asia where "night soil", or raw human excrement, is spread on fields. Although this keeps the soil enriched, it acts as a vector, or route of transmission, for disease organisms. The third way to deal with human excrement is to *slowly compost it over an extended period of time.* This is the way of most commercial composting toilets and mouldering toilets. Slow composting generally takes place at temperatures below that of the human body (98.6 °F or 37°C). This method of composting eliminates most disease organisms in a matter of months, and should eliminate all human pathogens eventually, although some sources suggest that the total destruction of pathogens may require a period of up to ten years. Slow composting or mouldering, however, creates a useful soil additive that is at least safe for ornamental gardens or orchard use. The fourth way to deal with human excrement is to ***thermophilically compost it.***

Thermophilic composting involves the cultivation of thermophilic (heat loving, or heat producing) microorganisms in the initial stage of the composting process. These bacteria and fungi can produce heat sufficient to destroy the disease organisms (human pathogens) that may be present in humanure. Thermophilic composting can render humanure into a friendly, pleasant-smelling, humus safe for food gardens. It's this type of composting which is the primary focus of this book, and this focus is not to be confused with the other three ways of dealing with human excrement. Thermophilically composted humanure is somewhat different from mouldered humanure, and *entirely different from night soil.*

What is compost anyway? I'm glad you asked that question. I remember when I first moved out to the country and started living off the land at the age of 22. I was fresh out of college, so naturally I knew very little. One word that was a mystery to me was "compost", another was "mulch". I didn't know what either of these things were, I only knew they had something to do with organic gardening, and that's what I intended to learn about. Of course, it didn't take me long to understand mulch. Anybody who can throw a layer of straw on the ground can mulch. But compost took a little longer.

Making compost is sort of like making bread, or maybe wine. My compost-learning experiences were a parallel of my wine-making experiences. Back then, having just graduated from the university, I had been conditioned to believe that everything had to be learned by using books. I had little awareness that instinct or intuition were powerful teachers. It seemed I was expected to believe that humans were the only thing in the universe with intelligence, and everything in nature was somehow below us. Furthermore, simple, natural processes had to be complicated with charts, graphs, measurements, devices, and all the wonderful tools of science, otherwise the processes had no validity. It was with this attitude that I set out to learn how to make wine.

Of course, the first thing I did was obtain a very scientific book replete with charts, graphs, tables, and detailed, step by step procedures. The book was titled something like "Foolproof Winemaking" and the trick, or so the author said, was simply to follow his procedures *to the letter.* This was no simple feat. The most difficult part of the process was acquiring the list of chemicals which the author insisted must be used in the winemaking process. After much searching and travel I managed to get the required materials and I then followed his procedures *to the letter.* This lengthy process involved boiling sugar, mixing chemicals etc. To make a long story short, I did succeed in making two kinds of wine in this way. Both tasted like hell though, and had to be thrown out. I was very discouraged.

It wasn't too long after that when a friend of mine, Bob, decided he would try his hand at winemaking. Bob and I had a friend, Jim, who worked at a Pennsylvania vineyard, and Jim offered to bring Bob five gallons of grape juice for a try at the oenologist's art. Jim, being the good sport that he is, even brought the juice in a five gallon glass winemaking container (carboy) with an airlock already on top of it (to allow fermentation gasses to escape while preventing air from entering). When he got the grape juice to Bob's house, Bob took one look at the heavy carboy of juice and said, *"Jim, would you mind carrying that into the basement for me?"* Which Jim obligingly did. That was it. That utterance constituted Bob's entire effort at winemaking. Two seconds of flapping jaws is the only work Bob did toward making that wine. He added no sugar, no yeast, did no racking, certainly used no chemicals. He didn't do a damn thing to that five gallons of grape juice except abandon it in his basement. And yet, that turned out to be the best homemade wine I had ever drunk. It tasted good and had a nice kick to it too. It was superb.

Now, I admit, there was an element of luck there, but I learned an important lesson about winemaking: the basic process is very simple - start with good juice and keep the air out of it. That simple, natural process can easily be ruined by complicating it with scientific procedures, and heck, all those charts and graphs took the *fun* out of it. Making compost is exactly the same sort of phenomenon.

NATURALCHEMY

What exactly *is* compost, you ask again? According to Webster, compost is *"a mixture of decomposing vegetable refuse, manure, etc. for fertilizing and conditioning the soil."* To compost means to convert organic refuse into soil or humus. Humus is a brown or black substance resulting from the decay of organic animal or vegetable refuse. Organic refuse could be considered anything on the Earth's surface that had been recently alive, or from a living thing, such as manure, plants, leaves, sawdust, peat, straw, grass clippings, food scraps, urine etc. A rule of thumb is that anything that will rot will compost. In some cases, even petroleum products are compostable.

In the Middle Ages alchemists sought to change base metals into gold. Old German folklore tells of a tale in which a dwarf named Rumpelstiltskin had the power to spin flax straw into precious metal. Somewhere in the psyche of the Western society was a belief that substances of little or no worth could be transmuted by a miraculous process into materials of priceless value. Our ancestors were right, but they were barking up the wrong tree. The miraculous process of thermophilic *composting* will transmute humanure into humus. In this way, a dangerous waste material becomes a soil additive vital for the processes of human life.

Our ancestors didn't understand that the key to this alchemy was right at their fingertips. Had they better known and understood natural processes they could have provided themselves with a wealth of soil fertility and saved themselves the tremendous suffering caused by diseases originating from fecal contamination of the environment. For some reason they believed that gold embodied value, and in pursuit of glittering riches they neglected the things of real value in life: health, vitality, self-sufficiency, sustainability.

Their ignorance involved microbiology. Our ancestors had little understanding of a vast, invisible world which surrounded them, a world of billions of creatures so small as to be quite beyond the range of human sight. And yet, some of those microscopic creatures were already being used to do work for humanity in the form of the fermentation of foods such as beer, wine or bread dough. Although *yeasts* have been used by people for centuries, *bacteria* have only relatively recently become harnessed by Western humanity. Composting is one means by which the power of bacteria can be utilized in a big way for the betterment of humankind. Unfortunately, our ancestors didn't understand the role of microorganisms in the decomposition of organic matter, and the efficacy of microscopic life in converting humanure, food scraps, plant residues and the like into soil. They didn't understand compost.

The decomposition of organic materials requires armies of bacteria which work so hard digesting (decomposing) the refuse they heat the stuff up. Other micro and macro organisms such as fungi and insects help in the composting process, too. When the compost cools down, earthworms often move in and eat their fill of delicacies, their excreta becoming a further refinement of the compost.

And so, successful composting requires the maintenance of an environment in which bacteria and fungi can thrive. Same for wine, except the microorganisms are yeast, not bacteria. Same for bread (yeast), beer (yeast), yogurt (bacteria), sauerkraut (bacteria); all of these things require the cultivation of microorganisms which do the work you want done. All of these things involve simple processes which, once you know the basic principles, are easy to carry out successfully. Sometimes bread doesn't rise, sometimes yogurt turns out watery, sometimes compost doesn't seem to turn out right. When this happens, a simple change of procedure will rectify the matter. Once you get the hang of it, you'd think that even a chimpanzee could be trained to make compost.

Often, in our household, we have yogurt being made by millions of hard-working bacteria in a few quart mason jars beside the cookstove. At the same time, millions of yeast cells are cheerfully brewing beer in carboys in the back pantry, millions more yeasts are happily brewing wine beside the beer, sauerkraut is blithely fermenting in a crock behind the stove, bread is rising on the kitchen counter, and fungi are tirelessly forcing their fruits from oak logs on the sunporch. And then there's the compost pile. At times like these, I feel like a real slave driver. But the workers never complain. Those little fellas work day and night, and they do a real nice job.

Making compost and using it agriculturally has its advantages. The end product of compost making, *humus*, consists of broken down organic matter that is the basis of soil life. Humus holds moisture, and therefore increases the soil's capacity to absorb and hold water. Compost is said to hold nine times its weight in water (900%), as compared to sand which only holds 2%, and clay 20%.[1] Compost also adds slow-release nutrients essential for plant growth, creates air spaces in soil, helps balance the soil pH, darkens the soil and thereby helps it absorb heat, and supports microbial populations that add life to the soil.

The building of topsoil by Mother Nature is a centuries long process. Adding compost to soil will help to quickly restore fertility that might otherwise take nature hundreds of years to replace. We humans deplete our soils in relatively short periods of time. We can restore that fertility also in relatively short periods of time by composting our organic refuse and returning it to the land.

Another way to look at it is by seeing organic refuse as stored solar energy. Every apple core or potato peel holds a tiny amount of stored energy, converted into useable plant food by the compost pile. Perhaps S. Sides of the *Mother Earth News* states it more succinctly: *"Plants convert solar energy into food for animals (ourselves included). Then the [refuse] from these animals along with dead plant and animal bodies, 'lie down in the dung heap,' are composted, and 'rise again in the corn.' This cycle of light is the central reason why composting is such an important link in organic food production. It returns solar energy to the soil. In this context such common compost ingredients as onion skins, hair trimmings, eggshells, vegetable parings, and even burnt toast are no longer seen as garbage, but as sunlight on the move from one form to another."*[2]

Adding compost to soil helps control plant diseases. Studies in 1968 by researcher Harry Hoitink indicated that compost, by adding beneficial microorganisms to the soil, inhibited the growth of disease-causing microorganisms in greenhouses. In 1987, he and a team of scientists took out a patent for compost that could reduce or suppress plant diseases caused by

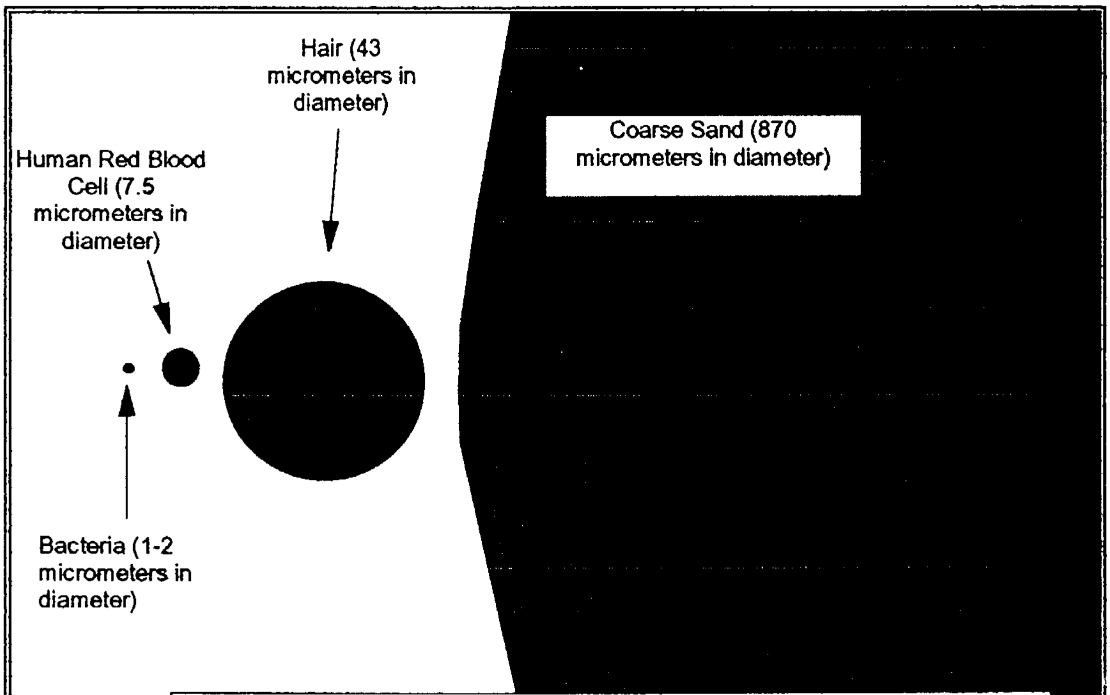


Figure 2.1

Size of Bacteria Relative to a Red Blood Cell, a Hair, and a Grain of Coarse Sand

Source: Gest, Howard (1993). Vast Chain of Being. Perspectives in Biology and Medicine, V. 36, No. 2, Winter 1993. University of Chicago Division of Biological Sciences. (p. 186).

Finished compost is being removed from a double chambered compost bin. The large pile of refuse in the chamber on the right is undergoing thermophilic decomposition, and represents nearly a year's worth of accumulated material, including humanure. When finished, it will shrink to half its size. Clean hay is stacked against the right side of the bin to be used as cover material.

three deadly microorganisms: *phytophtora*, *pythium*, and *fusarium*. Growers who used this compost in their planting soil reduced their crop losses from 25-75% to 1% without applying fungicides. The studies suggested that sterile soils could provide optimum breeding conditions for plant disease microorganisms, while a rich diversity of microorganisms in soil, such as that found in compost, would render the soil unfit for the proliferation of disease organisms.[3]

Besides helping to control soil diseases, compost helps control nematodes, attracts earthworms, and aids plants in producing growth stimulators.[4] It can also destroy some toxic wastes. One man who composted a batch of sawdust contaminated with diesel oil said, *"We did tests on the compost, and we couldn't even find the oil!"* The compost had apparently "eaten" it all.

Composting also seems to be able to decontaminate soil polluted with TNT from munitions plants. The microorganisms in the compost digest the hydrocarbons in TNT and convert them into carbon dioxide, water, and simple organic molecules. Furthermore, some bacteria "eat" uranium. Derek Lovley, a microbiologist, has been working with a strain of bacteria that normally lives 650 feet under the earth's surface. These microorganisms will eat, then excrete, uranium. The chemically altered uranium excreta becomes water insoluble as a result of the microbial digestion process, and can consequently be removed from the water it was contaminating.[5]

An Austrian farmer claims that the microorganisms he introduces into his fields have prevented them from being contaminated by the radiation from Chernobyl, the ill-fated Russian nuclear power plant, which contaminated his neighbor's fields. Sigfried Lubke sprays his green manure crops with compost-type microorganisms just before plowing them under. This practice has produced a soil rich in humus and teeming with microscopic life. After the Chernobyl disaster, crops from fields in Lubke's farming area were banned from sale due to high amounts of radioactive cesium contamination. However, when officials tested Lubke's crops, no trace of cesium could be found. The officials made repeated tests because they couldn't believe that one farm showed no radioactive contamination while the surrounding farms did. Lubke thinks that the humus just "ate up" the cesium.[6]

Finally, fertile soil yields food that promotes good health. One group of people, the Hunzas of northern India, has been studied to a great extent. One man who studied them extensively, Sir Albert Howard, stated, *"When the health and physique of the various northern Indian races were studied in detail the best were those of the Hunzas, a hardy, agile, and vigorous people, living in one of the high mountain valleys of the Gilgit Agency. . .There is little or no difference between the kinds of food eaten by these hillmen and by the rest of northern India. There is, however, a great difference in the way these foods are grown. . . [T]he very greatest care is taken to return to the soil all human, animal and vegetable wastes [sic]after being first composted together. Land is limited: upon the way it is looked after, life depends."*[7] We'll take another look at the Hunzas in chapter six.

GOMER THE PILE

Back to the compost pile. Notice I said "pile". Refuse is usually piled up in bins, racks, pits, drums or what have you. There are three basic reasons for piling the composting refuse. First, it keeps the pile from drying out or cooling down prematurely. A level of moisture (50-60%) is necessary for the bacteria to work happily.[8] A vertical stack prevents leaching, prevents waterlogging, and holds heat in the pile.

Vertical walls around a pile, especially if they're made of wood, keep the wind off and will prevent one side of the pile (the windward side) from cooling down prematurely.

Secondly, a neat, contained pile just plain looks better. It looks like you know what you're doing, instead of looking like a garbage dump.

Thirdly, a pile makes it easier to layer, or cover over the compost. It's a good idea to cover the pile with clean refuse when a smelly deposit is added to the top, in order to eliminate unpleasant odors and to trap necessary oxygen in the pile. Therefore, if you're going to compost your refuse, don't just fling it out in your yard in a heap. Construct a nice little bin and do it right. That bin doesn't have to cost money, it can be made from recycled wood or cement blocks. Wood may be preferable as it'll insulate the pile and prevent heat loss and frost penetration. A compost bin doesn't have to be complicated in any way. It doesn't require electricity, technology, gimmicks or doodads. You don't need shredders or choppers, grinders or any machines whatsoever.

Compost *pits* are more likely to be used in dry, arid or cool climates where conservation of moisture and temperature is imperative. The main disadvantage of pits is that they can become waterlogged in the event of an unexpected cloudburst, and excessive water will rob the pile of oxygen, a critical element in the process of decomposition by aerobic microorganisms. When pits are used, therefore, a roof over them may be an advantage.

What sort of environment does the bacterial community like? As stated, the compost must be moist. A dry pile will not work. When composting humanure, the urine provides quite a bit of the necessary moisture. Other moisture comes from food scraps. In some cases, a compost pile may have to be watered. This would most likely occur in a very dry climate where the pile may also require a roof over it to reduce dehydration. In Pennsylvania, where I live, we have ample rainfall (35 inches per year, nearly one meter) and my compost never dries out, unless during an unusual drought. It is never covered by a roof and leaching has never been a problem. I've rarely had to water my compost. On the other hand, we compost all of our refuse, including our urine. We use rotting hardwood sawdust in our waterless sawdust toilet as an odor-preventing cover material, which also soaks up the urine to create a good moisture balance. Compost should be moist, not wet.

The amount of moisture a compost pile receives or needs depends on the materials put into the pile and on the location of the pile. According to Sir Albert Howard, watering a compost pile in England where the annual rainfall is 24 inches is also unnecessary. Nevertheless, the water required for compost-making may be around 200 to 300 gallons for each cubic yard of finished compost.[9] This moisture requirement will be met when human urine is used in the compost and the top of the pile is open and receiving adequate rainfall. If adequate rainfall is not available and the contents of the pile are not moist, watering will be necessary to produce a moisture content equivalent to a squeezed out sponge.

The bacteria we want to cultivate in the compost pile in order to ensure thermophilic decomposition are *aerobic* and they will suffer from a lack of oxygen if drowned in liquid. Bacterial decomposition can also take place anaerobically, but this is a slower, cooler process, which can, quite frankly, stink.

A good, healthy, aerobic compost pile need not offend one's sense of smell. However, in order for this to be true, one simple rule must be followed: anything added to the compost collection that smells bad must be covered with clean organic material. This means in your compost toilet, this means on your compost pile. Shit stinks, I don't care what Adelle Davis* said. When you defecate or urinate in your toilet, cover it. Use sawdust, use peat, use clean soil, use leaves, but keep it covered. Then there will be no odor. When you deposit smelly manure on your compost pile, cover it. Use weeds, use straw, use hay, whatever you can get your hands on (especially bulky material which will trap oxygen), but keep it covered. That's the secret. That's all there is to it (the smell issue, that is).

Dehydration will cause your bacteria to go on strike and stop working. So will freezing. Compost piles will not work if frozen, as during the cold winters of the north. However, don't despair, the bacteria will wait until the temperature rises and then they'll work like hell. I continue to add to my outdoor compost pile all winter, even when the pile is frozen solid as a rock. The freezing stage helps to destroy potential pathogens, and after the thaw, the pile works up a steam as if nothing happened. (See page 164, and appendix 4 on page 187, for charts showing the rise of temperature after a frozen pile thaws.)

Actually, I consider this whole process to be one of the miracles of nature. I take humanure with urine mixed in sawdust from our low-impact toilet, buckets of food scraps from the kitchen, armfulls of weeds from the garden, and anything else on hand, and layer it all onto a pile where it's transformed into a rich loamy garden soil before my eyes. The final product looks and smells like a beautiful soil. This process requires no electricity, no technology, no bells or whistles, no heaters, and no dancing girls. It's a model of simplicity,

The top of a compost pile should be kept somewhat flat. Keep a garden utensil handy to the compost bin for this purpose. I use an old hay fork with a broken handle. The short handle is long enough to rake the top of my pile. The flat top collects water and prevents leaching. It makes it easier to layer things on the pile. Things don't roll off a flat-topped pile. This is just a simple and standard maintenance procedure. If the pile is frozen and can't be flattened, don't worry about it. When it thaws, flatten the top. Don't overdue it though, as your thermophiles may not like being disturbed!

Don't be confused by layering. Layering occurs naturally. Every time you add something to your pile you're adding another layer. No, you don't have to stir these layers up. Many people believe that you do, but you don't.

Don't be confused about mixing and blending the compost. This happens naturally when you add all of your organic refuse to the same compost pile, including humanure. By adding a variety of materials to the pile, you are creating a mix of ingredients, trapping oxygen into the pile, balancing nutrients, and eliminating the need to turn or stir the pile. If the bacteria like your compost, they'll heat the pile up and won't want to be disturbed by turning or stirring. If they don't like your compost, it's more than likely you're not adding a mix of materials to the pile. One can't just defecate in a 55 gallon drum, throw lime on it and expect it to compost. This is the single most common mistake I've seen made by people trying to compost humanure. They think humanure is dangerous and must be isolated, quarantined from all other compost. This is ironic, as the potential dangers of humanure are most effectively eradicated by thermophilic composting. To get a good, hot pile, you need organic material such as kitchen scraps, garden weeds, and maybe some hay or straw or leaves layered with your manure. These rough materials create interstitial air spaces in the pile that aid the aerobic digestion. They create a good blend of nutrients for the microbes. Think about it, how would *you* like it if you had only crap to eat?

THE CARBON/NITROGEN RATIO

One way to look at the blend of ingredients in your compost pile is by using the C/N ratio, the carbon/nitrogen ratio. Quite frankly, the chance of anyone measuring and monitoring the carbon and nitrogen quantities of their refuse is almost nil. This is like making wine the "foolproof" way. If composting requires this sort of drudgery, no one would do it.

However, I've found that by using all of the organic refuse my family produces, including humanure, urine, food refuse, weeds from our garden, rotting sawdust (which is hauled in), and maybe a little straw or hay now and then, we get the right mix of carbon and nitrogen for successful thermophilic composting.

Nevertheless, no discussion of composting is complete without a review of the subject of the carbon/nitrogen ratio. A good C/N ratio for a compost pile is between 20/1 and 35/1.[10] That's 20 parts of carbon to one part of nitrogen, up to 35

Table 2.1

Composition of Humanure

Fecal Material -

0.3-0.6 pounds per person per day, or 135-270 grams, wet weight.

Organic Matter (dry weight)	88-97%
Moisture Content	66-80%
Nitrogen	5-7%
Phosphorous	3-5.4%
Potassium	1-2.5%
Carbon	40-55%
Calcium	4-5%
C/N Ratio	5-10

Urine-

1.75-2.25 pints per person per day (1.0-1.3 liters)

Moisture	93-96%
Nitrogen	15-19%
Carbon	11-17%
Calcium	4.5-6%
Potassium	3.0-4.5%
Phosphorous	2.5-5%

Source: Gotaas, Composting, (1956), p. 35

parts of carbon to one part of nitrogen. Or, for simplicity you can figure on shooting for an optimum 30/1 ratio.

The reason this ratio is good is because the microorganisms that digest the compost need 30 parts of carbon for every part of nitrogen they consume. If there's too much nitrogen and not enough carbon, the microorganisms can't use the excess nitrogen. Then the excess nitrogen is lost in the form of ammonia gas, which you can smell. Nitrogen loss due to excess nitrogen in the pile (a low C/N ratio) can be over 60%. At a C/N ratio of 30 or 35 to 1, only one half of one percent of the nitrogen will be lost. That's why you don't want too much nitrogen in your pile: you'll lose a lot of it in the form of ammonia gas, and nitrogen is too valuable for plants to allow it to go to waste (see Table 2.3).[11]

Table 2.3

NITROGEN LOSS AND C/N RATIO

Initial C/N Ratio	Nitrogen Loss %
20	38.8
20.5	48.1
22	14.8
30	0.5
35	0.5
76	-8

Source: Gotaas, Composting, 1956, p. 92

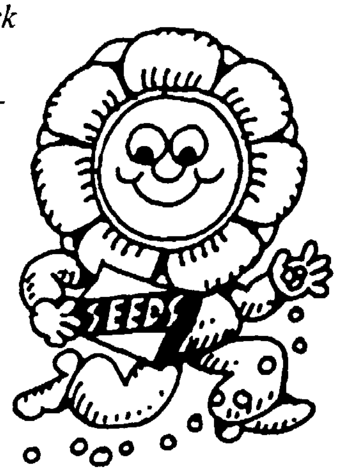
The C/N ratio of humanure is between 5 and 10, or roughly around

Table 2.2 (Source: Gotaas, Composting, 1956, p. 44)

Carbon/Nitrogen Ratios for Some Compostable Materials

MATERIAL	% N	C/N RATIO		MATERIAL	% N	C/N RATIO
Urine	15-18	0.8		Grass Clippings	2.4	19
Humanure	5-7	5-10		Amaranth	3.6	11
Activated Sludge	5-6	6		Lettuce	3.7	-----
Rotted Sawdust	0.25	208		Cabbage	3.6	12
Raw Sawdust	0.11	511		Tomato	3.3	12
Wheat Straw	0.3	128		Onion	2.65	15
Oat Straw	1.05	48		Pepper	2.6	15
Timothy Hay	0.85	58		Turnip Tops	2.3	19
Poultry Manure	6.3	-----		Raw Garbage	2.15	25
Sheep Manure	3.75	-----		Bread	2.10	-----
Pig Manure	3.75	-----		Seaweed	1.9	19
Horse Manure	2.3	-----		Red Clover	1.8	27
Farmyard Manure	2.25	14		Whole Carrot	1.6	27
Cow Manure	1.7	-----		Mustard	1.5	26
Blood	10-14	3		Potato Tops	1.5	25
Fish Scrap	6.5-10	-----		Fern	1.15	43
Meat Scraps	5.1	-----		Whole Turnip	1.0	44
Purslane	4.5	8				

The above chart reveals the ratio of carbon to nitrogen in various common organic materials. For example, the C/N ratio of rotted sawdust is 208, indicating that there are 208 parts of carbon to every one part of nitrogen. The optimum C/N ratio for compost is 25 or 30/1, so obviously sawdust should have quite a bit of nitrogen added to it to ensure vigorous microbial decomposition. It should be evident from the above chart that humanure requires a fair amount of carbonaceous material to be mixed with it in order to obtain the optimum C/N ratio of 25 or 30/1. Sawdust happens to work quite well for this purpose, especially if somewhat rotted. When rotted sawdust is used as a cover material in a compost toilet, it also very effectively eliminates odors. Presumably, many common organic materials will work well as compost toilet cover. The idea is to use what's locally available. Note that garbage has nearly an optimum C/N ratio and would feel right at home in a compost pile, and straw and hay are well suited as cover materials for compost piles when manure is to be covered. The carbon in the hay balances the nitrogen in the manure.



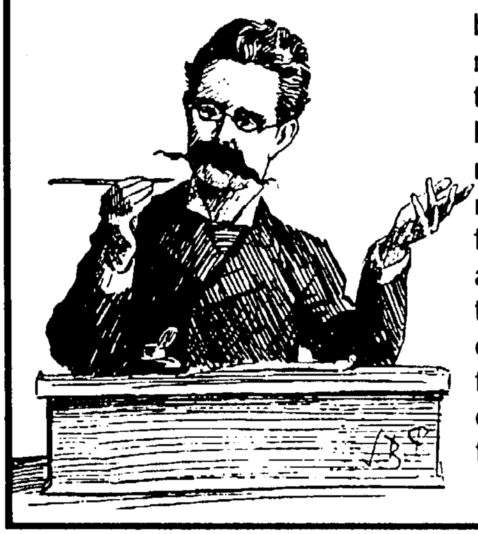
8/1, or eight parts of carbon to one part of nitrogen. Therefore, you need to add a fair amount of carbon to humanure to get a 30/1 ratio and good compost. I've found that the proper balance is obtained by putting all the organic refuse of my household in the same pile, layered with weeds, straw, hay or whatever else happens to be within reach. The humanure is collected in a twenty-liter non-corrodible receptacle where it is constantly kept covered with clean, partially rotted, hardwood sawdust (I live in a hardwood forest). The sawdust adds quite a bit of carbon, although no extra sawdust is ever added to the compost pile other than what's put into the toilet. I'm getting ahead of myself here, as I'll discuss a bio-solids (sawdust) toilet in detail in chapter 7.

MISINFORMATION

There was some literature published on the subject of composting humanure back in the 1970's which insinuated that humanure compost was practically as toxic as nuclear waste. And this information came from a publisher *promoting* the recycling of humanure.[12] Undoubtedly the publisher's intentions were good, and fecophobia (fear of fecal material) is understandable in our culture, but I must question the perpetuation of fecophobia from published information that is incomplete or incorrect. By some stroke of luck I didn't run across this book until recently, although I realize now that many of my acquaintances had been influenced by the publication and therefore feared the use of human excrement in compost. They were rendered fecophobic.

For example, the publisher had strongly recommended that human urine and feces be collected separately as the urine was "good" and the feces "bad". I had seen

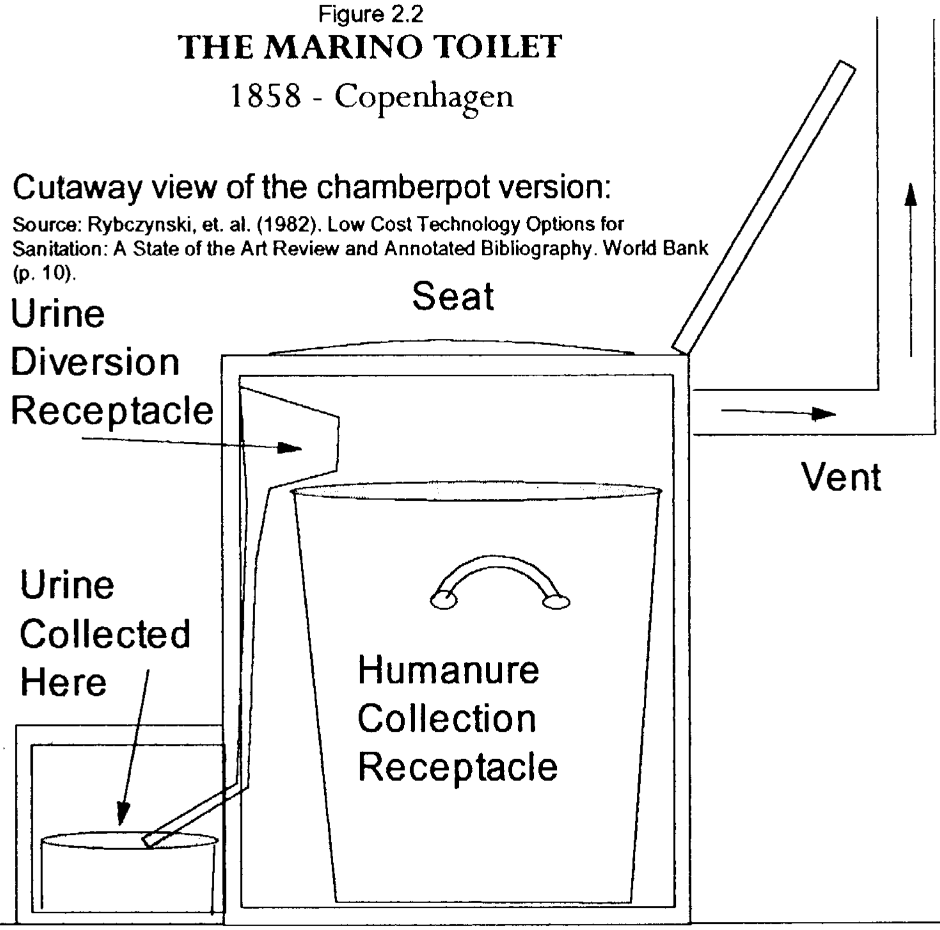
FUN FACTS



Proper composting requires a balance of carbon and nitrogen in the organic material being composted. Human excreta is not properly balanced as it is too high in nitrogen, and it requires a carbon material to be added to it for the encouragement of rapid and thorough microbial decomposition. In the mid 1800's, the concept of balancing carbon and nitrogen was not known, and the high nitrogen content of humanure in dry toilets prevented the organic material from efficiently decomposing. The result was a foul, fly-attracting stench. It was thought that this problem could be alleviated by segregating urine from feces (which thereby reduced the nitrogen content of the fecal material) and dry toilets were devised to do just that. Today, the practice of segregating urine from feces is still widespread, even though the simple addition of a carbonaceous material to the feces/urine will balance the nitrogen of the material and render the segregation of urine unnecesary.

Figure 2.2
THE MARINO TOILET
1858 - Copenhagen

Cutaway view of the chamberpot version:
Source: Rybczynski, et. al. (1982). Low Cost Technology Options for Sanitation: A State of the Art Review and Annotated Bibliography. World Bank (p. 10).



In the mid-1800's, attempts were made to devise humanure collection devices which did not require water. Since the organic material was not being composted, the urine was segregated from the fecal material to minimize odor problems. This technique is still in wide use today, even though the simple use of a semi-dry, organic cover material such as rotting sawdust in the toilet absorbs excess liquids, prevents odors, eliminates flies and makes unnecessary the need to segregate urine. Such a cover material further balances the carbon-nitrogen ratio of the organic material, rendering it suitable for composting.

people doing this, but I could never understand where they came up with this idea until I read that book and also did some additional research into the subject. Urine was to be collected in a bucket and applied to the garden or compost pile, while fecal material was to be collected in a separate receptacle and buried in a trench far away (as in a distant orchard, maybe on another planet) and covered with twelve inches of soil. Now, the idea of defecating in one receptacle and urinating in another seems bizarre enough (I've never tried it and don't intend to), but if you think fecal material stinks, you should smell a bucket of urine. It's enough to gag a maggot.

A neighbor of mine tried the separation method recommended in the book (defecating in one receptacle and urinating in another). However, the urine stank so bad that he couldn't continue to use this method without modifying the recommended system in some way. He said it was especially repulsive when he had to pour the urine from one container to another when applying it to the garden or compost pile. Now, my neighbor is a resourceful guy and he realized that all he had to do was fill a five-gallon bucket with *sawdust* and urinate in that to eliminate the odors. This worked so well that he wrote to the publisher suggesting this improvement to the method, but the publisher never responded.

In the Rodale Book of Composting (1992, Rodale Press, Emmaus, PA 18098), human feces is listed under "Materials to Avoid", where we are informed that *"human feces should not be used unless they have been properly treated and permitted to age sufficiently. Even then, concerns about disease pathogens make the use of such material dubious at best for the home gardener."*

Ironically, however, the best way to "properly treat" humanure is to thermophilically compost it, which destroys potential pathogens. When humanure is thermophilically composted and then left to age for a while, it makes a fine soil additive for the home gardener. Furthermore, humanure provides a source of nitrogen for compost-making that is available to all people. When that nitrogen source is discarded as waste, we not only lose an essential and critical compost ingredient and an agricultural resource, we also pollute the environment. Rather than perpetuate fecophobia by continuing to relentlessly portray humanure as dangerous and to be avoided, advocates of organic gardening would provide a greater service to society by objectively researching the merits of composted humanure for agricultural purposes.

For example, the World Health Organization Expert Committee on Environmental Sanitation stated at its third session in 1954 that *"the committee recognizes the widespread use, in many parts of the world, of human excreta as fertilizer . . . With the growing world population and the limited extent of world resources, all efforts to utilize sanitary by-products and return them to the soil should be encouraged. The necessity of controlling these activities in such a way as to reduce to an absolute minimum their inherent public health hazards cannot be too strongly emphasized"* (see Rybczynski et. al., 1982).

Granted, humanure can be dangerous. Drink some water polluted with fecal material that came from someone afflicted with typhoid or cholera. You'll soon find out how dangerous humanure can be when harboring disease organisms and polluting the environment. Cars can also be dangerous. Jump out in front of one on the highway some day and you'll see what I mean. Matches can be dangerous. Try lighting your bed sheets. No, don't. But do you get my point? There is potential danger everywhere. Humanure has the potential to be harmful too, but when *thermophilically composted* it is transformed into a friendly and valuable material.

Perhaps Gotaas (Composting, 1956, p.21) best sums it up: *"Van Vuren was unable to demonstrate any health hazards in properly managed [humanure] composting operations in South Africa. His findings are confirmed by Blair [South Africa]; Loots [South Africa]; Hamblin [South Africa]; Acharya [India]; Scharff [Malaya]; and others in Great Britain, Germany, Australia,, the Netherlands, Denmark, and New Zealand.*

HAVE A GOOD BLEND

A sawdust-filled receptacle makes a good urine depository, as my neighbor discovered, but it can also act as a receptacle for human fecal material. Instead of beginning with a full receptacle of sawdust as with the urine receptacle, the sawdust is added after each use so that *there's a clean layer on the top at all times.* Urine is added to the same receptacle. Sawdust is added after urination as well as after defecation, if needed. Then, when the bucket is full, the whole works goes on the compost pile - feces, urine and sawdust (which is saturated with urine). The bucket is then rinsed, and the rinse water also deposited on the compost pile. This, in essence, constitutes the collection process of an absolutely minimum technology hygienic toilet. Waste is completely eliminated using this routine, *but the humanure must be thermophilically composted in a responsible and conscientious manner.* That's the missing link that must be incorporated into the process. How?

At the risk of repeating myself, you must blend the humanure with a healthy mix of other materials if you want good finished compost. What constitutes a healthy mix? If you're a serious gardener, most of your food scraps and some of your garden refuse will do. A clean cover material (such as hay, straw or weeds) ices the cake. It's that simple. I compost everything in the way of organic refuse produced on my small (no livestock,) gardening homestead, in a bin that is approximately five feet by five feet and four feet high. Everything. This provides a nice mix which produces approximately 75 cubic feet of lovely compost each year. If your garden produces large quantities of weeds at times, pile the weeds *beside* the compost bin and use them for cover material *a little at a time* (see three-chambered bin designs on page 159). This subject will be discussed in detail in chapter seven.

Compost shrinks. Unbelievably. That 5x5 bin holds a year's worth of humanure (family of four), and a year's worth of everything else. We just keep piling it on and it just keeps shrinking down and down. We pile, it shrinks. When it's all done, it stops shrinking.

Toilet paper composts too. So do the cardboard tubes in the center of the rolls. Use unscented, undyed paper if you want to keep trace contaminants out of your compost. Unbleached, recycled paper is ideal. Or you can use the old fashioned toilet paper, otherwise known as corncobs. Popcorn cobs work best, they're softer. Corncobs don't compost very readily though, so you have a good excuse not to use them. There are other things that don't compost so well: eggshells, bones, hair, and woody stems, to name a few. We throw our eggshells back to our chickens, or into the woodstove. Bones (rare in our house) go into the woodstove, too, or to the cats or dog. Hair goes out to the birds for nests, if not into the compost pile.

And never put woody stemmed plants, such as tree saplings, on your compost pile. I hired a young lad to clear some brush for me one summer and he innocently put the small saplings on my compost pile without me knowing it. Later, I found them networked through the pile like iron reinforcing rods. I'll bet the lad's ears were itching that day - I sure had a lot of nasty things to say about him. Fortunately, only Gomer, the compost pile, heard me.

Applying thermophilically composted humanure to a raised bed garden in the springtime.

What about things like sanitary napkins and disposable diapers? Forget it. Sure, they'll compost, but they'll leave strips of plastic throughout your finished compost which is quite unsightly. Of course, that's OK if you don't mind picking the strips of plastic out of your compost. Otherwise, use cloth diapers and washable cloth menstrual pads instead.

Furthermore, it has been reported that food preserved with BHT should stay out of the compost pile, as research has shown that very small amounts of this antioxidant can alter plant growth profoundly.[13]

NEWSPAPER

What about newspapers? Yes, newspaper will compost, but there are some

The author probing a humanure compost pile in late winter. This compost had not yet become thermophilically active. Of the two thermometers, one has a long probe and the other a short one. PHOTO BY JEANINE JENKINS.

concerns about newsprint. For one, the glossy pages are covered with a clay that retards composting. For another, the inks can be petroleum-based solvents or oils with pigments containing toxic substances such as chromium, lead and cadmium in both black and colored inks. Pigment for newspaper ink still comes from benzene, toluene, naphthalene and other benzene ring hydrocarbons which may be quite harmful to human health if accumulated in the food chain. Fortunately, quite a few newspapers today are using soy-based inks instead of petroleum-based inks.** If you really want to know about the type of ink in your newspaper, call your newspaper office and ask them. Otherwise, don't use glossy paper or colored pages in your compost and keep the newspaper to a minimum. Remember, ideally, compost is being made to use for producing human food. One should try to keep the contaminants out of it if possible.[14]

On the other hand, Wood's End Laboratory in Maine did some research on composting ground up telephone books and newsprint, which had been used as bedding for dairy cattle. The ink in the paper contained common carcinogenic chemicals, but after composting it with dairy cow manure, the dangerous chemicals were reduced by 98%.[15] So it appears that if you're using shredded newspaper for bedding under livestock, you *should* compost it, if for no other reason than to eliminate some of the toxic elements from the newsprint. It'll probably make acceptable compost too, especially if layered with garbage, manure and the like.

LIME

One other thing. It is not necessary to put lime (ground agricultural limestone) on your compost pile. The belief that compost piles must be limed is a common misconception. Nor are other mineral additives needed on your compost. If your soil needs limed, put the lime on your soil, not your compost. Bacteria don't digest limestone. Why ruin their day? My compost is not acidic, even with the use of sawdust. The pH of my finished compost slightly exceeds 7 (neutral). I never put lime on my pile. I once put all my wood ashes on my compost pile, but in recent years I've put my wood ashes straight on my soil. The compost pile doesn't need them. Even without the wood ashes, the potassium content of my finished compost is more than adequate and the pH is good. It may seem logical that one should put into one's compost pile whatever one also wants to put into one's garden soil, as the compost will end up in the garden eventually, but that's not the reality of the situation. *What one should put into one's compost is what the microorganisms in the compost want or need, not what the garden soil wants or needs.*

According to a 1991 report, scientists who were studying various commercial fertilizers found that agricultural plots to which composted sewage sludge had been

ESSENTIAL READING FOR INSOMNIACS

pH: pH LITERALLY MEANS HYDROGEN POWER. It is a measure of the degree of alkalinity or acidity of a solution, and is often expressed as the logarithm of the reciprocal of the hydrogen ion concentration in gram equivalents per liter of solution: pH7= .0000001 gram atom of hydrogen per liter. Pure distilled water is regarded as neutral with a pH of 7. pH values from 0 to 7 indicate acidity, and from 7 to 14 indicate alkalinity.

0 acidic 7 alkaline 14

neutral

added made better use of lime than plots without composted sludge. The lime in the composted plots changed the pH deeper in the soil, indicating that organic matter assists calcium movement through the soil *"better than anything else"* according to Cecil Tester, Ph.D., research chemist at USDA's Microbial Systems Lab in Beltsville, MD.[16] The implications are that compost should be added to the soil when lime is added *to the soil.*

Sir Albert Howard, one of the most well-known proponents of composting, as well as J. I. Rodale, another organic gardening great, have recommended adding lime to compost piles.[17] They seemed to base their reasoning on the belief that the compost will become acidic during the composting process, and therefore the acidity must be neutralized by adding lime to the pile while it's composting. It may well be the case that compost becomes acidic during the process of decomposition, however, my experience shows me that it seems to neutralize itself if left alone, yielding a neutral end product. Therefore, I'd recommend that you make sure you need to neutralize the pH of your compost before you jump to the conclusion that you do. You can do that by testing your *finished* compost for pH.

I find it ironic that the same author who has recommended liming compost piles in one book (Rodale, as mentioned above), states in another, *"The control of pH in composting is seldom a problem requiring attention if the material is kept aerobic . . . the addition of alkaline material is rarely necessary in aerobic decomposition and, in fact, may do more harm than good because the loss of nitrogen by the evolution of ammonia as a gas will be greater at the higher pH."*[18] In other words, don't assume that you should lime your pile. Only do so if your finished compost is consistently acidic. Get a soil pH test kit and check it out.

What is pH? It's a measure of acidity and alkalinity. pH ranges from 1 - 14. Neutral is 7. Below seven is acidic, above seven is basic (alkaline). If the pH is too acidic or too alkaline bacterial activity will be hindered or stopped completely. Lime and wood ashes raise the pH. This is where things could get complicated, taking us into the domain of the chemist rather than the composter.

How does one become an accomplished composter, a master composter? That's easy - just do it. Then keep doing it. Throw the books away (not this one, of course) and get some good, old-fashioned experience. There's no better way to learn. Book learning will only get you so far, but not far enough. There's nothing worse than someone who's read a lot of books and thinks s/he knows everything. A book such as the one you're now reading is for inspiring you, for sparking your interest, and for reference. But you have to get out there and do it if you really want to learn.

One's best bet is to work with the compost, get the feel of the process, look at your compost, smell the finished product, buy or borrow a compost thermometer and get an idea of how well your compost is heating up, then use your compost for food production. Rely on your compost. Make it a part of your life. Need it and value it. In no time, without the need for charts or graphs, Ph.D.s, or worry, your compost will be as good as the best of them. Perhaps someday we'll be like the Chinese who give prizes for the best compost in a county, then have inter-county competitions. Now *that's* getting your shit together.

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*Adelle Davis was a popular nutritionist in the 1960's and 70's who advocated that people take dietary supplements to replace the lack of nutrition in the typical refined-food American diet. Much of what she wrote about in her list of books was on target. However, she also contended that a healthy person's shit won't stink. Dead wrong on that one, Adelle.

**** Contact the National Soy Ink Information Center, c/o Iowa Soybean Association, 1025 Ashworth Road, No. 310, West Des Moines, Iowa 50265-3542.**

DEEP SHIT

"I do not think that any civilization can be called complete until it has progressed from sophistication to unsophistication, and made a conscious return to simplicity of thinking and living."
Lin Yutang

The Asian people have recycled humanure for thousands of years. Why haven't we? This is a philosophical question which should be delved into. Now let's think about this for a second. The Asian cultures, namely Chinese, Korean, Japanese and others have evolved to understand human excrement to be a natural resource. Smelly perhaps, but not to be wasted, nor to be conceived of as a waste material. We have human waste, they have humanure (also known as night soil). We produce waste and pollution, they produce soil nutrients and food. It's clear to me that the Asians are more advanced than the Western world in this regard. And they should be, they've been working on developing sustainable lifestyles, especially sustainable agriculture for four thousand years on the same land. For four thousand years those people have worked the same land with little or no chemical fertilizers and, in many cases, have produced greater crop yields than Western farmers, the same farmers who are quickly destroying the soils of their own countries through depletion and erosion.

Here is a fact largely being ignored by people in Western agriculture: *agricultural land must produce a greater output over time because the human population is constantly increasing, but available agricultural land is not. Therefore, our farming practices should leave us with land more fertile with each passing year.* Nevertheless, we are doing just the opposite.

Back in 1938, the U.S. Department of Agriculture came to the alarming conclusion that *a full 61% of the total area under crops in the U.S. at that time had been completely or partly destroyed, or had lost most of its fertility.*[1] Nothing to worry about? We have artificial fertilizers, tractors, and oil to keep it all going? True, U.S. agriculture is heavily dependent upon fossil fuel resources. However, in 1993 we were importing about half our oil from foreign sources, and it's estimated that the U.S. will be out of domestic oil reserves by the year 2020. Some sources also report that the U.S. will be unable to export food beyond the year 2000.[2] If this is true, then a heavy dependence on foreign oil for our food production seems unwise at best, and probably just plain foolish, especially when we're producing soil nutrients every day in the form of organic refuse, then throwing those nutrients "away" by burying them in landfills.

Now, it seems to me that if we want to learn something about sustainability, we would look to those people who are doing it. The Chinese have it figured out: *waste not, want not.* But there's a lot more to it than that.

Why don't we follow the Asian example? It's not for a lack of information. Dr. F. H. King wrote an interesting book, published in 1910 and titled Farmers of Forty Centuries[3]. Dr. King (D.Sc.) was a former chief of the Division of Soil Management of the U.S. Department of Agriculture who traveled through Japan, Korea and China in the early 1900's as an agricultural visitor. He was interested in finding out how people could farm the same fields for 4,000 years without destroying their fertility. He states:

"One of the most remarkable agricultural practices adopted by any civilized people is the centuries long and well nigh universal conservation and utilization of all human waste [sic] in China, Korea and Japan, turning it to marvelous account in the maintenance of soil fertility and in the production of food. To understand this evolution it must be recognized that mineral fertilizers so extensively employed in modern Western agriculture has been a physical impossibility to all people alike until within very recent years. With this fact must be associated the very long unbroken life of these nations and the vast numbers their farmers have been compelled to feed.

When we reflect upon the depleted fertility of our own older farm lands, comparatively few of which have seen a century's service, and upon the enormous quantity of mineral fertilizers which are being applied annually to them in order to secure paying yields, it becomes evident that the time is here when profound consideration should be given to the practices the Mongolian race has maintained through many centuries, which permit it to be said of China that one-sixth of an acre of good land is ample for the maintenance of one person, and which are feeding an average of three people per acre of farm land in the three southernmost islands of Japan.

[Western humanity] is the most extravagant accelerator of waste the world has ever endured. His withering blight has fallen upon every living thing within his reach, himself not excepted; and his besom of destruction in the uncontrolled hands of a generation has swept into the sea soil fertility which only centuries of life could accumulate, and yet this fertility is the substratum of all that is living."[4]

According to King's research, the average daily excreta of the adult human weighs in at 40 ounces. Multiplied by 250 million, a rough estimate of the current U.S. population, Americans each year produce 1,448,575,000 pounds of nitrogen, 456,250,000 pounds of potassium, and 193,900,000 pounds of phosphorous, almost all of which is discarded into the environment as a waste material and a pollutant, or as Dr. King puts it, *"poured into the seas, lakes or rivers and into the underground waters."*

According to King, *"The International Concession of the city of Shanghai, in 1908, sold to a Chinese contractor the privilege of entering residences and public places early in the morning of each day and removing the night soil, receiving therefor more than $31,000 gold, for 78,000 tons of waste [sic]. All of this we not only throw away but expend much larger sums in doing so."*

In case you didn't catch that, the contractor *paid* $31,000 gold *for* the humanure, referred to as "night soil" and incorrectly as "waste" by Dr. King.

Furthermore, using Dr. King's figures, the U.S. population today produces approximately 228,125,000,000 pounds of fecal material annually. That's 228 billion pounds. You could call that the *Gross National Shit.*

Admittedly, the spreading of raw human excrement on fields, as is done in Asia, will probably never become culturally acceptable in the United States, and rightly so. The use of night soil in this regard produces an assault to the sense of smell, and provides a vector for various human pathogens (disease organisms). Americans who have traveled abroad and witnessed the use of raw human excrement in agricultural applications have largely been repulsed by the experience. That repulsion has instilled among many Americans an intransigent bias against, and even a fear of the use of humanure for soil enrichment. However, few Americans have witnessed the *composting* of humanure as a preliminary step in its recycling. Proper thermophilic composting converts humanure into a pleasant smelling material devoid of human pathogens.

Although the agricultural use of raw human excrement will never become a common practice in the U.S., the use of composted human refuse, including humanure, food refuse, and other organic municipal refuse such as leaves, can and should become a widespread and culturally encouraged practice in the United States. The act of composting humanure instead of using it raw will set Americans apart from Asians in regard to the recycling of human excrements, *for we too will have to constructively deal with all of our refuse materials eventually.* We can put it off, but not forever. As it stands now, at least the Asians are recycling their refuse. We're not.

WASTE VS. MANURE, AGAIN

Human *waste* is human excrement *that is not recycled.* A waste material is something *with no inherent value*. Waste is something we believe to be useless and we discard it. People who recycle things are not wasting them. People who compost their manure do not produce human waste in the form of body excrements.

Sorry, I know it's a hard concept to grasp, that human waste is *something we create by choice*. In the English language today, human waste is synonymous with human feces and urine. Eventually, this will change. We don't necessarily create human waste naturally. We produce human manure naturally. What we do with it constitutes whether it's waste or not. Now this may seem like a trivial matter to some. You've always known fecal material to be human waste, therefore you'll always call it human waste.

On the other hand, you may be capable of advancing your understanding. As understanding and consciousness change, so does language change. In the same way that the word "man" is no longer appropriate when referring to the human race because we've finally figured out that half of the human race is made up of women, human "waste" is no longer appropriate when referring to humanure, unless that manure is being wasted (which, in the USA, it usually is). There's no reason why we can't clarify our terms, evolve our language a bit, and thereby enhance communication and understanding.

What is human waste? Human waste is cigarette butts, empty beer cans lying along the road, plastic six-pack rings, styrofoam clamshell burger boxes, deodorant cans, disposable diapers, discarded appliances, discarded pop bottles, newspapers, old car tires, spent batteries, junk mail, nuclear garbage, convenience foods, exhaust emissions, the five billion gallons of drinking water we flush down our toilets every day, and the millions of tons of organic refuse discarded into the environment year after year after year.

My household produces one bag of waste, i.e. non-recyclable junk, every two months. Six garbage bags a year that end up in a landfill. I believe that's excessive. It's waste and my family produces it. Let's face it - six bags a year in fifty years means we've "thrown" 300 bags out into the environment. If those all stayed in my own backyard I'd eventually be living by a small mountain of garbage. Our consumption of electricity, use of internal combustion engines, and consumption of consumer goods also add to the waste my family contributes to our ecosystem. Unfortunately, in the United States we take waste for granted. It's a way of life, one promoted by our government and our business leaders and one far removed from the harmonious existence with our planet that a sustainable future requires of us. "Waste reduction - resource recovery" will not be meaningful words to Americans unless they're spoken, written, published, and most importantly, lived.

THE ADVANCES OF SCIENCE

How is it that the Asian peoples developed an excellent understanding of human nutrient recycling which pervades their collective consciousness and is completely accepted and taken for granted, and we haven't? After all, we're the advanced, developed, scientific nation, aren't we? Dr. King makes an interesting observation concerning scientists. He states:

"It was not until 1888, and then after a prolonged war of more than thirty years, generaled by the best <u>*scientists*</u> *of all Europe, that it was finally conceded as demonstrated that leguminous plants acting as hosts for lower organisms living on their roots are largely responsible for the maintenance of soil nitrogen, drawing it directly from the air to which it is returned through the processes of decay. But centuries of* <u>*practice*</u> *had taught the Far East farmers that the culture and use of these crops are essential to enduring fertility, and so in each of the three countries the growing of legumes in rotation with other crops very extensively, for the express purpose of fertilizing the soil, is one of their old fixed practices."*[5] [Emphasis mine.]

In our culture we believe we have to wait for the experts to figure things out before we can claim any real knowledge. This appears to have put us several centuries behind the Asians. It certainly seems odd to me that people who gain their knowledge in real life through practice and experience are shunned, ignored or trivialized by the academic world and associated government agencies. Such agencies will only credit learning that has taken place within their institutional framework. As such, it's no wonder that Western humanity's crawl toward a sustainable existence on the planet Earth is so pitifully slow.

"Strange as it may seem, says King, *there are not today and apparently never have been, even in the largest and oldest cities of Japan, China or Korea, anything corresponding to the hydraulic systems of sewage disposal used now by Western nations. When I asked my interpreter if it was not the custom of the city during the winter months to discharge its night soil into the sea, as a quicker and cheaper mode of disposal [than recycling], his reply came quick and sharp, 'No, that would be waste. We throw nothing away. It is worth too much money.'*[6] *The Chinaman,* says King, *wastes nothing while the sacred duty of agriculture is uppermost in his mind."*[7]

Perhaps, a few centuries from now, our scientific community will understand.

HOLY SHEESH

Here I must propose some philosophical speculation. My theory is this: the

Asians evolved over the millennia with a spiritual perspective that maintained, to some extent, a view of the earth, and of nature, as sacred. This was a relatively holistic spiritual perspective which did not single out the human race as being the pinnacle of creation, but instead recognized the totality of interconnected existence as sacred, and advocated human harmony with the Whole.

Now contrast this to our Western religious heritage which taught us that divinity lies only in the human form, and that peoples who revere nature are "pagans", "heathens", "witches" and worse. Admittedly, this is a broad and contentious topic, too broad for the scope of this book. Perhaps a few quotes here, however, will help to illustrate my point.

Hinduism, more common to India, but reaching into the Far East, seemed to be sensitive to the sanctity of the natural world:

"He who tries to give an idea of God by mere book learning is like the person who tries to give an idea of the city of Benares by means of a map or a picture." (Shri Ramakrishna)[8]

"When Svetaketu, at his father's bidding, had brought a ripe fruit from the banyan tree, his father said to him, Split the fruit in two, dear son.

Here you are. I have split it in two.

What do you find there?

Innumerable tiny seeds.

Then take one of the seeds and split it.

I have split the seed.

And what do you find there?

Why, nothing, nothing at all.

Ah, dear son, but this great tree cannot possibly come from nothing. Even if you cannot see with your eyes that subtle something in the seed which produces this mighty form, it is present nonetheless. That is the power, that is the spirit unseen, which pervades everywhere and is all things. Have faith! That is the spirit which lies at the root of all existence, and that also art thou, O Svetaketu." (Chandogya Upanishad)[9]

Buddhism is a dominant influence in vast sections of Asia:

"May all living things be happy and at their ease! May they be joyous and live in safety! All beings, whether weak or strong - omitting none - in high, middle, or low realms of existence, small or great, visible or invisible, near or far away, born or

to be born - may all beings be happy and at their ease! Let none deceive another, or despise any being in any state; let none by anger or ill will wish harm to another! Even as a mother watches over and protects her only child, so with a boundless mind should one cherish all living beings, radiating friendliness over the entire world, above, below and all around without limit; so let him cultivate a boundless good will toward the entire world, uncramped, free from ill will or enmity." (the Metta Sutra)[10]

Zen is a transliteration of the Sanskrit word "dyhana" meaning meditation, or more fully "contemplation leading to a higher state of consciousness", "union with Reality". It can be described as a blend of Indian mysticism and Chinese naturalism with a Japanese influence:

"When the mind rests serene in the oneness of things . . . dualism vanishes by itself." (from the Hsis-hsis-ming by Seng-ts'an)[11]

"Zen does not go along with the Judaic-Christian belief in a personal savior or a God - outside the Universe - who has created the cosmos and the human race. To the Zen view, the Universe is one indissoluble substance, one total whole, of which humanity is a part." (Nancy Wilson Ross)[12]

Confucius, like Buddha, was born in the sixth century B.C. and preached a philosophy of common Chinese virtue:

"The path of duty lies in what is near and people seek for it in what is remote. The work of duty lies in what is easy and people seek for it in what is difficult." (Confucius)[13]

The Tao (the way), written by Lao Tsu, a contemporary of Confucius, has provided one of the major underlying influences in Chinese thought and culture for 2,500 years:

"Those who know do not talk. Those who talk do not know. Keep your mouth closed. Guard your senses. Temper your sharpness. Simplify your problems. Mask your brightness. Be at one with the dust of the earth. This is primal union. He who has achieved this state is unconcerned with friends and enemies, with good and harm, with honor and disgrace. This therefore is the highest state of humanity." (Lao Tsu)[14]

Christianity, the primary religious influence of the Western world, strongly supported the idea that humans were separate from and dominant over the natural world:

"And God said, Let us make man in our image, after our likeness, and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth on the earth. . . And God blessed them, and God said unto them, Be fruitful and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth." (the Bible)[15]

Far Eastern culture is imbued with the concepts of oneness, with the belief that the highest state of human evolution is one of harmony and peace with one's inner self and with one's outer reality, i.e. the natural world, one's society, the Universe. This would certainly seem to contribute to the development of sustainable agricultural methods. When one accepts the sacredness of life, one can easily understand why one should create compost and soil rather than waste and pollution.

WHEN THE CRAP HIT THE FAN

While the Asians were practicing sustainable agriculture and recycling their organic resources and doing so over a period of millennia, what were the people of the West doing? What were the Europeans and those of European descent doing? Why weren't our ancestors returning their manures to the soil too? After all, it does make sense. The Asians who recycled their manures not only recovered a resource and reduced pollution, but by returning their excrement to the soil they succeeded in reducing threats to their health. There was no putrid sewage collecting and breeding disease germs. Instead the humanure was, for the most part, undergoing a natural, non-chemical purification process in the soil which required no technology.

Granted, a lot of "night soil" in the Far East today is not completely composted or composted at all, and is the source of health problems in Asia. However, even the returning of humanure raw to the land succeeds in destroying many human pathogens in the manure, and returns nutrients to the soil. We'll get more into this later. Let's take a look at what was happening in Europe from, say, the 1300's on, regarding public hygiene.

Great pestilences swept Europe throughout recorded history. The Black Death killed more than half the population of England in the fourteenth century. In 1552, 67,000 patients died of the Plague in Paris alone. Fleas from infected rats were the carriers of this disease. Did the rats dine on human waste? Other pestilences included the sweating sickness (attributed to uncleanliness), cholera (spread by food and water contaminated by the excrement of infected persons), "jail fever" (caused by a lack of sanitation in prisons), typhoid fever (spread by water contaminated with infected feces), and numerous others.

Andrew D. White, cofounder of Cornell University, writes, *"Nearly twenty centuries since the rise of Christianity, and down to a period within living memory, at the appearance of any pestilence the [Christian] Church authorities, instead of devising sanitary measures, have very generally preached the necessity of immediate atonement for offenses against the Almighty. In the principal towns of Europe, as well as in the country at large, down to a recent period, the most ordinary sanitary precautions were neglected, and pestilences continued to be attributed to the wrath of God or the malice of Satan.'"*[16]

It's now known that the main cause of such immense sacrifice of life was a lack of proper hygienic practices. It's argued that certain theological reasoning at that time resisted the evolution of proper hygiene. According to Mr. White, *"For century after century the idea prevailed that filthiness was akin to holiness."* Living in filth was regarded by holy men as an evidence of sanctity, according to Mr. White, who lists numerous saints who never bathed parts or all of their bodies, such as St. Abraham, who washed neither his hands nor his feet for fifty years, or St. Sylvia, who never washed any part of her body save her fingers.[17]

Interestingly, after the Black Death left its grim wake across Europe, *"an immensely increased proportion of the landed and personal property of every European country was in the hands of the church.'"*[18] Apparently, the church was reaping some benefit from the deaths of huge numbers of people. Perhaps the church had a vested interest in maintaining public ignorance about the sources of disease. This insinuation is almost too diabolical for serious consideration. Or is it?

Somehow, the idea developed around the 1400's that Jews and witches were causing the pestilences. Jews were suspected because they didn't succumb to the pestilences as readily as the Christian population did, presumably because they employed a unique sanitation system more conducive to cleanliness, including the eating of kosher foods. Not understanding this, the Christian population arrived at the conclusion that the Jew's immunity resulted from protection by Satan. As a result, attempts were made in all parts of Europe to stop the plagues by torturing and murdering the Jews. Twelve thousand Jews were reportedly burned to death in Bavaria alone during the time of the plague, and additionally thousands more were likewise killed throughout Europe.[19]

In 1484, the "infallible" Pope Innocent VIII issued a proclamation supporting the church's opinion that witches were causes of disease, storms, and a variety of ills affecting humanity. The feeling of the church was summed up in one sentence: *"Thou shalt not suffer a witch to live."* From the middle of the sixteenth to the middle of the seventeenth centuries, women and men were sent to torture and death by the thousands, by both Protestant and Catholic authorities. It's estimated that the number of victims sacrificed during that century in Germany alone was over a hundred thousand.

The following case in Milan, Italy summarizes the ideas of sanitation in Europe during the seventeenth century:

The city was under the control of Spain, and had received notice from the Spanish government that witches were suspected of being on the way to Milan to "anoint the walls" (smear the walls with disease-causing ointments). The church rang the alarm from the pulpit, putting the population on the alert. One morning, in 1630, an old woman looking out of her window saw a man who was walking along the street wipe his fingers on a wall. He was promptly reported to the authorities to whom he claimed he was simply wiping ink from his fingers which had rubbed off the ink-horn he carried with him. Not satisfied with this explanation, the authorities threw the man into prison and tortured him until he "confessed". The torture continued until the man gave the names of his "accomplices", who were subsequently rounded up and tortured. They in turn named their "accomplices" and the process continued until members of the foremost families were included in the charges. Finally, a large number of innocent people were sentenced to their deaths, which is all reportedly a matter of record.[20]

One loathsome disease of the 15-1700's was the jail fever. The prisons of that period were filthy; people were confined in dungeons connected to sewers with little ventilation or drainage. Prisoners incubated the disease and spread it to the public, especially the police, lawyers and judges. In 1750, for example, the disease killed two judges, the lord mayor, various aldermen and many others in London, not to mention prisoners.[21]

The pestilences at that time in the Protestant colonies in *America* were also attributed to divine wrath or satanic malice, but when the pestilences afflicted the Native Americans, they were considered acts of divine mercy. *"The pestilence among the Indians, before the arrival of the Plymouth Colony, was attributed in a notable work of that period to the Divine purpose of clearing New England for the heralds of the gospel."*[22]

Well, let's not get too far off the track. But perhaps the reason the Asian countries have such large populations in comparison to Western countries is because they escaped some of the pestilences common to Europe, especially pestilences spread by the failure to responsibly recycle human excrement. They presumably plowed their manure back into the land because their spiritual perspectives supported such behavior. Westerners were too busy burning witches and Jews with the church's wholehearted assistance to bother to think about recycling humanure.

Our ancestors did eventually come to understand that poor hygiene was a causal factor in epidemic diseases. Nevertheless, it was not until the late 1800's in England that improper sanitation and sewage were suspected as causes of epidemics. At that time, large numbers of people were still dying from pestilences, especially cholera, which killed at least 130,000 people in England in 1848-9 alone. In 1849, an English medical practitioner published the theory that cholera was spread by water contaminated with sewage. Ironically, even where sewage was being piped away from the population, the sewers were still leaking into drinking water supplies.

The English government couldn't be bothered with the fact that hundreds of thousands of (mostly poor) citizens were perishing like flies year after year. So it rejected a Public Health Bill in 1847. A Public Health Bill finally became an act in 1848 in the face of the latest outbreak, but wasn't terribly effective. However, it did bring poor sanitation to the attention of the public, as the following statement from the General Board of Health (1849) implies: *"Householders of all classes should be warned that their first means of safety lies in the removal of dung heaps and solid and liquid filth of every description from beneath or about their houses and premises."* This may make one wonder if a compost heap would have been considered a "dung heap" in those days, and therefore banned.

The wealthy folks, including the Tories or "conservatives" of the English government still thought that spending on social services was a waste of money and an unacceptable infringement by the government on the private sector (sound familiar?). A leading newspaper, "The Times", maintained that the risk of cholera was preferable to being bullied by the government. However, a major act was finally passed in 1866, the Public Health Act, with only grudging support from the Tories. Once again, cholera was raging through the population, and it's probably for that reason that any act was passed at all. Finally, by the end of the 1860's, a framework of public health policy was established in England. Thankfully, that cholera epidemic of 1866 was the last and the least disastrous.[23]

The powers of the church eventually diminished enough for scientists to have their much delayed say about the origins of disease. Today, the church no longer remains such an insurmountable obstacle to the progress of society, and in many cases acts as a force of hope for peace, justice, and even environmental awareness in the Western world. Our modern sanitation systems have yielded a life safe for most of us, although not without shortcomings. The eventual solution developed by the West was to collect humanure in water and discard it, perhaps chemically treated and dehydrated, in the seas, on the surface of the land, and in landfills, somewhere away from population centers.

Finally, I'm not naive enough to suggest that the Asian societies are perfect by any stretch of the imagination. Asian history is rife with the problems that have plagued humanity since the first person hatched out of the first egg. You know what I mean: wars, oppressive rule by the rich, more war, famine, natural catastrophes, oppressive rule by heathens, more war, and now overpopulation. There is also ample evidence of diseases and parasites afflicting the Asian peoples even to this day. However, the causes of the health problems that are linked to human excrement most likely stem from the failure to responsibly compost it. Not all Asian families strive to attain impeccably clean surroundings, and they pay for their lax habits with poor health. That is a universal problem.

I'll leave you with a quote from Dr. Arthur Stanley, health officer of the city of Shanghai, China, in his annual report for 1899, when the population of China amounted to about 500 million people, roughly double that of the U.S. today, and no artificial fertilizers were being employed for agricultural purposes - only organic, natural materials such as agricultural residues and humanure were being used:

"Regarding the bearing on the sanitation of Shanghai of the relationship between Eastern and Western hygiene, it may be said, that if prolonged national life is indicative of sound sanitation, the Chinese are a race worthy of study by all who concern themselves with public health. It is evident that in China the birth rate must very considerably exceed the death rate, and have done so in an average way during the three or four thousand years that the Chinese nation has existed. Chinese hygiene, when compared to medieval English, appears to advantage."[24]

Sounds like an understatement to me.

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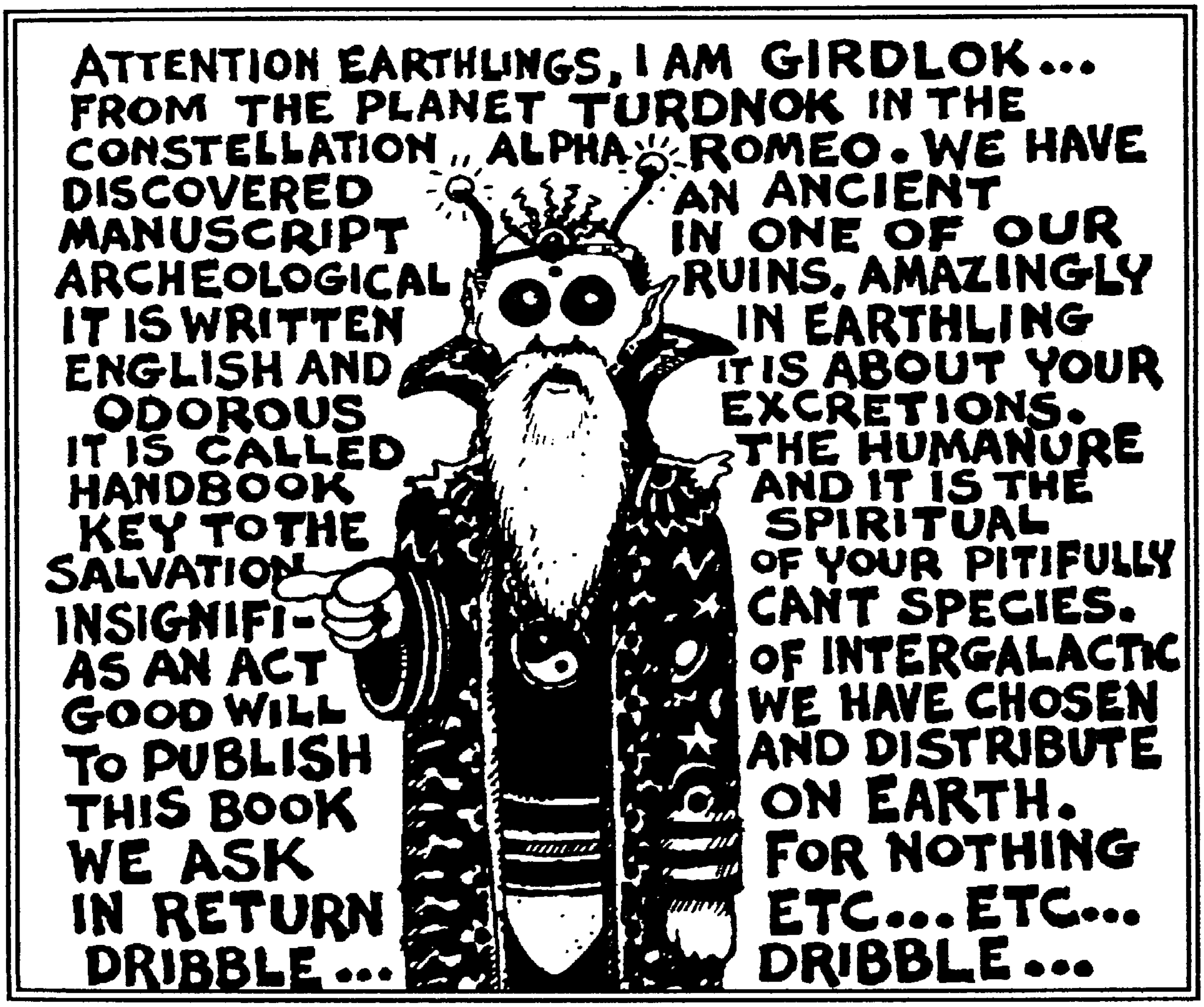

ATTENTION EARTHLINGS, I AM GIRDLOK...
FROM THE PLANET TURDNOK IN THE
CONSTELLATION ALPHA ROMEO. WE HAVE
DISCOVERED AN ANCIENT
MANUSCRIPT IN ONE OF OUR
ARCHEOLOGICAL RUINS. AMAZINGLY
IT IS WRITTEN IN EARTHLING
ENGLISH AND IT IS ABOUT YOUR
ODOROUS EXCRETIONS.
IT IS CALLED THE HUMANURE
HANDBOOK AND IT IS THE
KEY TO THE SPIRITUAL
SALVATION OF YOUR PITIFULLY
INSIGNIFI- CANT SPECIES.
AS AN ACT OF INTERGALACTIC
GOOD WILL WE HAVE CHOSEN
TO PUBLISH AND DISTRIBUTE
THIS BOOK ON EARTH.
WE ASK FOR NOTHING
IN RETURN ETC... ETC...
DRIBBLE... DRIBBLE...

A DAY IN THE LIFE OF A TURD

"Civilization is a limitless multiplication of unnecessary necessaries."
Mark Twain

"Most of the luxuries, and many of the so-called comforts of life, are not only not indispensable, but positive hindrances to the elevation of [humanity]."
Henry David Thoreau

I remember when I was a kid and veterans would talk about their stints in the Korean war. Usually after a beer or two they'd turn their conversation to the "outhouses" used by the Koreans. They were amazed, even mystified about the fact that the Koreans tried to lure passers-by to use their outhouses by making the toilets especially attractive. The idea of someone wanting someone else's shit always brought out a good guffaw from the vets. Only a groveling, impoverished, backward gink would stoop so low as to beg for a turd. Haw, Haw.

Perhaps this attitude sums up the consciousness of Americans. Humanure is a waste product, plain and simple. We have to get rid of it and that's all there is to it. Only fools and scoundrels would think otherwise. One of the effects of this sort of consciousness is that Americans don't know and probably don't care where their organic refuse goes after it emerges from their backsides, so long as they don't have to deal with it.

MEXICAN BIOLOGICAL DIGESTER

Well, where it goes depends on the type of "waste disposal system" used. Let's start with the simplest: the Mexican biological digester, also known as the stray dog. In India this may be known as the stray pig (see figure 4.1). I spent a few months in southern Mexico in the late 70's in Quintana Roo on the Yucatan peninsula. There, toilets were not available and people simply used the sand dunes on the coast. No problem though, one of the small, unkempt, and ubiquitous Mexican dogs

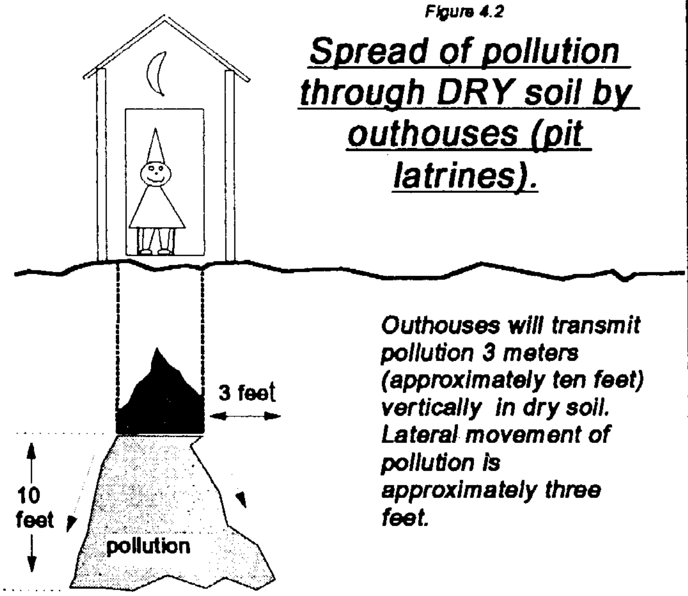
Biological Digester-
South India
Figure 4.1

would wait nearby with watering mouth until you've done your thing. Burying your excrement in that situation would have been an act of disrespect to the dog. No one wants sand in their food. A good, healthy, steaming turd at the crack of dawn on the Caribbean coast never lasted more than 60 seconds before it became a hot meal for a human's best friend. Yum.

THE OLD-FASHIONED OUTHOUSE

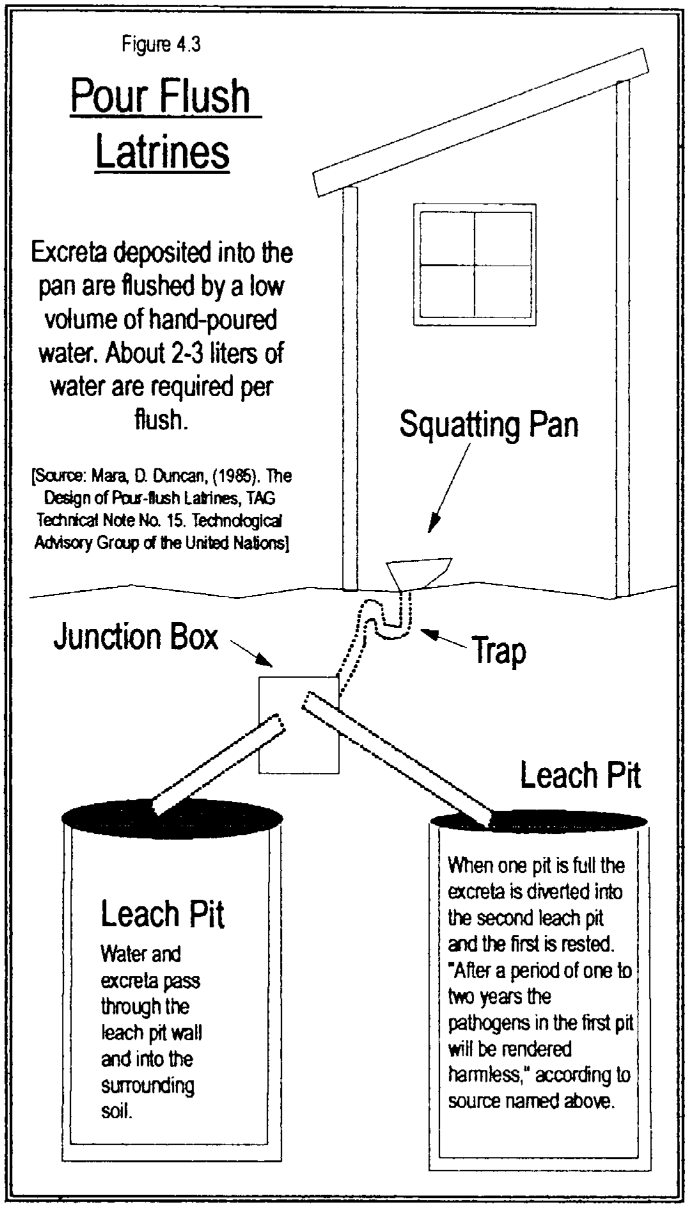
Next up the ladder of sophistication is the old-fashioned outhouse, which is also known as the pit latrine. Simply stated, one digs a hole and defecates in it, and then does so again and again until the hole fills up. It's nice to have a small building (privy) over the hole to provide some privacy and to keep the elements off. However, the concept is simple: dig a hole and bury your excrement. Interestingly, this level of sophistication has not yet been surpassed in America. We still bury our excrement, in the form of sewage sludge, in landfill holes. But I'm getting ahead of myself again.

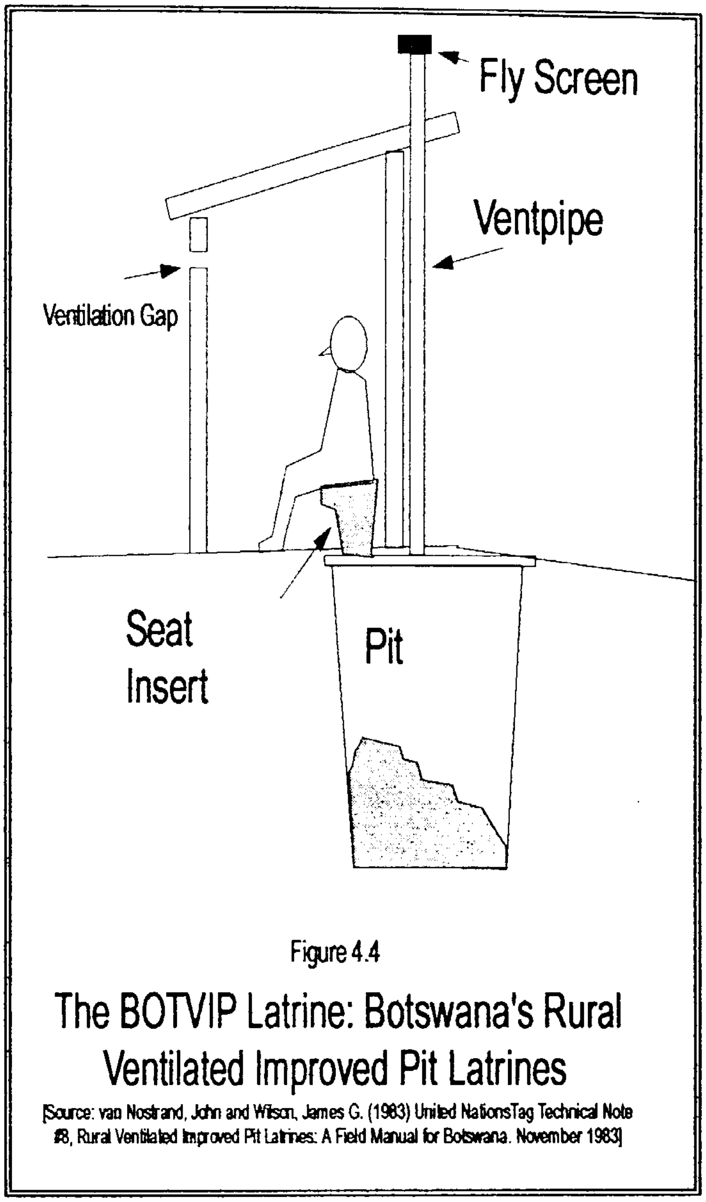
Figure 4.2



Source: Rybczynski et. al. (1982). Appropriate Technology for Water Supply and Sanitation - Low-Cost Technology Options for Sanitation, A State of the Art Review and Annotated Bibliography. World Bank, Transportation and Water Department (p. 52).

The first farmhouse I lived in during the mid-seventies had an outhouse behind it and no plumbing whatsoever. What I remember most about the outhouse is the smell, which could be described as quite undesirable, to say the least. The flies and wasps weren't very inviting either, and of course the cold weather made the process of "going to the bathroom" uncomfortable. When the hole filled up, I simply dug another hole twenty feet away from the first and dragged the outhouse from one hole to the other. The dirt from the second hole was used to cover the first. The excrement was left in





the ground, probably to contaminate groundwater. Of course, I didn't know I might be contaminating anything because, as I've stated earlier, I had just graduated from college and was quite ignorant about practical matters. Therefore, I plead not guilty to environmental pollution on the grounds of a college education.

Outhouses create very real health, environmental and aesthetic problems. The hole in the ground is accessible to flies and mosquitoes which can transmit disease over a wide area. The pits leak pollutants into the ground even in dry soil. And the smell. *Hold your nose.*

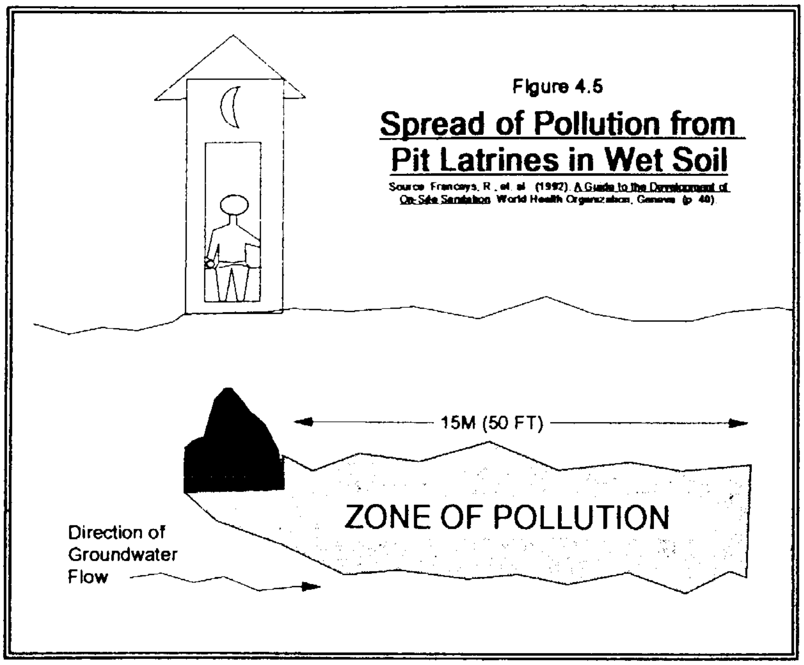


Figure 4.5

Spread of Pollution from Pit Latrines in Wet Soil

Source Franceys, R., et. al. (1992). A Guide to the Development of On-Site Sanitation. World Health Organization, Geneva (p. 40).

SEPTIC SYSTEMS

Another step up on the sophistication ladder one finds the septic tank, which is a common method of human waste disposal in rural and suburban areas of the United States. In this technique of organic waste disposal, the turd is deposited into a container of water, usually pure drinking water such as in a toilet, and the water is piped away.

After the turd, now carried by the water, travels away from the house inside a sewage pipe, it plops into a fairly large underground storage tank, or septic tank, which is usually made of concrete and sometimes of fiberglass. In Pennsylvania (USA), a 900 gallon tank is the minimum size allowed for a home with three or fewer bedrooms.[1] The heavier solids settle to the bottom of the tank and the liquids continue on to drain off into a leach field, which consists of an array of drain pipes situated below the ground surface allowing the liquid to seep out into the soil (see figures 4.6 and 4.7). While in the tank, the wastewater should be undergoing anaerobic decomposition. If septic

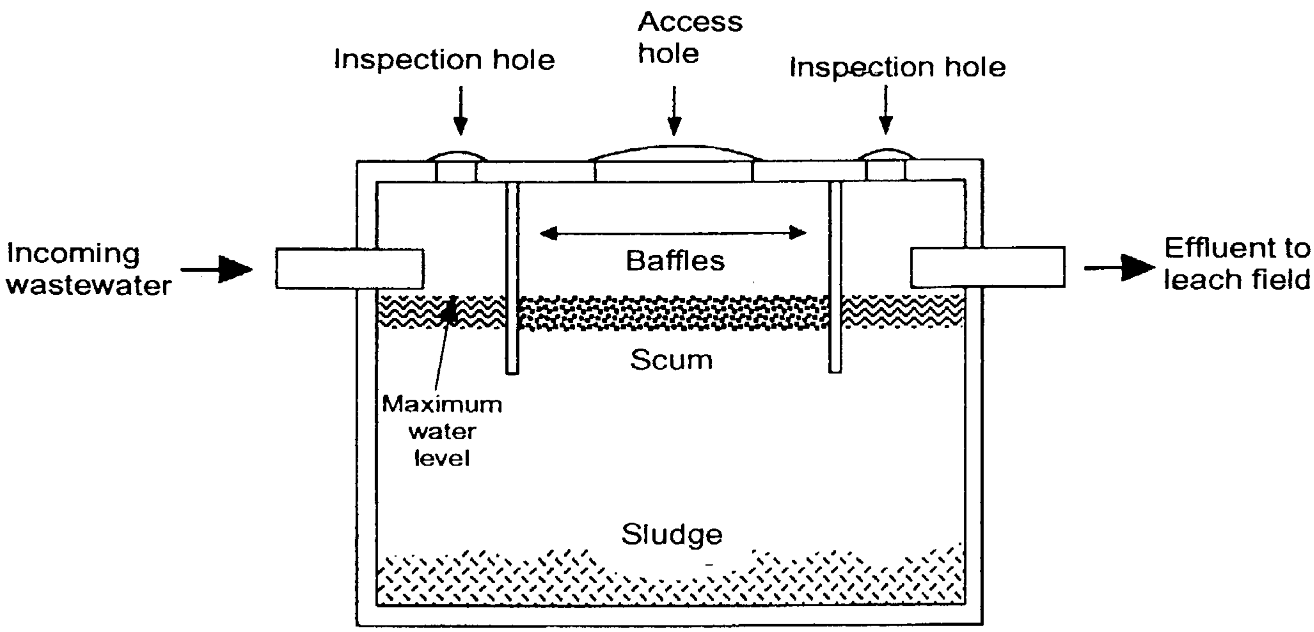
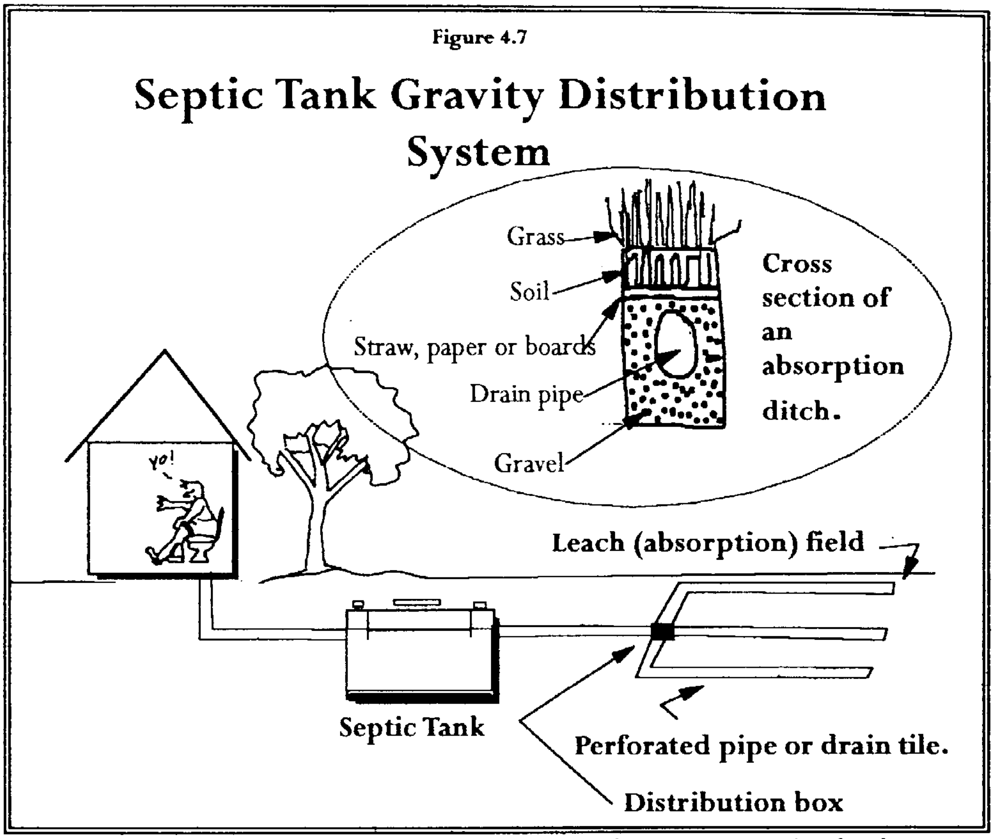


Figure 4.6

CROSS SECTION OF SEPTIC TANK

Source: Penn State College of Agriculture, Cooperative Extension, Agricultural Engineering Fact Sheet SW-165 tanks fill up, they are pumped out and the waste material is supposed to be trucked to a sewage treatment plant.



SAND MOUNDS

Some soils drain poorly because they may have a high clay content or may be low-lying or otherwise water impermeable. In the event of poorly drained soil, a standard leach field will not work very well, especially when the ground is saturated with rain water or snow melt. One can't drain wastewater into soil that is already saturated with water. That's when the *sand mound* sewage disposal system is useful. In this method of waste disposal, when the septic tank isn't draining properly, a pump will kick in and pump the effluent into a pile of sand and gravel above ground (although sometimes a pump isn't necessary and gravity does the job). In the pile of sand is a perforated pipeline which allows the effluent to drain down through the mound. Sand mounds are usually covered with soil and grass. In Pennsylvania, sand mounds must be at least one hundred feet downslope from a well or spring, fifty feet from a stream, and five feet from a property line.[2]

According to local excavating contractors, sand mounds cost \$5,000 to \$12,000 to construct (1993). They must be built to exact government specifications, and aren't usable until they pass an official inspection (see figure 4.8).

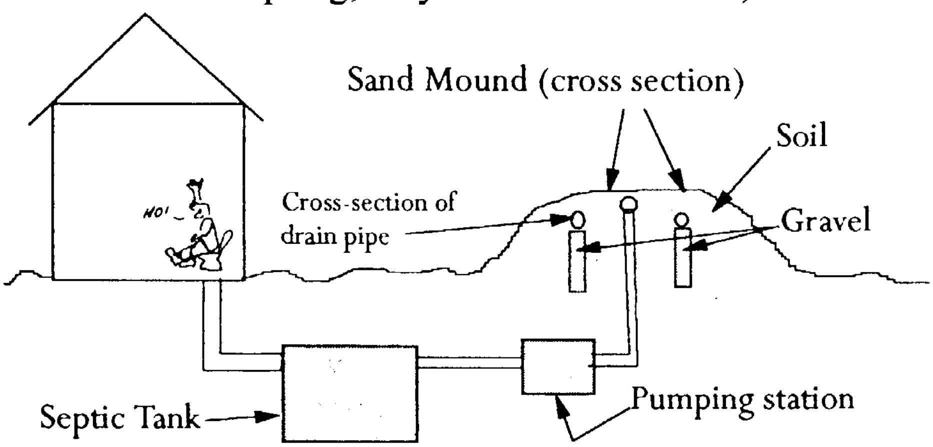


Figure 4.8

Sand Mound (or Trench Mound) Waste Distribution System

GROUND WATER POLLUTION FROM SEPTIC SYSTEMS

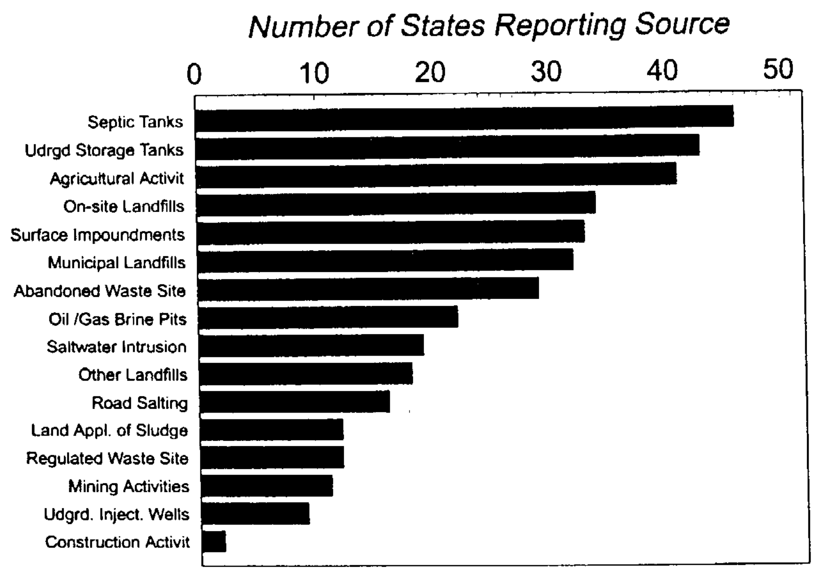
We civilized humans started out by defecating into a hole in the ground (outhouse), then discovered we could float our turds out to the hole using water and never have to leave the house. However, one of the unfortunate problems with septic systems is, like outhouses, they pollute our groundwater.

There are currently 22 million septic system sites in the United States issuing contaminants such as bacteria, viruses, nitrates, phosphates, chlorides, and organic compounds such as trichloroethylene into the environment. An EPA study of chemicals in septic tanks found toluene, methylene chloride, benzene, chloroform, and other volatile synthetic organic compounds related to home chemical use.[3] Between 820 and 1,460 *billion* gallons of this contaminated water are discharged per year to our shallowest aquifers.[4] According to the EPA, states reported septic tanks as a source of ground water contamination more than any other source, with 46 states citing septic systems as sources of groundwater pollution, and nine of these reporting them to be the primary source of groundwater contamination in their state[5] (see figures 4.9 and 4.10).

The word "septic" comes from the Greek "septikos" which means "to make putrid". Today it still means "causing putrefaction", putrefaction being "the decomposition of organic matter resulting in the formation of foul-smelling products" (see

Figure 4.9

Sources of Ground-Water Contamination in the United States



Source: U.S. Environmental Protection Agency, National Water Quality Inventory 1986 Report to Congress, EPA-440/4-87-008

Webster). Septic systems are not designed to destroy human pathogens that may be in the human waste that enters the septic tank. Septic systems are instead designed to collect human wastewater, settle out the solids and anaerobically digest them to some extent, and then leach the effluent into the ground. Therefore, septic systems can be highly pathogenic, allowing the transmission of disease-causing bacteria, viruses, protozoa and intestinal parasites through the system.

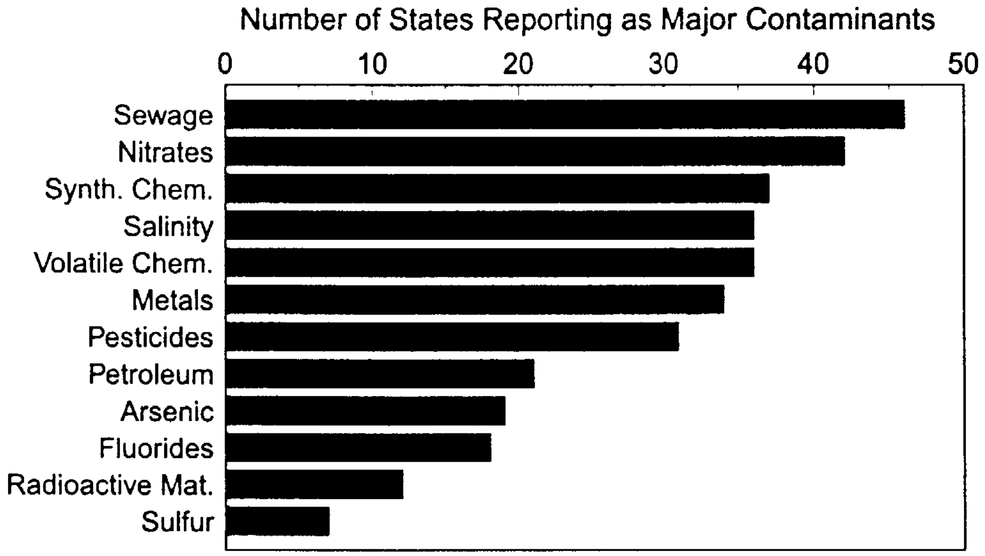
One of the main problems associated with septic systems is the problem of human population density. Too many septic systems in any given area will overload the soil's natural purification systems and allow large amounts of wastewater to contaminate the underlying watertable. A density of more than forty household septic systems per square mile will cause an area to become a likely target for subsurface contamination, according to the EPA.[6]

Toxic synthetic organic chemicals are commonly released into the environment from septic systems because people dump toxic chemicals down their drains. The chemicals are found in pesticides, paint and coating products, toilet cleaners, drain cleaners, disinfectants, laundry solvents, many other cleaning solutions, antifreeze, rust proofers, even septic tank and cesspool cleaners. In fact, over 400,000 gallons of septic tank cleaner liquids containing synthetic organic chemicals were used in one year by just the residents of Long Island alone. Furthermore, some synthetic organic chemicals can corrode pipes thereby causing even more heavy metals to enter septic systems.[7]

In many cases, people who have septic tanks are forced to connect to sewage lines when the lines are made available to them. A U.S. Supreme Court case in 1992 reviewed a situation whereby town members in New Hampshire had been forced to connect to a sewage line that simply discharged untreated, raw sewage into the Connecticut River for 57 years. Despite the crude

Figure 4.10

Ground Water Contaminants in the United States



U.S. Environmental Protection Agency, National Water Quality Inventory 1986 Report to Congress, EPA-440/4-87-008 method of sewage disposal, state law required properties within 100 feet of the town sewer system to connect to the system when it was built in 1932. This sewage disposal system apparently continued to operate in this barbaric manner until 1989, when state and federal sewage treatment laws forced a stop to the dumping of raw sewage into the river.[8]

WASTEWATER TREATMENT PLANTS

There's still another step up the ladder of wastewater treatment sophistication: the wastewater treatment plant, or sewage plant. The wastewater treatment plant is like a huge, very sophisticated septic tank, because it collects the water-born excrement of large numbers of humans. Inevitably, when one defecates or urinates into water, one pollutes the water. Therefore, that "wastewater" must somehow be rendered fit to return to the environment in order to avoid environmental pollution. The liquid entering the wastewater treatment plant is 99% water because all sink water, bath water and everything else that goes down one's drain ends up at the plant too, which is why it's called a *water* treatment plant. In some cases, storm water runoff also enters wastewater treatment plants via *combined sewers.* Also, a lot of contaminants can and do enter this wastewater stream from industries, hospitals, gas stations, and any place with a drain.

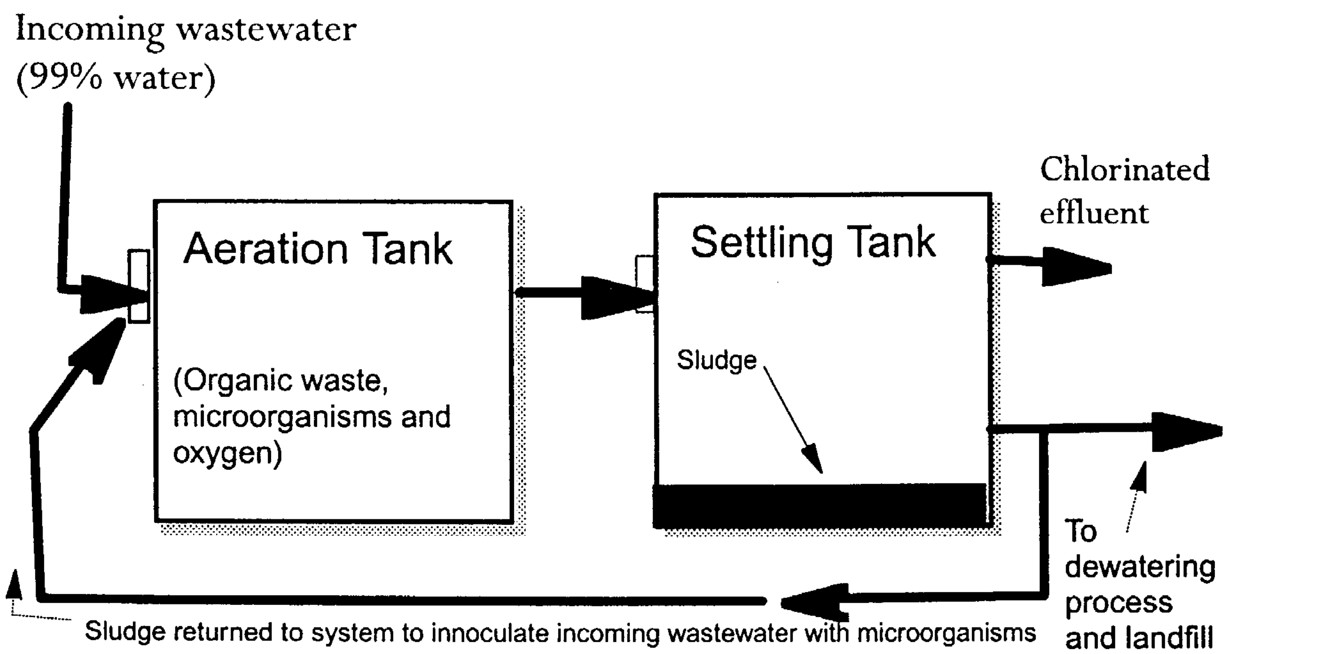


Figure 4.11

Activated sludge wastewater treatment process

Many modern wastewater plants use a process of activated sludge treatment whereby oxygen is vigorously bubbled through the wastewater in order to activate microbial digestion of the solids. This aeration stage is combined with a settling stage that allows the solids to be removed. The removed solids (sludge) are either used to reinoculate the incoming wastewater, or they're dewatered to the consistency of a dry mud and buried in landfills (see figure 4.11). Sometimes the sludge is applied to agricultural land. The microbes that digest the sludge consist of bacteria, fungi, protozoa, rotifers, and nematodes.[9] The water left behind is treated (usually with chlorine) and discharged into a stream, river, or other body of water. Sewage treatment water releases to surface water in the United States in 1985 amounted to nearly *31 billion gallons per day.*[10]

U.S. sewage treatment plants generated about 7.6 million dry tons of sludge in 1989.[11] New York City alone produces 143,810 dry tons of sludge every year.[12] In 1993, the amount of sewage sludge produced annually in the U.S. was 110-150 million wet metric tons. Incidentally, the amount of toilet paper used (1991) to send all this waste to the sewers was 2.3 million tons.[13]

CHLORINE

Wastewater leaving wastewater treatment plants is often treated with chlorine before being released into the environment. For this reason, the act of defecating into water often ultimately contributes to the contamination of water resources with *chlorine* in addition to feces.

Chlorine, used since the early 1900's, is one of the most widely produced industrial chemicals with about 10 million metric tons manufactured in the U.S. each year - $72 billion worth.[14] Approximately 5% of the chlorine manufactured is used for wastewater treatment and drinking water "purification", amounting to about 1.2 billion pounds annually. The lethal liquid or green gas is mixed with the wastewater from sewage treatment plants, in order to kill disease causing microorganisms, before the water is discharged into streams, lakes, rivers and seas. It is also added to household drinking water via household and municipal water treatment systems.

Chlorine (CL2) doesn't exist in nature. It's a potent poison which reacts with water to produce a strongly oxidizing solution that can damage the moist tissue lining of the human respiratory tract. Ten to twenty parts per million (ppm) of chlorine gas in air rapidly irritates the respiratory tract, and even brief exposure at levels of 1,000 ppm (one part in a thousand) can be fatal.[15] Chlorine also kills fish, and reports of fish kills caused chlorine to come under the scrutiny of scientists in the 1970's.

The fact that harmful compounds are formed as *by-products* of chlorine use also raises concern. In 1976, the U.S. Environmental Protection Agency (EPA) reported that chlorine use not only poisoned fish, but could also cause the formation of cancer-causing compounds such as chloroform. Some known effects of chlorine-based pollutants on animal life include memory problems, stunted growth and cancer in people; reproductive problems in minks and otters; reproductive problems, hatching problems and death in lake trout; and embryo abnormalities and death in snapping turtles.[16]

In a national study of 6,400 municipal wastewater treatment plants, the EPA estimated that two thirds of them used too much chlorine, which exerts lethal effects at all levels of the food chain. Chlorine damages the gills of fish, inhibiting their ability to absorb oxygen. It also can cause behavioral changes in fish, thereby affecting migration and reproduction. Chlorine in streams can create chemical "dams" which prevent the free movement of some migratory fish. Fortunately, since 1984, there has been a 98% reduction in the use of chlorine by sewage treatment plants, although chlorine use continues to be a widespread problem because a lot of wastewater plants are still discharging it into small receiving waters.[17]

Another controversy associated with chlorine use involves "dioxin", which is a common term for a large number of chlorinated chemicals that are classified as possible human carcinogens by the EPA. It's known that dioxins cause cancer in laboratory animals, but their effects on humans are still being debated. Dioxins, byproducts of the chemical manufacturing industry, are present in the total environment, and are concentrated through the food chain where they're deposited in human fat tissues. A key ingredient in the formation of dioxin is chlorine, and indications are that an increase in the use of chlorine results in an increase in the dioxin content of the environment, even in areas where the only dioxin source is the atmosphere.[18] Dioxins are unintended byproducts of chlorine use.

In the upper atmosphere, chlorine molecules gobble up ozone, in the lower atmosphere they bond with carbon to form organochlorines. Some of the 11,000 commercially used organochlorines include hazardous compounds such as DDT, PCBs and carbon tetrachloride. Organochlorines rarely occur in nature, and living things have little defense against them. They've been linked not only to cancer, but also to neurological damage, immune suppression, and reproductive and developmental effects. When chlorine products are washed down the drain to a septic tank, they're producing organochlorines.

"Any use of chlorine results in compounds that cause a wide range of ailments," says Joe Thorton, a Greenpeace researcher, who adds, *"Chlorine is simply not compatible with life. Once you create it you can't control it."*[19]

There's no doubt that our nation's sewage treatment systems are polluting our drinking water sources with pathogens (see chapter 6). As a result, chlorine is also being used to disinfect *the water we drink* as well as to disinfect discharges from wastewater treatment facili-

ties. According to a 1992 study, *chlorine is added to 75% of the nation's drinking water* and is linked to cancer. The results of the study suggested that at least 4,200 cases of bladder cancer and 6,500 cases of rectal cancer each year in the U.S. are associated with consumption of chlorinated drinking water.[20]

In December, 1992, the U.S. Public Health Service reported that pregnant women who routinely drink or bathe in chlorinated tap water are at a greater risk of bearing premature or small babies, or babies with congenital defects.[21]

According to a spokesperson for the chlorine industry, 87% of water systems in the U.S. use free chlorines, and 11% use chloramines. Chloramines are a combination of chlorine and ammonia. The chloramine treatment is becoming more widespread due to the health concerns over chlorine.[22] However, EPA scientists admit that we're pretty ignorant about the potential byproducts of the chloramine process, which involves ozonation of the water prior to the addition of chloramine.[23]

Of course, we don't have to worry. The government will take care of us, and if the government doesn't, then industry will. Won't they? Well, not exactly. According to a U.S. General Accounting Office report in 1992, consumers are poorly informed about potentially serious violations of drinking water standards. In a review of twenty water systems in six states, out of 157 drinking water quality violations, the public received a timely notice in only 17 of the cases.[24]

ALTERNATIVE WASTEWATER TREATMENT SYSTEMS

New systems are being developed to purify wastewater. One popular experimental system today is the *constructed, or artificial wetlands system*, which runs wastewater through an aquatic environment consisting of aquatic plants such as water hyacinths, bullrushes, duckweed, lilies, and cattails (see figure 4.12). The plants act

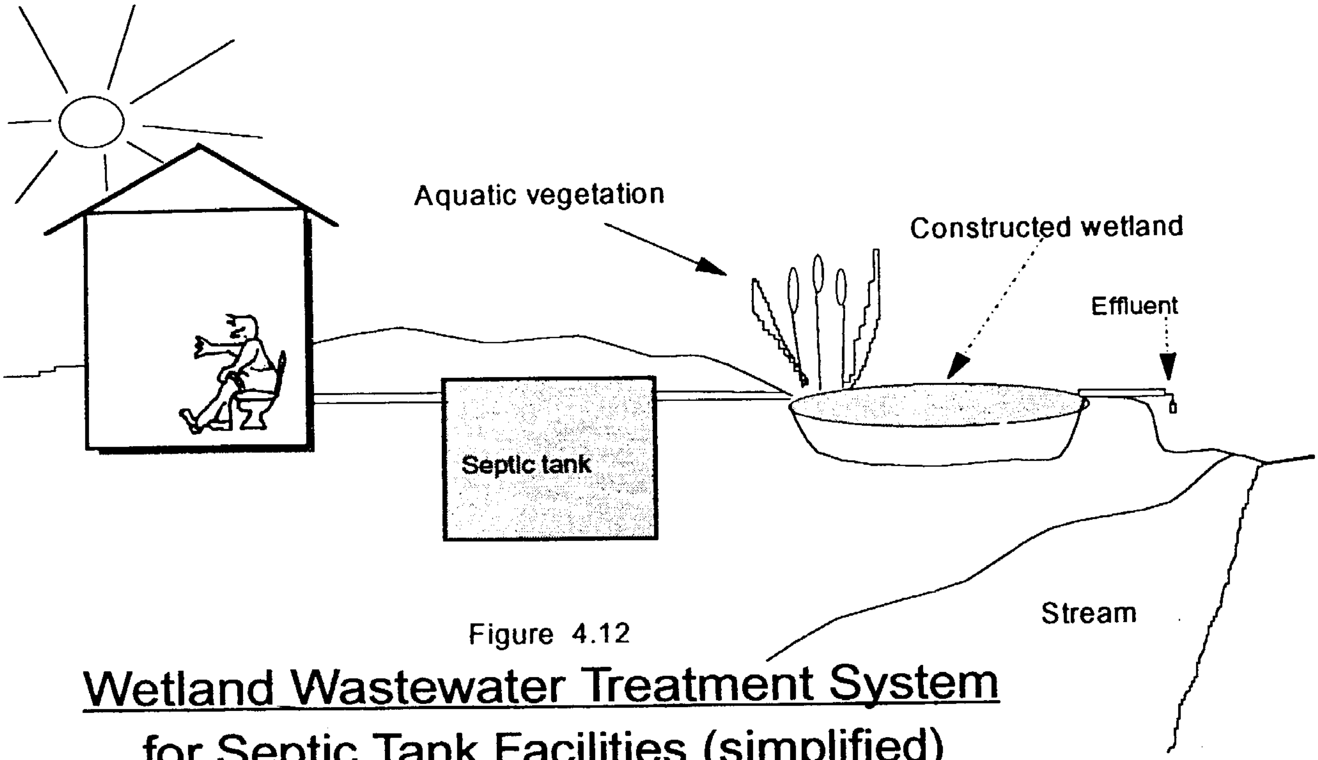


Figure 4.12

Wetland Wastewater Treatment System
for Septic Tank Facilities (simplified)

as marsh filters, and the microbes which thrive on their roots do most of the work. They break down nitrogen and phosphorous compounds as well as toxic chemicals. Although they don't break down heavy metals, the plants absorb them, and they can then be harvested and incinerated or landfilled.[25]

According to EPA officials, the emergence of constructed wetlands technology shows great potential as a cost effective alternative to wastewater treatment. The wetlands method is said to be relatively affordable, energy efficient, practical and effective. However, scientists don't yet have the data to determine with assurance the performance expectations of wetlands systems, or contaminant concentrations released by these systems into the environment. However, the treatment efficiency of properly constructed wetlands is said to compare well with conventional treatment systems.[26] Unfortunately, wetlands systems don't recover the agricultural resources available in humanure.

Another system uses solar powered greenhouse-like technology to treat wastewater. This system uses hundreds of species of bacteria, fungi, protozoa, snails, plants and fish, among other things, to produce advanced levels of wastewater treatment. These solar aquatics systems are also experimental, but appear hopeful.[27] Again, the agricultural resources of humanure are lost when using this or any disposal method or wastewater treatment technique instead of a humanure recycling method.

AGRICULTURAL USE OF SEWAGE SLUDGE

Now here's where a thoughtful person may ask, "Why not put *sewage sludge* back into the soil for agricultural purposes?"

One reason: government regulation. When I asked the supervisor of my local wastewater treatment plant if the one million gallons of sludge the plant produces each year (for a population of 8,000) was being applied to agricultural land, he said, *"It takes six months and five thousand dollars to get a permit for a land application. Another problem is that due to regulations, the sludge can't lie on the surface after it's applied so it has to be plowed under shortly after application. When farmers get the right conditions to plow their fields, they plow them. They can't wait around for us, and we can't have sludge ready to go at plowing time."* It may be just as well.

Sewage sludge is a lot more than organic human refuse. It can contain DDT, PCBs, mercury, other heavy metals, and the like.[28] One scientist alleges that more than 20 million gallons of used motor oil are dumped into sewers every year in the United States.[29] America's largest industrial facilities released over 550 million pounds of toxic pollutants into U.S. sewers in 1989 alone, according to the U.S. Public Interest Research Group. In 1987, 614 million pounds of toxic pollutants were released into sewers, and in 1988, another 570 million pounds were released, although the actual levels of toxic discharges are said to be much higher than these.[30] Of the top ten states responsible for toxic discharges to public sewers in 1991, Michigan took the cake with nearly 80 million pounds, followed in order by New Jersey, Illinois, California, Texas, Virginia, Ohio, Tennessee, Wisconsin and Pennsylvania (around 20 million pounds from PA).[31]

An interesting study on the agricultural use of sludge was done by a Mr. Purves in Scotland. He began applying sewage sludge at the rate of 60 tons per acre to a plot of land in 1971. After fifteen years of treating the soil with the sludge, he tested the vegetation grown on the plot for heavy metals. On finding that the heavy metals (lead, copper, nickel, zinc and cadmium) had been taken up by the plants, he concluded, *"Contamination of soils with a wide range of potentially toxic metals following application of sewage sludge is therefore virtually irreversible."*[32] In other words, the heavy metals don't wash out of the soil, they enter the food chain.

Other studies have shown that heavy metals accumulate in the vegetable tissue of the plant to a much greater extent than in the fruits, roots or tubers. Therefore, if one must grow food crops on soil fertilized with sewage sludge contaminated with heavy metals, one might be wise to produce carrots or potatoes instead of lettuce.[33] Guinea pigs experimentally fed with swiss chard grown on soil fertilized with sewage sludge showed no observable toxicological effects, however their adrenals showed elevated levels of antimony, their kidneys had elevated levels of cadmium, there was elevated manganese in the liver and elevated tin in several other tissues.[34]

Furthermore, *"the fact that sewage sludge contains a large population of fecal coliforms renders it suspect as a potential vector of bacterial pathogens and a possible contaminant of soil, water and air, not to mention crops. Numerous investigations in different parts of the world have confirmed the presence of intestinal pathogenic bacteria and animal parasites in sewage, sludge, and fecal materials."*[35] (See chapter 6)

Another interesting study was published in 1989 indicating that the bacteria that survive in sewage sludge show a high level of resistance to antibiotics, especially penicillin, one of the most commonly used. The theory is this: because heavy metals are concentrated in sludge during the treatment process, the bacteria that survive in the sludge can obviously resist heavy metal poisoning. But these same bacteria also show an inexplicable resistance to antibiotics, suggesting that somehow the resistance of the two environmental factors are related in the bacterial strains that survive. The implication is that sewage sludge selectively breeds antibiotic-resistant bacteria, which may enter the food chain if the agricultural use of the sludge becomes widespread. The results of the study indicated that more knowledge of antibiotic-resistant bacteria in sewage sludge should be acquired before sludge is disposed of on land, as this method of disposal can be dispersing countless antibiotic resistant bacteria into the environment.[36]

This poses somewhat of a problem. Collecting human excrement with wastewater and industrial pollutants seems to render the organic refuse incapable of being adequately sanitized. It becomes contaminated enough to be unfit for agricultural purposes. As a consequence, sewage sludge is not highly sought after as a soil additive. For example, the state of Texas sued the U.S. EPA in July of 1992 for failing to study environmental risks before approving the spreading of sewage sludge in west Texas. Sludge was being spread on 128,000 acres there by an Oklahoma firm, but the judge nevertheless refused to issue an injunction to stop the spreading.[37] Considering that the sludge was from New York City, who can blame the Texans?

Now that ocean dumping of sludge has been stopped, where's it going to go? Researchers at Cornell University have suggested that sewage sludge can be disposed of by surface applications in forests. Their studies suggest that brief and intermittent applications of sludge to forestlands won't adversely affect wildlife, despite the nitrates and heavy metals that are present in the sludge. They point out that the need to find ways to get rid of sludge is compounded by the fact that many landfills are expected to close over the next several years and ocean dumping is now banned. Some sources say that landfills in the U.S. are being closed permanently at the rate of two per day.[38] In a report to congress by the EPA in 1989, 45% of the landfills then currently in operation were expected to be closed by 1991.[39]

Under the Cornell model, one dry ton of sludge could be applied to an acre of forest each year.[40] New York state alone produces 370,000 tons of dry sludge per year, which would require 370,000 acres of forest each year for New York state sludge disposal. Then there are the other forty-nine states and the 7.6 million dry tons of sludge produced in the U.S.. Then there's figuring out how to get the sludge into the forests and how to spread it around. With all this in mind, a guy has to stop and wonder. The woods used to be the only place left to get away from it all.*

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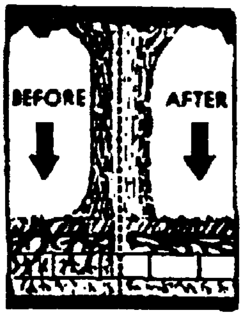

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The problem of treating and dumping sludge isn't the only one. The costs of maintenance and upkeep of wastewater treatment plants is another. According to a report issued by the EPA in 1992, U.S. cities and towns need as much as $110.6 billion over the next twenty years for enlarging, upgrading, and constructing wastewater treatment facilities.[41]

Ironically, when sludge is *composted*, it may help to keep heavy metals *out* of the food chain. According to a 1992 report, composted sludge lowered the uptake of lead in lettuce that had been deliberately planted in lead-contaminated soil. The lettuce grown in the contaminated soil to which composted sludge had been added had a 64% lower uptake of lead than lettuce planted in the same soil but without the compost. The composted soil also lowered lead uptake in spinach, beets and carrots by more than 50%.[42] Three cheers for compost!

Some scientists claim that the composting process transforms heavy metals into benign materials. According to Joseph C. Horvath, a soil and compost scientist who designs facilities that compost sewage sludge, *"at the final product stage, these [heavy] metals actually become beneficial micro-nutrients and trace minerals that*

Dripless toilets China's top priority

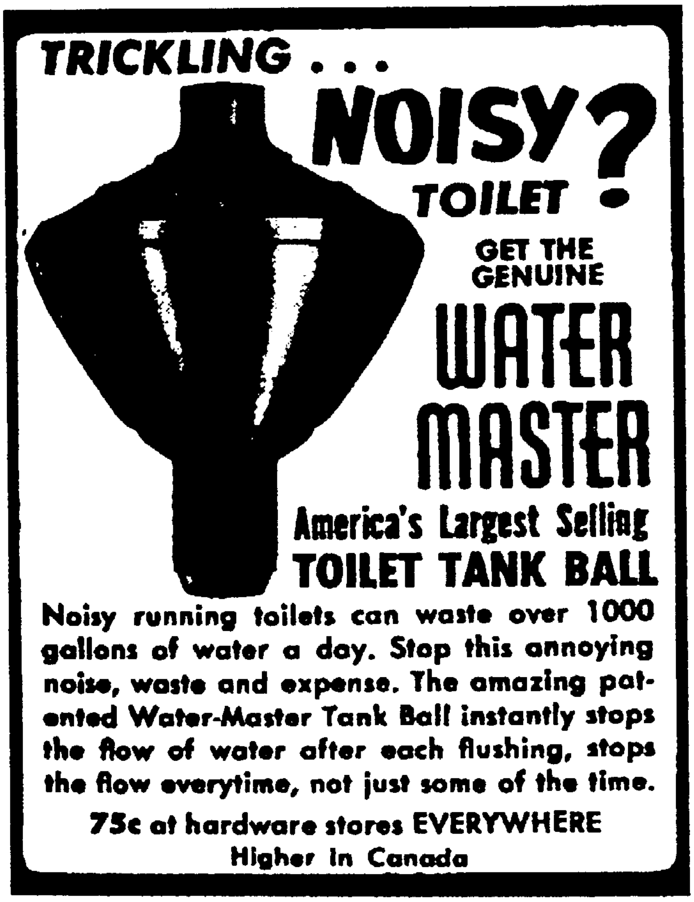
BEIJING, June 7 —— With oceans of scarce water literally going down China's drains, Communist Party chief Jiang Zemin has made the dripless toilet a national priority. "If the country can send satellites and missiles into space, it should be able to dry up its latrines," today's China Daily quoted Jiang as saying. The Construction Ministry estimates leaky toilets sold by negligent manufacturers waste 200 million cubic meters of water a year. Vice Minister of Construction Ye Rutang launched a purge of leaky and substandard toilet hardware. Three hundred of China's 570 cities, including the capital, Beijing, face serious water shortages, China Daily said.

(From a Saudi Arabian newspaper, 1994)

add to the productivity of soil. This principal is now finding acceptance in the scientific community of the USA and is known as biological transmutation, or also known as the Kervran-Effect." Composted sewage sludge that is microbiologically active can also be used to detoxify areas contaminated with nuclear radiation or oil spills, according to Dr. Horvath. Clearly, the composting of sewage sludge is a grossly underutilized alternative to landfill application, and it should be strongly promoted.**

GLOBAL SEWERS AND PET TURDS

Let's assume that the whole world adopted the sewage philosophy we have in the United States: defecate into water and then treat the polluted water. What would that scenario be like? Well, for one thing it wouldn't work. It takes between 1,000 and 2,000 tons of water at various stages in the process to flush one ton of humanure. In a world of just five billion people producing a conservative estimate of one million metric tons of human excrement daily, the amount of water required to flush it all would not be obtainable.[43] When one adds to this equation the increasing landfill space that would be needed to dispose of the increasing amounts of sewage sludge, and the tons of toxic chemicals required to "sterilize" the wastewater, then one can see that this system of human waste disposal is not sustainable and will not serve the needs of humanity in the long term.



As one person puts it, *"Conventional 'Western' methods of waterborne sewerage are simply beyond the reach of most [of the world's] communities. They are far too expensive. And they often demand a level of water use that local water resources cannot supply. If Western standards were made the norm, some $200 billion alone [early 1980's] would have to be invested in sewerage to achieve the target of basic sanitation for all. Resources on this scale are simply not in sight."* (Barbara Ward, President of the International Institute for Environment and Development).

To quote Lattee Fahm, *"In today's*

world [1980], some 4.5 billion people produce excretal matters at about 5.5 million metric tons every twenty-four hours, close to two billion metric tons per year. [Humanity] now occupies a time/growth dimension in which the world population doubles in thirty five years or less. In this new universe, there is only one viable and ecologically consistent solution to the body waste problems - the processing and application of [humanure] for its agronutrient content."[44] In other words, we have to understand that humanure is a natural substance, produced by a process vital to life (human digestion), originating from the earth in the form of food, and valuable as an organic refuse material that can be returned to the earth in order to produce more food for humans. That's where composting comes in.

But hey, wait, let's not be rash. We forgot about incinerating our excrements. We can dry our turds out, then truck them to big incinerators and burn the hell out of them. That way, instead of having fecal pollution in our drinking water or forests, we can breathe it in our air. Unfortunately, burning sludge with other municipal waste produces *emissions* of: particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide, lead, volatile hydrocarbons, acid gasses, trace organic compounds and trace metals. The left-over *ash* has a high concentration of heavy metals, such as cadmium and lead.[45] Doesn't sound so good if you live downwind, does it?

How about microwaving it? Don't laugh, someone's already invented the microwave toilet.[46] This just might be a good cure for hemorrhoids, too. But heck, let's get serious and shoot it into outer space. Why not? It probably wouldn't cost too much per fecal log after we've dried the stuff out. This could add a new meaning to the phrase "the Captain's log". Beam up another one, Scotty!

Better yet, we can dry our turds out, chlorinate them, get someone in Taiwan to make little plastic sunglasses for them, and we'll sell them as pet turds! Now that's a realistic entrepreneurial solution, isn't it? Any volunteer investors out there?

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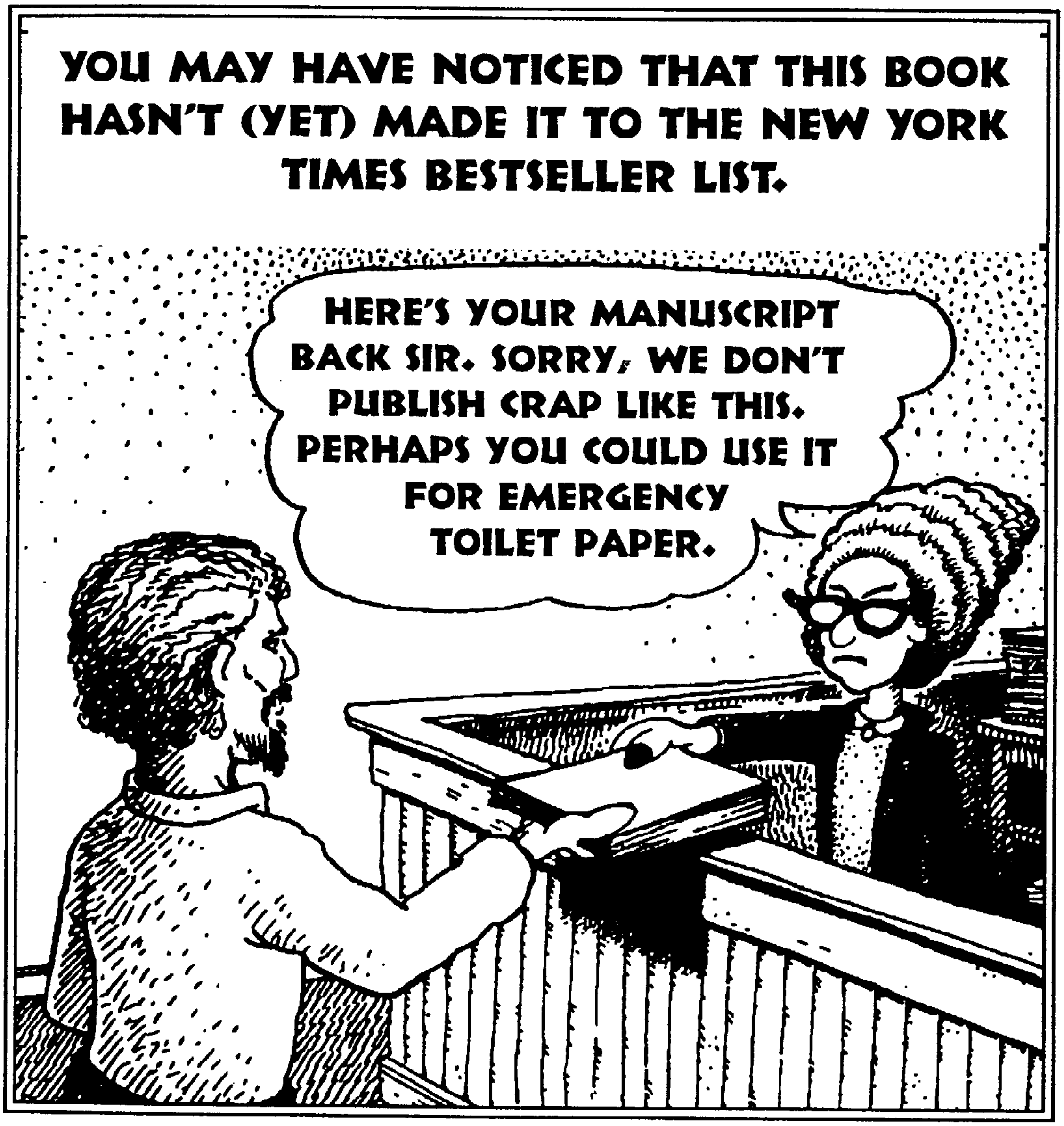
* ***"All sewer sludge is not bad,"* according to Ancil Schmidt, West Virginia Division of Environmental Protection Extension Agent. Mr. Schmidt offers a very helpful packet of information about the use of sewage sludge for agricultural purposes ("Use and Disposal of Municipal Wastewater Sludge"), which is available from: West Virginia University Extension Service, 200 1/2 South Kanawha Street, Beckley, West Virginia, 25801-5616; Phone (304) 255-9321.**

** **Contact JCH Environmental Engineering, Inc., 2730 Remington Court, Missoula, MT 59801-7121. Phone (406) 721-1164.**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COMPOSTING TOILETS AND SYSTEMS

"Simplicity of life, even the barest, is not misery but the very foundation of refinement."
William Morris

The act of composting humanure can be done *actively*, with full and voluntary participation by the person(s) creating the refuse, or it can be done *passively*, with little or no participation in the composting process by the person(s) creating the refuse. Many people in the West who agree with the idea of composting humanure want to do so, but only if the process is passive. They don't want to be actively involved in the compost-making process. They want the toilet to do the work, although they may be willing to haul the finished compost off somewhere to be disposed of, usually desiring to do so as infrequently as possible. For many people, a composting toilet is another disposal system, one that doesn't require water (usually), and one that is not to be used in the human nutrient cycle.

Others, those who make compost through an aerobic, thermophilic process, know that there's a technique to building a compost pile that must be respected in order to achieve the desired result, i.e. good quality garden compost. These people use their finished compost to produce food for themselves to eat, therefore they want to be actively involved in the composting process in order to assure quality control over the finished product.

People who actively compost their organic refuse, including humanure, are as rare as hen's teeth in the West. The practice is so alien to Western culture that a person who thermophilically composts humanure may as well walk around with a bone through his or her nose. This is ironic because well-managed thermophilic composting ensures the destruction of human pathogens in the composted material and transforms organic refuse into humus in a relatively short period of time compared to passive composting, which is not thermophilic (the compost does not heat up). However, as pointed out in chapter three, Westerners gained a deep distrust of human excrement over the past several hundred years. This was largely due to terrible epidemic diseases during the Middle Ages and up to the late 1800's spread by fecal contamination of the environment, a condition caused by a cultural ignorance of both the origins of disease and of the the benefits of composting in destroying human pathogens. That deeply entrenched bias against the use of humanure agriculturally, still currently prevalent in the West, will not be easily rooted out, although eventually it must be. I call the belief that humanure is unsafe for agricultural use: ***fecophobia***.

People who are fecophobic can suffer from severe fecophobia or a relatively mild fecophobia, the mildest form being little more than a healthy concern about personal hygiene. Severe fecophobics do not want to use humanure for food growing, composted or not. They believe that it's dangerous and unwise to use such a material in their garden. Milder fecophobics may, however, compost humanure passively and use the finished compost in horticultural applications. People who are not fecophobic may thermophilically compost humanure and utilize it in their food garden. Some may even use it raw, a practice not recommended by the author.

In any case, humanure is best rendered hygienically safe by proper thermophilic composting. Passive, low-temperature composting is very unlikely to become thermophilic and usually does not focus on the destruction of possible human pathogens in the organic refuse being composted. Yet, even passive composting will eventually yield a relatively pathogen-free compost after a period of time, a period which, according to some sources, may be as long as five and a half[1] or even ten[2] years. This is in contrast to thermophilic composting which will destroy human pathogens in a matter of hours or days, or, for larger quantities, weeks or months.

Commercial composting toilets are, for the most part, passive. They are *mouldering* toilets, meaning that the compost moulders or decomposes slowly at temperatures lower than that of the human body. The consumer who buys a commercially distributed composting toilet can rest assured that s/he will have to do little more than use the toilet and then once a year (or two or three) empty out some compost. Often, a dry, organic cover material such as peat moss is recommended to be added to the contents of the toilet on a regular basis. Other than that, there's not much to it.

On the other hand, *non-commercial* mouldering toilets, or *toilets constructed by the users,* are in widespread use throughout the world since many people do not have the financial resources required to purchase commercially produced toilets. Non-commercial mouldering toilets usually require the separation of urine from feces when collecting the organic refuse. This is done by urinating in a separate container or into a diversion device which causes the urine to collect separately from the feces. The rationale for separating urine from feces is that the urine/feces blend contains too much nitrogen to allow for effective composting and the collected refuse gets too wet and odorous. Therefore, the urine is collected separately, thereby reducing the nitrogen, the liquid content, and the odor of the collected refuse.

However, there is a little known alternative method of achieving the same result which does not require the separation of urine from feces. Organic material with too much nitrogen for effective composting (such as a urine/feces mixture) *can be balanced by adding sufficient carbon material such as cellulose in the form of sawdust or a similar material, rather than removing nitrogen.* The extra carbon material also absorbs excess liquids and can cover the collected refuse to eliminate odor completely. This alternative of adding a carbon material to humanure instead of segregating urine from it, also sets the stage for thermophilic composting because of the carbon/nitrogen balancing. However, almost all commercial and non-commercial composting toilets are designed to only achieve mouldering conditions in the compost and not to generate thermophilic conditions.

A *commercial* composting toilet such as a Clivus Multrum (see figure 5.4 on page 93 and the photos on pages 94 and 95) is a manufactured device including a toilet seat and a composting chamber whereby individuals can deposit their feces with little or no active involvement in a nutrient cycling process. In other words, you can take a shit and forget about it, and urine does not need to be segregated. Commercial composting toilets are convenient for that reason. The compost may or may not be suitable for a kitchen garden, as the composting process is usually slow and usually maintains a relatively low temperature which can allow some pathogens to survive. These toilets are popular among those who understand that defecating in water doesn't make sense, or among those who have no electricity or water in their summer cottages and can't use a water-based waste disposal system even if they wanted to. Commercial composting toilets often strive to dehydrate the organic refuse deposited in them so as to reduce bulk and minimize the quantity of compost being produced. This is done by blowing air through and over the organic refuse with fans, and/or by heating the refuse electrically, or by draining excess liquids out into the soil.

On the other hand, an *active, thermophilic composting system* (not a mouldering system) may only use a toilet for *collection* purposes. The humanure may be collected regularly, perhaps daily or weekly, in a simple, low-cost receptacle and deposited on a compost pile or in a compost pit away from the toilet area and layered with other organic materials so that a high aerobic decomposition temperature is generated in order to kill all potential pathogens. (By the way, *a pathogen is any microorganism or worm that can cause a disease.* See glossary or see next chapter.) In some cases, the humanure is deposited directly onto a compost pile in a basement or under an elevated toilet, and layered with other household organic refuse and organic cover materials. Those who use such an active composting system understand that the composting process is only one step in a larger cyclical system of nutrient transfer: soil produces food, we eat the food, we discharge organic refuse (feces, urine, food scraps, agricultural refuse), the humanure is composted with other vegetable or animal refuse, the compost turns back into soil, the soil produces more food, we eat the food, we discharge refuse, and so on. This never-ending human nutrient cycle, when humanure is composted and used to grow human food, maintains a harmonious balance between the human and the earth. It's an active process and requires diligent and conscientious involvement by the human participant(s). What's of value here is the entire, unbroken system, the process itself. The physical toilet may only be a small but important part of the entire cycle. When the actual composting takes place away from the toilet area, this approach requires little construction cost. An active composting system is more labor intensive, but requires little use of technology or natural resources, including water.

Thermophilic composting of humanure has not gained popularity among Westerners for three basic reasons: 1) You can't take a shit and forget about it. The organic refuse has to be dealt with on a regular basis, even if only covered after each deposit and the finished compost removed regularly. S/he who defecates and/or urinates must acknowledge and take responsibility for what comes out of his/her body. 2) Fecophobia. There seems to be a general fear that if you don't die outright from actively composting humanure, you'll die a slow, miserable and wretched death, or you'll surely cause an epidemic of something like the plague and everyone within two hundred miles of you will die, or you'll become so infested with worms that you'll no longer be recognized as human. 3) Misinformation. Much of the information in print concerning the recycling of humanure is confusing, erroneous or incomplete.

As chapter 6 deals with pathogens and chapter 7 deals with the subject of practical thermophilic composting, I won't go into either subject here in any great detail. Let's take a look at some commercial and/or passive composting toilets instead.

THE NON- COMMERCIAL (HOME-MADE) MOULDERING TOILET

The objectives of a mouldering toilet are to achieve safe and sanitary treatment of fecal material, to conserve water, to function with a minimum of maintenance and energy consumption, to operate without unpleasant odors, and to recycle humanure for horticultural use in a form usable to nature (see figures 5.1, 5.2, and 5.3).

The decomposition process is akin to what happens on a forest floor, i.e. cool, slow decomposition. Because the temperature of the compost does not elevate high enough to destroy all pathogens, the resulting compost, also known as duff, is considered suitable only for horticultural purposes, not for agricultural purposes, except, perhaps, for orchard use where the duff is covered or buried after application.

It is well known that humanure contains the potential to harbor disease-causing microorganisms, or pathogens. Compost temperatures must rise significantly *above the temperature of the human body* (98.6°F or 37°C) in order to begin eliminating disease-causing organisms, as human pathogens can live happily in temperatures similar to that of the human being. The human body attempts to destroy pathogenic infections by elevating its own temperature, thereby creating a fever, which pathogens don't like. Human fevers rarely rise above 104°F (40° C), and when they do, they rarely sustain that level of heat for more than a day or two. Compost must also generate heat in order to destroy human pathogens, and fortunately thermophilic composting will readily create temperatures much higher than the human body temperature and sustain them, perhaps for weeks.

However, mouldering toilets generally do not achieve thermophilic conditions and therefore do not achieve temperatures higher than that of the human body. Consequently, some human pathogens may smugly reside in the finished compost, perhaps for years. According to current scientific evidence, which is discussed at greater length in chapter six, a few months retention time in just about any compost toilet will result in the deaths of nearly all human pathogens. The most persistent pathogen seems to be the roundworm (*Ascaris lumbricoides*) however, and particularly the egg of the roundworm, which is pro-

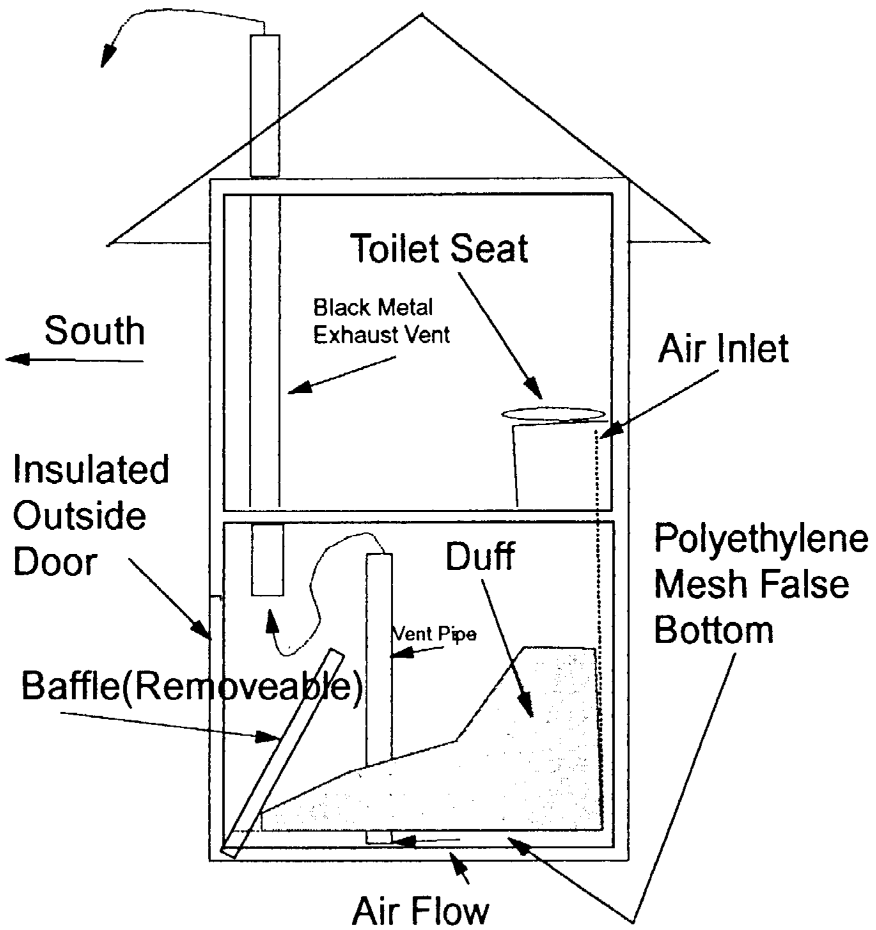

FIGURE 5.1

Simplified Cutaway Side View of

Mouldering Toilet

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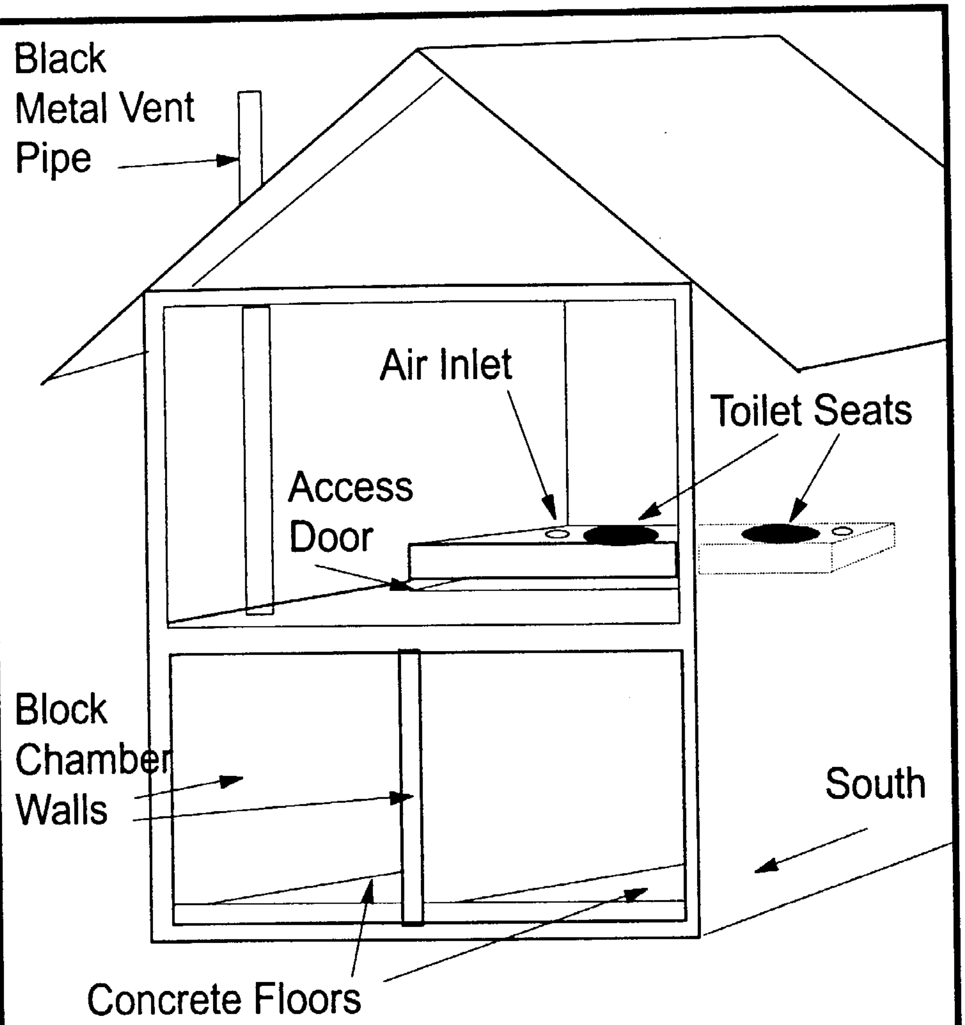


FIGURE 5.2

Mouldering Toilet (simplified)

Cutaway view of south side of building showing mouldering toilet chambers and toilet room above.

For details contact Gap Mountain Permaculture, 9 Old County Road, Jaffrey, NH 03452.

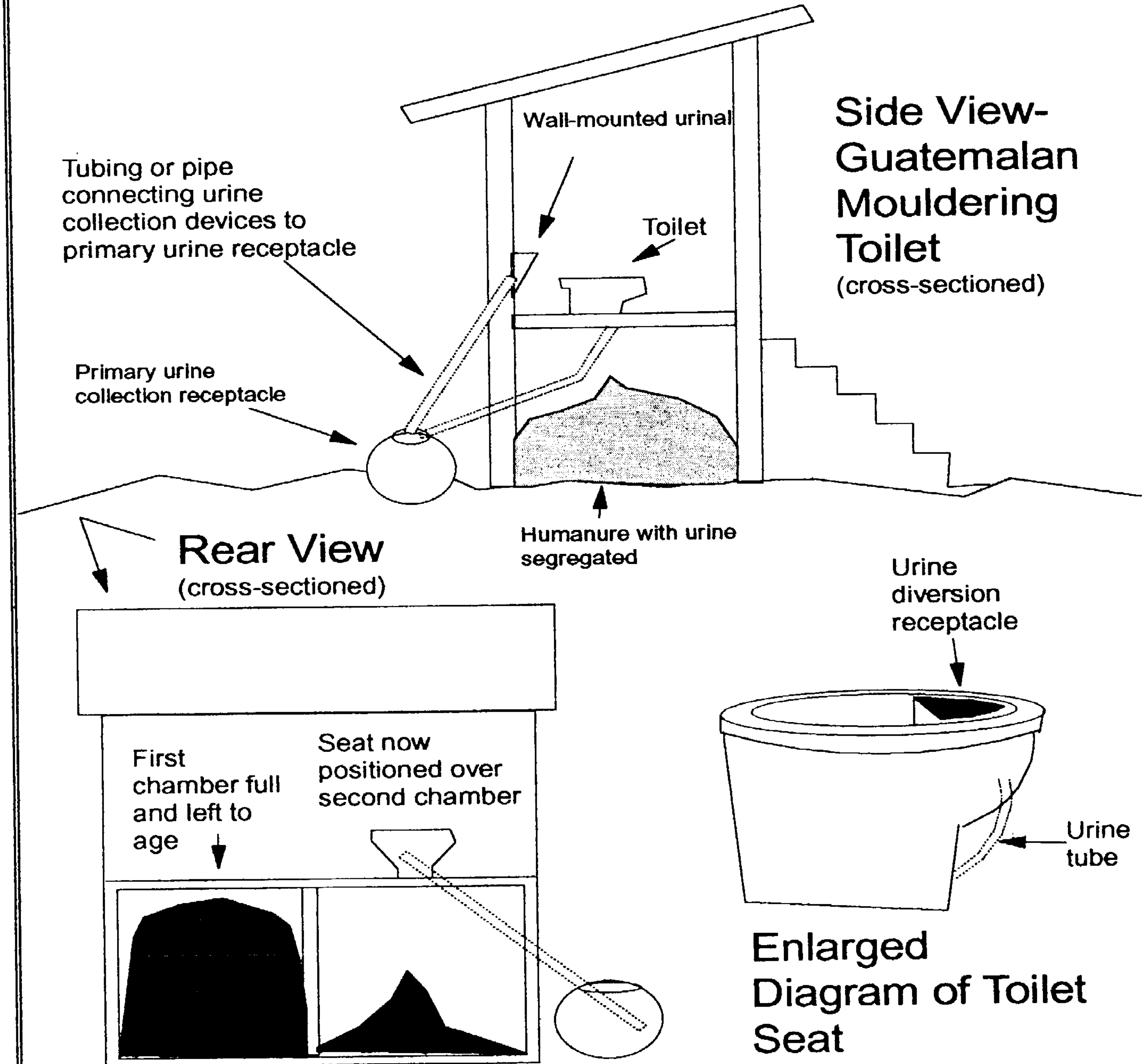
tected by an outer covering which renders the egg resistant to chemicals and adverse environmental conditions. Estimates of the viability of Ascaris eggs in soil range as high as ten years. Although the Ascaris and the eggs are readily destroyed by thermophilic composting, the eggs may survive in conditions generated by a mouldering toilet. This is why the compost resulting from a mouldering toilet is not recommended for human food production, and why mouldering toilets are only used as elements of the human nutrient cycle in groups of people who are willing to accept the possibility of a level of *Ascaris* infection in their population.

The primary advantage to this sort of toilet is the passive involvement of the user, as the toilet collection area need not be entered into more than every two or three years, unless to rake the pile flat. The pile that collects in the chamber must be raked and mixed somewhat every few months (which can be done through a floor access door), and the chamber is emptied only after nothing has been deposited in it for at least two years, although this time period may vary depending on the individual systems used.

In order for this system to work well, each toilet must consist of two chambers. The first is deposited into until it's full, then the second is used. By the time the

FIGURE 5.3

Guatemalan Mouldering Toilet



Source: Schiere, Jacobo. (1989). LASF Una Letrina Para la Familia.Comite Central Menonita, Tecnologia Apropiada, Santa Maria Cauque, Sacatepequez, Apartado Postal 1779, Guatemala Cuidad, Guatemala.

second side is full the first should be emptied. It may take five years to fill a side. In addition to feces, carbonaceous organic matter such as sawdust is regularly added to the chamber in use. One drawback to this system may be the desire to segregate urine from feces in order to minimize odors and waterlogging of the duff. Urination then takes place in a separate container and the collected urine is deposited on a garden or compost pile. Some toilets, such as one currently being used in Guatemala (see figure

5.3 on page 91), automatically separate urine from feces during defecation. However, an alternative to segregating urine to prevent waterlogging of the duff would be to simply add more dry cover material to soak up the excess moisture. Urine-soaked sawdust composts quite well.

An advantage to this system is that there are no moving parts or electrical devices. Air ventilation may take place through a large, black vertical pipe which passes indoors through the toilet room in front of a south-facing window (in the northern hemisphere) where it will be heated, passively causing the air to rise.

In short, the mouldering toilet seems to offer a method of composting humanure that would be attractive to persons wanting a low-maintenance, low-cost, passive approach to excrement recycling. However, urination in a separate receptacle seems to somewhat offset the passive nature of this type of toilet, as the urine must be dealt with on a regular basis. The other primary drawback, as I see it, aside from occasional fly infestations, is the low-temperature composting of the humanure rendering it unfit for growing human food, except for orchard application, until after a quite lengthy period of time. The total destruction of human pathogens should be the goal of anyone composting humanure. However, any effort which successfully returns organic refuse to the soil without polluting water or the environment and without using electricity certainly demands a high level of commendation.[3]

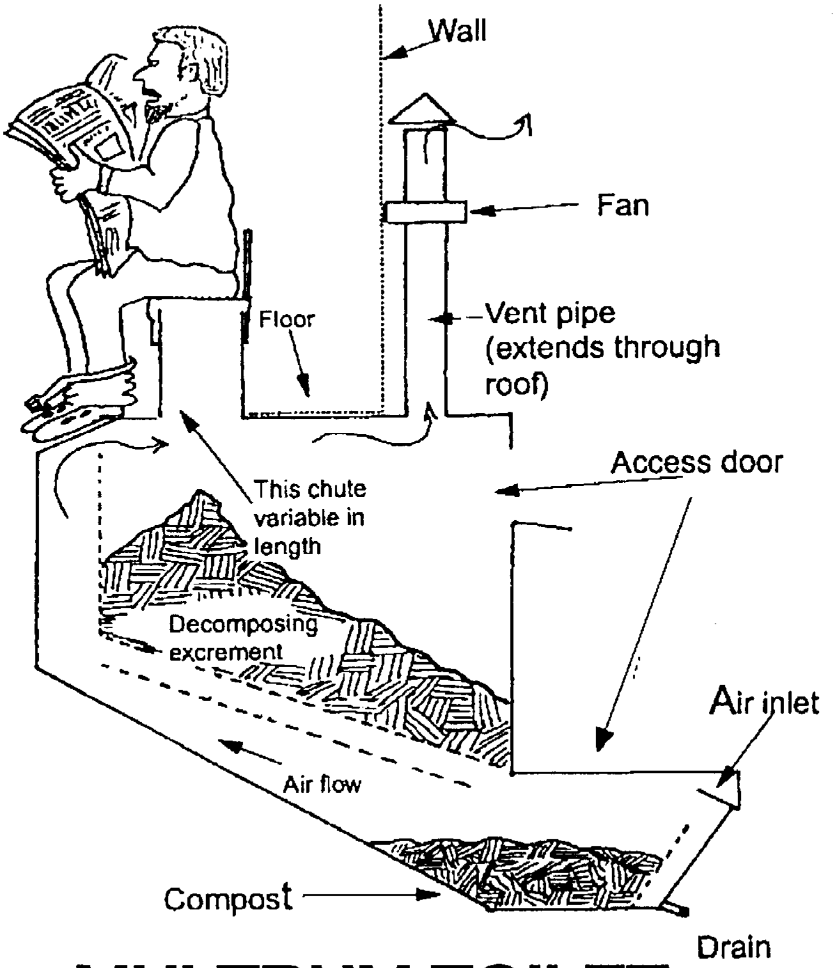
COMMERCIAL MOULDERING (OR MULTRUM) TOILETS

Commercial mouldering toilets have been popular in Scandinavia for some time, and at least twenty-one different mouldering toilets were on the market in Norway alone in 1975.[4] One of the most popular types of commercially available composting toilets in the United States today is the multrum toilet, invented by a Swedish engineer and first put into production in 1964. These toilets have found their way into public buildings, banks, even universities. The concept is similar to that of a simple double-chambered mouldering toilet, although fecal material and urine are deposited *together* into a single chamber with a double bottom. The decomposition takes place slowly over a period of years, and the finished compost gradually falls down to the very bottom of the toilet chamber where it can be removed. Again, the decomposition temperatures remain cool, not usually climbing above 90^0 F, which is not high enough to kill all pathogens. Therefore, it is recommended that the finished compost be buried under one foot of soil or used in an ornamental garden.[5]

The advantages of this type of toilet include the passive nature of user participation. Anybody will happily use a multrum toilet because they know full well that *someone else* someday will have to empty it out. Also, no water is used or required during the operation of this toilet, thereby keeping human excrement out of the water supplies as well as conserving water. According to one report, a single person using a Clivus Multrum will produce 40 kg (88 lbs) of compost per year while refraining from polluting 25,000 liters (6,604 gallons) of water annually.[9] Finally, the finished compost can be used as a soil additive where the compost will not come in contact with food crops.

Drawbacks include the cost, which can easily exceed two or three thousand dollars (1990's), and the fact that the composting chamber is usually made of plastic, which means that for every plastic multrum toilet purchased, a non-biodegradable plastic multrum toilet will probably end up someday in a landfill. If these toilets were made from recycled plastic, that would certainly be a bonus, but that currently doesn't seem to be the case. Also, the multrums require electricity to run both a fan-driven ventilation system and a pump for pumping excess liquid (urine) from the composting chamber. Finally, the composting process does not kill all pathogens in the manure by means of thermophilic composting, although the lengthy retention time of the compost undoubtedly contributes to the destruction of most pathogens that may exist in the excrement (see table 6.11 on page 127).

I'm aware of a couple of multrum toilets currently being used by friends of mine, and they both have had problems with odors, while one has had problems with flies and excess liquid buildup in the composting chamber.

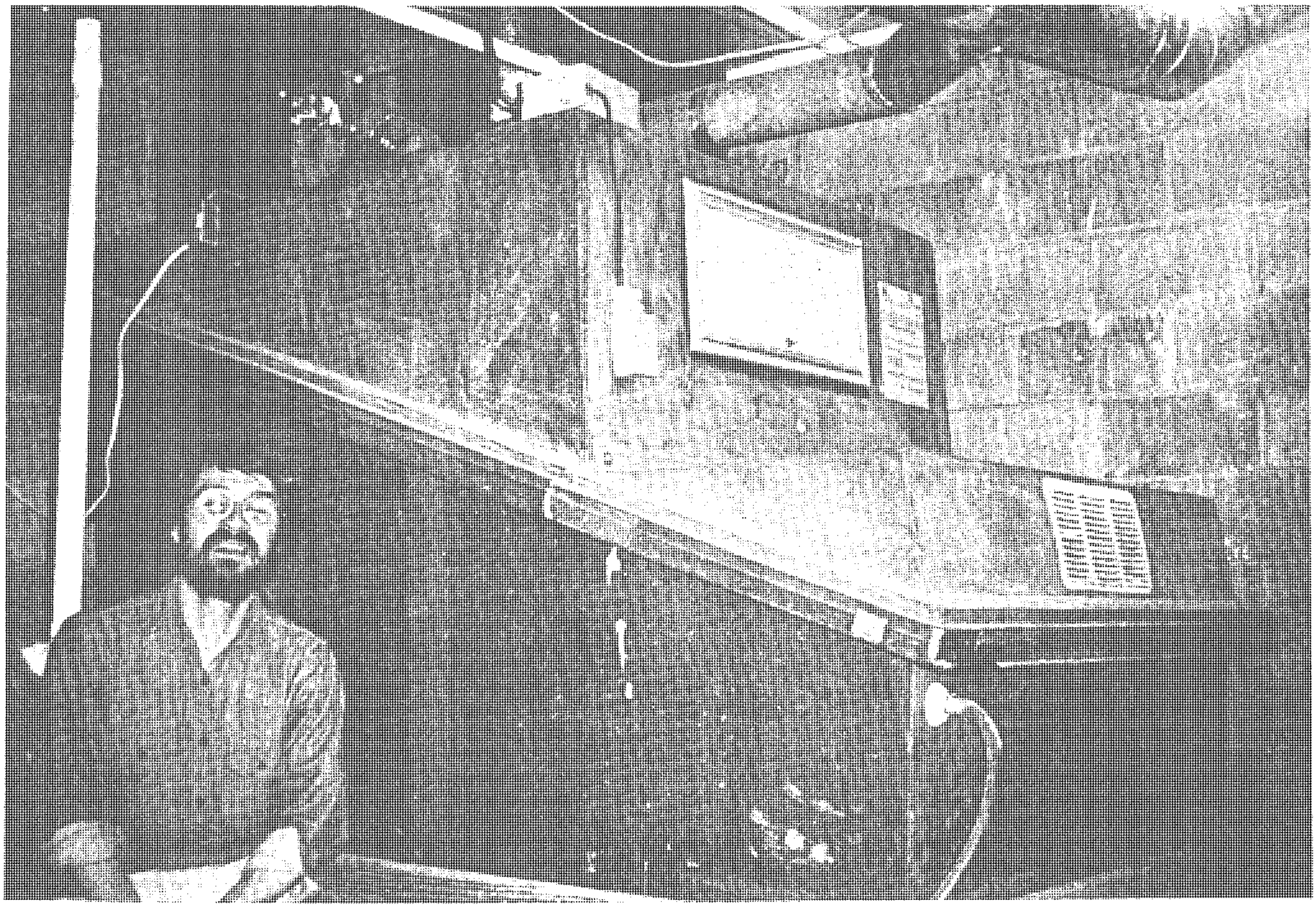


MULTRUM TOILET

(Garbage chute not shown)

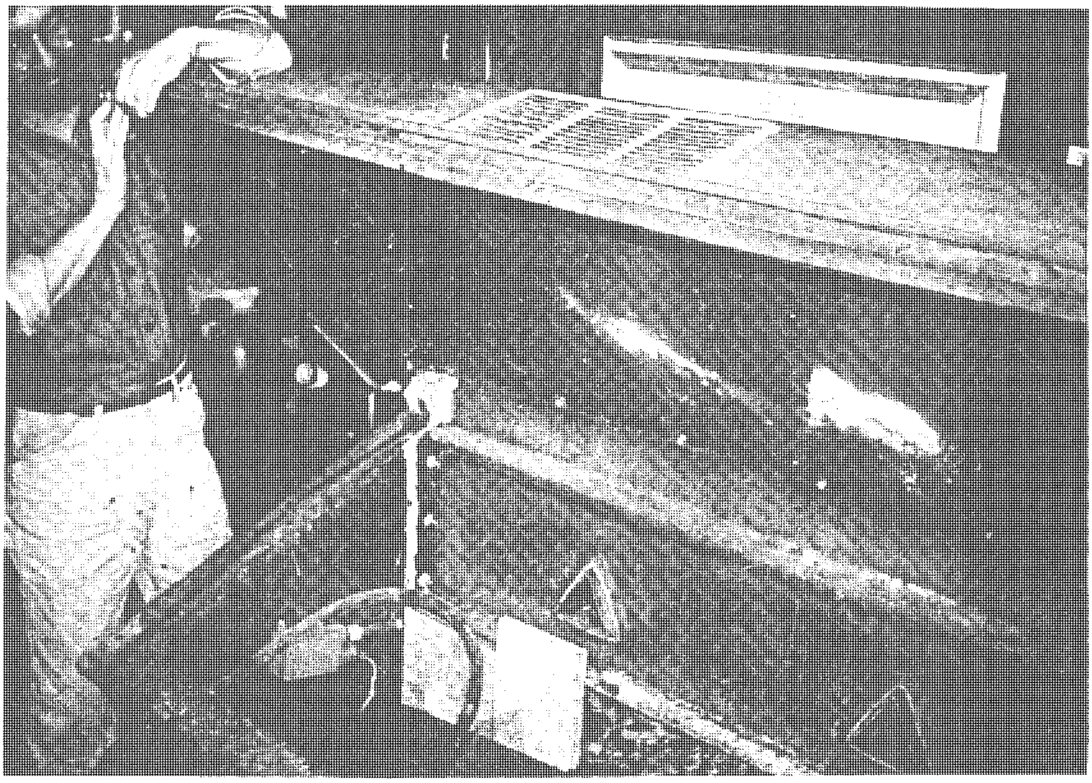
FIGURE 5.4

Now, it seems to me that these problems *are due to improper use of the toilet, not necessarily to the toilet itself*, as eventually both parties managed to get their toilets working well, without odors or flies. However, this indicates that some management of the composting toilet is required by someone using the toilet in order to avoid these kinds of problems. For example, organic bulking materials such as sawdust or fine wood shavings must be added regularly to the toilet to absorb excess liquids, aid the composting process, and minimize or eliminate odors. If a multrum toilet is managed properly, it should easily be odor and worry free. As always, a good understanding of the basic concepts of composting will help anyone who wishes to use a composting toilet. Nevertheless, the multrum toilets, when used properly, should provide a suitable alternative to flush toilets for people who want to stop defecating in their drinking water. You can probably grow a heck of a rose bed with the compost, too.



A CLIVUS MULTRUM IN THE BASEMENT OF SLIPPERY ROCK UNIVERSITY'S HARMONY HOUSE. THE TOILET AND THE KITCHEN COMPOST DISPOSAL CHUTE ARE ON THE FIRST FLOOR.

Finished compost from seven Clivus Multrum toilets which had been in use for 4 to 14 years was analyzed for nutrients, according to a report issued by Clivus Multrum USA in 1977. The compost averaged 58% organic matter, with 2.4% of nitrogen, 3.6% of phosphorous, and 3.9% of potassium, which is reportedly higher than composted sewage sludge, municipal compost, or ordinary garden compost. Suitable concentrations of trace nutrients were also found. Toxic metals were found to exist in concentrations far below recommended safe levels.[9]



THE CONTENTS OF A CLIVUS MULTRUM ARE BEING EXAMINED THROUGH ITS MAIN ACCESS DOOR.

MORE COMMERCIAL COMPOSTING TOILETS

There are a variety of other composting toilets available on the market today (see reference list and additional sources of composting toilets on pages 107-108). One manufacturer (*Sun Mar*) claims that over 200,000 composting toilets have been sold worldwide. The same manufacturer produces a fiberglass and stainless steel toilet which consists of a drum under the toilet seat or under the bathroom floor into which the feces and urine are deposited. The drum is rotated by hand in order to blend the ingredients, which should include garbage and a carbon material such as peat moss. The toilet can come equipped with an electric heating system and an electrical fan ventilation system. The compost is produced in small quantities which are removed by pulling out a drawer beneath the drum. The compost is said to be suitable for garden purposes.

Drawbacks? Some of the models require water as well as electricity (although some require no electricity or water). Again, the cost may be prohibitive to some, although these smaller, more self-contained toilets seem to cost less that the multrums. 1993 price quotes ranged from $1100.00 to $1400.00. Also, for every fiberglass toilet unit purchased, someday a fiberglass toilet unit will undoubtedly end up thrown "out" somewhere when it wears out.

However, as the manufacturer insists that the toilet produces absolutely no odor and generates compost suitable for a food garden, it must be assumed that the heating element in the electric toilets in combination with the active compost blending create optimum composting conditions which kill all pathogens. The literature on these toilets doesn't discuss the pathogen issue in any detail though, and as some of the toilets aren't electrically heated, the destruction of pathogens in the finished compost remains a matter of speculation.[6]

Another composting toilet that is currently on the market (*AlasCan*) is even further up the ladder of technological sophistication. Made in Alaska and costing upwards of $10,000 or more, the toilet is complete with an insulated tank, conveyers, motor-driven agitators, a pump and sprayer, and exhaust fan.[7]

Finally, another source of a composting toilet[8] (*Composting Toilet Systems*) manufactures a fiberglass unit similar to a multrum toilet, and advertises it as a "waste disposal system". The 1993 price for this unit, which uses no water, but does require electricity, is $3656.00. According to the manufacturer, waterless composting toilets reduce household water consumption by 40,000 gallons per year. This is significant when one considers that only 3% of the Earth's water is fresh, even more so when one realizes that two thirds of that fresh water is locked up in ice. That means that less than one percent of the Earth's water is available as fresh water. Why shit in it?

ASIAN COMPOSTING

As stated in chapter three, it is well known that Asians have *recycled* humanure for centuries, possibly millennia. However, historical information concerning the *composting* of humanure in Asia seems difficult to find. Rybczynski et. al.[9] in fact state that such composting was only introduced to China in a systematic way in the 1930's, and that it wasn't until 1956 that compost toilets were used on a wide scale in Vietnam. On the other hand, Franceys et. al. tell us that composting, *"has been practiced by farmers and gardeners throughout the world for many centuries."* They add that, *" In China, the practice of composting human wastes [sic] with crop residues has enabled the soil to support high population densities without loss of fertility for more than 4000 years."* [10]

However, a book published in 1978 and translated directly from the original Chinese (Compost, Fertilizer and Biogas Production from Human and Farm Wastes in the People's Republic of China, by M. G. McGarry and J. Stainforth, International Development and Research Center, Ottawa)[13] indicates that composting has *not* been a cultural practice in China until only recently. An agricultural report from the Province of Hopei, for example, states that the standardized management and hygienic disposal (i.e. composting) of excreta and urine was only initiated there in 1964. The composting techniques being adopted and developed at that time included the segregation of feces and urine, which were later "*poured into a mixing tank and mixed well to form a dense fecal liquid*" before piling on a compost heap. The compost was made of 25% human feces and urine, 25% livestock manure, 25% miscellaneous organic refuse, and 25% soil.

Two *aerobic* methods of composting were reported to be in widespread use in China, according to the 1976 report. The two methods are described as a) surface aerobic continuous composting, and b) pit aerobic continuous composting. The *surface* method involves constructing a compost pile around an internal framework of bamboo, approximately nine feet by nine feet by three feet high (3m x 3m x 1m).

A YOUNG LADY SETTING CEDAR POSTS IN THE GROUND FOR THE CONSTRUCTION OF A DOUBLE-CHAMBERED COMPOST BIN.

Compost ingredients include fecal material (both human and non-human), organic refuse, and soil. The bamboo is removed from the constructed pile and the resultant holes allow for the penetration of air into this rather large pile of refuse. The pile is then covered with earth or an earth/horse manure mix, and left to decompose for 20 - 30 days, afterwhich the composted material is used in agriculture. The *pit* method involves constructing compost pits five feet wide and four feet deep by various lengths, then digging channels in the floor of the pits. The channels (one lengthwise and two widthwise) are covered with coarse organic material such as millet stalks, and a bamboo pole is placed vertically along the walls of the pit at the end of each channel. The pit is then filled with organic refuse and covered with earth, and the bamboo poles are removed to allow for air circulation.[11]

Additional light is shed on the subject of Chinese composting by a report from a hygienic committee of the Province of Shantung, as published in the aforementioned work by McGarry and Stainforth. The report lists three traditional methods used in that Province for the recycling of humanure: 1) drying it ("*drying has been the most common method of treating human excrement and urine for years*"), 2) using it raw for agricultural purposes, and 3) "*connecting the household pit privy to the pigpen . . . a method that has been used for centuries*", a method in which the excrement was simply eaten by a pig. No mention is made whatsoever of composting being a traditional method used by the Chinese for recycling humanure. On the contrary, all indications were that the Chinese government in the 1960's was *at that time* attempting to establish composting as preferable to the three traditional recycling methods listed above, mainly because the three methods were hygienically unsafe, while composting, when properly managed, would destroy pathogens in humanure while preserving agriculturally valuable nitrogen. Once again, the report describes composting techniques in which soil was being used as a main ingredient in the compost, or, to quote directly, "*Generally, it is adequate to combine 40-50% of excreta and urine with 50-60% of polluted soil and weeds*".

For further information on Asian composting I must defer to Rybczynski et. al., whose World Bank research on low-cost options for sanitation considered over 20,000 references and reviewed approximately 1200 documents. Their review of Asian composting is brief, but includes the following information, which I have condensed:

There are no reports of composting privys (toilets) being used on a wide scale until the 1950's, when the Democratic Republic of Vietnam initiated a five-year plan of rural hygiene and a large number of *anaerobic* composting toilets were built. These toilets, known as the Vietnamese double vault (see figure 5.5), consisted of two, above ground water-tight tanks, or *vaults*, for the collection of humanure. For a family of five to ten people, each vault was required to be 1.2 m wide, 0.7 m high, and 1.7 m long (approximately 4 feet wide by 28 inches high and 5 feet seven inches long). One tank is used until full then left to decompose while the other tank is used. The use of this sort of composting toilet requires the segregation of urine, which is diverted to a separate receptacle by means of a groove on the floor of the toilet. The fecal material is collected in the tank and covered with soil, where it anaerobically decomposes. Kitchen ashes are added to the fecal material for the purpose of reducing odor. Intestinal worm eggs, which are one of the most persistently viable forms of human pathogens, were found to be 85% destroyed after a two month composting period in this system.

Another anaerobic double-vault composting toilet in use in Vietnam includes the use of fecal material *and* urine, but the bottom of the vaults are perforated to allow drainage, and the urine is filtered through limestone to neutralize acidity. Other organic refuse is also added to the vaults, and ventilation is provided via a pipe.

In India, the composting of organic refuse and humanure is advocated by the government. A study of such compost prepared in pits in the 1950's showed that intestinal worm parasites were completely eliminated in 3 months and pathogenic bacteria were also completely destroyed. The destruction of pathogens in the compost was attributed to the maintenance of a temperature of about 104°F for a period of 10-15 days. However, it was also concluded that the compost pits had to be properly constructed and managed, and the compost not removed until fully "ripe", in order to achieve the total destruction of human pathogens. If done properly, it is reported that *"there is very little hygienic risk involved in the use and handling of [humanure] compost for agricultural purpos-*

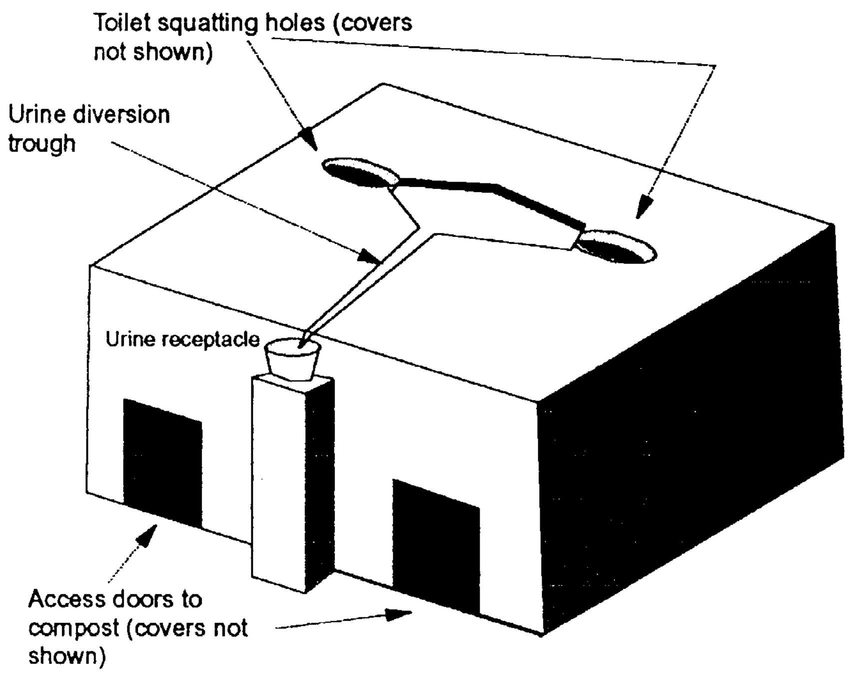


FIGURE 5.5

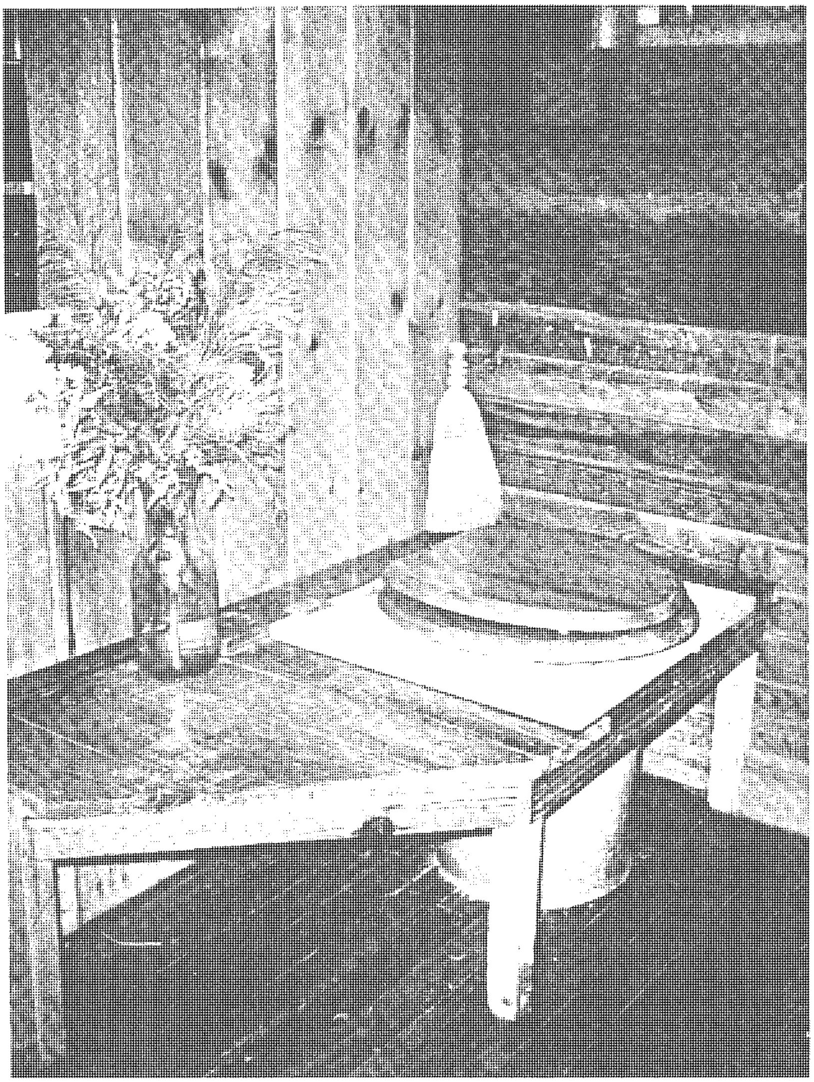
Vietnamese Double Vault

(Simplified diagram)

Source: Rybczynski, W. et. al. (1982). Low-Cost Technology Options for Sanitation - A State of the Art Review and Annotated Bibliography. World Bank, Washington D.C. (p.17).

es". The issue of pathogens will be discussed at length in the next chapter.

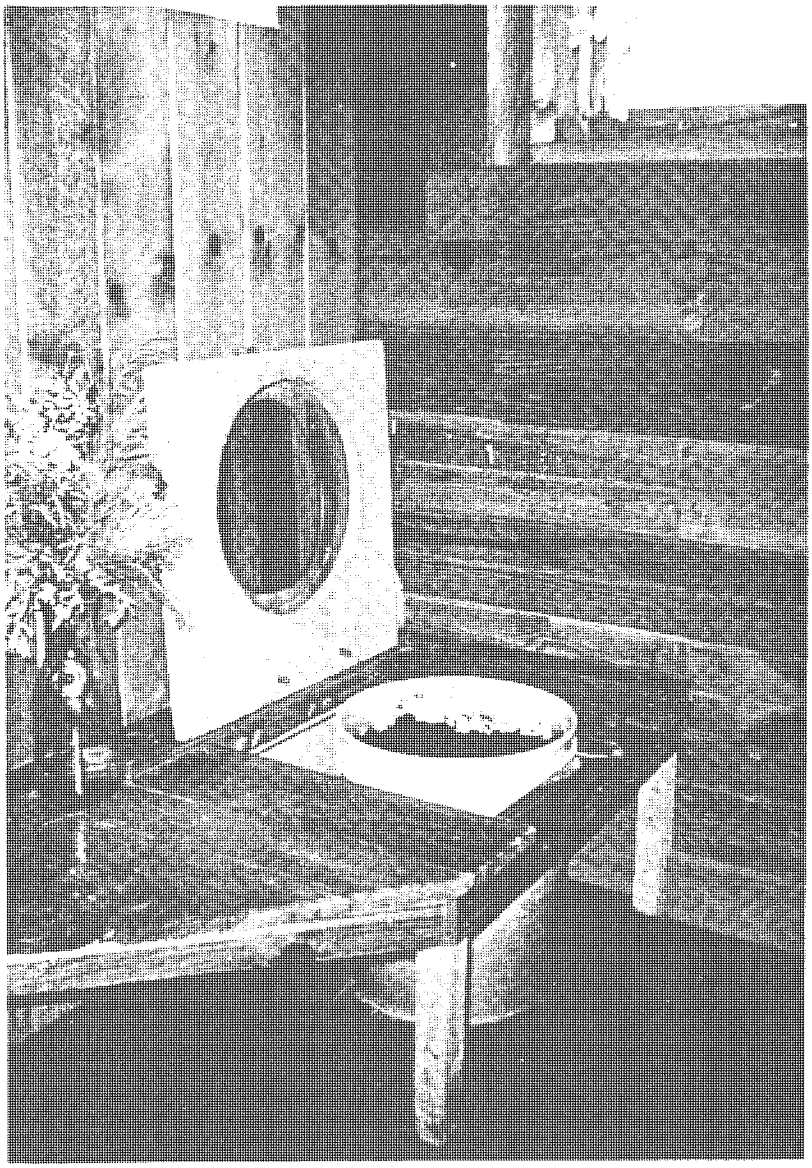
SIMPLE, LOW-TECH HUMANURE COMPOSTING



A SAWDUST TOILET. HUMANURE IS COLLECTED IN THE FIVE-GALLON CONTAINER UNDER THE SEAT AND KEPT COVERED WITH ROTTED SAWDUST. WHEN FULL, THE ORGANIC MATERIAL IS DEPOSITED INTO A COMPOST BIN FOR THERMOPHILIC COMPOSTING (SEE NEXT PAGE). SUCH A TOILET COSTS VERY LITTLE TO INSTALL OR OPERATE AND REQUIRES NO WATER OR ELECTRICITY.

Simple, low-tech compost systems are traditionally used by people who do not have the luxury of buying expensive, electrically powered, plastic or fiberglass receptacles to defecate in. Instead, they develop simple methods of collecting their manure and composting it, often away from their living spaces. Sometimes these systems are called cartage systems or bucket systems, as the manure is carried to the compost pit, chamber or bin, often in buckets or other waterproof vessels. People who utilize such simple techniques for composting humanure simply take it for granted that feces recycling is one of the regular and necessary chores of sustainable human life on this planet.

How it works is a model of simplicity. One begins by depositing one's organic refuse (feces and urine) into a plastic bucket, clay urn or other non-corrodible waterproof receptacle with about a five gallon (approximately 20 liters) capacity. Food scraps may be collected in a separate receptacle. The humanure is kept covered with a clean, organic material such as sawdust, peat moss, soil, etc. in order to prevent odors, absorb urine, and eliminate any fly nuisance, and a lid is kept on the receptacle when not in use. A standard, hinged toilet seat is quite suitable as a lid. This system of using an organic cover material works well enough in preventing odors to allow the toilet to be indoors, year round. When the bucket is full, it is carried to the composting area and deposited on the pile. The deposit is then immediately covered with a layer of clean, bulky, organic material such as straw or weeds, in order to eliminate odors and trap air. The bucket is then thoroughly scrubbed with a small quantity of water, which can be rain water or wastewater, and biodegradable soap, if available or desired. A long-handled toilet brush works well for this purpose. The soiled water is then poured on the compost pile. Rain water or wastewater is ideal for this purpose as its collection requires no electricity. The bucket is then replaced in the toilet area. The inside of the bucket can then be dusted with clean, dry sawdust and it's ready to "go".



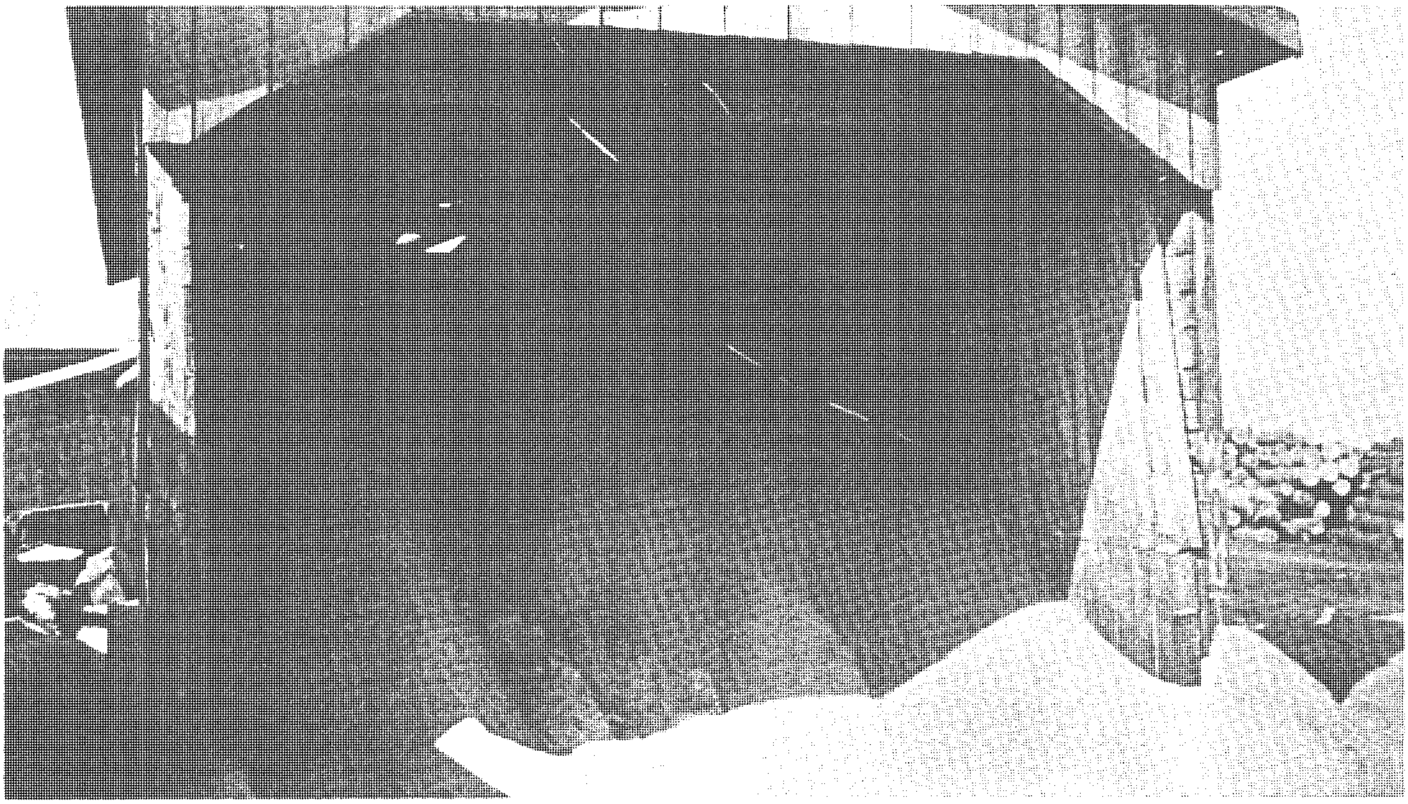
THE FULL SAWDUST TOILET RECEPTACLE IS SIMPLY LIFTED OUT OF THE TOILET AND EMPTIED INTO A COMPOST BIN OUTDOORS. ALL URINE AND FECES IS COLLECTED IN SUCH A TOILET. A FAMILY OF FOUR CAN EXPECT TO FILL A SAWDUST TOILET OF THIS SORT IN THREE OR FOUR DAYS. THE SAWDUST COVER ELIMINATES ODORS AND FLIES, AND BALANCES THE NITROGEN OF THE HUMANURE WITH CARBON, THEREBY FACILITATING THERMOPHILIC COMPOSTING. SUCH A TOILET SHOULD BE LOCATED INSIDE, BUT NEAR AN OUTSIDE DOOR FOR EASE OF REMOVAL.

Drawbacks to this system include the inconvenience of carting buckets of excrement on a regular basis; having to look at and smell the excrement (mixed in sawdust), no matter how briefly, when depositing it on the compost pile; having to clean the bucket after emptying; and having to keep a supply of clean, organic material (e.g. sawdust, peat or clean soil, and straw/hay, weeds or leaves) available to use as cover materials, which is absolutely essential to the success of this sort of humanure composting system. Furthermore, when the bucket gets full, it can't be used until it's been emptied, no matter how bad one has to go. There is a degree of conscientious and serious responsibility involved in this system of composting in order for it to work well.

The advantages to this system include low financial cost in the creation of the facilities and low, or no energy consumption in its operation. Also, such a simple system, when the refuse is thermophilically composted, has a low environmental cost, as little or no technology is required for the system's operation, and the finished compost is as nice and benign a material as humanure can ever hope to be. No large, non-biodegradable composting chambers are required, and no composting facilities are necessary in or near one's living space, unless by choice (the manure collection can and should be inside one's home and can be quite comfortably designed). No electricity is needed, and no water is required except a small amount for cleaning purposes. The compost, if properly managed, will heat up sufficiently to kill all pathogens and thereby be useful for gardening purposes. A complete natural cycle is maintained, unbroken. Finally, the composting process is fast, i.e. the humanure is converted quickly (within a few days if not frozen) into an inoffensive substance that will neither attract rodents nor flies. In cold winter months, the compost simply freezes until spring thaw, then heats up.

The thought of carrying humanure to a compost site away from one's living space is one that will cause most Westerners to immediately reject the idea of composting their manure in this manner. The Western culture is built upon the idea of convenience, which is one reason why commercial composting toilets are relatively popular in the West, and the inconvenience of carrying refuse (*any* refuse) to a compost pile on a regular basis is just unacceptable. It is more convenient to *discard* organic refuse, such as down a toilet or in a garbage can, and that's why Western cultures do so. However, there are still more than a few people on the planet who are happy to endure a small inconvenience in exchange for less waste, a cleaner environment, and for soil-building compost. Furthermore, there are many people who do not have the luxury of choosing the convenience of waste disposal, as they don't have electricity, running water, or garbage pick-up, and they are therefore prime candidates for the thermophilic composting of their manure.

Likewise, there are those who want to compost their manure, are willing to endure some inconvenience, and still don't want to have to carry it anywhere. Those are people who may want to try situating their toilets directly above their compost piles, such as is done with a mouldering toilet. This may be best suited in warm climates where an outdoor toilet is acceptable, or in situations where an easily accessible basement is available for the location of the compost pile. There's no reason why this scenario would not work *if the compost is properly managed.* Proper management can be summed up simply with four requirements:



This sawmill shed is full of raw, hardwood sawdust. Large quantities of this carbon-rich organic material are typically available at numerous sawmills throughout any forested area, either free for the hauling, or at very little cost. The above sawdust is being protected from the weather so it won't freeze, however, for composting purposes it is best to leave the sawdust exposed to the elements so it will become damp and will more rapidly decompose. Rotted sawdust is better for a compost pile than raw sawdust; kiln-dried sawdust (from a lumber yard) is the worst due to its relatively inert dehydrated state which resists microbial decomposition (let it sit out in the rain to rehydrate it).Sawdust alone decomposes slowly and may take 15 years to fully decompose. However, when blended with nitrogen rich, moist humanure, it will decompose relatively rapidly, returning to humus in year or two.

An Important Note About Sawdust

Not all sawdust decomposes well. Some tree species contain antibiotic oils that retard the development of microorganisms, and sawdust from these trees does *not* make good compost. These trees include **CEDAR, REDWOOD, BLACK LOCUST, OSAGE ORANGE, CYPRESS, WHITE OAK,** and perhaps others. Some rot-resistant hardwoods such as white oak *will* make good compost if the sawdust is left to decompose outside for a year or two before using for compost. Although the author uses only hardwood sawdust for compost because he lives in a hardwood forest area, **softwood sawdust makes good compost too, and some say it's even better than hardwood.** You be the judge. Experiment!

1) *Use at least a double chambered, above ground compost bin.* Deposit in one chamber for a period of time (e.g. a year), then switch to the other for an equal period of time.

2) *Deposit a good mix of organic refuse into the compost pile*, including kitchen scraps.

3) *Always cover humanure deposits with an organic cover material* such as sawdust, leaves or hay. Make sure that enough cover is applied so that there is neither excess liquid build-up nor offensive odors escaping the compost pile. The trick to using cover material is quite simple: *if it smells bad, cover it.*

4) *Keep good access to the pile* in order to rake the top flat, to apply bulky cover material when needed, and to monitor the temperature of the pile, if desired. The advantage of aerobic composting, as is typical of an above-ground pile, over anaerobic composting typical of sealed pits, is that the aerobic compost will generate higher temperatures, thereby ensuring a more rapid and complete destruction of potential human pathogens. It is still widely reported today that the aeration of a compost pile is best achieved by manual methods, especially turning of the pile, such as with a shovel, although I dispute this. Because of the widespread encouragement to turn compost piles, I turned my compost every year for over a decade, until I started monitoring the temperature of my compost pile using a compost thermometer. That's when I discovered that when I turned my compost, the thermophilic activity of the pile immediately stopped, and the pile cooled down, which is just the opposite of what one would expect. Yet the explanation is simple.

Perhaps my composting technique is unique in that it is as simple as it can get. I build the same pile for a year in an above-ground wooden bin, then I leave it to age for another year as I build a second pile. After the second year, I remove the first pile, which is now finished, and I start over in the first bin with a new pile. I use an annual system because my growing season is based on an annual system. I apply compost to my garden once a year because I only plant a garden once a year. When one builds the same pile *continuously* for a year, one will find during the course of that year that the thermophilic area of the pile is on the top where the fresh deposits reside. The lower sections of the pile have already heated and are now undergoing a cooler decomposition by fungi, earthworms etc. The pile is constantly growing on top and constantly shrinking beneath, and the thermophilic layer is therefore constantly rising to digest the newer deposits. When a pile such as this is turned, the thermophilic layer on top becomes diluted with the cooler, thermophilically-spent lower layers, and the carbon/nitrogen balance consequently becomes disrupted. The thermophiles don't have the proper balanced diet, and they cool down and die off, oxygen or no oxygen. All the oxygen in the world isn't going to ensure a successful compost pile when the other requirements for successful compost are not met.

When I came to understand this phenomenon as it relates to continuous composting, I realized that if the compost pile is heating sufficiently, it obviously has enough oxygen. There is no need to add more, and if one tries to do so by turning the pile, one instead runs the risk of disrupting the C/N ratio of the thermophilic layer of the compost, thereby putting out its fire. Since my compost heats more than adequately for the purposes of hygiene, I've been forced to come to the conclusion that the simple act of covering humanure deposits with coarse materials such as straw or weeds, actually helps to trap sufficient oxygen in the pile *to render any additional or manual aeration of the compost unnecessary*.

Furthermore, in my case, all human urine is collected with fecal material and composted in the same elevated pile. This is made possible and convenient by using an absorbent carbonaceous material in the toilet receptacle itself, which absorbs the urine and covers the humanure deposits, thereby eliminating odors, flies and any other problems. I use rotting sawdust from logs because it is a readily available and inexpensive local resource, and it works. I used to haul a free load home every so often in the back of my pick-up truck, but now I just have a fellow with a small dump truck deliver me a load every year or two. I have the sawdust dumped outside where it can remain exposed to the elements and thereby slowly decompose on its own, as rotting sawdust makes compost more quickly than fresh sawdust. The sawdust doesn't cost anything, but it usually costs about five dollars to have it loaded and another twenty or so to have it hauled. This is an expense I'm happy to pay in order to ensure for myself a functional compost toilet system. However, my guess is that any cellulose-based material or combination of materials would work, including perhaps ground newsprint, or even just plain soil, if collected and kept dry enough to be absorbent.

Anaerobic systems seem best suited in situations where large amounts of refuse need to be composted, such as in an anaerobic pit where municipal refuse is deposited. Compost microorganisms, in the absence of oxygen (anaerobic), convert organic nitrogen to ammonia, while carbon is reduced to methane, and sulfur to hydrogen sulfide. This results in rather severe odor problems, and the destruction of pathogens proceeds slowly due to the relatively low composting temperatures. Such destruction may take up to twelve months for roundworm eggs.[12]

When I read about all of the styles and techniques for composting humanure, including vaults, pits, segregation of urine, liming, ashing, sealing, turning, etc., I wonder if anyone has tried to simply collect humanure, with urine and a carbon cover material, and pile it in a bin with garbage and other local organic cover materials such as weeds. Such a simple system, although not glamorous or sophisticated, works.

And that's what really matters, doesn't it?

Simple, low-tech compost systems not only have a low negative impact on the Earth's ecosystems, but are proven to be sustainable. Westerners may think that any system not requiring technology is too primitive to be worthy of respect. However, when Western culture is nothing more than a distant and fading memory in the collective mind of humanity thousands (hundreds?) of years from now, the humans who will have learned how to survive on this planet in the long term will be those who have learned how to live in harmony with it. That will require much more than intelligence or technology - it'll require a sensitive understanding of our place as humans in the web of life. That self-realization may be beyond the grasp of our egocentric intellects. Perhaps what is required of us in order to gain such an awareness is a sense of humility, and a renewed respect for that which is simple.

Some would argue that a very simple system of humanure composting can also be the most advanced system known to humanity. It may be considered the most advanced because it works well *while consuming little, if any, non-renewable resources, producing no pollution, and actually creating a resource vital to life.*

Now others may argue that in order for a system to be considered "advanced", it must display all the gadgets, doodads and technology normally associated with advancement. The argument is that something is advanced if it's been created by the scientific community, by humans, not by nature. That's like saying the most advanced method of drying one's hair is using a nuclear reaction in a nuclear power plant to produce heat in order to convert water to steam in order to turn electric generators in order to produce electricity in order to power a plastic hair-drying gun in order to blow hot air on one's head. But that's only technological advancement. It reflects humanity's *intellectual* progress . . . (I think).

True advancement, others would argue, instead requires the *balanced* development of humanity's intellect with physical and spiritual advancement. We must link what we know intellectually with the physical effects of our resultant behavior, and with the understanding of ourselves as small, interdependent, interrelated life forms in relation to a greater sphere of existence. Otherwise, unbalanced technological advancement uses technology to excessively consume non-renewable resources and to create toxic waste and pollution in order to do a simple task such as hair drying, which is easily done by hand with a towel. If that's advancement, we're in trouble.

Perhaps we're really advancing ourselves when we can function healthfully, peacefully and sustainably without squandering resources and without creating pollution. That's not a matter of mastering the intellect or of mastering the environment with technology, it's a matter of mastering one's self, a much more difficult undertaking, but certainly a worthy goal.

1 - Crook, James. (1985). "Water Reuse in California", *Journal American Water Works Association*, v.77, no.7, as seen in The Water Encyclopedia (van der Leeden, et. al., 1990, Lewis Publishers, Chelsea, Mich. 48118).

2 - Boyd, Robert F. and Hoerl, Bryan G. (1977). Basic Medical Microbiology. Little, Brown and Co., Boston. (p.494).

3 - Clayton, D., and Jacke, D. (1992). The Gap Mountain Permaculture Mouldering Toilet. Published by Gap Mountain Permaculture, 9 Old County Road, Jaffrey, NH 03452, phone:(603) 532-6877. Cost of mouldering toilet publication is $12.00.

4 - Rybczynski, W. et. al. (1982). Appropriate Technology for Water Supply and Sanitation - Low Cost Technology Options for Sanitation, A State of the Art Review and Annotated Bibliography. World Bank. (p. 63). [see below]

5 - See ***Clivus Multrum*** *Maintenance Manual,* Clivus Multrum, Inc., 21 Canal St., Lawrence, Mass. 01840. (Also contact Hanson Assoc., Lewis Mill, Jeferson, MD 21755)

6 - Contact ***Sun Mar*** *Corp.*, 900 Hertel Ave., Buffalo, NY 14216 USA; or 5035 North Service Road, Burlington, Ontario, Canada L7L5V2.

7 - Contact ***AlasCan,*** *Inc.*, 3400 International Way, Fairbanks, Alaska 99701, phone/fax (907) 452-5257 [as seen in *Garbage,* Feb/Mar 1993, p.35].

8 - ***Composting Toilet Systems***, PO Box 1928 (or 1211 Bergen Rd.), Newport, WA 99156, phone: (509) 447-3708/ fax (509) 447-3753.

9 - Rybczynski, W. et. al. (1982). Appropriate Technology for Water Supply and Sanitation - Low Cost Technology Options for Sanitation, A State of the Art Review and Annotated Bibliography. World Bank. Transportation and Water Department, 1818 H Street N.W., Washington D.C. 20433 USA. *[Note: This work contains a bibliography on compost toilets that the reader may find useful.]*

10 - Franceys et. al. (1992). A Guide to the Development of On-Site Sanitation. World Health Organization, Geneva. (p. 213).

11 - Rybczynski, as above. (p. 114).

12 - Franceys, et. al., as above. (p.214).

13 - McGarry, Michael G., and Stainforth, Jill (eds.) (1978). Compost, Fertilizer, and Biogas Production from Human and Farm Wastes in the People's Republic of China, International Development Research Center, Box 8500, Ottawa, Canada, K1G 3H9 (pages 9, 10, 29, 32).

Additional Sources of Composting Toilet Plans and/or General Information:

*__Appalachia Science in the Public Interest__. Route 5, Box 423, Lexington KY 40445. [ASPI has a technical bulletin on composting toilets which includes a schematic for a compost toilet which ASPI designed.]

*__Water Conservation Systems, Inc.__ Damonmill Square, Nine Pond Lane, Concord, MA 01742 (508) 369-3951 [A source of several brands of composting toilets, including Biolet, Sunmar, Carousel, Alascan, Ecos Soltran, Sealand, Pactosan, and Nepon, as well as a variety of toilet accessories.]

*EKAT, Robert J. Fairchild, Executive Director, 150 Gravel Lick Branch Road, Dreyfus, KY 40426-9700, ph. (606) 986-6146. ["Big Batch Composting Toilet Plans" $7. Describes the do-it-yourself construction of compost toilets built of large, rolling, polyethylene dump carts, or "tilt trucks".]

*Long Branch Environmental Education Center. P.O. Box 369, Leicester, NC 28748 (704) 683-3662. ["Do-It Yourself Passive Solar Compost Toilet" ($25.00 for blueprints); Goodbye to the Flush Toilet by Carol Stoner ($18.00 postpaid); "Compost Toilets: A Guide for Owner Builders" ($8.00 postpaid).]

*National Center for Appropriate Technology. 3040 Continental Drive, PO Box 3838, Butte MT 59702 (406) 494-4572. ["Compost Toilets: Suggested Readings", 1992, 6 pages, $2; and "Wastes to Resources: Appropriate Technologies for Waste Conversion", 1984, 28 pages, $4.]

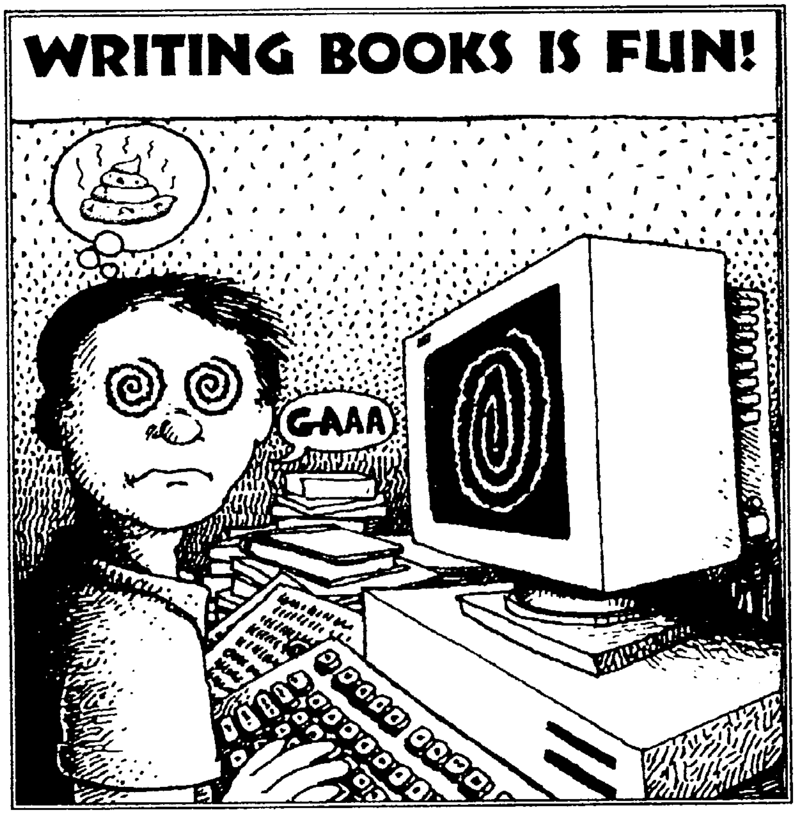
*Real Goods. 966 Mazzoni St., Ukiah, CA 95482-9486 USA, (800)762-7325. [They sell compost toilets and many other things.]

* Biolet (International, Canada, and USA)
Biolet USA Inc., Damonmill Square, Nine Pond Lane, Concord, MA 01742; 1-8005BIOLET.
In Canada: Biolet Toilets Ltd., 1177 West Hastings Street, Suite 1106, Vancouver, BC, V6E2K3; Ph: 604-685-5265.

*Jade Mountain 717 Poplar Ave., Boulder, CO 80304, or PO Box 4616, Boulder, CO 80306-4616; Ph: 303-449-6601 or 800-442-1972. (They sell various toilets).

*Lehman Hardware, Box 41, Kidron, Ohio 44636; Ph: 216-857-5441. (They have a selection of toilets).

*Soiltech (Biolet distributer) 607 E. Canal St., Newcomerstown, Ohio 43832-1207; Ph: 614-498-5929 or 800-296-6026.



WORMS AND DISEASE

"Compost heaps. We built them regularly out of all the waste material we could find and watered them lavishly with liquid from the communal cesspool. I had, as chief composter, responsibility for seeing that they heated properly . . . A well-made compost heap steams like a tea kettle and gets hot enough to destroy all pathogens that may be present when one uses human sewage. An extraordinary device when one thinks about it. Thermophilic bacteria. Bacteria that can live and flourish in temperatures hot enough to cook an egg. How can they survive in such heat? Truly the tricks of nature are extraordinary!"

Robert S. deRopp

I well remember in 1979 when I first informed a friend that I intended to compost my own manure and grow my own food with it. "*Oh my God, you can't do that!*" she cried.

"Why not?"

"Worms and disease!"

Of course. What else would a fecophobe think of when one mentions using humanure as a fertilizer?

An English couple was visiting me one summer after I had been composting humanure for about six years. One evening, as dinner was being prepared, the couple suddenly understood the horrible reality they now found themselves faced with: the food they were about to eat was *recycled shit.* When this "fact" dawned upon them it seemed to set off some kind of instinctive English alarm in their minds, possibly inherited directly from Queen Victoria. *"We don't want to eat shit!"* they quite seriously informed me (that's an exact quote), as if in preparing dinner I was simply defecating on plates and setting them on the table. Never mind that the food appeared quite palatable. It was the *thought* of it that mattered.

Fecophobia is alive and well and currently residing in about a billion Westerners. Oh well, ignorance is a problem. I have no doubt that if I were living five hundred years ago, I'd be considered one of those "witches" of bygone days. What made a person a witch was their refusal to accept the intellectual constraints of the era, which forced them to be seen as nonconforming and threatening to the status quo. The solution at that time reflected the puny intelligences and spiritual destitution of the establishment leaders: they'd simply gather up the non-conformists and burn them alive. Yes, ignorance is a chronic human problem.

One common misconception is that fecal material, when composted, remains fecal material. *It does not.* Humanure comes from the earth, and through the miraculous process of composting, returns to earth. When the composting process is finished, the end product is earth, not shit. That earth, or humus, is useful in growing food. My friends unfortunately didn't understand this, and they chose instead to continue clinging to their misconceptions, despite my attempts to clarify the matter for their benefit. Apparently, some fecophobes will always remain fecophobes.

THE HUNZAS

It's already been mentioned that entire civilizations have recycled humanure for thousands of years. That should provide a fairly convincing testimony about the usefulness of humanure as an agricultural resource. Nearly everyone's heard of the "healthy Hunzas", a people in what is now a part of Pakistan who live among the Himalayan peaks, and routinely survive to be 120 years old. The Hunzas gained fame in the United States during the 1960's health food era, at which time several books were written about the fantastic longevity of this ancient people. Their extraordinary health has been attributed to the quality of their overall lifestyle, including the quality of the natural food they eat and the soil it's grown on. Few people, however, realize that the Hunzas also compost their humanure and use it to grow their food. The Hunzas, who call themselves "Hunzakuts", have bronzed but Caucasian features like southern Europeans. They're said to have virtually no disease, no cancer, no heart or intestinal trouble, and they regularly live to be over a hundred years old while *"singing, dancing and making love all the way to the grave."*

According to Tompkins (1989), *"In their manuring, the Hunzakuts return everything they can to the soil: all vegetable parts and pieces that will not serve as food for humans or beast, including such fallen leaves as the cattle will not eat, <u>mixed with their own seasoned excrement</u>, plus dung and urine from their barns. Like their Chinese neighbors, the Hunzakuts save their own manure in special underground vats, clear of any contaminable streams, there to be seasoned for a good six months. Everything that once had life is given new to life through loving hands* (emphasis mine).*"*[1]

Sir Albert Howard wrote in 1947, *"The Hunzas are described as far surpassing in health and strength the inhabitants of most other countries; a Hunza can walk across the mountains to Gilgit sixty miles away, transact his business, and return forthwith without feeling unduly fatigued."* Sir Howard maintains that this is illustrative of the vital connection between a sound agriculture and good health, insisting that the Hunzas have evolved a system of farming which is perfect. He adds, *"To provide the essential humus, every kind of waste [sic], vegetable, animal and human, is mixed and decayed together by the cultivators and incorporated into the soil; the law of return is obeyed, the unseen part of the revolution of the great Wheel is faithfully accomplished."*[2]

Sir Howard's view is that soil fertility is the real basis of public health. A medical professional associated with the Hunzas claimed, *"During the period of my association with these people I never saw a case of asthenic dyspepsia, of gastric or duodenal ulcer, of appendicitis, of mucous colitis, of cancer. . .Among these people the abdomen over-sensitive to nerve impressions, to fatigue, anxiety, or cold was unknown. Indeed their buoyant abdominal health has, since my return to the West, provided a remarkable contrast with the dyspeptic and colonic lamentations of our highly civilized communities."*

Sir Howard's response to this is, *"The remarkable health of these people is one of the consequences of their agriculture, in which the law of return is scrupulously obeyed. All their vegetable, animal and human wastes [sic] are carefully returned to the soil of the irrigated terraces which produce the grain, fruit, and vegetables which feed them."*[3]

PATHOGENS

[Much of the following information is adapted from Appropriate Technology for Water Supply and Sanitation, by Feachem, et. al., World Bank, 1980.[4] This comprehensive work cites 394 references from throughout the world, and was carried out as part of the World Bank's research project on appropriate technology for water supply and sanitation. The reader can assume that the following facts and figures for which no references are shown originated in the above work. Other sources used for reference are as indicated.]

Clearly, the recycling of humanure for agricultural purposes does not necessarily pose a threat to human health, as evidenced by the Hunzas. And yet, it can. Feces can harbor any of a host of disease germs which can make their way into the environment to infect innocent people, as was apparently the case in medieval Europe. In fact, even a healthy person apparently free of disease can pass potentially dangerous pathogens through the feces, simply by being a carrier. Even urine, usually considered sterile, can contain disease germs (see table 6:1).

Table 6.1 (Source: Feachem et. al., 1980)

POTENTIAL PATHOGENS IN URINE

Healthy urine on its way out of the human body may contain up to 1,000 bacteria, of several types, per milliliter. More than 100,000 bacteria per milliliter of a single type signals a urinary tract infection.[23] Infected individuals will pass pathogens in the urine that may include:

Bacteria	Disease
1. *Salmonella typhi*	*typhoid*
2. *Salmonella paratyphi*	*paratyphoid fever*
3. *Leptospira*	*leptospirosis*
4. *Yersinia*	*yersiniosis*

Worms	Disease
Schistosoma haematobium	*schistosomiasis*

The following information is not meant to be alarming. It's included for the sake of thoroughness, and to illustrate the need to *thermophilically compost* humanure, rather than to try to use it raw for agricultural purposes. Humanure has been used raw in farm fields and is still used in such a state at times in various places throughout the world, including China. This is where the danger lies, as the process of thermophilic composting is required in order to kill dangerous pathogens that may reside in human excrement. When the composting process is side-stepped and pathogenic organic material is distributed throughout the environment, various diseases and worms can infect the population living in the contaminated area. This fact has been widely documented in societies where members recycle their manure carelessly as well as in those that don't recycle at all.

For example, consider the following quote from Jervis (1990): *"The use of night soil [raw human fecal material and urine] as fertilizer is not without its health hazards. Hepatitis B is prevalent in Dacaiyuan [China], as it is in the rest of China. Some effort is being made to chemically treat human waste [sic] or at least to mix it with other ingredients before it is applied to the fields. But chemicals are expensive, and old ways die hard. Night soil is one reason why urban Chinese are so scrupulous about peeling fruit, and why raw vegetables are not part of the diet. Negative features aside, one has only to look at satellite photos of the green belt that surrounds China's cities to understand the value of night soil."*[5]

On the other hand, "worms and disease" are not spread by properly prepared compost, nor by healthy people. There is no reason to believe that the manure of a healthy person is dangerous unless left to accumulate, pollute water with intestinal bacteria, and breed flies and/or rats, all of which are the results of negligence or bad customary habits. It should be understood that the breath one exhales can also be the carrier of dangerous pathogens, as can one's saliva and sputum. The issue is confused by the notion that if something is potentially dangerous, then it is always dangerous, which is not true. Furthermore, it is generally not understood that the carefully managed thermophilic composting of humanure kills all human pathogens in the manure. No other system of fecal material and urine recycling or disposal does this without the use of dangerous chemical poisons or a high level of technology and energy consumption.

The pathogens that can exist in human feces can be divided into four general categories: ***viruses, bacteria, protozoa, and worms*** *(helminths).*

There are more than 100 types of **viruses** worldwide that can be passed through human feces, including polioviruses, coxsackieviruses (causing meningitis and myocarditis), echoviruses (causing meningitis and enteritis), reovirus (causing enteritis), adenovirus (causing respiratory illness), infectious hepatitis (causing jaundice), and others (see table 6:2).

Of the pathogenic **bacteria**, the genus Salmonella is significant because it contains species causing typhoid fever, paratyphoid, and gastrointestinal disturbances. Another genus of bacteria, Shigella, causes dysentery. Myobacterium cause

Table 6.2 *(Source: Feachem et. al., 1980)*

POTENTIAL VIRAL PATHOGENS IN FECES

Virus	Disease	Can Carrier Be Symptomless?
1. *Rotaviruses*	Diarrhea	*yes*
2. *Hepatitis A*	Infectious hepatitis	yes
3. *Adenoviruses*	varies	*yes*
4. *Reoviruses*	varies	*yes*
5. *Coxsackievirus*	varies	*yes*
6. *Echoviruses*	varies	yes
7. *Polioviruses*	Poliomyelitis	*yes*

Rotaviruses may be responsible for the majority of infant diarrheas. Hepatitis A causes infectious hepatitis, but is often without symptoms, especially in children. Coxsackievirus infection can lead to meningitis, fevers, respiratory diseases, paralysis, and myocarditis. Echovirus infection can cause simple fever, meningitis, diarrhea, or respiratory illness. Most poliovirus infections don't give rise to any clinical illness, although sometimes infection causes a mild, influenza-like illness which may lead to virus-meningitis, paralytic poliomyelitis, permanent disability or death. It's estimated that almost everyone in developing countries becomes infected with poliovirus, and that one out of every thousand poliovirus infections leads to paralytic poliomyelitis.

tuberculosis (see table 6:3).

The pathogenic **protozoa** include Entamoeba histolytica (amoebic dysentery), and members of the Hartmanella-Naegleria group (meningo-encephalitis). The cyst stage in the life cycle of protozoa is the primary means of dissemination as the amoeba die quickly once outside the human body. Cysts must be kept moist in order to remain viable for any extended period (see table 6:4).[6]

Finally, a number of parasitic **worms** pass their eggs in feces, including hookworms, roundworms, and whipworms (see table 6:5). Various researchers have reported 59 to 80 worm eggs in sampled liters of sewage. This suggests that billions of pathogenic worm eggs may reach an average wastewater treatment plant daily. These eggs tend to be resistant to environmental conditions due to a thick outer covering.[7]

Now here's a good place to stop and do some calculations. If there are fifty-nine to eighty worm eggs in a liter sample of sewage, then we could reasonably estimate that there are 70 eggs per liter, or 280 eggs per gallon to get a ballpark average.

Table 6.3 *(Source: Feachem et. al., 1980)*

POTENTIAL BACTERIAL PATHOGENS IN FECES

Bacteria	**Disease**	***Symptomless Carrier***
1. *Salmonella typhi*	Typhoid fever	*yes*
2. *Salmonella paratyphi*	Paratyphoid fever	*yes*
3. Other *Salmonellae*	Food poisoning	*yes*
4. *Shigella*	Dysentery	*yes*
5. *Vibrio cholerae*	Cholera	*yes*
6. Other *Vibrios*	Diarrhea	*yes*
7. *E. coli*	Diarrhea	*yes*
8. *Yersinia*	Yersiniosis	*yes*
9. *Campylobacter*	Diarrhea	*yes*

Table 6.4 *(Source: Feachem et. al., 1980)*

POTENTIAL PROTOZOAN PATHOGENS IN FECES

Protozoa	**Disease**	**Symptomless carrier?**
1. *Balantidium coli*	Diarrhea	yes
2. *Giardia lamblia*	Diarrhea	yes
3. *Entamoeba histolytica*	Dysentery, colonic ulceration, liver abscess	yes

Table 6.5 (*Source: Feachem et. al., 1980*)

POTENTIAL WORM PATHOGENS IN FECES

	Common Name	Pathogen	Transmission	Distribution
1.	Hookworm	*Ancylostoma doudenale* *Necator americanus*	Human-soil-human	Warm, wet climates
2	———	*Heterophyes heterophyes*	Dog/cat-snail-fish-human	Middle east, S. Europe, Asia
3.	———	*Gastrodiscoides*	Pig-snail-aquat. veg.-human	India, Bangladesh, Vietnam, Philippines
4.	Giant Intestinal fluke	*Fasciolopsis buski*	Human/pig-snail-aq. veg.-human	S.E. Asia, China
5.	Sheep liver fluke	*Fasciola hepatica*	Sheep-snail- aq. veg.-human	Worldwide
6.	Pinworm	*Enterobius vermicularis*	Human-human	Worldwide
7.	Fish tapeworm	*Diphyllobothrium latum*	Human/animal-capepod-fish- human	Mainly temperate
8.	Cat liver fluke	*Opisthorchis felineus,* *O. viverrini*	Animal-aq. snail-fish-human	USSR,Thailand
9.	Chinese liver fluke	*Chlonorchis sinensi*	Animal/human-snail-fish-human	S.E. Asia
10.	Roundworm	*Ascaris lumbricoides*	Human-soil- human	Worldwide
11.	Dwarf tapeworm	*Hymenolepsis spp*	Human/rodent-human	Worldwide
12.	———	*Metagonimus yokogawai*	Dog/cat-snail-fish-human	Japan, Korea, China, Taiwan, Siberia
13.	Lung fluke	*Paragonimus westermani*	Animal/human- snail-crab/crayfish-human	S.E. Asia, Africa, S.America
14.	Schistosome, bilharzia	*Schistosoma haematobium*	Human-snail- human	Africa, M. East, India
	-----------	*S. mansoni*	Human-snail- human	Africa, Arabia , Latin America
	----------	*S. japonicum*	Animal/human- snail-human	S.E. Asia
15.	Threadworm	*Strongyloides stercoralis*	Human-human (dog-human?)	Warm, wet climates
16.	Beef tapeworm	*Taenia saginata*	Human-cow- human	Worldwide
	Pork tapewrom	*T. solium*	Human-pig-human or human-human	Worldwide
17.	Whipworm	*Trichuris trichiura*	Human-soil-human	Worldwide

That's approximately 280 pathogenic worm eggs per gallon of wastewater entering wastewater treatment plants. My local wastewater treatment plant serves a population of eight thousand people and collects about 1.5 million gallons of wastewater daily. That means there could be 420 million worm eggs entering the plant each day and settling into the sludge. In a year's time over 153 *billion* parasitic eggs can pass through my local small-town wastewater facility. Now let's look at the worst scenario: all the eggs survive in the sludge because they're resistant to the environmental conditions at the plant. Well, in a year's time, 30 tractor-trailer loads of sludge are hauled out of the local facility. Each truckload of sludge could then contain over *5 billion* pathogenic worm eggs, en route to maybe a farmer's field, but probably a landfill. Now, if we were composting that manure instead of floating it downstream, we'd be killing those eggs. But there I go getting ahead of myself again.

INDICATOR PATHOGENS

Indicator pathogens are pathogens whose detectable occurrence in soil or water serves as evidence that fecal contamination exists.

The astute reader will have noticed that many of the pathogenic worms listed previously are not found in the United States. Of those that are, the *Ascaris lumbricoides* (roundworm) is the most persistent, and can serve as an indicator for the presence of pathogenic helminths in the environment.

A single female roundworm may lay as many as 27 million eggs in her lifetime.[8] These eggs are protected by an outer covering that is resistant to chemicals and that can enable the eggs to remain viable in soil for long periods of time. The reported viability of roundworm eggs (*Ascaris* ova) in soil ranges from a couple of weeks under sunny, sandy conditions[9], to 2 and a half years[10], four years[11], five and a half years[12] or even ten years[13] in soil, depending on the source of the information. Consequently, the *eggs* of the roundworm seem to be the best indicator for the determination of parasitic worm pathogens in compost. In China, current standards for the agricultural reuse of humanure require an Ascaris mortality of greater than 95 percent.

Ascaris eggs develop at temperatures between 15.5°C (59.90° F) and 35°C (95.00° F), but the eggs disintegrate at temperatures above 38°C (100.40° F)[14]. The temperatures generated during thermophilic composting can significantly exceed levels necessary to destroy roundworm eggs.

One way to determine if the compost you're using is contaminated with viable roundworm eggs is to have a stool analysis done at a local hospital. If your compost is contaminated and you're using the compost to grow your own food, then there's a good chance that you've contaminated yourself. A stool analysis will reveal whether that is the case or not. Such an analysis cost about $41.00 (1993). [*See page 135]

Indicator bacteria include fecal coliforms, which reproduce in the intestinal systems of warm blooded animals. If one wants to test a water supply for fecal contamination, then fecal coliforms, usually *Escherichia coli*, are looked for. The absence of *E. coli* in water indicates that the water is free from fecal contamination.

Water tests, however, often determine the level of *total coliforms* in the water, reported as the number of coliform/100 ml. Such a test measures *all* species of the coliform group and is not limited to species originating in warm-blooded animals. Since some coliform species come from the soil, the results of this test are not always indicative of fecal contamination in a *stream* analysis. However, this test can be used for *ground water* supplies, as no coliforms should be present in ground water unless it has been contaminated by a warm blooded animal.

Fecal coliforms do not multiply outside the intestines of warm blooded animals, and their presence in water is unlikely unless there is fecal pollution, They survive for a shorter time in natural waters than the coliform group as a whole, therefore their presence indicates relatively recent pollution. In domestic sewage, the fecal coliform count is usually 90% or more of the total coliform count, but in natural streams fecal coliforms may range from 10-30% of the total coliform density. Almost all natural waters have a presence of fecal coliforms, since all warm-blooded animals excrete them. Most states in the U.S. limit the fecal coliform concentration allowable in waters used for water sports to 200 fecal coliform/100ml.

Table 6.13
Average Density of Fecal Coliforms Excreted in 24 Hours (million/100ml)

Human	13.0
Duck	33.0
Sheep	16.0
Pig	3.3
Chicken	1.3
Cow	.23
Turkey	.29

Bacterial analyses of drinking water supplies are routinely provided for a small fee (in 1994 around $20.00) by agricultural supply firms, water treatment companies, or private labs.

PERSISTENCE OF PATHOGENS IN SOIL, CROPS, MANURE AND SLUDGE

According to Feachem, et. al. (1980), the persistence of fecal pathogens in the environment can be summarized as follows:

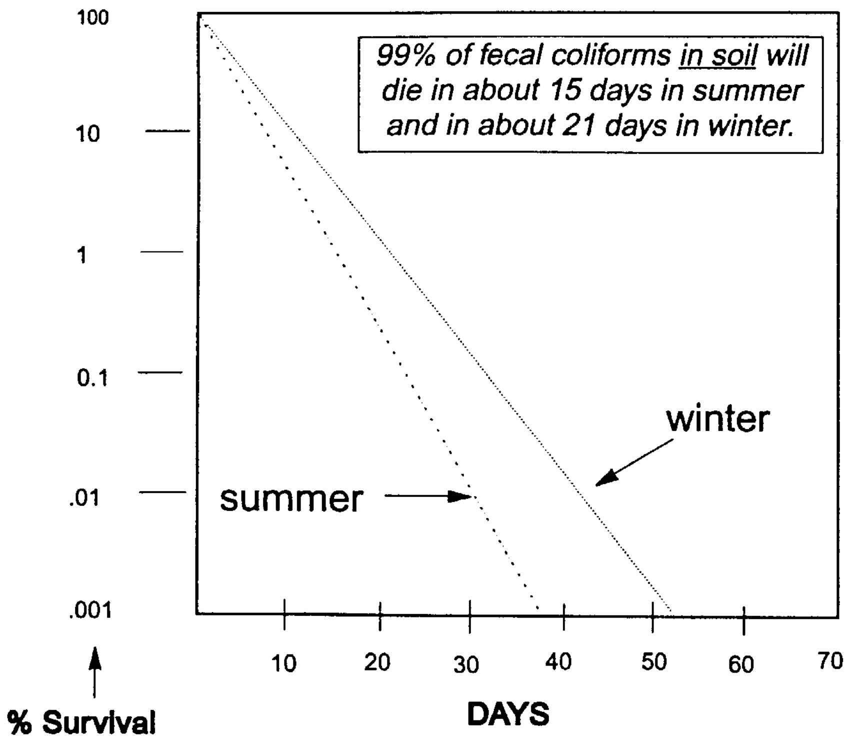


Figure 6G: Survival Times of Fecal Coliforms in Soil
Source: *Recycling Treated Municipal Wastewater and Sludge through Forest and Cropland,* edited by William E. Sopper and Louis T. Kardos, 1973, p.82, based on the work of Van Donsel *et al,1967.*

In Soil

Survival times of pathogens in soil are affected by soil moisture, pH, type of soil, temperature, sunlight, and organic matter. Although **fecal coliforms** can survive for several years under optimum conditions, a 99% reduction is likely within 25 days in warm climates (see Figure 6G). **Salmonella bacteria** may survive for a year in rich, moist, organic soil, although 50 days would be a more typical survival time. **Viruses** can survive up to three months in warm weather, and up to six months in cold. **Protozoan cysts** are unlikely to survive for more than 10 days. **Roundworm eggs** can survive for several years.

The viruses, bacteria, protozoa and worms that can be passed in human excrement all have limited survival times outside of the human body. Let's take a look at their survival times when deposited raw into soil (refer to tables 6.6 through 6.10):

Survival of pathogens On Crops

Bacteria and **viruses** cannot penetrate undamaged vegetable skins. However, pathogens can survive on the surfaces of vegetables, especially root vegetables. Sunshine and low air humidity will promote the death of pathogens. **Viruses** can survive up to 2 months on crops but usually less than one month. **Indicator bacteria** up to several months, but usually less than one month. **Protozoan cysts** usually less than two days. **Worm eggs** usually less than one month.

For example, lettuce and radishes sprayed with sewage inoculated with poliovirus I showed a 99% reduction in pathogens after 6 days, 100% after 36 days (in Ohio). Radishes grown outdoors in soil fertilized with fresh typhoid feces four

Table 6.6 *(Source: Feachem et. al., 1980)*

SURVIVAL OF ENTEROVIRUSES IN SOIL

Viruses - These parasites, which are smaller than bacteria, can only reproduce inside the animal or plant they parasitize. However, some can survive for long periods outside of their host:

Enteroviruses - Enteroviruses are those that reproduce in the intestinal tract. They have been found to survive in soil for periods ranging between 15 and 170 days. The following chart shows the survival times of enteroviruses in various types of soil and soil conditions:

Soil Type	pH	% Moisture	°C	Days of Survival (less than)
Sterile, sandy	7.5	10-20%	3-10	130-170 days
		"	18-23	90-110
	5	"	3-10	110-150
		"	18-23	40-90
Non-sterile, sandy	7.5	"	3-10	110-170
		"	18-23	40-110
	5	"	3-10	90-150
		"	18-23	25-60
Sterile, loamy	7.5	"	3-10	70-150
		"	18-23	70-110
	5	"	3-10	90-150
		"	18-23	25-60
Non-sterile, loamy	7.5	"	3-10	110-150
		"	18-23	70-110
	5	"	3-10	90-130
		"	18-23	25-60
Non-sterile, sandy	7.5	"	18-23	15-25

Table 6.7 *(Source: Feachem et. al., 1980)*

SURVIVAL TIME OF SOME PROTOZOA IN SOIL

Protozoa	Soil	Moisture	Temp°C	Survival
E. histolytica	loam/sand	Damp	28-34	8-10 days
"	soil	Moist	?	42-72 hr
"	"	Dry	?	18-42 hrs.

Table 6.8 *(Source: Feachem et. al., 1980)*

SURVIVAL TIME OF SOME BACTERIA IN SOIL

Bacteria	Soil	Moisture	Temp.°C	Survival
Streptococci---------------	*Loam*	*?*	*?*	*9-11 weeks*
"-------------------------	Sandy loam	?	?	5-6 weeks
S. Typhi------------------	*various soils*	*?*	*22*	*2 days-400 days*
Bovine tubercule bacilli	*soil &dung*	*?*	*?*	*less than 178 days*
Leptospires---------------	*varied*	*varied*	*summer*	*12 hrs-15 days*

Table 6.9 *(Source: Feachem et. al., 1980)*

SURVIVAL OF POLIOVIRUSES IN SOIL

Soil Type	Virus	Moisture	Temp. °C	Days of Survival
Sand dunes--------------	Poliovirus	dry moist	? ?	Less than 77 " 91
Loamy fine sand--------	Poliovirus I	moist moist	4 20	90% reduction in 84 days 99.999% red. in 84 days
Soil irrigated w/-------- effluent, pH=8.5	Polioviruses 1,2 &3	9-20%	12-33	Less than 8
Sludge or effluent------ irrigated soil	Poliovirus I	180mm total rain	-14-27--------	96-123 after sludge applied
			-14-27--------	89-96 after effluent applied
		190mm total rain	15-33--------	less than 11 days after sludge or effluent applied

Table 6.10 *(Source: Feachem et. al., 1980)*

SURVIVAL TIME OF SOME PATHOGENIC WORMS IN SOIL

Worm	Soil	Moisture	°C	Survival
Hookworm larvae	Sand	?	rm. temp.	less than 4 months
	Soil	?	open shade, Sumatra	less than 6 months
	Soil	Moist	Dense shade	9-11 wks
			Mod. shade	6-7.5 wks
			Sunlight	5-10 days
	Soil	Water covered	varied	10-43 days
	Soil	Moist	0°	less than 1 week
			16	14-17.5 weeks
			27	9-11 weeks
			35	less than 3 weeks
			40	less than 1 week
Hookworm ova (eggs)	Heated soil with night soil	water covered	15-27	9% survival after 2 weeks
	Unheated soil with night soil	water covered	15-27	3% survival after 2 weeks
Roundworm ova	Sandy, shaded		25-36	31% dead after 54 days
	Sandy, sun		24-38	99% dead after 15 days
	Loam, shad		25-36	3.5% dead after21 days
	Loam, sun		24-38	4% dead after 21 days
	Clay, shade		25-36	2% dead after 21 days
	Clay, sun		24-38	12% dead after 21 days
	Humus, shade		25-36	1.5% dead after22 days
	Clay, shade		22-35	more than 90 days
	Sandy, shade		22-35	less than 90 days
	Sandy, sun		22-35	less than 90 days
	Soil irrigated with sewage		?	less than 2.5 years
	Soil		?	2 years, 5.5 years[24], even 10 years[13]

days after planting showed a pathogen survival period of less than 24 days. Tomatoes and lettuce contaminated with a suspension of roundworm eggs showed a 99% reduction in eggs in 19 days and a 100% reduction in 4 weeks. These tests indicate that if there is any doubt about pathogen contamination of compost, the compost should be applied to long-season crops at the time of planting, so that sufficient time ensues for the pathogens to die before harvest.

Pathogen survival In Sludge and Feces/Urine

Viruses can survive up to 5 months, but usually less than 3 months in sludge and night soil. **Indicator bacteria** up to 5 months, but usually less than 4 months.

Salmonellae up to 5 months, but usually less than one month. Tubercle bacilli up to 2 years, but usually less than 5 months. **Protozoan cysts** up to one month, but usually less than 10 days. **Worm eggs** vary depending on species, but roundworm eggs may survive for many months.

When I started writing this book, I'd been composting my own humanure for nearly fourteen years and using it to grow about 50% of my food (the other 50% I buy). My sawdust toilet was used by many other people during that time period, especially since I operated an alternative school for five years on my property with a peak enrollment of 23 kids, which involved frequent use of my composting toilet system. I had many gatherings of people at my homestead over the years, as many as 150 people during a weekend. Not long before I began writing this book, I had 130 people visit within a twenty-four hour period. The humanure receptacle had to be emptied onto the compost pile four times that day. I've had little control over who's been using my toilet. There may have been people infected with all manner of pathogens depositing their contaminated feces into my composting system. However, I've had faith that the thermophilic composting routine I use has been killing any human pathogens present in the compost. Nevertheless, for the sake of thoroughness I had two stool analyses conducted by the local hospital laboratory as I wrote this, and no intestinal worms or eggs were found.

ELIMINATING PATHOGENS FROM HUMANURE

It should be evident to the reader by now that humanure certainly possesses the capability of transmitting various diseases. For this reason, it should also be evident that the composting of humanure is a serious undertaking and should not be done in a frivolous, careless or haphazard manner. The pathogens that may be present in humanure have various survival periods outside the human body and maintain varied capacities for re-infecting people. This is why the *careful management* of a thermophilic compost system is so important. Nevertheless, there is no proven, natural, low-tech method for destroying human pathogens in organic refuse that is as successful and accessible to the average human as well-managed thermophilic composting.

The following information illustrates the various waste treatment methods and composting methods commonly used today and shows the transmission of pathogens through the individual systems:

Outhouses and Pit Latrines

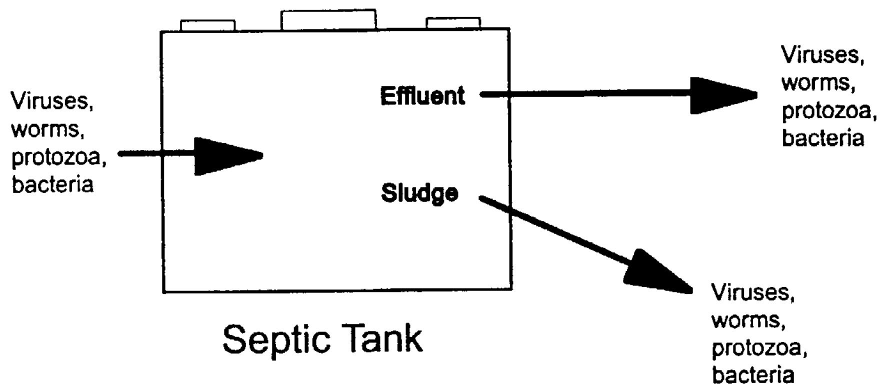
Outhouses have odor problems, breed flies and possibly mosquitoes, and pollute groundwater. However, if the contents of a pit latrine have been filled over and left for a minimum of one year, there will be no surviving pathogens except for the possibility of roundworm eggs, according to Feachems. This risk is small enough that the contents of pit latrines, after twelve months burial, can be used agriculturally. Franceys, et. al. (1992) state, *"Solids from pit latrines are innocuous if the latrines have not been used for two years or so, as in alternating double pits."*[15]

Septic Tanks

It is safe to assume that septic tank effluents and sludge are highly pathogenic (see figure 6A).

Figure 6A: Transmission of Pathogens through Septic Tank Waste Disposal Systems

(Source: Feachem et. al., 1980)



Septic tanks are waste disposal systems and are not designed to destroy or eliminate pathogens. The four major pathogen groups can pass through septic systems and remain viable. Septic systems, therefore, are considered highly pathogenic.

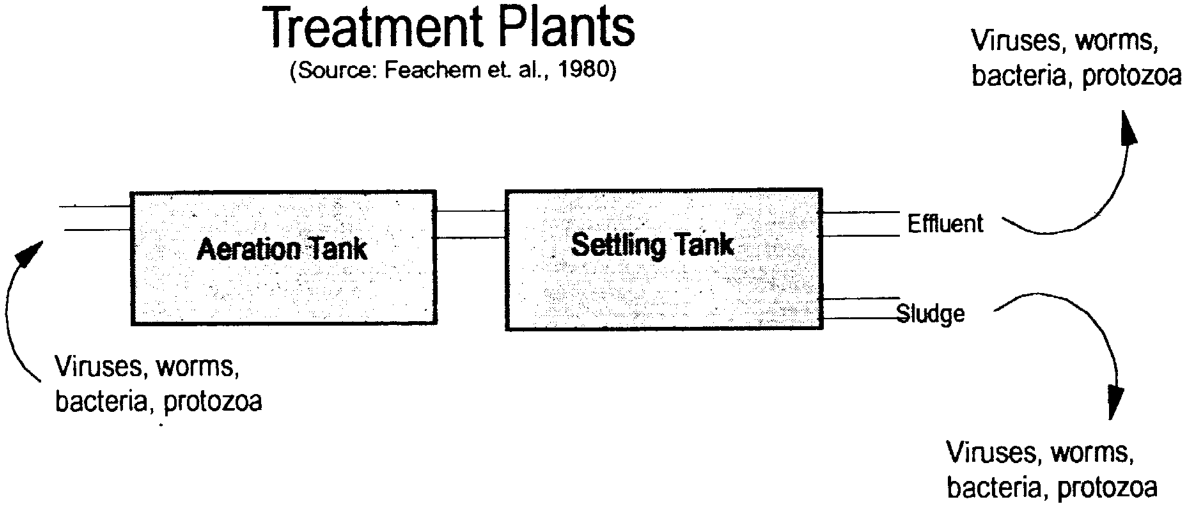
Conventional Sewage Treatment Plants

The only sewage digestion process producing a guaranteed pathogen-free sludge is batch thermophilic digestion in which all of the sludge is maintained at 50°C (122°F) for 13 days. All other sewage digestion processes will allow the survival of worm eggs and possibly pathogenic bacteria. Typical sewage treatment plants instead use a continuous process where wastewater is added daily or more frequently, thereby guaranteeing the survival of pathogens.

I took an interest in my local wastewater treatment plant when I discovered that the treated water it was discharging into our local creek had ten times the level of nitrates that unpolluted water has, and three times the level of nitrates acceptable for drinking water.[16] In other words, the water being discharged from the water treatment plant was polluted with nitrates (we didn't test for pathogens or chlorine levels). Despite the pollution, the levels were within legal limits for wastewater discharges (see figure 6B).

Figure 6B: **Transmission of Pathogens through Conventional Sewage Treatment Plants**

(Source: Feachem et. al., 1980)

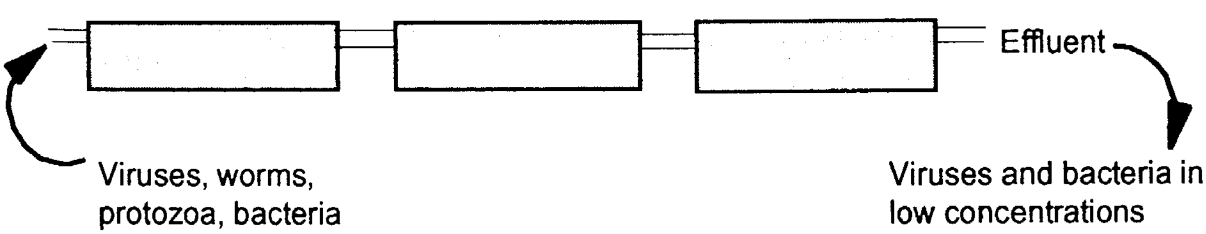


Conventional sewage treatment plants allow the transmission of pathogens through them. Consequently, the effluent is commonly treated with chemical poisons such as chlorine, and the sludge is commonly buried in landfills.

Waste Stabilization Ponds

Waste stabilization ponds, large shallow ponds widely used in North America, Latin America, Africa and Asia, involve the use of both beneficial bacteria and algae in the decomposition of organic waste materials. Although they can breed mosquitoes, they can be designed and managed well enough to yield pathogen-free waste

Figure 6C: **Transmission of Pathogens through Waste Stabilization Ponds**



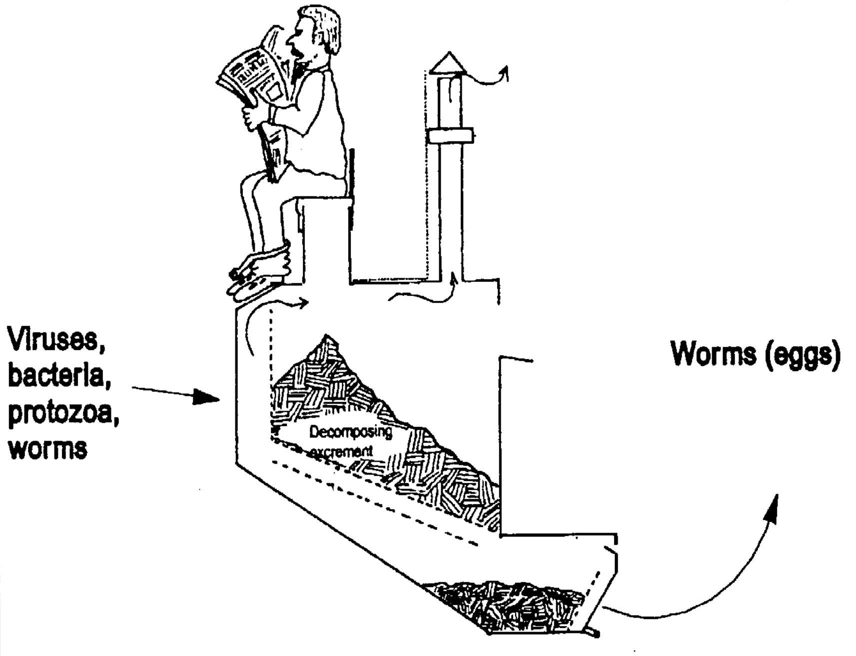
(Source: Feachem et. al., 1980)

water. However, they typically yield water with low concentrations of both pathogenic viruses and bacteria (see figure 6C).

Composting Toilets and Mouldering Toilets

Due to the relatively anaerobic conditions of the multrum and mouldering toilets and the consequently low decomposition temperatures, complete elimination of pathogens from the manure is not likely to be obtained. However, according to Feachems, et. al., a minimum retention time of three months produces a compost free of all pathogens except possibly some intestinal worm eggs. Also, the compost obtained from these types of toilets can conceivably be composted again in a thermophilic pile and rendered suitable for food gardens (see figure 6D and table 6.11).

Figure 6D: **Transmission of Pathogens through Passive, Low Temperature Composting Toilets and Mouldering Toilets** (Source: Feachem et. al., 1980)

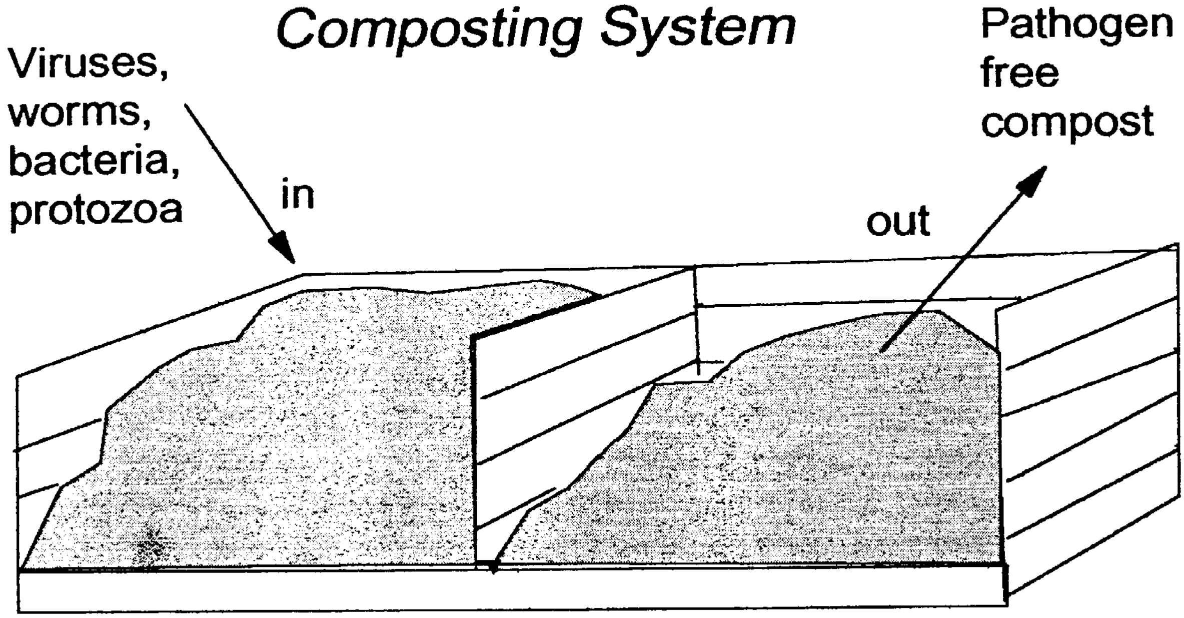


Due to the low composting temperatures of most commercial composting toilets and of mouldering toilets, the eggs of certain pathogenic worms such as the roundworm (*Ascaris*) can survive the composting process.

Well-managed Thermophilic Composting System

Complete pathogen destruction is guaranteed by arriving at a temperature of 62°C (143.6°F) for one hour, or 50°C (122°F) for one day, or 46°C (114.8°F) for one week, or 43°C (109.4°F) for one month. It appears that no excreted pathogen can survive a temperature of 65°C (149°F) for more than a few minutes. A compost pile containing entrapped oxygen may rapidly rise to a temperature of 55°C (131°F) or above, or will maintain a temperature hot enough for a long enough period of time to thoroughly destroy human pathogens (see figure 6E). Table 6.11 indicates survival times of pathogens in a) soil, b) anaerobic decomposition conditions, c) composting toilets and d) thermophilic compost piles.

Figure 6E: **Transmission of Pathogens through a Thermophilic Composting System** (Source: Feachem et. al., 1980)



A properly managed thermophilic composting system will generate enough heat to destroy all four groups of human pathogens including parasitic worms and their eggs, viruses, bacteria and protozoa. The resulting finished compost is a hygienically safe, user friendly, soil-building humus.

MORE ON PARASITIC WORMS

This is a good topic to discuss in greater detail as most people know so little about it. Therefore, I'll take a few minutes here to discuss the most common of human worm parasites: pinworms, hookworms, whipworms and roundworms.

Pinworms

I confess, my kids had pinworms during childhood. I know exactly who they

Table 6.11 *(Source: Feachem et. al. 1980)*

PATHOGEN SURVIVAL BY COMPOSTING OR SOIL APPLICATION

Pathogen	***Soil Application***	***Unheated Anaerobic Digestion***	***Composting Toilets (3 mo. min. ret.)***	***Thermophilic Composting***
Enteric viruses	May survive 5 months	Over 3 months	Probably eliminated	Killed rapidly at 60°C
Salmonellae	3 months to 1 year	Several weeks	A few may survive	Killed in 20 hrs. at 60°C
Shigellae	Up to 3 months	A few days	Probably eliminated	Killed in 1 hr.at 55°C or in 10 days at 40°C
E. coli	Several months	Several weeks	Probably eliminated	Killed rapidly above 60°C
Cholera vibrio	1 week or less	1 or 2 weeks	Probably eliminated	Killed rapidly above 55°C
Leptospires	Up to 15days	2 days or less	Eliminated	Killed in 10 min. at 55°C
Entamoeba histolytica cysts	1 week or less	3 weeks or less	Eliminated	Killed in 5 min. at 50°C or 1 day at 40° C
Hookworm eggs	20 weeks	Will survive	May survive	Killed in 5 min.at 50°C or 1 hr at 45°C
Roundworm (Ascaris) eggs	Several years	Many months	Survive well	Killed in 2 hrs. at 55°C, 20 hrs. at 50°C, 200 hrs. at 45°C
Schistosome eggs	One month	One month	Eliminated	Killed in 1 hr. at 50°C
Taenia eggs	Over 1 year	A few months	May survive	Killed in 10 min. at 59°C, over 4 hrs. at 45°C

got them from (another kid), and getting rid of them was a simple matter. However, the rumor was circulated that they got them from our compost. We were also told to worm our cats to prevent pinworms in the kids (these rumors allegedly originated in a doctor's office). Yet, the pinworm life cycle does not include a stage in soil, compost, manure or cats. These unpleasant parasites are spread from human to human by direct contact, and by inhaling eggs.

Pinworms (*Enterobius vermicularis*) lay microscopic eggs at the anus of a human being, its only known host. This causes itching at the anus which is the primary symptom of pinworm infestation. The eggs can be picked up almost anywhere, and once in the human digestive system they develop into the tiny worms. Some estimate that pinworms infest or have infested 75% of all New York City children in the 3-5 year age group, and that similar figures exist for other cities.[17]

These worms have the widest geographic distribution of any of the worm parasites, and are estimated to infect 208.8 million people in the world (18 million in Canada and the U.S.). An Eskimo village was found to have a 66 per cent infection rate, a 60% rate has been found in Brazil, and a 12-41 % rate in Washington D.C.

Infection is spread by the hand to mouth transmission of eggs resulting from scratching the anus, as well as from breathing airborne eggs. In households with several members infected with pinworms, 92% of dust samples contained the eggs. The dust samples were collected from tables, chairs, baseboards, floors, couches, dressers, shelves, window sills, picture frames, toilet seats, mattresses, bath tubs, wash basins and bed sheets. Pinworm eggs have also been found in the dust from school rooms and school cafeterias.

Pregnant female pinworms contain 11,000 to 15,000 eggs. Fortunately, pinworm eggs don't survive long outside their host. At room temperature and 30% to 54% relative humidity more than 90% of the eggs will die within two days. At higher summer temperatures, 90% will die within three hours. Eggs survive longest (2-6 days) under cool, humid conditions; in dry air, none will survive for more than 16 hours.

A worm's life span is 37-53 days and an infection would self-terminate in this period, without treatment, in the absence of reinfection. *The amount of time that passes from ingestion of eggs to new eggs being laid at the anus is from 4 to 6 weeks.*[18]

Although dogs and cats do not harbor pinworms, the eggs can get on their fur and find their way back to their human hosts. In about one-third of infected children, eggs may be found under the fingernails.

In 95% of infected persons, pinworm eggs aren't found in the feces. Transmission of eggs to feces and to soil is not part of the pinworm life cycle, which is one reason why the eggs aren't likely to end up in either feces or compost. Even if they do, they quickly die outside the human host.

One of the worst symptoms of pinworm infestation is the trauma of the parents, whose feelings of guilt, no matter how clean and conscientious they may be, are understandable. However, if you're composting your manure, you can be sure that you are not thereby breeding or spreading pinworms. Quite the contrary, any pinworms or eggs getting into your compost are being destroyed.[19]

Hookworms

Hookworm species in humans include *Necator americanus, Ancylostoma duodenale, A. braziliense, A. caninum, and A. ceylanicum.*

The small worms are about a centimeter long, and humans are almost the exclusive host of *A. duodenale* and *N. americanus.* A hookworm of cats and dogs, *A. caninum*, is an extremely rare intestinal parasite of humans.

The eggs are passed in the feces and mature into larvae outside the human host in favorable conditions. The larvae attach themselves to the human host usually at the bottom of the foot when they're walked on, and then enter their host through pores, hair follicles or even unbroken skin. They tend to migrate to the upper small intestine where they suck their host's blood. Within 5 or 6 weeks they'll mature enough to produce up to 20,000 eggs per day.

Hookworms are estimated to infect 500 million people throughout the world, causing a *daily blood loss of more than 1 million liters,* which is as much blood as can be found in all the people in the city of Erie, PA, or Austin, Texas. An infection can last 2 - 14 years. Light infections can produce no recognizable symptoms, while a moderate or heavy infection can produce an iron deficiency anemia. Infection can be determined by a stool analysis.

These worms tend to be found in tropical and semi-tropical areas and are

Table 6.12
Hookworms:

Hookworm larvae develop outside the host and favor a temperature range of 23°C to 33°C (73°F to 91°F).

Temperature	**Survival Time of Eggs**	**Larvae**
45°C (113°F)	Few hours	less than 1 hour
0°C (32°F)	7 days	less than 2 weeks
-11°C (12°F)		less than 24 hours

Both thermophilic composting and freezing weather will kill hookworms and eggs.

spread by defecating on the soil. Both the high temperatures of composting will kill the eggs and larvae, as will the freezing temperatures of winter. Drying is also destructive[20]

Whipworm

Whipworms (*Trichuris trichiura)* are usually found in humans, but also may be found in monkeys or hogs. They're usually under two inches long and the female can produce 3,000 to 10,000 eggs per day. Larval development occurs outside the host, and in a favorable environment (warm, moist, shaded soil) first stage larvae are produced from eggs in 3 weeks.

Hundreds of millions of people worldwide, as much as 80% of the population in certain tropical countries, are infected by whipworms. In the U.S., whipworm is found in the south where there is heavy rainfall, a subtropical climate, and soil polluted with feces. The lifespan of the worm is usually considered to be 4 to 6 years.

Infection results from ingestion of the eggs, which can contaminate the hands of persons handling soil that has been defecated on by an infected person. Light infections may not show any symptoms. Heavy infections can result in anemia, and death. A stool examination will determine if there is an infection.

Cold winter temperatures of -8°C to -12°C (17.6°F to 10.4°F) are fatal to the eggs, as are the high temperatures of thermophilic composting.[21]

Roundworms

The roundworms (*Ascaris lumbricoides)* are fairly large worms (10 inches) which parasitize the human host by eating semi-digested food in the small intestine. The females can lay 200,000 eggs per day for a lifetime total of 26 million or so. The larvae develop from the eggs *in soil* under favorable conditions (21°C to 30°C or 69.8°F to 86°F). Above 37°C (98.6°F) they cannot fully develop.

Approximately 900 million people are infected with roundworms worldwide, one million of them in the U.S. The eggs are usually transmitted hand to mouth by people, usually children, who have come into contact with the eggs in his/her environment. Infected persons usually complain of a vague abdominal pain. Diagnosis is by stool analysis.[22]

The eggs are destroyed by direct sunlight within 15 hours, and are killed by temperatures above 40°C (104°F), dying within an hour at 50°C (122°F). Roundworm eggs are resistant to freezing temperatures, chemical disinfectants, and other strong chemicals. Thermophilic composting will kill them.

Roundworms, like hookworms and whipworms, are spread by fecal contamination of soil. Much of this contamination is caused and spread by children who defecate outdoors within their living area. One sure way to eradicate fecal pathogens is to conscientiously collect and thermophilically compost *all* fecal material. Therefore, it is very important when composting humanure to be certain that *all* children use the toilet facility and do not defecate elsewhere. When changing soiled diapers, scrape the fecal material into the humanure receptacle with toilet paper or another biodegradable material. It's up to adults to keep an eye on kids and make sure they understand the importance of *always using a toilet facility.*

Fecal environmental contamination can also be caused by using raw fecal material for agricultural purposes. *Proper thermophilic composting of all fecal material is essential for the eradication of fecal pathogens.*

SUMMARY OF CONDITIONS NEEDED TO KILL PATHOGENS

There are two primary factors leading to the death of pathogens in humanure. The first is ***temperature.*** A compost pile that is properly managed in order to cultivate thermophilic organisms will destroy pathogens with the heat it generates.

The second factor is ***time.*** The lower the temperature of the compost, the longer the retention time needed for the destruction of pathogens. That period may be long if the pile doesn't heat at all, such as in a mouldered pile, as roundworm eggs have been known to survive for years in soil, and some bacteria can survive for two years in sludge and over a year in soil. Feachem, however, states that three months retention time will kill all of the pathogens in a low-temperature composting toilet except worm eggs, although table 6.11 (also from Feachem) indicates that some additional pathogen survival may occur.

A high-temperature thermophilic compost pile will destroy pathogens, including worm eggs, quickly, possibly in a matter of minutes. Lower temperatures require longer periods of time, possibly hours, days, weeks or months, to effectively destroy pathogens. One need not strive for extremely high temperatures (say 150°F or 65°C) in a compost pile to feel confident about the destruction of pathogens. Instead, it may be more realistic for one to strive to maintain lower temperatures in a compost pile for longer periods of time (say 120°F or 50°C for twenty four hours, or 115°F or 46°C for a week). For example, as one source puts it, *"All fecal microorganisms, including enteric viruses and roundworm eggs, will die if the temperature exceeds 46°C (114.80° F) for one week."*[15]

A sound approach to pathogen destruction when composting humanure is to thermophilically compost the organic refuse, then allow the compost to sit, undisturbed, for a lengthy period of time after the thermophilic heating stage has ended. The subject of thermophilic composting is discussed in greater detail in chapter seven.

In the words of Feachem (et. al.), *"The effectiveness of excreta treatment methods depends very much on their time-temperature characteristics. The effective processes are those that either make the excreta warm (55°C) [131°F], hold it for a long time (one year), or feature some effective combination of time and temperature."*

In short, the combined factors of temperature and time will do the job of converting "turds into tomatoes" (The time/temperature factor of pathogen destruction is illustrated in figure 6F.)

CONCLUSIONS

Humanure is a valuable resource suitable for agricultural purposes and has been recycled for such purposes by large segments of the world's human population for thousands of years.

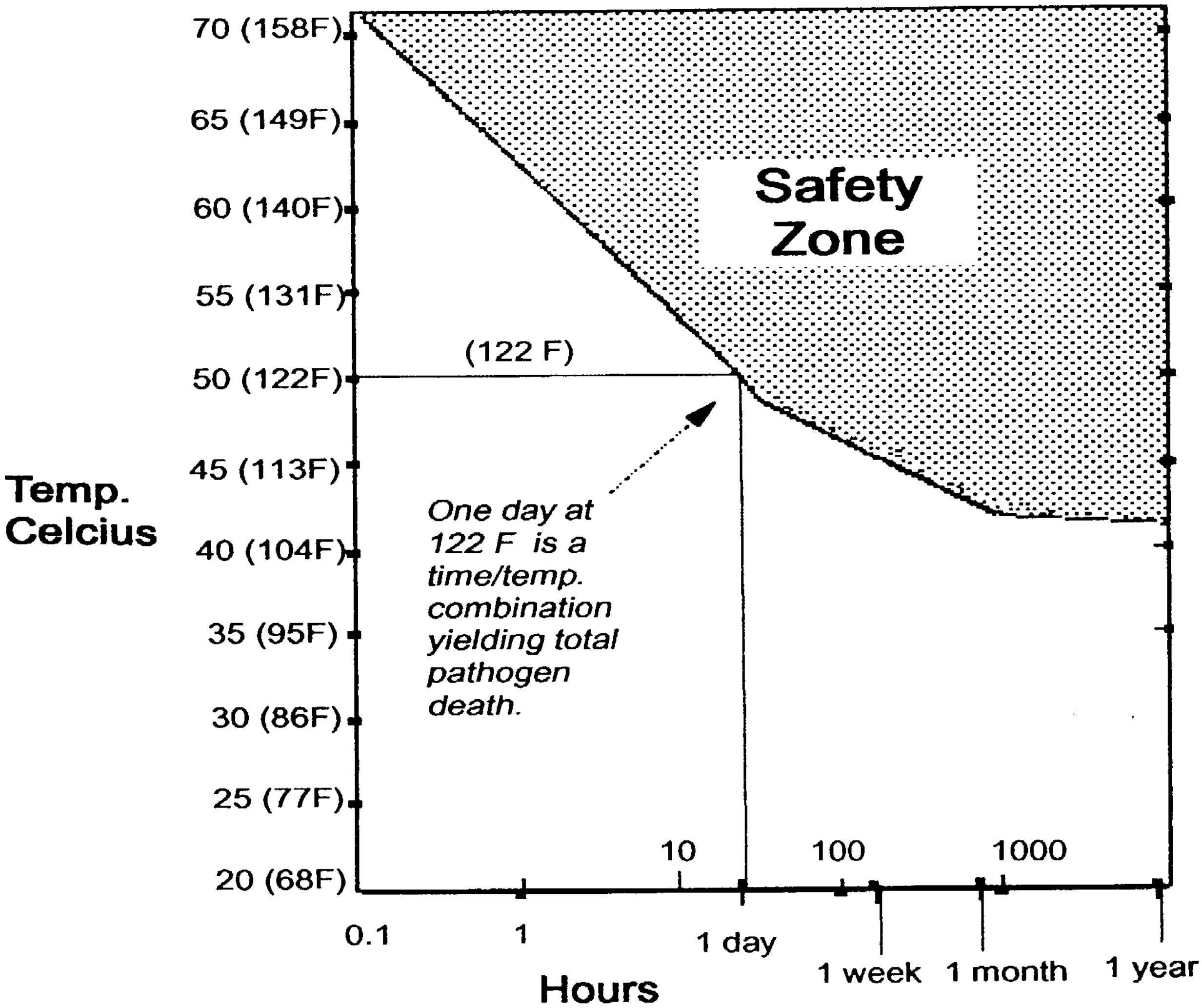
However, humanure contains the potential for harboring human pathogens, including bacteria, viruses, protozoa and parasitic worms or their eggs, and thereby can contribute to the spread of disease. When pathogenic raw humanure is applied to soil, pathogenic bacteria may continue to survive in the soil for over a year, and roundworm eggs may survive for many years, thereby maintaining the possibility of human reinfection for lengthy periods of time.

However, when humanure is thermophilically composted, human pathogens are rapidly destroyed, and the humanure is thereby converted into a hygienically safe form suitable for soil applications for the purpose of human food production.

Finally, it must be added that thermophilic composting requires no electricity and therefore no coal combustion, no acid rain, no nuclear power plants, no nuclear waste, no petrochemicals, and no consumption of fossil fuels. The composting process produces no waste, no pollutants, and no toxic byproducts. Thermophilic composting of humanure can be carried out century after century, millennium after millennium, with no stress on our ecosystems, no consumption of resources, no garbage or sludge for our landfills. And all the while it will produce a valuable resource necessary for our survival while preventing the accumulation of dangerous and pathogenic waste. If that doesn't describe *sustainability,* nothing does.

Figure 6 F (Source: Feachem et. al. 1980)

Safety Zone for Pathogen Death



The above pathogen death boundaries include those for *enteric viruses, shigella, taenia, vibrio cholera, Ascaris (roundworm), salmonella, and entamoeba histolytica.* Source: Feachem, et. al., 1980.

Table 6.14- **Parasitic Worm Egg Death**

Eggs	Temp.(°C)	Time required to die
Schistosome	53.5	1 minute
Hookworm	55.0	1 minute
Roundworm	55.0	10 minutes
"	60.0	5 seconds
"	0	4 years
"	-30	24 hours

[Source: Compost, Fertilizer, and Biogas Production from Human and Farm Wastes in the People's Republic of China, (1978), M. G. McGarry and J. Stainforth, editors, International Development Research Center, Ottawa, Canada. (page 43)]

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*** A wide range of compost analyses and tests for pathogens and other contaminants such as pesticides and herbicides are available from Woods End Research Laboratory, Inc., Route 2, Old Rome Road, Box 1850, Mt. Vernon, ME 04352; Phone (207) 293-2457. In 1995, a helminth ova test cost $145.00, and required a one gallon sample of compost.**


WE DO IT EVERY DAY. BUT DO WE EVER THINK ABOUT IT!
I DEFECATE, THEREFORE I AM . . .

THE TAO OF COMPOST

"Always bear this in mind, that very little indeed is necessary for living a happy life."
Marcus Aurelius

"Aspire to simple living? That means, aspire to fulfill the highest human destiny."
Charles Wagner

I will never forget the day I introduced my mother to my composting system. She came to visit me at my newly established homestead one spring day in 1980 and I gave her a tour of my garden, which was already quite vibrant. A fresh pile of finished compost had been dumped from a wheelbarrow onto one of the raised garden beds and, as we passed, I reached down and scooped up a big handful, thrusting it toward her. "Smell this," I said. So she put her nose right up to the black earth I held out before me and took a deep breath.

"Boy, that smells good!" she said, inhaling the rich, sweet-smelling aroma of fertile soil, and smiling.

"This is my alternative to a septic system!" I proudly informed her, still holding the compost out in front of me as I watched her smile suddenly freeze. I will always remember the look on her face when I caught her so completely by surprise in an unexpected, and perhaps awkward, situation. My dear mother, although very open-minded, had not, prior to that moment, had the experience of so intimately communing with composted humanure. But the compost did smell good, like a rich soil from the woods.

PRIMAL COMPOST

Try to imagine yourself in an extremely primitive setting, maybe sometime around 10,000 B.C. Imagine that you're just slightly more enlightened than your brutish companions and it dawns on you one day that your feces should be disposed of properly. Everyone else is defecating in the back of the cave, creating a smelly mess, and you don't like it. You're going to improve on the system.

Your first revelation is that *smelly refuse should be deposited in one place*, not spread around for everyone to smell or to step in, and it should be deposited away from one's living area somehow. You watch the wild cats and see that they each go to a special spot to defecate. But the cats are still one step ahead of the humans, as you soon find out, because they cover their excrement.

When you've shat outside the cave on the ground in the same place several times you see that you've still created a foul smelling, fly-infested mess. Your second revelation is that *the refuse you're depositing on the ground should be covered after each deposit.* So you scrape up some leaves every time you defecate and throw them over the feces. Or you pull some tall grass out of the ground and use it for cover.

Soon your companions are also defecating in the same spot and covering their fecal material as well. They were encouraged to follow your example when they noticed that you had conveniently located the defecation spot between two large rocks, and positioned logs across the rocks to provide a convenient perch, allowing for care-free defecation above the collecting refuse underneath.

A pile of dead leaves is now being kept beside the toilet area in order to make the job of covering it more convenient. As a result, the offensive odor of human feces and urine no longer foul the air. Instead, it's food scraps that attract flies and smell bad. This is when you have your third revelation: *food scraps should be deposited on the same spot and covered as well.* Every stinky bit of refuse you create is now going to the same spot and is being covered with a natural material to eliminate odor. This hasn't been hard to figure out, it makes good sense and it's easy to do.

You've succeeded in solving three problems at once: no more humanure scattered around your living area, no more garbage, and no more offensive odors assaulting your keen sense of smell and generally ruining your day. You also begin to realize that the illnesses that were prone to spread through the group have subsided, a fact that you don't understand, but you suspect may be due to the group's new found hygienic practices.

Quite by accident, you've succeeded in doing one very revolutionary thing: *you've created a compost pile.* You begin to wonder what's going on when the pile gets so hot it's letting off steam. What you don't know is that you've done exactly what nature intended you to do by piling all your organic refuse together, layered with natural, biodegradable cover materials. In fact, nature has "seeded" your excrement with a breed of microscopic animal that proliferates in and digests the pile you've created, and, in the process, heats the compost to such an extent that any disease-causing pathogens resident in the humanure are destroyed. The invisible microscopic animals, otherwise known as thermophilic bacteria, would not multiply rapidly in the discarded refuse unless you created the pile, and thereby the conditions, which favor their rapid proliferation. By daring to be different, you stumbled upon a miracle of nature.

Finally, you have one more revelation, a big one. You see that the pile, after it gets old, sprouts all kind of vibrant plant growth. You put two and two together and realize that *the stinking refuse you carefully disposed of has been transformed into rich earth, and ultimately into food.* Thanks to you, humankind has just climbed another step up the ladder of evolution.

Yet there is one basic problem with this scenario: *it didn't take place 12,000 years ago. It's taking place now.*

THE EVOLUTION OF COMPOST

The hypothetical discovery of compost in a primal situation would be most likely to occur in a group of humans who had settled into an agricultural lifestyle rather than a nomadic, hunter-gatherer one. Nomadic people can walk away from the trash they leave behind, allowing nature to deal with it. Settled peoples don't have that luxury. The development of rooted human settlements and the development of agriculture go hand in hand, for it is the working of the land to grow food crops that forces a people to stay put year after year. Unless, of course, they deplete the soil of nutrients and are then forced to move on to find a new patch of fertile ground.

More enlightened peoples will develop an understanding of the human nutrient cycle instinctively, and will strive to maintain that cycle intact on a day-to-day basis as if it were a natural and necessary part of their lives, as natural and necessary as growing or cooking their food, or bathing, or nursing their children. For settled, agricultural peoples, there is an abundance of organic refuse materials needing to be recycled on a regular or daily basis, these materials may include potato peels, apple cores, crop residues, humanure, garden refuse and on and on. In most cases, those organic materials would be recycled without question, day in and day out, year in and year out, not as a chore or a burden, but as a necessary responsibility for human life on the planet Earth. Such is the Tao of compost, the balanced way, the natural way, not the glamorous way, not the exciting way, not the get-rich-quick way of contemporary pop culture. The Tao is the endless way.

Although such recycling has apparently been a common practice in the East for thousands of years, it is a relatively unknown phenomenon in the West. In fact, compost itself is a relatively new phenomenon in the West and perhaps even in the East, a phenomenon that never gained recognition throughout the ages in Europe, despite its potentially valuable utility. Perhaps people in Europe who developed an instinctive understanding of natural phenomenon were simply rounded up and burned at the stake by religious fanatics. One can only speculate as to why the West has been so slow to catch on to humanure recycling, and in view of the religious extremism of the past ages in Europe, such speculation can be both gruesome and saddening.

Much of compost's current popularity in the West can be attributed to the work of Sir Albert Howard, who wrote An Agricultural Testament (1943) and several other works on aspects of what has become known as *organic* agriculture. Sir Howard's discussions of composting techniques focus on the Indore process of composting, a process developed in Indore, India between the years of 1924 and 1931. The Indore process was first described in detail in Sir Howard's work (co-authored with Y. D. Wad), The Waste Products of Agriculture, in 1931.

The two main principles underlying the Indore composting process include 1) mixing animal and vegetable refuse with a neutralizing base, such as agricultural lime, and 2) managing the compost pile by physically turning it. These Indore process composting techniques subsequently became adopted and espoused by composting enthusiasts in the West, and today one still commonly sees people turning and liming compost piles. For example, Robert Rodale wrote in the February, 1972 issue of *Organic Gardening* concerning composting humanure, *"We recommend turning the pile at least three times in the first few months, and then once every three months thereafter for a year."*

However, as composting becomes more deeply looked into over the years by us Westerners, new information is bound to be brought forth that challenges the conventional wisdom. For years I also believed that compost should be turned, and perhaps limed or treated with rock dusts. Yet, after monitoring my own compost, I've come to understand differently. Now, due to my own experiences, I contend that compost piles need not be limed, and need not be turned at all. Turning is unnecessary unless one is perhaps trying to accelerate the composting process, trying to compost piles of refuse that are exceedingly large, or trying to stir the outer areas of a batch of compost into the center in order to subject all parts of the batch to the high inner temperatures. I discussed the liming issue in chapter 2 of this book, and I'll discuss the turning (aerating and mixing) issue later in this chapter. I realize now that compost-making is really simpler than I could have imagined, and the arduous task of turning a compost pile may actually do more harm than good *if the pile is being continuously added to.* This is by no means an attempt by me to disparage the work of anyone, including Robert Rodale or Sir Albert Howard, who both very justifiably remain held in high regard by proponents of organic gardening and farming.

The Tao of compost, however, requires that *compost-making be an integral part of normal and daily life.* Such compost-making is a natural and *bioregional* phenomenon. Organic refuse from a given population and geographic area is layered together for the purpose of cultivating the microscopic organisms that convert the refuse into humus. As there are thousands of geographic areas on the earth each with its own unique human population, climatic conditions and available organic refuse materials, there will also be potentially thousands of composting methods and styles. What works in one place on the planet for one group of people may not work at all for another group in another geographic location. Where one group uses above-ground, continuous compost bins such as described in this book, another group will use below-ground pits sealed with clay. Where one group chooses to compost aerobically, as described in this book, another may choose to compost anaerobically such as in a sealed pit. Where a group only uses natural, organic materials in their compost, another may add chemical fertilizers or rock dusts. Where one group may compost each family's refuse separately, another group may compost the refuse of many people all together.

It is not my intention to unfairly promote certain methods of composting as superior over others. My intention is to describe my own experiences in the hope that others may benefit from such descriptions. I would hope that others with different experiences would also make their information available for the benefit of the general public. If I must insist upon anything, I would insist that the compost-maker be clear in understanding why s/he is making compost. If compost is being made in order to eliminate waste and pollution as well as recover resources, as it should be, then the compost-maker will strive to utilize local refuse resources in a wise and efficient manner. The availability of local, organic refuse materials in combination with local climatic conditions, and cultural predispositions toward the recycling of humanure, will determine the methods of composting for a given location, or bioregion.

When composting humanure, the additional factor of pathogen destruction must be taken into account and incorporated into the composting formula. The destruction of human pathogens occurs most readily under the conditions of aerobic, thermophilic composting, because of the heat generated by the process. This is the sort of composting in which I engage and which this book primarily entails. In short, humanure composting requires 1) a knowledge of accessible local refuse materials suitable for composting, 2) a sensitivity to and understanding of seasonal fluctuations in weather conditions, and 3) a willingness to combine the refuse materials in a manner that suits the climate and still promotes the growth of aerobic, thermophilic bacteria.

I would add to this formula one more thing: the technique one finally settles on for composting humanure should be sustainable. It should not be creating waste or pollution or squandering resources.

Bearing all this in mind, perhaps Sir Albert Howard's Indore process of composting was the most appropriate for his purposes, in Indore, India in the 1920's. But that's no reason for anyone else to believe that the compost they are producing in their area of the world for their own purposes should utilize the same techniques that the Indore process calls for. This is especially important to understand when one realizes that if all compost required both liming and turning, many people would be unable to make compost. Agricultural lime is not available to everyone, everywhere, and turning compost can be quite an arduous task, especially for the frail or elderly. Whereas, *all people, everywhere, should be able to make compost.*

Additionally, people who recommend the frequent turning of humanure compost are people who have never engaged in humanure composting as a way of life. We simple humans of meager material resources who insist on recycling our daily refuse are aware of this one important fact: we produce organic refuse *continuously*, and therefore we must engage in *continuous composting,* which involves the continuous addition of organic refuse to a compost pile. Such a continuous compost pile requires the slow and constant upward movement of thermophilic organisms in the pile, which digest incoming refuse deposited on the pile above them, and abandon digested refuse below them. Such a pile of compost is always growing on top and always shrinking on the bottom, and does not need to be turned for aeration. In fact, such turning could be extremely disruptive.

This is in contrast to *experimental* composting, whereby large amounts of refuse are suddenly made available for the purpose of experimentation. Such experiments have a purpose and value all their own, but they may not reflect real situations in real life in the real world. When a person is suddenly faced with a large mass of raw organic material to be composted, perhaps turning the pile is a useful management technique. Certainly if the refuse is piled out in the open, the outer surfaces of the pile may remain unacceptably cool and will need to be turned into the center periodically. This can possibly be remedied by keeping the refuse in bins that hold in the heat, and covering the piles with insulating organic materials such as straw.

In other words, there is a big difference between the Tao of compost, which is composting *as a way of life*, and composting done for agricultural or academic experimentation. And although from an evolutionary standpoint we are slowly advancing our understanding of compost in the West, we are still back in the cave when it comes to incorporating composting into our daily lives.

In any case, I contend that not much has changed since ten thousand B.C. in the eyes of the compost pile. The thermophilic microorgánisms that convert humanure into humus don't care what techniques we use today anymore than they cared what techniques were used eons ago, *so long as their needs are met.* And those needs haven't changed in human memory, nor are likely to change as long as humans roam the earth. Those needs include: 1) *temperature* (compost microorganisms won't work if frozen); *2) moisture* (they won't work if too dry or too wet); *3) oxygen* (they won't work without it; and 4) *a balanced diet* (otherwise known as balanced carbon/nitrogen). In this sense, compost microorganisms are a lot like people, and, with a little imagination, we can think of compost microorganisms as a working army of microscopic people who need the right food, water, air and warmth.

The art of compost-making then, remains the simple and yet profound art of providing for the needs of these invisible workers so that they work as vigorously as possible, season after season. And although those needs may be the same worldwide, the techniques used to arrive at them may differ from time to time and from place to place.

THERMOPHILIC MICROORGANISMS

Converting humanure back into soil requires microorganisms that produce and thrive at high temperatures - high enough to kill the human pathogens that may be found in the excrement. The beneficial microorganisms are primarily thermophilic (heat-loving) microscopic bacteria, and they're extremely valuable to humanity. They ask for very little and they give a lot in return, and, for the most part, we ignore them. However, people interested in composting humanure need to know something about the little buggers and how to keep them happily working.

Bacteria are usually divided into three classes based upon the temperatures in which they grow best. The low temperature bacteria are the *psychrophiles*, which can grow at temperatures down to -10°C, but whose optimum temperature is above 20°C (68°F). The *mesophiles* live at medium temperatures, 20°C - 37°C (68°F-98.6°F).

ESSENTIAL READING FOR INSOMNIACS

A number of thermophilic microorganisms may be found in the composting process including bacteria: *Bacillus stearothermophilius*, and *Clostridium thermocellum*; fungi: *Geotrichum candidum, Aspergillus fumigatus, Mucor pusillus, Chaetomium thermophile, Thermoascus auranticus, Torula thermophila*, and *Humicola insolens*; and actinomycetes (a cross between a bacterium and an imperfect fungus): *Thermoactinomyces, Actinomyces thermophilis, Talaromyces (Penicillium) duponti*, and *Thermomonospora*.3

Thermophiles thrive above 40°C (104°F), and the optimum temperature for some thermophilic strains may be as high as 65°C (149°F) or higher. These bacteria occur naturally in hot springs, tropical soils and compost heaps, to name a few places. Some thermophilic bacteria have been found at temperatures as high as 89°C (192°F), and perhaps higher.

Thermophiles are responsible for the spontaneous heating of hay stacks which can cause them to burst into flame. When growing on bread, they can raise the temperature of the bread to 74°C (165°F). Heat from bacteria also warms germinating seeds, as sterile seeds are found to remain cool while germinating.[1]

Thermophilic bacteria were first isolated in 1879 by Miquel, who found bacteria capable of developing at 72°C (162°F). He found these bacteria in soil, dust, *excrement,* sewage and river mud. It wasn't long afterward that a variety of thermophilic bacteria were discovered in soil - bacteria that readily thrived at high temperatures, but not at room temperature. These bacteria are said to be found in the sands of the Sahara Desert, but not in the soil of cool forests. Composted or manured garden soils may contain 1-10 percent thermophilic types of bacteria, while field soils may have only 0.25% or less. Uncultivated soils may be entirely free of thermophilic bacteria.[2]

The presence of thermophilic bacteria in garden soil to which compost has been added indicates that the use of garden weeds in one's compost pile, including soil clinging to roots, may help keep the pile inoculated with the necessary bacterial strains. However, it seems more likely that the bulk of the thermophilic bacteria enter the compost pile from the humanure itself. In which case, it would seem that mother nature has provided for the human race a built-in solution to the problem of getting rid of human excrement. The thermophilic bacteria are already in it; we just have to provide the conditions they need to do their thing, which is heating and digesting the manure sufficiently to render it hygienically safe. Nature provides us with seeds to grow our food too, but those seeds won't grow unless we create the right conditions for them. We've already figured *that* out.

Humanure is said to contain 100 *billion* bacteria per gram (there are 28.34 grams in an ounce).[4] This means that *one gram of humanure contains a bacterial population twenty times greater than the entire human population of the earth*, which seems unbelievable. If the average excrement weighs about 40 ounces, then each stool could contain 113 *trillion* bacteria, a figure totally beyond human comprehension.

When a pile of organic refuse begins to undergo the composting process, the mesophilic bacteria proliferate, raising the temperature of the composting mass up to 44°C (111°F). These mesophilic bacteria can include E. Coli and other bacteria from the human intestinal tract, but these soon become increasingly inhibited by the temperature as the thermophilic bacteria take over in the transition range of 44°C-52°C (111°F-125.6°F). Thermophilic growth can then continue up to about 70°C (158°F).[5] These bacteria combine organic carbon with oxygen to produce carbon dioxide as well as to release energy. Some of the energy is used by the microorganisms to proliferate, the rest is given off as heat.

The heat produced by thermophilic bacteria kills the pathogenic microorganisms, viruses, bacteria, protozoa, worms and eggs that may inhabit humanure. A temperature of 122° F (approx. 50°C), if maintained for twenty-four hours, is sufficient to kill all of the pathogens. A lower temperature will take longer to kill pathogens (a temperature of 115°F may take nearly a week to kill pathogens completely), a higher temperature may only take minutes. For example, when Westerberg and Wiley composted sewage sludge which had been inoculated with polio virus, salmonella, roundworm eggs, and *Candida albicans*, they found that a temperature of 116°F to 130°F (46.66°C to 54.44°C) maintained for three days killed all of these pathogens (see *Applied Microbiology*, December 1969). This sort of phenomenon has been confirmed by many other researchers, not the least of which being Gotaas, who indicates that few organisms are able to survive temperatures of 120°F (48.88°C) for more than one hour. However, for safety's sake, a period of twenty-four hours at 122°F is generally recommended for the assurance of total pathogen destruction. Therefore, the first goal in composting humanure should be to create a compost pile that will heat sufficiently to kill all potential human pathogens that may be found in the manure (see figure 6F and table 6.14 on page 133, and table 6.11 on page 127).

It should be understood though, that *the heating process carried out by thermophilic bacteria occurs only in the initial stage of organic decomposition.* The heating stage takes place rather quickly and may only last a few days, weeks or months. The thorough decomposition of organic material, or the conversion of organic refuse into humus may take a year or two. After the initial thermophilic heating period, the humanure will appear to have been digested, but the coarser organic material will not. The fungi and macroorganisms that break the coarser elements down into humus wait for the heat to die down before they move in. Then they take their good old time, and I say "more power to them!" I only plant a garden once a year, so I only need compost once a year. No need to hurry the process.

FOUR NECESSITIES FOR GOOD COMPOST

1. Moisture

In order for the composting process to work properly, several conditions must be met. The first is proper moisture content. A correct moisture content is 50-60%. The pile should be quite moist, but not wet or water logged. How does one determine the moisture content of the compost? How does one regulate the moisture content? First, don't worry. Second, if the pile is getting too much moisture (not likely in an open topped pile with an earth bottom), add more dry materials such as hay, straw, weeds, leaves etc. These things soak up excess moisture.

In extreme cases, a roof over your compost pile may be needed to keep the rain out, or to keep the sun from drying the pile. You may want a roof over your pile so you can collect rain water to use for cleaning composting containers and utensils, then you can use the cleaning water to help keep your pile damp. In any case, the more you work with your compost, the easier you'll find the process to be.

I don't water my compost except to empty cleaning water on it after cleaning the toilet container, and I don't cover it to keep the rain out. Average annual rainfall where I live is about 35 inches per year. There is no apparent leaching from the compost pile into the surrounding environment, and no visible surrounding environmental deterioration whatsoever resulting from my humanure compost bin which has been situated in the same place for fifteen years. I do, however, have my compost bin under tree cover so it has protection from the pouring rain, and I keep the top of the pile flat to minimize water runoff. When monitoring the temperature of my compost pile during a period of drought, I found that the temperature rose dramatically after a heavy rain. This has led me to believe that rain water is good for compost, and provides a source of essential moisture. Compost tends to soak up rain water like a sponge, especially if the pile has a flat top.

On the other hand, much of the moisture in our compost pile comes from human urine. Urine not only provides needed moisture, but it also provides needed nutrients such as nitrogen, and it expedites the decomposition of the sawdust or other organic cover material used in the toilet. If one wants to use a cover material in one's toilet to eliminate odors (and one should), then one needs urine in the toilet to provide the extra moisture and nitrogen to balance the dry carbonaceous cover material so that it'll all compost together thermophilically. If one wants to compost urine as well as feces, then one will have to add a significant amount of relatively dry carbonaceous material to soak up the urine and balance its nitrogen. Cover materials and urine go hand in hand. You shouldn't have one without the other in a composting toilet system.

The segregation of urine from feces in composting systems has been promoted far and wide. I strongly disagree with this practice when applied to thermophilic composting systems, as the alternative of using a carbonaceous cover material is much more simple, pleasant and beneficial. People who segregate urine from feces claim that the urine creates foul odors and waterlogs the compost. However, it is a lack of cover material that allows for the creation of foul odors and waterlogging, not the existence of excess urine. Collecting urine (and feces) in a receptacle filled with sawdust or other organic and fairly dry material before depositing it on the compost pile will ensure that adequate carbonaceous material is added to the pile to balance the nitrogenous urine. The covering of such deposits again, *after application to a compost pile,* with additional organic cover materials such as grass or weeds will ensure an odor free system. This will be discussed in greater detail later in this chapter.

2. Oxygen

The second necessity for a good compost pile is oxygen. Thermophilic bacteria are aerobic bacteria, they need oxygen. One way to oxygenate your pile is by turning it, chopping it, running pipes through it with little holes in them, moving it on augers, blending, agitating, sweating, digging, etc. The belief that one must turn one's compost pile surely is the leading reason why many people don't have them. Especially little old ladies.

I also believed that turning was an essential step in the aeration of a pile and therefore essential in making good compost, and I turned my pile once a year for over a decade. It wasn't until I conducted the more detailed research for this publication when I discovered that turning the pile was not assisting the process of thermophilic decomposition. In fact, after I turned my pile, the bacterial activity slowed way down instead of speeding up as it was supposed to. The microorganisms continued to work, but not as earnestly, and the temperature of the compost dropped significantly (about 30°F) immediately after the pile was turned, then petered out altogether.

The reason this happened was a revelation to me at the time: The thermophilic bacteria in my compost were happily multiplying in the fresher, upper layers of the pile, which contained the proper conditions for vigorous microbial proliferation, namely fresh food, and that layer was around 120°F or 50°C. The lower, older layers of the pile had already been digested by the thermophilic bacteria and were "spent", or cool. When I turned the pile, I diluted the fresh, hot, upper half of the pile with the spent lower half and left the thermophilic bacteria without enough food. Or, in other words, I disrupted their carbon/nitrogen balance. They had plenty of oxygen, but that wasn't good enough. So they quickly cooled down. Now I realize that if a compost pile is arriving at temperatures adequate for the destruction of human pathogens, the microorganisms are enjoying the proper conditions and should be left alone. Turning the pile after it has cooled down will reintroduce oxygen, but it won't refresh the food supply, so why bother? Now I don't turn my compost at all, and the process of compost-making has become that much more enjoyable.

It seems that the act of turning and artificially aerating compost piles is advocated for the purpose of accelerating the compost-making process so that it takes less time. There are many examples in the available literature showing compost piles finished and removed for agricultural application in a few weeks. This may be appropriate for the composting of large quantities of municipal refuse or something of that sort, but for individual families who produce compost for gardening purposes, such compost acceleration will provide little advantage. Furthermore, such tales of fast, hot, compost apply to situations where a sufficient quantity of organic refuse becomes immediately available for piling, turning, and composting. The reality for individual families is that compostable refuse is produced daily in small quantities, day after day, year after year, forever. Therefore, a sudden large heap of compost (a batch) cannot be readily created, and an alternative approach must be used. That approach requires the use of a continuous composting system (as mentioned earlier, but worthy of repeating), in which refuse is continuously added to a pile, and the thermophilic layer continually rises in the pile to digest the incoming refuse. This sort of system is not aided by manually turning the pile. Instead, the pile is aerated by providing it with a blend of ingredients which trap air space in the pile. For those of you who aren't in a hurry, turning or aerating compost manually will not be necessary. I produce compost to use in my food garden, which I plant annually. Therefore, I only need finished compost on an annual basis. An annual cycle works well in a temperate climate such as the one I live in, although shorter cycles may be useful in tropical climates with year-round growing seasons.

In many cases, batch composting piles (not continuous composting piles) are turned in order to insure that all parts of the pile are subjected to the high internal temperatures, thereby ensuring total pathogen destruction. However, small-scale composting by individual families, if done in wooden bins where the compost is kept covered by an insulating layer of organic refuse (such as straw), may be sufficient to retain the necessary temperatures throughout the pile, without turning.

Another reason why compost piles are manually turned or aerated is because they are just too big, and the inside of the pile is smothered. This can be remedied by not making big compost piles. A workable bin size is 5'w x 5'd x 4'h (1.5m x 1.5m x 1.2m), or smaller. There are easy ways to oxygenate a pile this size sufficiently to allow for proper thermophilic decomposition to occur. The easiest way to get oxygen into your pile is by using coarse cover materials such as hay, straw, grasses, or weeds (a main crop in my garden) to cover over odorous compost deposits. These coarse materials trap air spaces in the pile, as well as trap odors. A pile constructed with layered materials including coarse cover materials would have to be under water to be starved of oxygen.

Finally, there is an abundance of evidence that the more compost piles are turned, the greater they suffer from a loss of nutrients, particularly nitrogen and organic matter. Unturned compost retains the highest nutrient value. It also costs much less to produce, as the need for equipment or labor is kept to a minimum.

3. A Balanced Diet

A good carbon-nitrogen balance (a good blend of materials) is required for a nice, hot compost pile (see page 38 to refresh your memory on the topic of carbon and nitrogen). Since most of the materials commonly added to a compost pile are very high in carbon, this means that a source of nitrogen must be incorporated into the blend of composting ingredients. This isn't as difficult as it may seem. You can carry bundles of weeds to your compost pile, add hay, straw, leaves and garbage, but you'll still need one thing: nitrogen. Of course the solution is simple - add manure. Where can you get manure? From an animal. Where can you find an animal? Look in a mirror.

And be sure to keep that kitchen garbage going into the compost. Variety is the spice of life, even for a microscopic critter.

4. Temperature

Compost ceases to be active when frozen, and may slow down considerably when the ambient air temperature is consistently below freezing. However, frozen compost can resume vigorous activity after thawing, providing that it has adequate moisture, oxygen and a balanced diet (see Figure 7.6 on page 164, and appendix 4 on page 187).

DOING IT

OK. You should know by now that anyone can compost humanure at little if any cost in money or resources. You know that, if done properly, the manure will be rendered hygienically safe, no matter what pathogens were in it before composting. The next question is, "*How can I do it, considering our cultural predisposition against the idea, and my own personal circumstances?*" My guess is that if you're living in downtown Pittsburgh, you won't be composting humanure in the near future. On the other hand, if done properly, you could probably compost humanure almost anywhere else without causing a problem. Let me fill you in on my own experiences, and on some possibilities for adapting my experiences to different situations. Maybe this will give you some ideas.

In 1974, after graduating from a university, I set out to learn a thing or two. I soon learned that diet and lifestyle are keys to good health. I decided to experiment a little and eventually put money down on land for the purpose of establishing a homestead and growing my own food. My intentions were to proceed in a manner that was gentle on the Earth, so to speak, while maximizing my own self-reliance and independence.

I traded a wood-burning cookstove for a canvas tipi and set the tipi up on my newly acquired wooded land. I soon had an area cleared for a garden. The first obstacle I ran into was a lack of soil fertility. How was the soil to be built up? Obviously, I had to replace what I took from the land when I gardened. It occurred to me that I had to complete the human nutrient cycle by returning my manure to the soil in the form of compost. It was either that or truck in manure from nearby farms year after year, while my own manure collected underground in a septic tank as toxic waste, thereby threatening the quality of my spring water. So I started composting in a serious way.

I varied my techniques and methods of composting until I hit upon what seemed to work best for me, having now composted in the same bin since 1979. The system I use requires no electricity, running water or technology (although a little technology, such as a truck to haul sawdust, or a sawmill to create it, is useful). And it's not very labor intensive. Most of the work involves regularly emptying organic materials into the compost bin (my sawdust toilet is usually used by four people and is usually emptied every three or four days), and occasionally (annually) removing finished compost from the bin. What's important is that the system works well.

During the development of my composting experiences, I knew at least a dozen families who lived in my surrounding area and were also composting humanure. Today, half of them have converted to flush toilets and conventional septic systems. This is an indication of the obvious: that composting is not for everyone, even the well-intentioned. However, none of the families I knew had done their homework and understood the importance of thermophilic composting or its ability to destroy the pathogens in humanure. Perhaps they weren't sure they were doing the right thing, and in fact many of them were mouldering their compost rather than thermophilically composting it. One family who composts humanure by a mouldering process uses it to fertilize trees in a field, having banned it from their garden, which, of course, is better than shitting in drinking water. Ironically though, it is a simple matter to convert a mouldering system into a thermophilic one, thereby rendering the compost fit for food production.

I now have a house built primarily of bioregional and recycled materials. The tipi ended up at a local state-owned environmental center where it was used to teach kids environmental ethics until a wind storm blew it to shreds. I lived "off the grid", without mainstream electricity, for the first ten years, eventually incorporating photovoltaics (solar electricity) into my home, then mainstream electricity, conservatively consumed. I added the mainstream electricity when I realized I would never want to pay for a photovoltaic system big enough to even light my house, not only because of the prohibitively high cost, but also because of the toxic lead-acid batteries I would have had to buy and eventually discard in order to store the solar power. Besides, the kerosene lamps we had to use were causing indoor air pollution and creating a fire hazard. I also married a woman who owned a freezer, which not only required electricity, but which proved itself to be very useful in preserving food for the winter. The woman's pretty nice too.

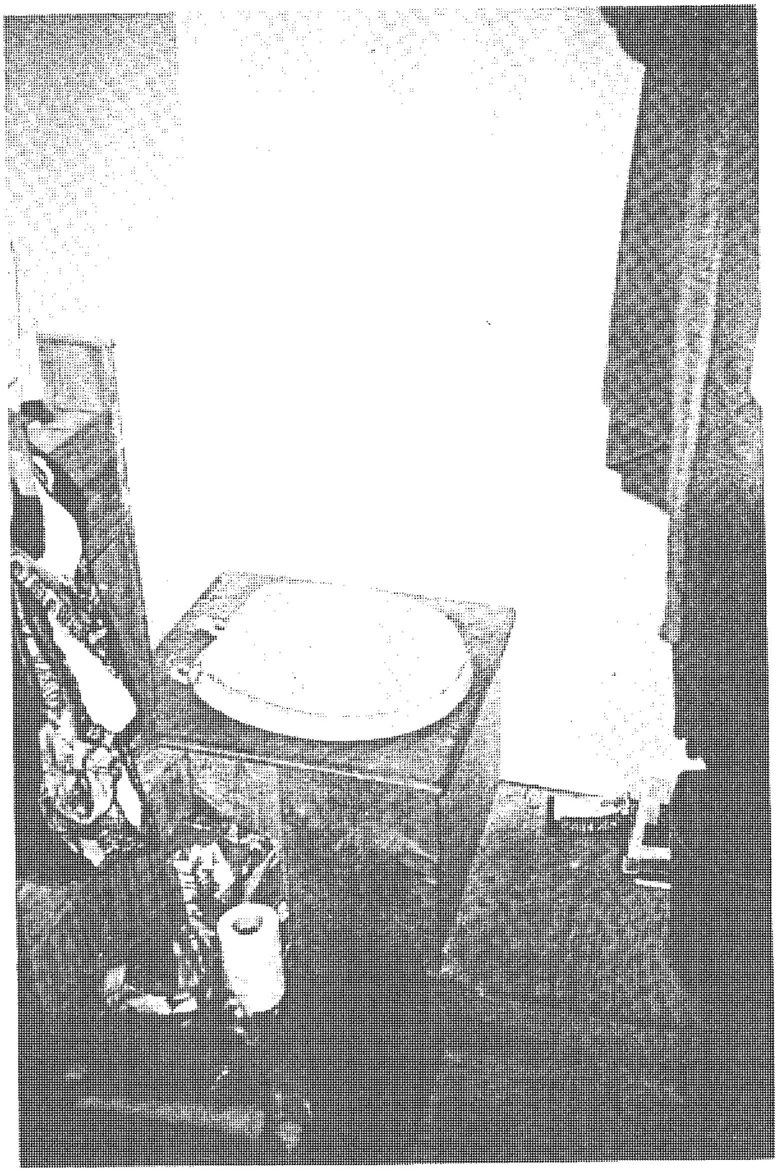
In short, ideals carved in stone are eventually molded by the constant rain of reality, which transforms them into a practical wisdom.

On the other hand, my composting system has changed little. I've upgraded it by moving the original "outhouse" indoors, where it works much better and does not

A Tip From Mr. Turdley

Sawdust **works best in compost when it comes from logs, not kiln-dried lumber.** Although kiln-dried sawdust (from a wood-working shop or retail lumber yard) will compost, it is a dehydrated material and will not decompose as quickly as sawdust from "green" logs, which is a byproduct of sawmills. Kiln-dried sawdust may also contain sawdust from pressure treated lumber, a dangerous addition to any compost pile. Sawdust from logs makes a better cover material in a sawdust toilet, as it prevents the escape of odor more effectively than the lighter, airier, kiln-dried material. Sawdust from logs is an inexpensive and plentiful local resource in forested areas, and can be found at local sawmills, usually free for the hauling. Sawdust should be stored outside where it will remain damp and continue to decompose, although during the winter special provisions must be made to ensure a supply of unfrozen sawdust. Some people will tell you that sawdust will make your soil or your compost acidic. That's not true. A comprehensive study of sawdust done between 1949 and 1954 by the Connecticut Experiment Station showed no instance of it making the soil more acidic.[6] This is verified by the author's experience.

create an odor problem at all. In fact, the most common remark visitors offer concerning the toilet is *"Gee, why doesn't it smell?"* The system itself is still the same model of simplicity that I've been employing all along, if not more so. People ask me when I'm going to get a septic system. They take one look at the compost toilet and say things like *"I respect the way you're living, but I could never do it."* Well, I could install a septic system, as I have the running water and the electricity. However, in doing so I'd likely create environmental pollution and threaten the quality of my ground water, which I drink. That's what septic systems do. They're *waste disposal* systems. They collect and store waste, allowing the waste to slowly seep into the environment. I'd rather engage in resource recovery instead of waste disposal. My compost is my reward, and that's too valuable for me to be willing to sacrifice. It helps me to grow my food.



A SIMPLE, COMPACT, INDOOR SAWDUST TOILET IN A NEWLY CONSTRUCTED HOME.

Finally, I don't understand humans. We line up and make a lot of noise about big environmental problems like incinerators, dumps, acid rain, and pollution. But we don't understand that when we add up all the tiny environmental problems each of us creates, we end up with those big environmental dilemmas. Humans are content to blame someone else, like government or corporations, for the messes we create, and yet we continue doing the same things ourselves day in and day out that have created the problems. Sure, corporations create pollution. If they do, don't buy their products. If you have to buy their products (gasoline for example), keep it to a minimum. Sure, municipal waste incinerators pollute the air. Stop throwing trash away. Minimize your production of waste. Recycle.

Buy food in bulk and avoid packaging waste. Simplify. Take a few months off work each year and don't spend money. Turn off your TV. Grow your own food. Plant a garden. Be part of the solution, not part of the problem. If you don't, who will?

THE SAWDUST TOILET

By now the reader should realize that the thermophilic composting of humanure will render it hygienically safe for garden use. However, thermophilic composting requires managing a compost pile by ensuring that the composting microorganisms have their basic needs of oxygen, food and moisture met. That management process simply entails heaping a mix of organic refuse in a constructed bin on bare soil, using some coarse (but not woody) material in the heap, and making sure the pile doesn't dry out. An additional important management practice involves occasionally raking the exposed outer edges of the compost pile onto the top of the pile to ensure that no material is escaping the thermophilic process.

In any case, when composting humanure one may ask, "*How does one get the humanure to the compost pile?*" There are two basic answers to that question. First, the compost pile may be situated under the toilet. I have never used such a toilet and therefore cannot discuss such a system with any authority. I don't see why this sort of collection system would not work as long as the compost pile is readily accessible and closely managed to ensure thermophilic decomposition and to prevent odor and waterlogging. Secondly, the humanure may be collected in one location, then moved to the compost pile in another location on a regular basis. This is the sort of system I am most familiar with, therefore, it is the system on which I focus my discussion.

Another
TIP FROM MR. TURDLEY

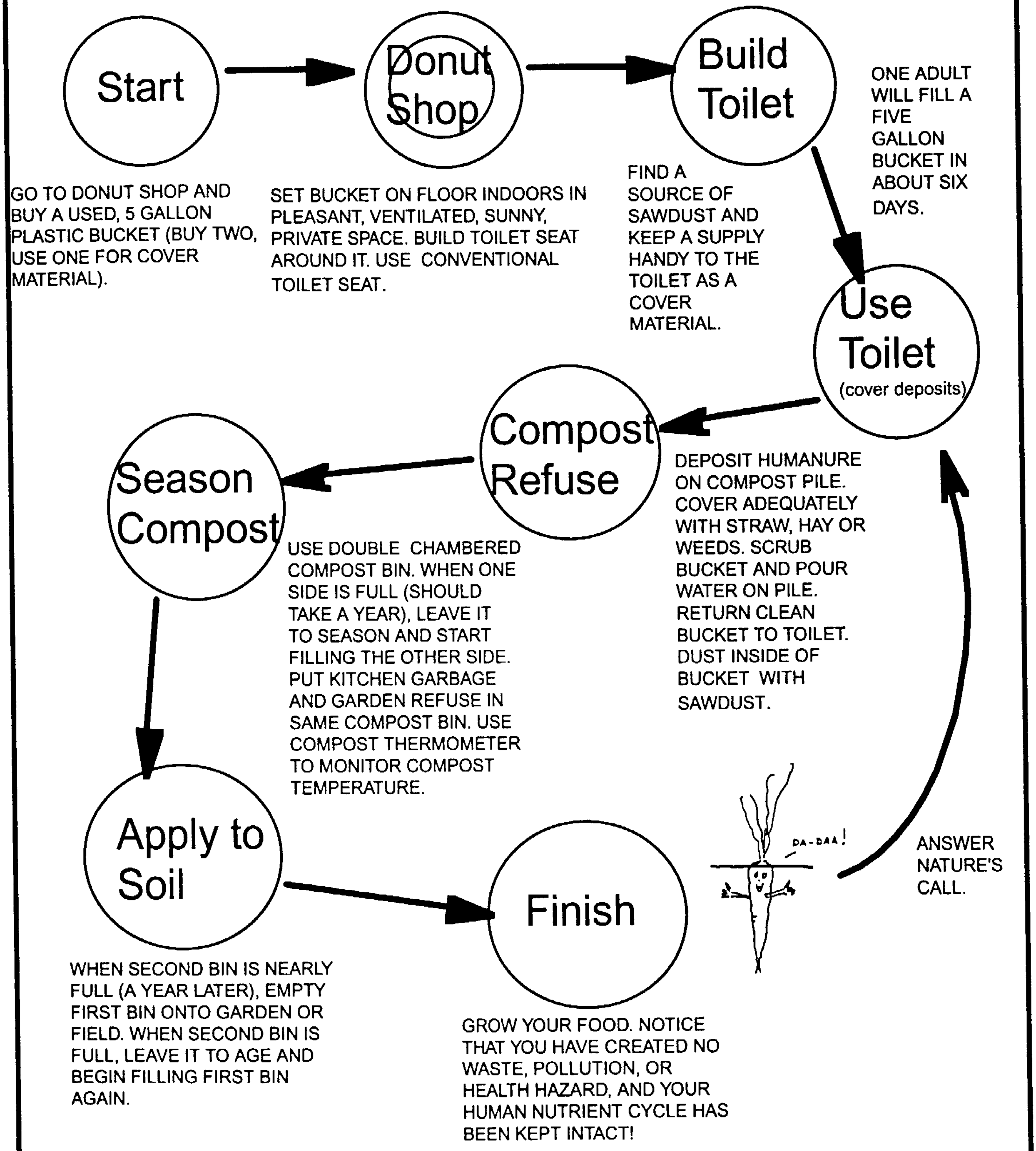
THE SECRET

to composting humanure is to keep it covered.

Always cover toilet deposits thoroughly with a clean, organic cover material such as rotting sawdust. When depositing humanure onto a compost pile always cover the deposit with another cover material, preferably a coarse one such as straw or weeds. Proper cover materials eliminate odors and flies, and balance the nitrogen in the humanure.

Figure 7.1

The Tao of the Sawdust Toilet



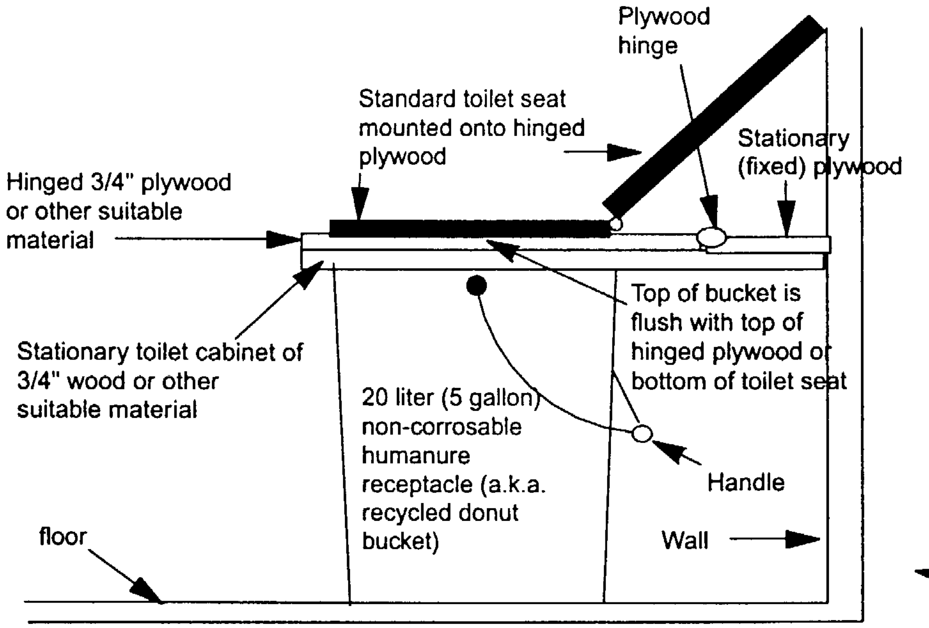


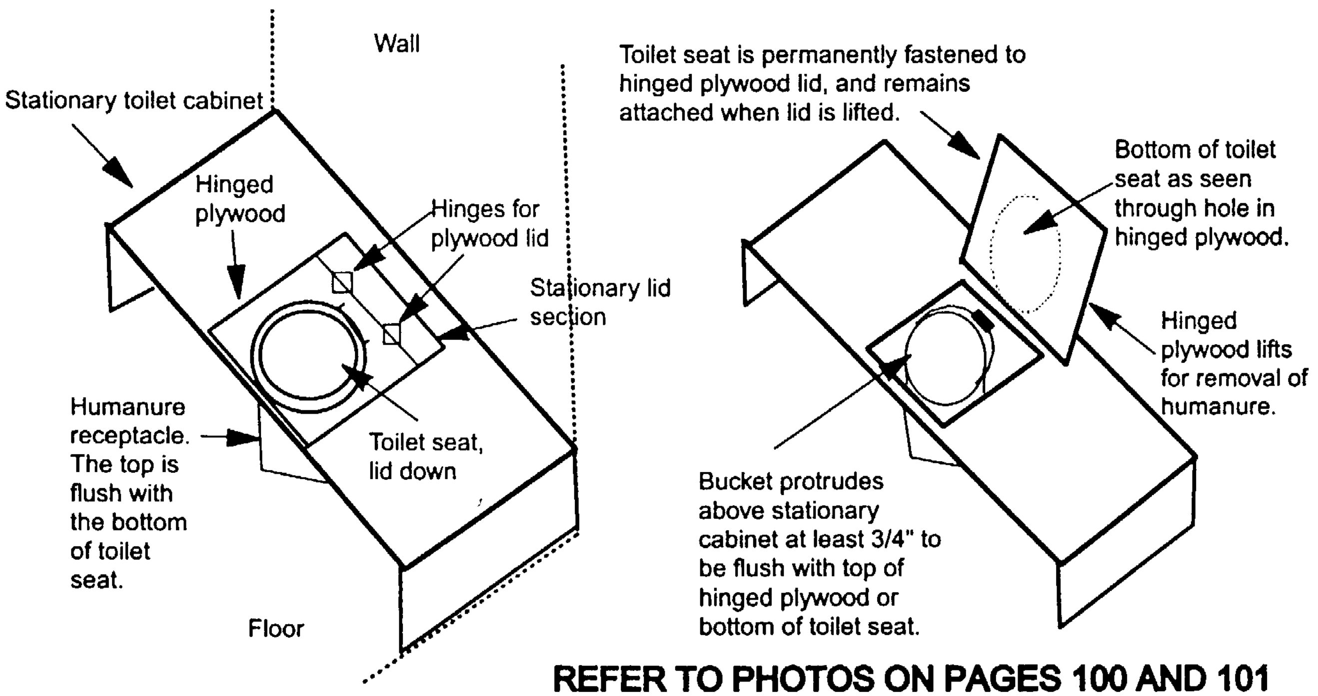
Figure 7.2

CUTAWAY VIEW OF SAWDUST TOILET HUMANURE RECEPTACLE

SAWDUST TOILET VITAL STATISTICS

100 pounds of human body weight will fill approx. *3 gallons* (.4 cubic feet, or 693 cubic inches or approx. 11 liters) in a sawdust toilet *per week* - this volume includes the sawdust cover material.100 pounds of human body weight will also require approximately 3 gallons of semi-dry, deciduous, rotting sawdust per week for use as a cover material in a toilet. This amounts to a requirement of approximately 20 cubic feet of sawdust cover material per 100 pounds of body weight per year for the proper functioning of a sawdust toilet. Human excrement tends to add weight rather than volume to a sawdust toilet as it is primarily liquid and fills the air spaces in the sawdust. Therefore, for every gallon of sawdust-covered excrement collected in a sawdust toilet, nearly a gallon of cover material will have been used.

Diagram of Simple Humanure Sawdust Toilet Arrangement



REFER TO PHOTOS ON PAGES 100 AND 101

A simple collection system whereby humanure is collected regularly, then moved to a compost pile has its advantages and disadvantages. The advantages include:

1) A very low cost is required to initiate such a system. The lower the cost of a system, the more universally available it is to humans on planet earth. A collection receptacle that is non-corrosable with a 20 liter or five gallon capacity is ideal. A larger capacity receptacle would be too heavy when full. Plastic, five-gallon food grade buckets with handles are available in the United States for a very small cost as discarded from donut shops and other food establishments. Such a receptacle will withstand many years of constant use with little or no degradation.

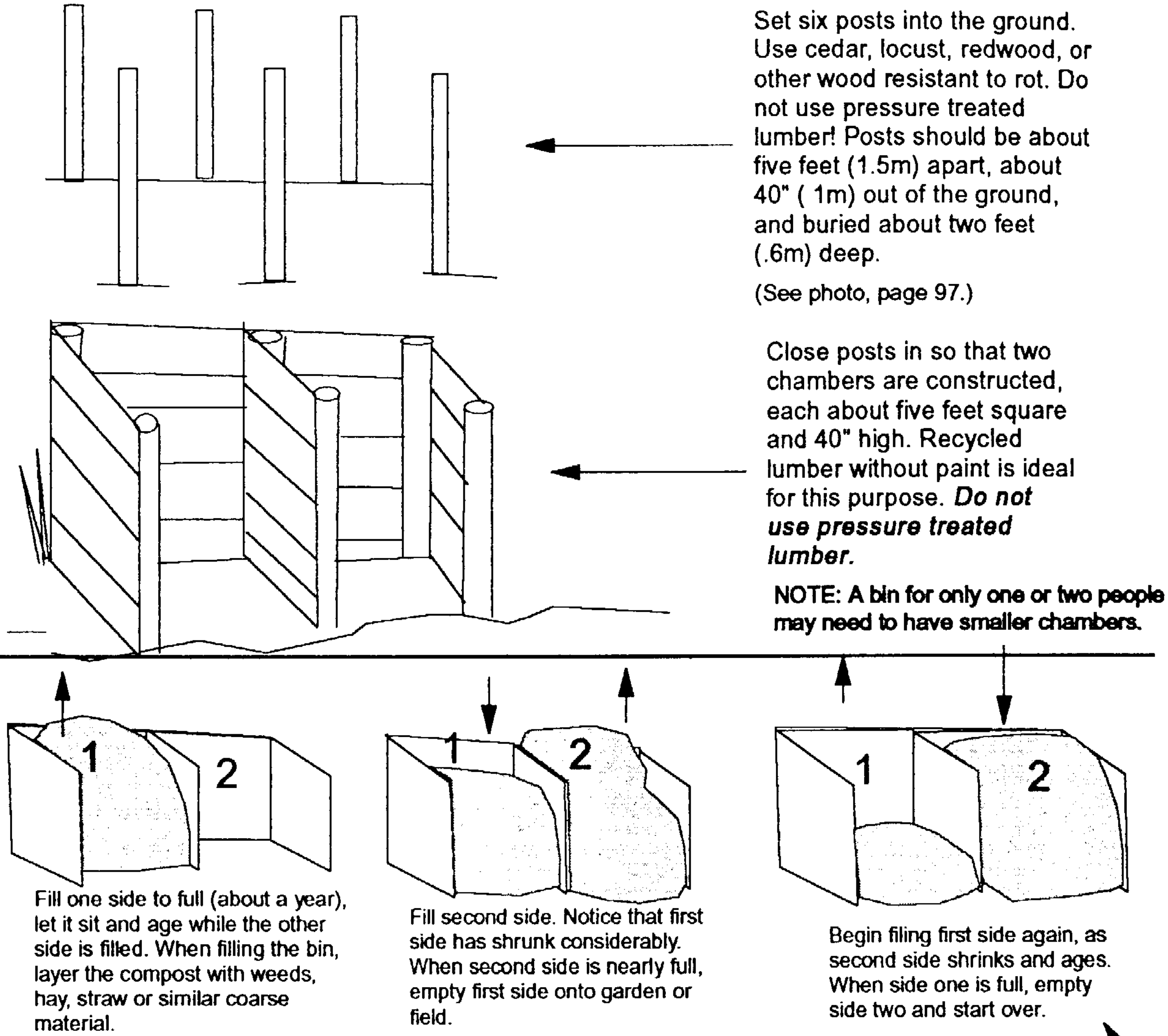
2) The toilet can (and should) be comfortably indoors, with no odor. In order to prevent odors, a cover material *must* be used in the collection receptacle. Sawdust from logs is ideally suited for this purpose, although other organic materials would also work. Not only does the cover material trap odor in the collection receptacle, but it also completely eliminates any fly or insect problems. If sawdust from logs is not available, the compost-maker will have to find an alternative that is available in his or her locality. The cover material should be natural, organic, clean and not wet, although it may be damp, and a slight dampness may actually be preferred for odor prevention purposes. Some people use peat moss. Other possibilities would include leaves (preferably dead or dried), ground corncobs or stalks, plain dirt, grain chaff,

Yet Another Tip from Mr. Turdley

PRESSURE TREATED LUMBER SHOULD NEVER BE USED FOR CONSTRUCTING COMPOST BINS, or for anything else. Pressure treated lumber is saturated with chromated copper arsenate. Both arsenic and chromium have been classified as human carcinogens (causing cancer) and are suspected mutagens (causing mutations). The poisons in pressure treated lumber will leach into your soil and into your compost, and may enter your food chain. You can't even safely burn pressure treated lumber to get rid of it - it produces highly toxic fumes and ash! When using sawdust in compost, don't use sawdust from a lumber yard as it may be made from pressure treated lumber! [See *Organic Gardening*, July/August, 1992. p. 8-10]

Figure 7.3

CONSTRUCTING A SIMPLE COMPOST BIN



THE CEASELESS CYCLE OF COMPOST MAKING

(Refer to page 159 for additional illustrations.)

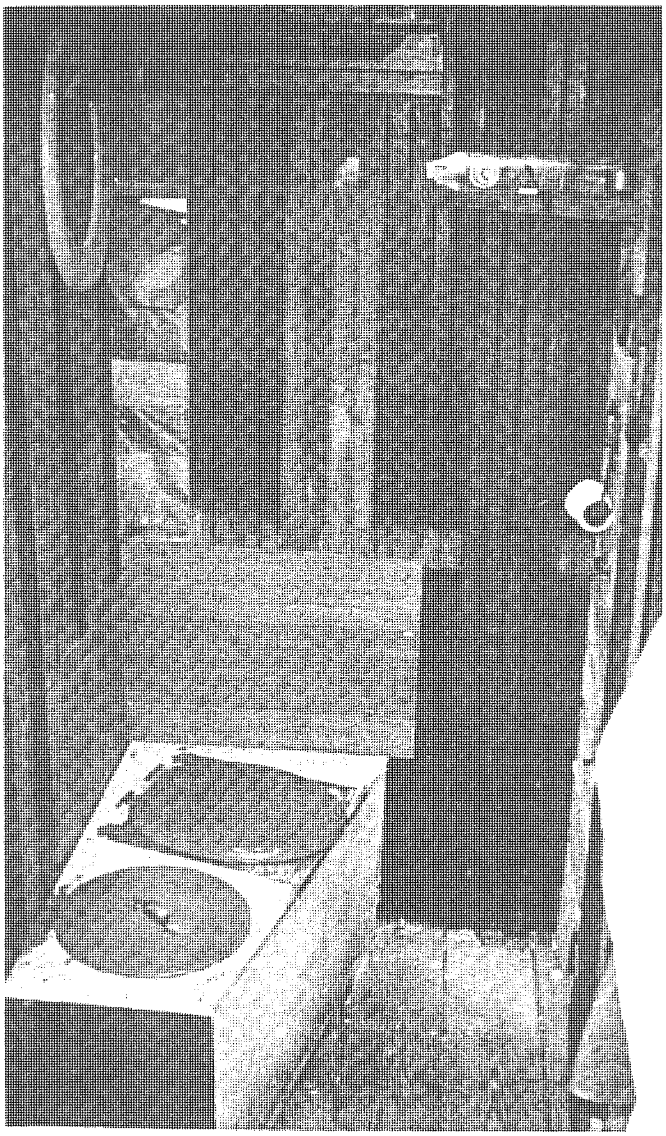
possibly ground newsprint, perhaps even green leaves, etc. The cover material is an absolutely essential part of a thermophilic compost toilet - it not only eliminates odors and insects, but it also balances the nitrogen of the humanure by providing carbon, thereby setting the stage for the desired thermophilic decomposition.

3) No energy is required to operate such a system. No ventilation is necessary if the composting does not take place inside one's home. In which case, no fans or electricity are needed, and no running water is needed, although a small quantity of water is needed (a minimum of 2 quarts or 2 liters) to wash out the collection receptacle after emptying, which is also essential for maintaining an odor free system. The

soiled wash water can be dumped on the compost pile, or at the base of a fenced-off bush or shrub which is inaccessible to people, especially children. Or the water can be deposited into a standard septic system, or into a natural wetland wastewater treatment system.

4) The thermophilically composted organic refuse is transformed into a hygienically safe, valuable resource. The process eliminates sewage, fecal contamination of the environment, and the spread of disease by human pathogens resident in human excrement.

The disadvantages of a collection system requiring the regular removal of humanure to a compost pile are obvious. They include: 1) the inconvenience of carrying the organic refuse to the compost pile; 2) the inconvenience of keeping a supply of organic cover material available and handy to the toilet; 3) and the inconvenience of maintaining and managing the compost pile itself.



A PEAT TOILET WITH A RECESSED CONTAINER HOLDING PEAT MOSS FOR USE AS A COVER MATERIAL.

In researching the literature during the preparation of this book, I found it surprising that almost no mention is ever made of the thermophilic composting of humanure as a viable alternative to on-site sanitation. When "bucket" systems are mentioned, they are also called "cartage" systems, and are universally decried as being the least desirable sanitation alternative. For example, in A Guide to the Development of On-Site Sanitation by R. Franceys et. al., published by the World Health Organization in 1992, "bucket latrines" are described as *"malodorous, creating a fly nuisance, a danger to the health of those who collect or use the nightsoil, and the collection is environmentally and physically undesirable"*. This sentiment is echoed in Rybczynski's (et. al.) World Bank funded work on low-cost sanitation options, where it is stated that *"the limitations of the bucket latrine* *include the frequent collection visits required to empty the small container of [humanure], as well as the difficulty of restricting the passage of flies and odors from the bucket."*

Now, I've personally used what could be called a bucket latrine (actually *sawdust toilet* or *biosolids toilet* would be more appropriate terms) for fifteen years and

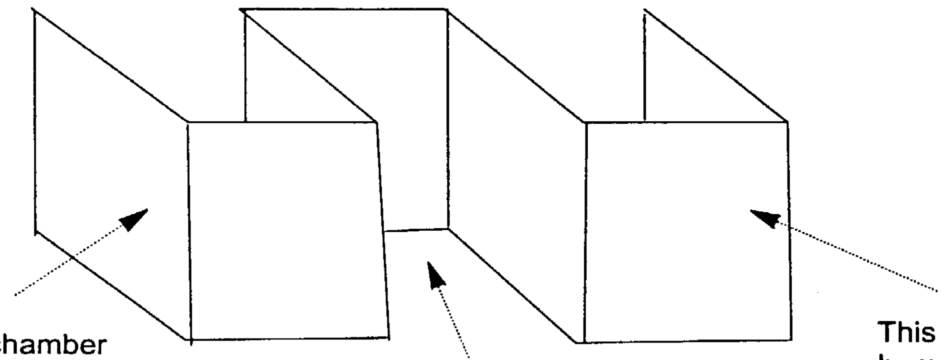
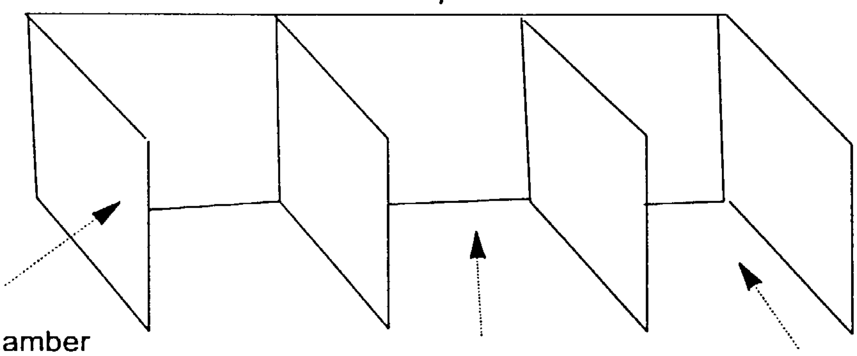


Figure 7.4

Two Styles of Three-Chambered Compost Bins

The three-chambered bin is very useful when low nitrogen and/or bulky organic refuse becomes available in large quantities, such as when weeding the garden, or raking leaves in the fall. Too much of this refuse at one time in the thermophilic compost may disrupt the carbon/nitrogen balance and cause the pile to cool. Therefore, excess organic material is conveniently stored in the center chamber and slowly added to the humanure compost as a cover material when needed. By separating the humanure compost bins in such a manner, one can be assured that the aging compost will not be in any way contaminated by leakage from the fresh compost.



HELPFUL HINT:
Stack bales of straw (or hay) in front of open end of compost chamber to make temporary wall. Use straw later for compost.

it has never given me odor problems, fly problems, health problems, or environmental problems. Quite the contrary. Nevertheless, Franceys et. al. go on to say that *"[humanure] collection should never be considered as an option for sanitation improvement programmes, and all existing bucket latrines should be replaced as soon as possible."* Say what?

Obviously Franceys et. al. are referring to the practice of collecting humanure in buckets without a cover material (which would surely stink to high heaven and attract flies) and without any intention of composting the humanure. Such buckets of feces and urine are presumably dumped raw into the environment. Naturally, such a practice should be decried and strongly discouraged, if not outlawed. However, rather than forcing people who use such crude waste disposal methods to switch to other more prohibitively costly waste disposal methods, perhaps it would be better to edu-

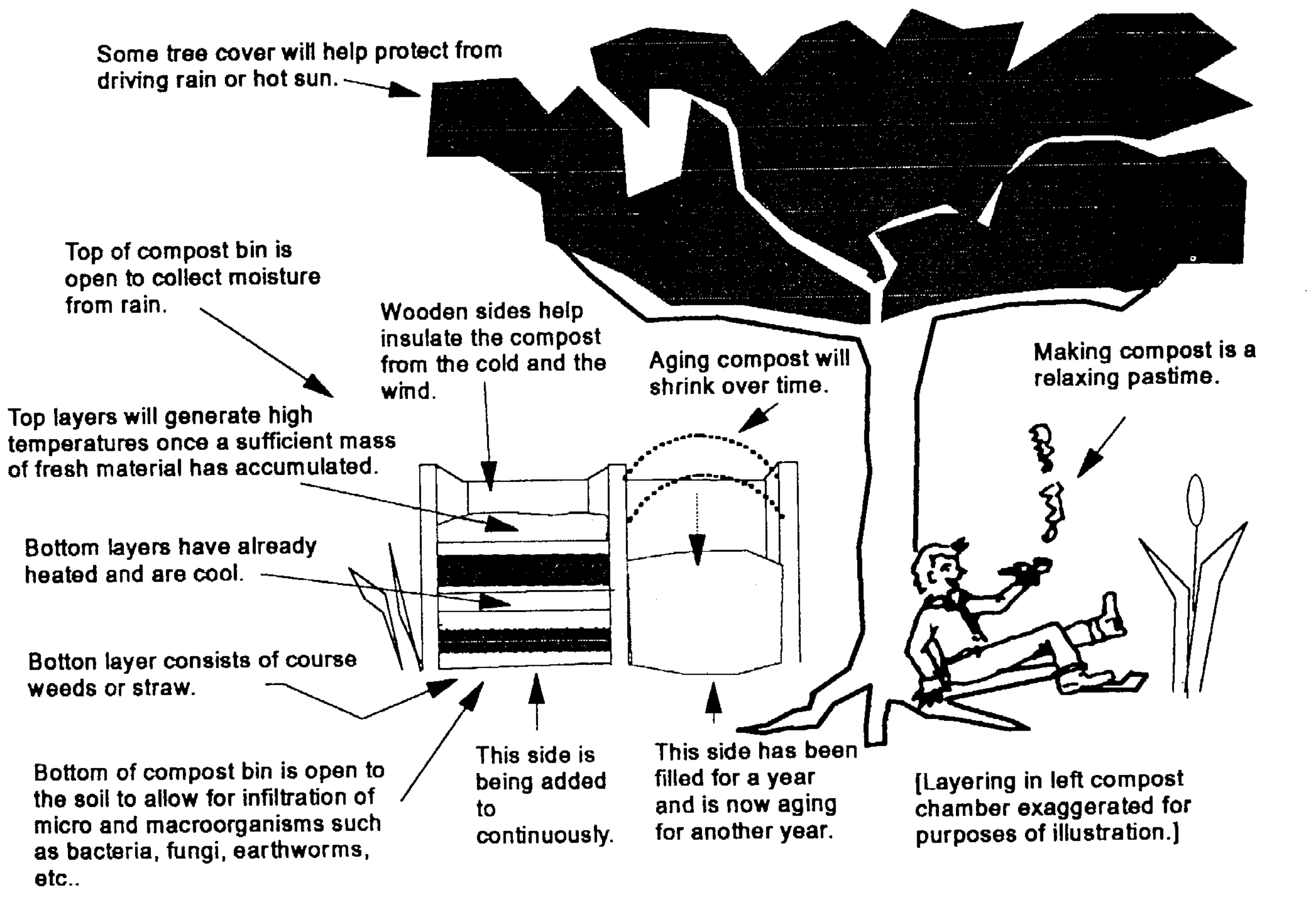


Figure 7.5

ANATOMY OF A LOW COST, ABOVE GROUND, CONTINUOUS THERMOPHILIC COMPOST BIN

cate those people about *resource recovery*, about the *human nutrient cycle*, and about *thermophilic composting*, and help them acquire adequate and appropriate *cover materials* for their toilets, assist them in constructing *compost bins*, and thereby eliminate waste, pollution, odor, flies and health hazards altogether. I find it inconceivable that intelligent, educated scientists who observe bucket latrines and the odors and flies associated with them do not see that the simple addition of a clean organic cover material to the system would solve the aforementioned problems. Plus balance the nitrogen of the human feces and urine with carbon.

Franceys, et. al. state, however, in their aforementioned book, that *"Apart from storage in double pit latrines, the most appropriate treatment for on-site sanitation is composting."* I would agree that composting, when done properly, is the most appropriate method of on-site sanitation available to humans. I would not agree that double pit storage is more appropriate than thermophilic composting unless it could be proven that all human pathogens could be destroyed using such a double pit system, and that such a system would not require the segregation of urine from feces. According to Rybczynski, the double pit latrine shows a reduction of *Ascaris* ova of 85% after two months, a statistic which does not impress me. When my compost is finished, I don't want *any* pathogens in it.

Ironically, the work of Franceys et. al. further illustrates a "decision tree for selection of sanitation" that indicates that the use of a "compost latrine" as being one of the least desirable sanitation methods, and one which can only be used if the user is willing to collect urine separately. Unfortunately, contemporary professional literature is rife with this sort of inconsistent and incomplete information which would surely lead a reader to believe that composting humanure just isn't worth the trouble.

On the other hand, Hugh Flatt, who, I would guess, is a practitioner and not an academic, in Practical Self-sufficiency tells of a sawdust toilet system he had used. He lived on a farm for more than thirty years which made use of "bucket lavatories". The lavatories serviced a number of visitors during the year and often two families in the farmhouse, but they used no chemicals. They used sawdust, which Mr. Flatt described as "absorbent and sweet-smelling." The deciduous sawdust was added after each use of the toilet, and the toilet was emptied on the compost pile daily. The compost heap was located on a soil base, the deposits were covered each time they were added to the heap, and kitchen refuse was added to the pile (as was straw). The result was "*a fresh-smelling, friable, biologically active compost ready to be spread on the garden*."[7]

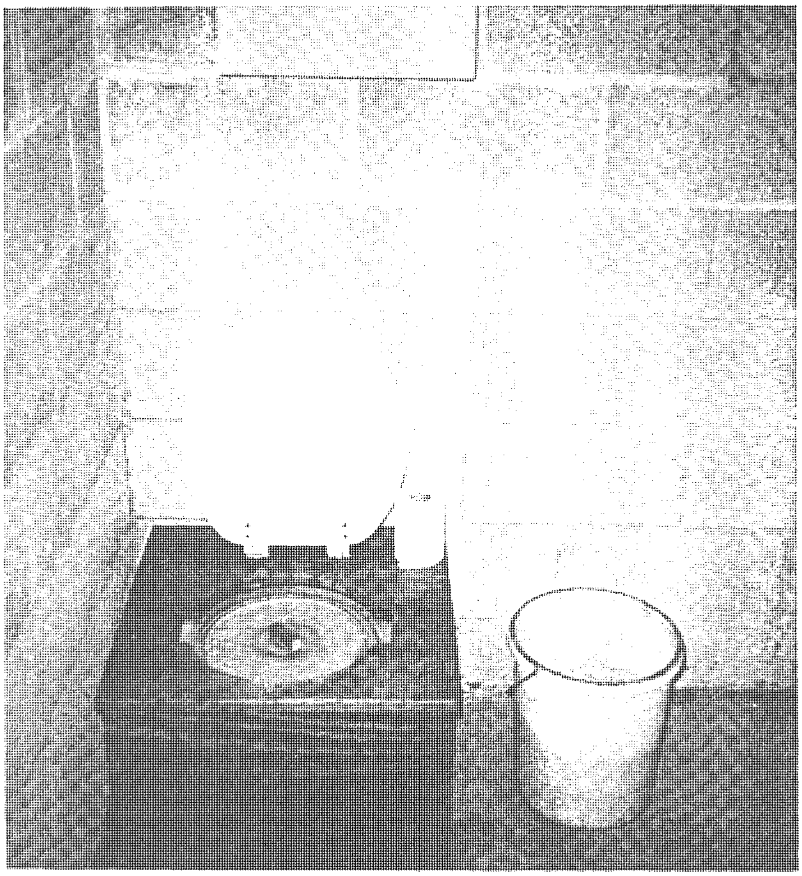
Perhaps the "experts" will one day understand, accept, and advocate simple humanure composting techniques such as the sawdust or biosolids toilet. However, we may have to wait until Composting 101 is taught at the university.

After nearly fourteen years of composting all of my family's and visitor's humanure on the same spot about fifty feet above my garden, and using all of the finished compost to grow the food in our single garden, I analyzed my garden soil, my yard soil (for comparison), and my compost, each for fertility and pH, using LaMotte test kits from the local university[8]. I also sent samples of my feces to a local hospital lab to be analyzed for indicator pathogenic ova or worms. The analyses are as follows:.

The humanure compost proved to be adequate in nitrogen (N), and rich in phosphorus (P), and potassium (K), and higher than either the garden or the yard soil in these constituents as well as in various beneficial minerals. The pH of the compost was 7.4 (slightly alkaline), and no lime or wood ashes had been added during the composting process. This is one reason why I don't recommend adding lime (which raises the pH) to a compost pile. A finished compost would ideally have a pH around 7 (neutral).

The garden soil was slightly lower in nutrients (N, P, K) than the compost, and the pH was also slightly lower at 7.2. I had added lime and wood ashes to my garden soil over the years, which may explain why it was slightly alkaline. The garden soil, however, was still significantly higher in nutrients and pH than the yard soil (pH of 6.2), which remained generally poor.

My stool sample was free of pathogenic ova or worms. I used my own stool for analysis purposes because I had been exposed to



A SAWDUST TOILET IN A BASEMENT.
THIS TOILET IS USED AS AN EMERGENCY BACKUP IN A HOUSE WITH A SEPTIC SYSTEM. NOTE THAT THE HUMANURE RECEPTACLE EMPLOYS AN INNER LID, WHICH IS NOT NECESSARY WHEN ROTTED DECIDUOUS SAWDUST IS USED AS A COVER MATERIAL AND THE REGULAR TOILET SEAT FITS SNUGLY AGAINST THE TOP OF THE HUMANURE RECEPTACLE. THE BUCKET TO THE RIGHT CONTAINS CLEAN SAWDUST, WHICH IS ADDED TO THE TOILET AFTER EACH USE.

the compost system and the garden soil longer than anyone else in my family by a number of years. I had freely handled the compost year after year with no reservations (my garden is mostly hand-worked). I repeated the stool analysis a year later (after fifteen years of composting humanure) again with negative results (no ova or parasites observed).

These results indicate that the compost is a good soil builder, and that no intestinal parasites were transmitted from the compost to the compost handler. This wasn't a laboratory experiment; it was a real life situation conducted over a somewhat lengthy period of time. The whole process, for me, has been a success.

LOW-IMPACT COMPOSTING

It's very important to understand that *two* factors are involved in destroying pathogens in humanure. Along with heat, the *time* factor is important. Once the organic material in a compost pile has been heated by thermophilic microorganisms, it should be left to age or "season". This part of the process allows for the final decomposition to take place, decomposition that may be dominated by fungi and macroorganisms such as earthworms. Therefore, a good compost system will utilize at least two sections or chambers in a single bin, or two separate bins, one to fill and leave to age, and another to fill while the first is aging. One may want to have two separate single-chambered compost bins, or a three-chambered compost bin, or any variation of the double-chambered bin that meets the individual's needs.

When using two compost chambers, fill them one at a time. Stop filling the first one when it's full, which may take a year, and leave it alone. Don't turn it unless you want some exercise, however it should still be heating on the top layer, and turning it now may put out the fire. At that time start filling the second chamber. Then, when the second chamber is nearly full (a year later?), the first one can begin to be emptied onto the garden. The object is to let the compost rest for about a year after the pile has been fully constructed. Pure simplicity (see figures 7.3, 7.4 and 7.5).

A compost pile can accept a huge amount of refuse, and even though the pile may seem to be full, as soon as you turn your back it will shrink down and leave room for more material. So when I say fill the first chamber before filling the second, I mean *FILL* it. You'll know when it's getting full when nothing else will fit on the pile without trying to roll out of the bin.

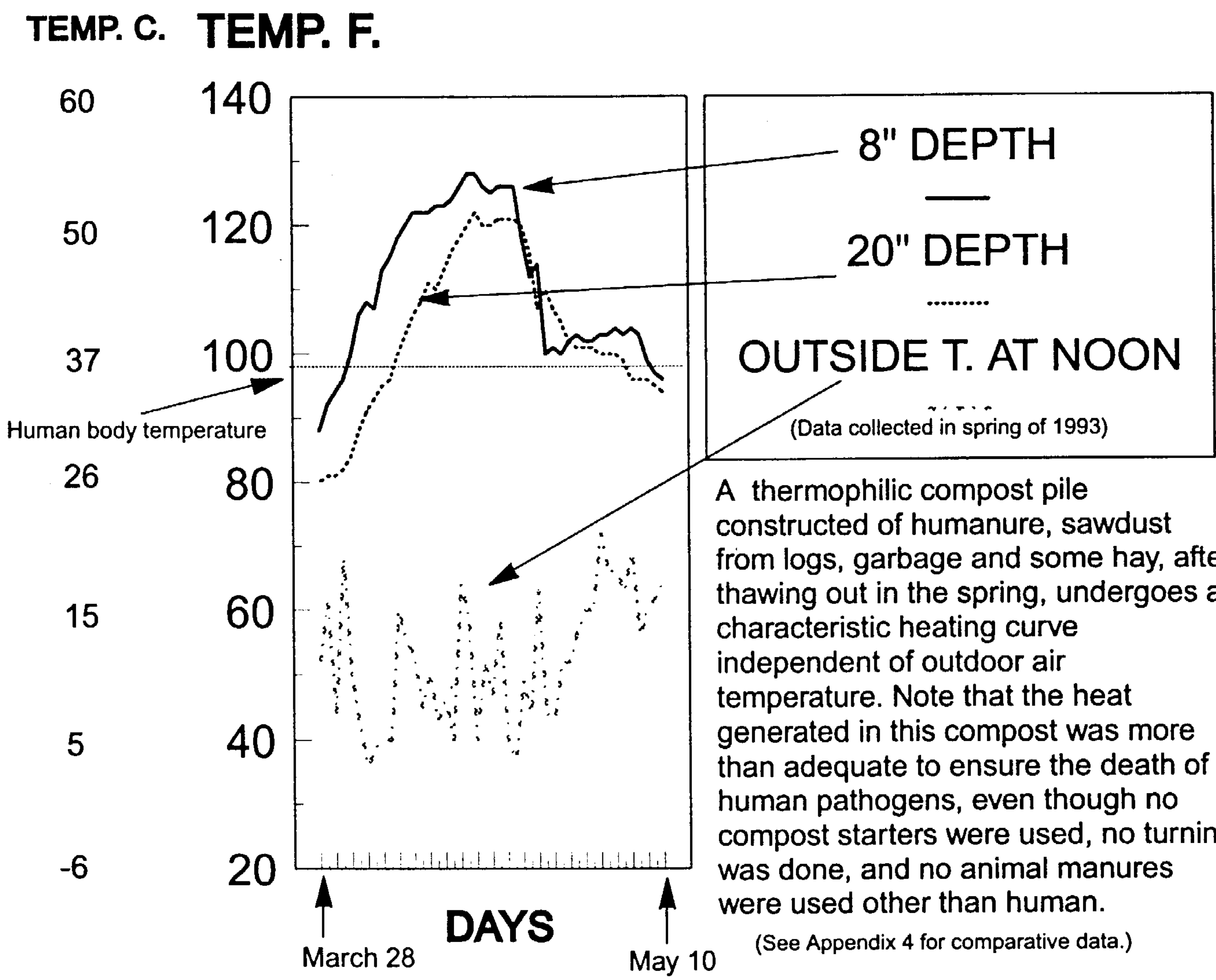
The timing cycle I follow for compost-making is natural. Natural cycles of time include daily cycles, or "circadian rhythms". For humans that usually involves a daily defecation, a daily sleeping period, etc. For the planet it involves the daily rotation. This cycle of time connects us, as humans, to the other life forms on the earth. It's something we all share in common.

Monthly cycles include the waxing and waning of the moon, the monthly new and full moons, or the monthly revolution of the moon around the earth. This involves tidal cycles, menstrual cycles, and probably a heck of a lot more that I'm not aware of.

Seasonal cycles break up the annual revolution of the Earth around the sun. They're marked by the spring and fall equinoxes and the winter and summer solstices, and by the weather changes of the seasons. All of these cycles are included in the yearly cycle, which involves gardening, farming, planting, harvesting, and anything else done on an annual schedule, including an annual period of rest.

Figure 7.6

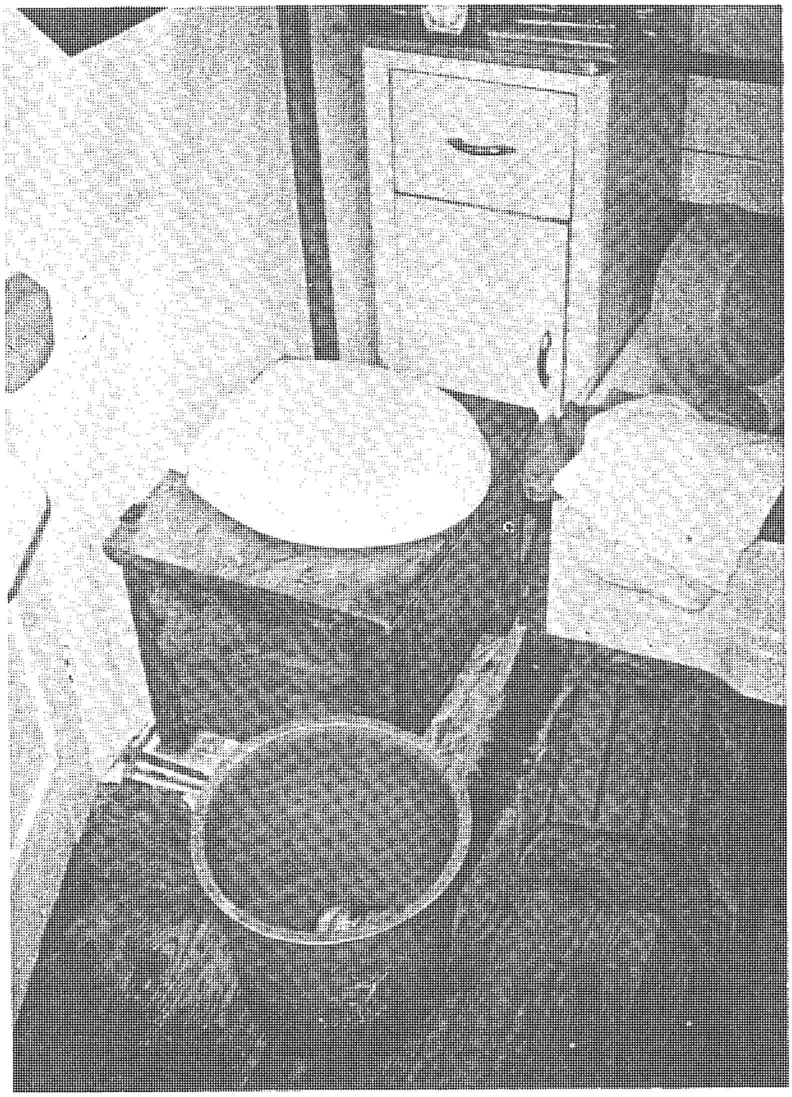
Temperature Curve of Frozen Humanure Compost Pile After Spring Thaw



A thermophilic compost pile constructed of humanure, sawdust from logs, garbage and some hay, after thawing out in the spring, undergoes a characteristic heating curve independent of outdoor air temperature. Note that the heat generated in this compost was more than adequate to ensure the death of human pathogens, even though no compost starters were used, no turning was done, and no animal manures were used other than human.

(See Appendix 4 for comparative data.)

When working with natural cycles such as with the composting stage of the human-nutrient cycle, it's best, I believe, to follow natural cycles of time as well. They go hand in hand. Therefore, I've found a yearly cycle to work best for me in making compost. By late spring, the compost bin is full and it's time to leave it sit until the next spring, when the finished compost will be ready to be removed to the garden. The removal of the finished compost takes place in the spring prior to or during planting time.



THIS SAWDUST TOILET CONSISTS OF A WOODEN BOX SITUATED OVER A FIVE GALLON, PLASTIC HUMANURE RECEPTACLE (NOT VISIBLE). THE BOX IS LIFTED OFF THE RECEPTACLE WHEN IT IS FULL, AND THE ORGANIC REFUSE IS THEN REMOVED TO THE COMPOST BIN OUTDOORS.

MONITORING COMPOST TEMPERATURE

The preceding graph shows the rise in temperature of a humanure compost pile (feces, urine, and garbage) which had been frozen all winter. That particular spring was very cold, so the pile didn't thaw out until late March. Until then it was hard as a rock, a large pile of frozen mass, nearly filling a 5' x 5'x 4' bin.

The compost consisted primarily of deposits from the sawdust toilet, which contained raw hardwood sawdust (just enough to cover the material in the toilet), humanure including urine, and toilet paper. In addition to this material, kitchen garbage was added to the pile intermittently throughout the winter, and hay was used to cover the toilet deposits on the pile. Some weeds and whatnot may have been thrown in now and then, but garden material isn't available during the winter except in the form of

DO's and DONT's
of a thermophilic toilet composting system:

DO - Collect urine in the toilet. Urine provides essential moisture and nitrogen.

DO - Have a supply of cover material for the toilet to eliminate odor, absorb excess moisture and urine, and balance the C/N ratio. Examples: rotting sawdust, peat moss.

DO - Have another supply of cover material to cover the compost pile itself, for odor prevention, air entrapment, and C/N balance. Examples: Hay, straw, weeds, leaves, grass.

DO - Occasionally rake exposed outer surfaces of the compost pile onto the top of the pile.

DO - Add a mix of organic material to the compost pile, including organic garbage.

DO - Keep top of compost pile somewhat flat. This allows rain to be absorbed, and added organic material to stay on top.

DO - Use a compost thermometer. If the temperature of your compost does not seem adequate to you, use finished compost for berries, fruit trees, and ornamentals, instead of garden crops.

DON'T - Segregate urine from feces.

DON'T - Turn the pile if it is being continuously added to.

DON'T - Cover fresh compost deposits with lime or wood ashes. Put lime and wood ashes directly on soil. Cover compost with clean organic materials that will benefit the composting process, such as mentioned at left.

DON'T - Deposit urine/feces/sawdust into a compost bin without cover materials and other organic refuse and expect it to thermophilically compost. The layering of a wider mix of materials traps air and provides nutrients that stimulate thermophilic activity.

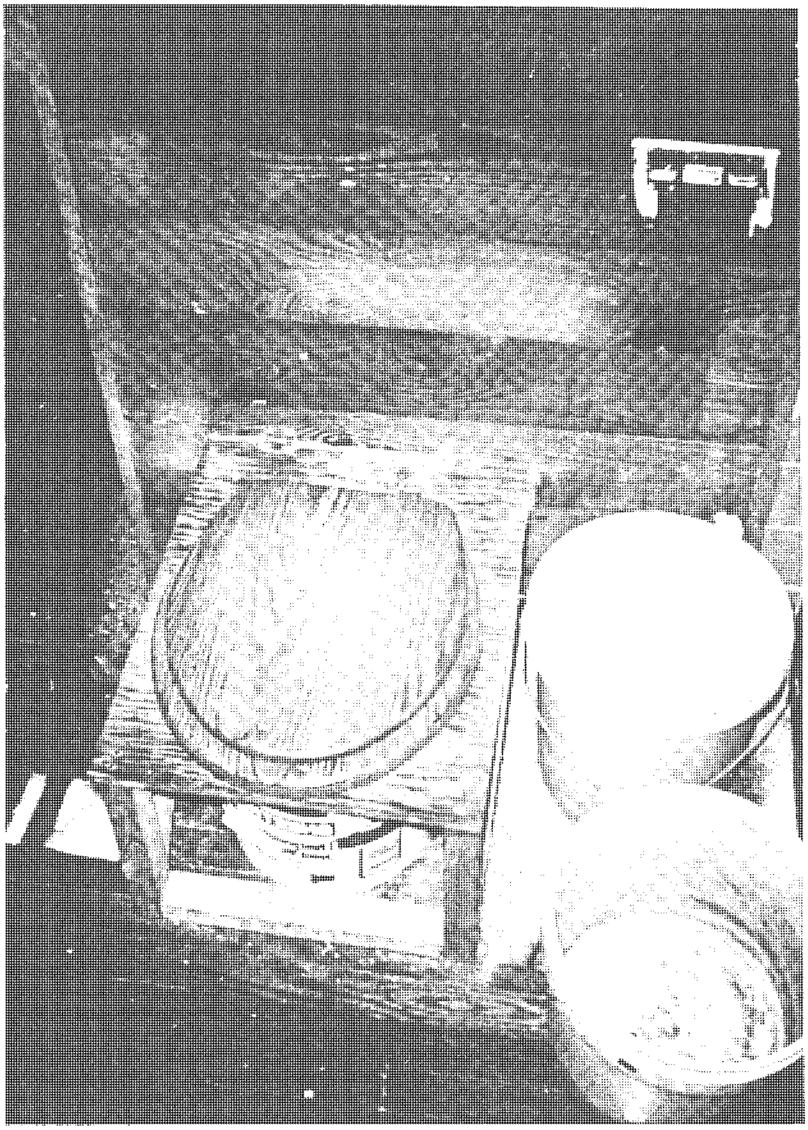
DON'T - Worry if your compost does not reach an extremely high temperature quickly. Temperatures above 110° F indicate thermophilic activity, which may peak periodically in a continuous compost pile when sufficient organic mass has accumulated.

Temperatures above 104°F may be sufficient to kill pathogens (see page 99).

A compost bin may require some time to develop a resident thermophilic population. If your compost does not achieve thermophilic temperatures, after collecting it for a year and aging it for another year, use it to plant berries, fruit trees, or ornamental plants.

kitchen refuse, so not much in the way of garden weeds was in this pile.

The material was collected over a period of about four months from a family of four. Nothing special was done to the pile at any time. No unusual ingredients were added, no compost starters, no water, no animal manures other than human, and no turning whatsoever. The compost pile was situated in a three-sided, open-topped wooden bin on the dirt ground, outside. Only normal household organic refuse such as produced by any human being was added to the pile including human fecal material and urine. The only imported materials (not from the home) were sawdust, a locally abundant resource, and hay from a neighboring farm (one or two bales were used during the entire winter).



A SAWDUST TOILET IN A MOBILE HOME. THE FRAME IS HINGED TO THE WALL AND LIFTS UP OFF THE HUMANURE RECEPTACLE WHEN REMOVAL IS NECESSARY.

Notice that the outside of the pile was heated by thermophilic activity before the inside. The outside thawed first, so it started to heat first. Soon thereafter the inside thawed and also heated. By April 8th the outer part of the pile had reached 120°F (50°C) and the temperature remained at that level or above until April 22 (a two week period). The inside of the pile reached 120°F on April 16, over a week later than the outside, and remained there or above until April 23. The data suggest that the entire pile was at or above 120°F for a period of eight days before starting to cool. Two thermometers were used to monitor the temperature of this compost, one having an 8" probe, the other having a 20" probe. The 8" thermometer came from Edmund Scientific Co.; the 20" thermometer came from Real Goods, 966

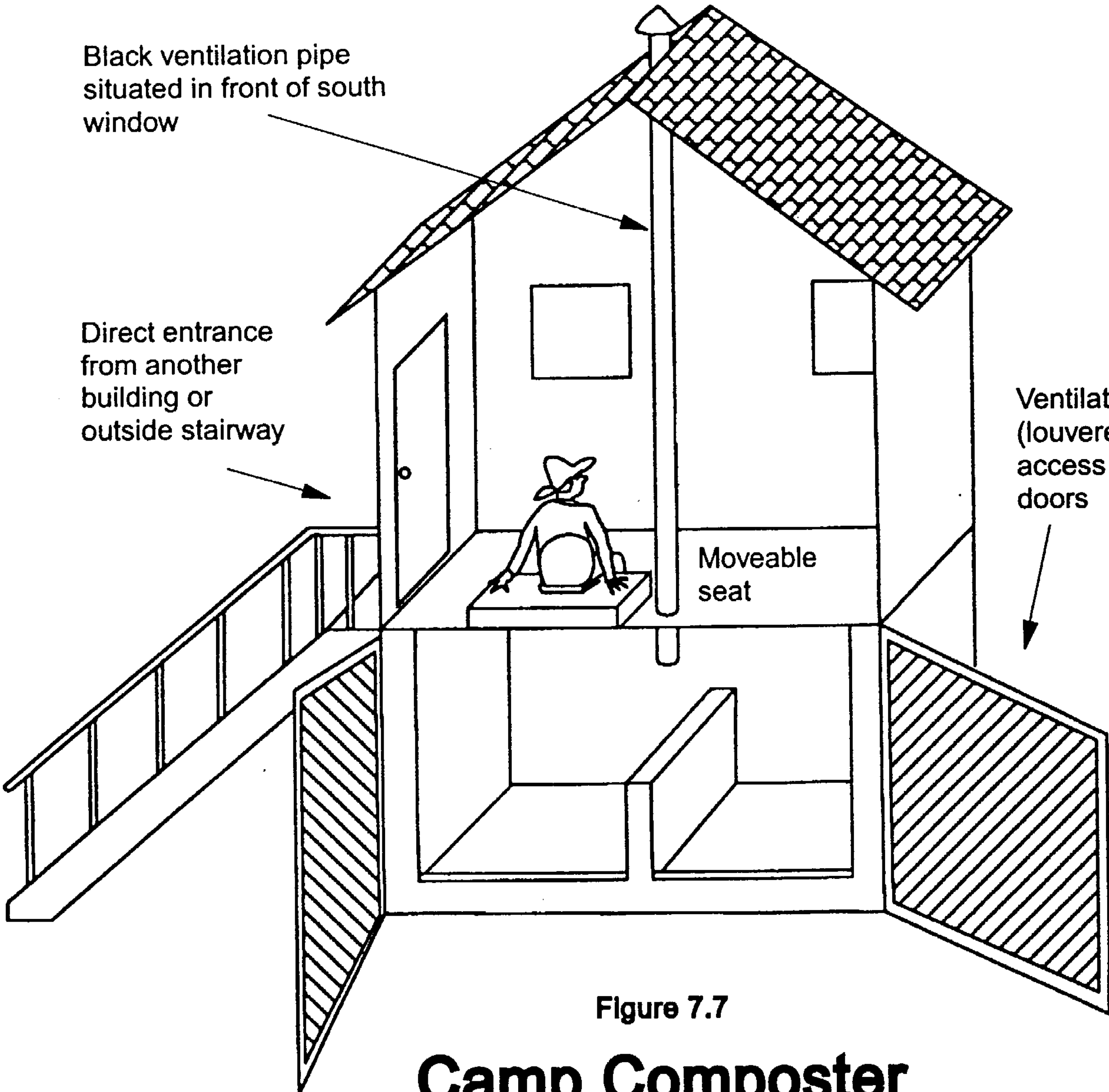


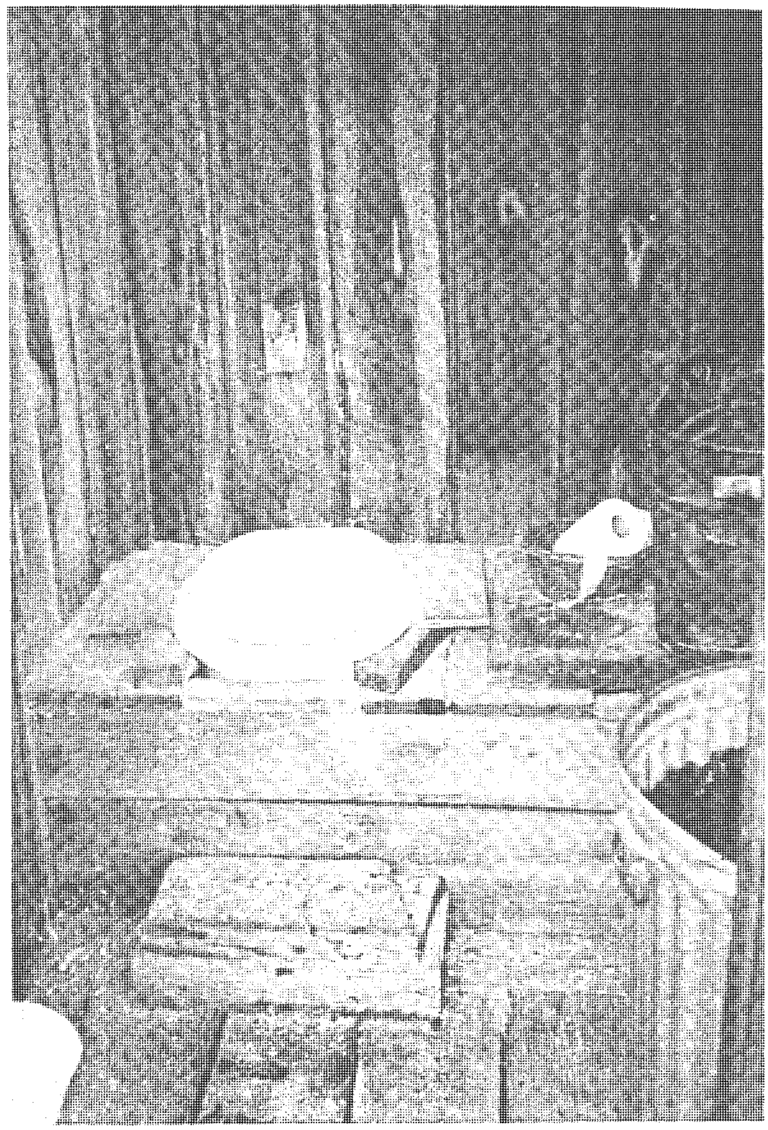
Figure 7.7

Camp Composter
(simplified)

Composting chambers would be accessed frequently from outside for the addition of straw, weeds, hay and/or garbage and food scraps.

Mazzoni St., Ukiah, CA 95482-9292. The Real Goods thermometer was the best buy (see appendix 1 on page 185 for sources of compost thermometers).

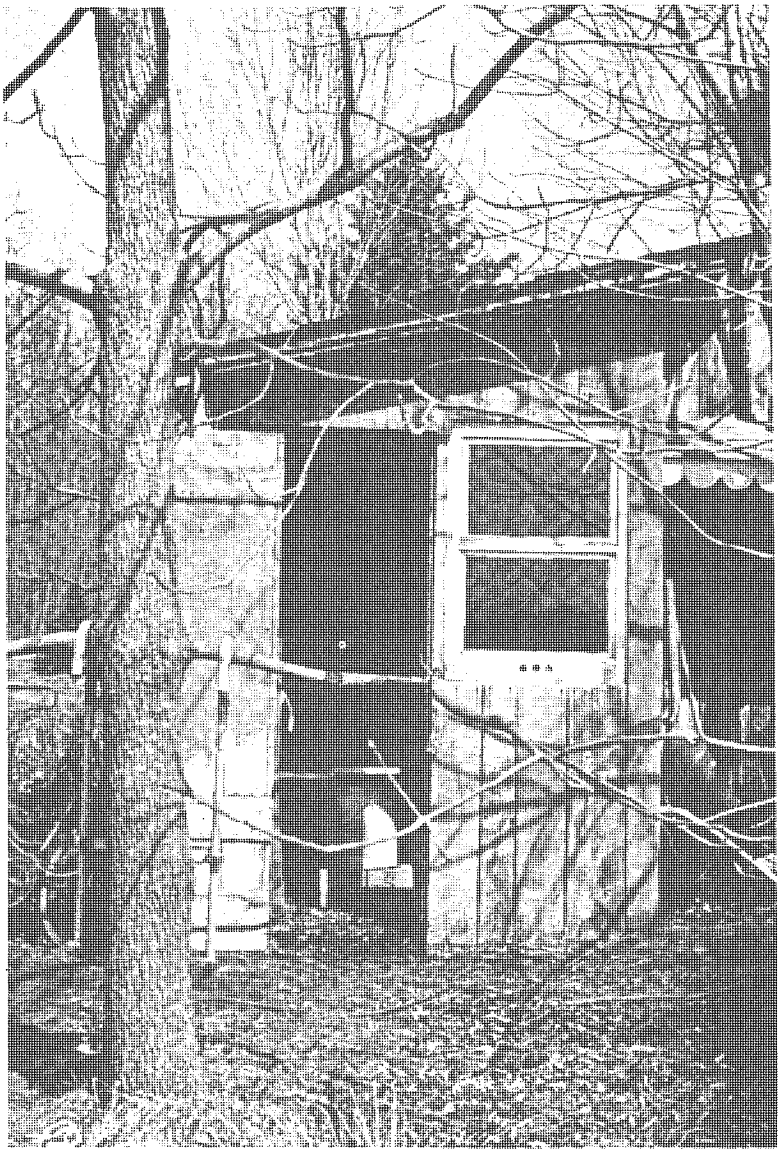
According to Dr. T. Gibson, Head of the Department of Agricultural Biology at the Edinburgh and East of Scotland College of Agriculture, *"All the evidence shows that a few hours at 120 degrees Fahrenheit would eliminate [pathogenic* *microorganisms] completely. There should be a wide margin of safety if that temperature were maintained for 24 hours."* (See The Complete Book of Composting , 1960, J. I. Rodale, p. 650, Rodale Books, Emmaus, PA). This opinion is corroborated by Feachem et. al. and many others, and is illustrated in figure 6F, page 133, titled "Safety Zone for Pathogen Death", which is a diagram adapted from Feachem's work (Appropriate Technology for Water Supply and Sanitation) extensively used as a reference in chapter 6. That diagram indicates that one day at 122°F will kill the human pathogens that can be resident in humanure. A week at 115°F will do the same thing. Higher temperatures kill things faster, lower temperatures take more time. A combination of heating the compost then retaining the heated and cooled compost in storage for a period of months seems to be a good bet for making fine kitchen-garden compost from humanure. That's the sawdust or biosolids toilet system in a nutshell.



AN OUTDOOR SAWDUST TOILET BUILT OF RECYCLED MATERIALS. A REMOVABLE BUCKET LINGERS UNDER THE TOILET SEAT, WAITING TO BE FILLED, EMPTIED AND COMPOSTED.

The significance of the aforementioned graph is that it shows the humanure required no coaxing to heat up sufficiently to be rendered hygienically safe. It just did it on its own, having been provided the simple requirements a compost pile needs.

A comparative temperature curve monitored the following spring indicated that the addition of a small amount of chicken manure improved the thermophilic activity of the compost (see appendix 4, p. 187).



THIS UNPRETENTIOUS STRUCTURE HOUSES A SAWDUST TOILET. ALTHOUGH CONSIDERED AN "OUT-HOUSE", THERE IS NO PIT UNDERNEATH AND NO LEACHING OF POLLUTION INTO THE GROUND. THE HUMANURE IS INSTEAD COLLECTED AND COMPOSTED.

LEGALITIES

I knew of some local folks, Amish, who had a baby at home a couple of years ago. Babies born at home nowadays are no big deal; most of the Amish have a midwife deliver their babies. All of my six children were born at home. However, a local county health worker decided to put a stop to this practice and *charged the young Amish couple with child abuse for not having their baby born in a hospital.*

Here we have an otherwise happy young couple who just had a beautiful baby, and some poor, deluded authority figure was actually telling them he'd have their baby taken away and put in a foster home if they didn't tell him who delivered the kid. This is a true story. The couple gave him the name of their midwife, a highly respected and eminently qualified woman who has now delivered over one thousand babies. She was promptly arrested. To make a long story short, the local magistrate threw the charge (practicing medicine without a license) out, the authorities actually appealed, then the higher court threw the charges out.

What's that have to do with compost? Composting humanure, is like having babies where and how you want them, or educating your kids alternatively. It's behavior out of the mainstream of Western society. It may be something different, and different things can scare people when they don't know anything about them, especially those people who have oatmeal for brains and have somehow gravitated into a position of authority. Whether it's legal or not often isn't the issue. The Amish story is one of many in which the basic rights of humans have been subverted by the ignorance and the misuse of authority by others.

Ideally, laws are made to protect society. Laws requiring septic, waste, and sewage disposal systems are supposedly designed to protect the environment, the health of the citizens and the water table. This is all to be commended, and conscientiously carried out by those who produce *sewage*, a waste material. If you don't produce sewage, you have no need for a sewage disposal system, and laws pertaining to sewage disposal are not your concern. The number of people who produce compost instead of sewage is so minimal, that few, if any, laws have been enacted to regulate the practice. The thermophilic composting of humanure is not a threat to society, it produces no pollution, does not threaten the health of humans or contaminate the ground water or environment. Unfortunately, this fact is not understood by many people, and ignorance is a problem.

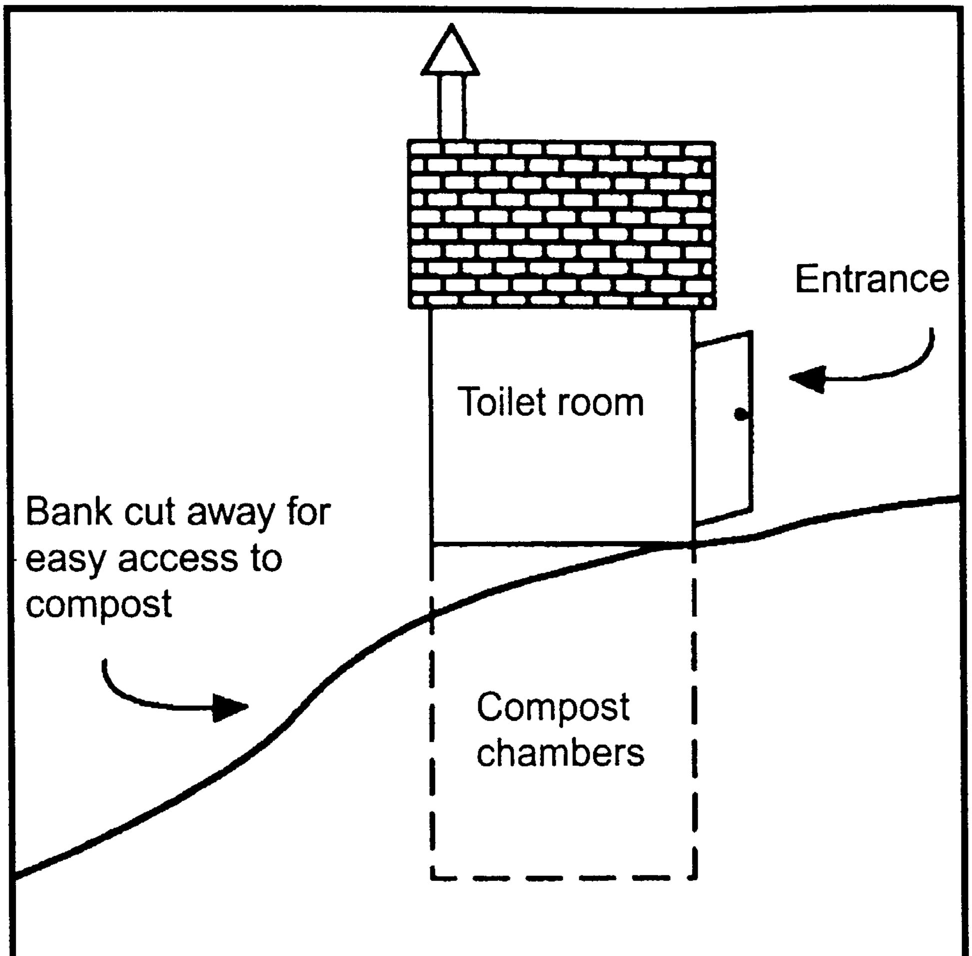


Figure 7.8

Camp Composter on a Bank

It would be hard to intelligently argue that a person who produces no sewage must have a costly sewage treatment system. What would they do with it? That would be like requiring someone who doesn't own a car to have a garage. And it would be very difficult to prove that composting humanure is threatening to society, especially given the facts as presented in this book. On the other hand, Galileo, the astronomer, was arrested as a heretic and forced to renounce his theory that the Earth revolves around the sun. Sure, that was three hundred years ago. But sometimes I think the consciousness of our society as it relates to human manure is still back in the middle ages.

One way to dispel the darkness of ignorance is with the light of knowledge. Knowledge is best gained by experience. Therefore, I'd like to hear from any of you readers about your composting experiences. You may be able to add to the body of knowledge, and I may someday revise and update this book to include the experiences of others. So don't hesitate at any time to write to the address at the front of this book and let me know how it's going for you. I'd welcome *any* feedback at all.

If you're concerned about your local laws, go to the library and see what you can find about regulations concerning compost. Or also inquire at your county seat or state agency as statutes, ordinances, and regulations vary from locality to locality.* Where I live septic system permits aren't required for new home construction, but the next county is two properties over and people there are required to have septic system permits before they can build a new dwelling. This is largely due to the fact that the water table tends to be high in my area, and septic systems don't always work, so sand mounds are required by law for sewage disposal. Now, if you don't want to dispose of your manure but want to compost it instead (which will certainly keep it out of the water table, not to mention raise a few eyebrows at the local municipal office), you may have to stand up for your rights.

In Pennsylvania, the state legislature has enacted legislation *"encouraging the development of resources recovery as a means of managing solid waste, conserving resources, and supplying energy."* Under such legislation the term "disposal" is defined as *"the incineration, dumping, spilling, leaking, or placing of solid waste into or on the land or water in a manner that the solid waste or a constituent of the solid waste enters the environment, is emitted into the air or is discharged to the waters of the Commonwealth"* (Pennsylvania Solid Waste Management Act, Title 35, Chapter 29A). Further legislation has been enacted in Pennsylvania stating that *"waste reduction and recycling are preferable to the processing or disposal of municipal waste,"* and further stating *"pollution is the contamination of any air, water, land or other natural resources of this Commonwealth that will create or is likely to create a public nuisance or to render the air, water, land, or other natural resources harmful, detrimental or injurious to public health, safety or welfare. . ."* (Pennsylvania Municipal Waste Planning, Recycling and Waste reduction Act (1988), Title 53, Chapter 17A). In view of the fact that the thermophilic composting of humanure involves recovering a resource, requires no disposal of waste, and creates no environmental pollution, it is unlikely that anyone who *conscientiously* engages in such an activity would be successfully convicted of criminal activity.

If there aren't any regulations concerning compost in your area, then be sure that when you're making your compost, you're doing a good job of it. It's not hard to do it right. The most likely problem you could have is an odor problem, and that's simply due to not keeping your deposits adequately covered with clean organic material. If you keep it covered, it does not give off offensive odors. It's that simple. Perhaps shit stinks so people will be naturally compelled to cover it with something. That makes sense when you think that thermophilic bacteria are already in the feces waiting for the manure to be layered into a compost pile so they can get to work. Sometimes the simple ways of nature are really profound.

Few people understand that the composting of humanure is a benign method of recycling what would otherwise be a toxic waste material. For that reason, this book is recommended reading for people involved in municipal, county, or township waste treatment or permitting, or resource recovery.

What about gray water? You're still producing gray water and therefore you may still need a septic system or something of the sort as required by law, you may wonder. Maybe, maybe not. Gray water is relatively easy to deal with. A biological treatment system such as an artificial wetland, algae pond, or heck, a patch of woods can effectively absorb gray water, especially if you have sense enough to keep toxic materials and fecal material out of your drains. However, now we're getting beyond the scope of this book. Low-impact gray water treatment systems could involve another whole publication.

And what about flies, could they create a public nuisance? I have never had problems with flies on my compost. Perhaps the compost heats up so fast that flies don't have a chance to enjoy it. And rats? I've never seen one on my homestead. I guess steaming compost doesn't appeal to them.Nor does it appeal to raccoons, dogs or cats.

Concerning flies, F. H. King, who traveled through China, Korea and Japan in the early 1900's when organic material, especially humanure, was the only source of soil fertilizer, stated, *"One fact which we do not fully understand is that, wherever we went, house flies were very few. We never spent a summer with so little annoyance from them as this one in China, Korea and Japan. If the scrupulous husbanding of waste [sic] refuse so universally practiced in these countries reduces the fly nuisance and this menace to health to the extent which our experience suggests, here is one great gain."* He added, *"We have adverted to the very small number of flies observed anywhere in the course of our travel, but its significance we did not realize until near the end of our stay. Indeed, for some reason, flies were more in evidence during the first two days on the steamship out from Yokohama on our return trip to America, then at any time before on our journey."*[9]

If an entire country the size of the United States, but with twice the population (at that time), could recycle all of its organic refuse without the benefit of electricity or automobiles and not have a fly problem, surely we in the United States can recycle a greater portion of our own organic refuse with similar success today.

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***Maryland residents (or anyone else) can obtain: "A Farmers' Guide to Maryland Compost Regulations", from Pickering Creek Environmental Center, 27370 Sharp Road, Easton, Maryland 21601.**

"The On-Farm Composting Handbook" is available from The Northeast Agricultural Engineering Service, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853-5701.

Two information packages on Farm Scale Composting and Yard Waste Composting are available free from the Appropriate Technology Transfer for Rural Areas, PO Box 3657, Fayetteville, AR 72702, phone: (800) 346-9140.

A journal of composting and recycling which may contain pertinent information is: Biocycle, JG Press, Inc., 419 State Ave., Emmaus, PA 18049.

The Agricultural Composter Newsletter is available from: The Agricultural Composting Association, PO Box 608, Belchertown, MA 01007.

THE END IS NEAR

"If you want to be free, learn to live simply. Use what you have and be content where you are."
J. Heider

Ladies and gentlemen, allow me to introduce you to a new and revolutionary literary device: the ***Self-Interview!*** [Applause heard in background. Someone whoops.] Today I'll be interviewing myself. In fact here I am now. [Myself walks in.]

Me: Good morning sir. Haven't I seen you somewhere before?

Myself: Cut the crap. It's too early in the morning for this. You see me every time you look in the mirror, which isn't very often, thank God. What, for crying out loud, would possess you to interview yourself anyway?

M: If I don't, who will?

MS: You do have a point there. In fact, that may be a point worthy of contemplation.

M: Well, let's not get off the track. The topic of discussion today is a material substance near and dear to us all. Shall we step right into it?

MS: What the hell are you talking about?

M: I'll give you a hint. It often can be seen with corn or peanuts on its back.

MS: Elephants?

M: Close, but no cigar. In fact, cigar would have been a better guess. We're going to talk about *humanure*.

MS: You dragged me out of bed and forced me to sit here in front of all these people to talk about CRAP?!

M: You wrote a book on it, didn't you?

MS: So what? OK, OK. Let's get on with it. I've had enough of your theatrics.

M: Well first off, do you expect anyone to take your *Humanure Handbook* seriously?

MS: Why wouldn't they?

M: Because nobody gives a damn about humanure. The last thing anyone wants to think about is a turd, especially their own. Don't you think that by bringing the subject to the fore you're risking something?

MS: You mean like mass constipation? Not quite. I'm not going to put any toilet bowl manufacturers out of business. Like I said, I'd estimate that one in a million people have any interest at all in the topic of resource recovery in relation to human excrement. Nobody thinks of shit as a resource, it's just too bizarre a concept. When I've printed and distributed the 250th copy of the *Humanure Handbook* in the USA, I'll probably consider that market saturated.

M: Then what's the point?

MS: The point is that long-standing cultural prejudices and phobias need to be challenged once in a while by somebody, anybody, or they'll never change. Fecophobia is a deeply rooted fear in the American, and perhaps Western, psyche. But you can't run from what scares you. It just pops up somewhere else where you least expect it. We've adopted the policy of defecating in our drinking water and then piping it off somewhere to let someone else, if anyone, deal with it. So now we're finding that our drinking water sources are becoming increasingly contaminated. What goes around comes around.

M: Oh, come on. I drink water everyday and it's never contaminated. We Americans probably have the most abundant supply of safe drinking water of any country on the planet.

MS: Yes and no. Your water may suffer from no fecal contamination, true, and when I say fecal contamination I mean intestinal bacteria in water. But how much chlorine do you drink instead? Then there's beach pollution. But I don't want to get into all this again. I've already discussed human waste pollution in chapter one.

M: Then you'll admit that American water supplies are pretty safe?

MS: Yes, they are. Even though we defecate in our water, we go to great lengths and expense to clean the pollutants back out of it. We do a good enough job to keep most of our drinking water safe, albeit with chemical additives. However, drinking water supplies are dwindling all over the world, water tables are sinking, and water consumption is on the increase with no end in sight. That seems to be a good reason to not pollute water with our daily bowel movements. And still, that's only *half* the equation.

M: What do you mean?

MS: Well, we're still throwing away the agricultural resources that humanure should be providing us. We're not maintaining an intact human nutrient cycle. By piping sewage into the sea we're essentially dumping grain into the sea. By burying sludge, we're burying a source of food. That's a cultural practice that should be challenged. It's a practice that's not going to change overnight, but will change incrementally if we begin acknowledging it now.

M: So what're you saying? You think everybody should shit in donut buckets?

MS: God forbid. Then you would see mass constipation!

M: Well then, I don't understand. Where do we go from here?

MS: I'm not suggesting a mass cultural revolutionary change in toilet habits. I'm suggesting a change in the way we *understand* our habits. Most people never heard of such a thing as a nutrient cycle. Recycling humanure is just not something anyone ever thinks about. I'm simply suggesting that we begin thinking about new approaches to the age-old problem of what to do with human excrement.

M: That's a beginning, but that's probably all we'll ever see in our lifetime, don't you think?

MS: Don't be so sure about that. Things are changing. I predict that compost toilets and toilet systems will be designed and redesigned in our lifetimes. Eventually, entire housing developments will utilize compost toilet systems. Some municipalities will someday install compost toilet systems in all new homes.

M: You think so? What would that be like?

MS: Well, each home might have a removable container made of recycled plastic that would act as both a toilet receptacle and a garbage disposal.

M: How big a container?

MS: You'd need about five gallons of capacity per person per week. A container the size of a fifty gallon drum should fill in two to three weeks for an average family. Every household will deposit all of its organic refuse except gray water into this glorified donut bucket, including maybe grass clippings and yard leaves. The municipality will provide a cover material for odor prevention of something like ground leaves or rotted sawdust, neatly packaged for each household and possibly dispensed automatically into the toilet after each use. *This would eliminate the production of all garbage and all sewage by human households,* as it would all be collected without water and composted at a municipal compost yard away from town.

M: Who'd collect it?

MS: Once every couple of weeks or so the *Resource Recovery Team* would stop by and take the compost receptacle from your house, sliding it out a side wall in a manner similar to the old coal chutes, using a hand-operated fork lift type machine specially suited for this purpose. A new compost receptacle would then be slid back in to replace the old, and the air-tight gasket joining it to the toilet seat and ventilation pipe would be locked into place. Your manure and your garbage, mixed together with ground leaves and other organic refuse or crop residues would be collected regularly just like your garbage is collected now. Except the destination would not be a landfill, it'd be the compost yard where the organic material would be converted, through thermophilic composting, into an agricultural resource, and sold to farmers who'd use it to grow food. The natural cycle would be complete, immense amounts of landfill space would be saved, a valuable resource would be recovered, pollution would be reduced, and soil fertility would be enhanced. So would our long-term survival as human beings on this planet.

M: I don't know. . ., how long before Americans will be ready for that?

MS: In Japan today, a similar system is in use, except that, rather than removing the container and replacing it with a clean one, the truck that comes to pick up the humanure suctions it out of the container it's in. Sort of like a truck sucking the contents out of a septic tank. What they do with it after that I don't know. I also don't know whether they mix their garbage with it at home or not. (I need to travel to Asia.)

Such a truck system involves a capital outlay about a third of that for sewers. One study which compares the cost between manual humanure removal and waterborne sewage in Taiwan estimates the manual collection costs to be less than one fifth the cost of waterborne sewage treated by oxidation ponds. That takes into account the pasteurization of the humanure as well as the market value of the resultant agricultural soil additive.[1]

We Americans have a long way to go. The biggest obstacle is in understanding and accepting humanure and other organic materials as resource materials rather than waste materials. We have to stop thinking of human excrement and garbage as waste. When we do, then we'll stop defecating in our drinking water and sending our garbage to landfills.

It's critical that we separate water from humanure. As long as we keep defecating in water we'll have a problem that we can't solve. The solution is to stop fouling our water, not to find new ways to clean it up. Don't use water as a vehicle for transporting human excrement or other waste. Humanure must be collected along with other solid (and liquid) organic refuse produced by human beings and composted. We won't be able to do this as long as we insist upon defecating into water. Granted, we can dehydrate the water-borne sewage sludge and compost that. However, this is a complicated, energy-intensive process, and then the sludge is contaminated with all sorts of bad stuff from our sewers which becomes concentrated in the compost.[2]

M: It'll never happen. Face it. Americans, Westerners, will never stop shitting in water. They'll never, as a society, compost their manure. It's unrealistic. It's against our cultural upbringing. We're a society of Howdy-Doody, hotdogs, hairsprays and Ho-Hos, not composted humanure fer christsake. We don't *believe* in balancing human nutrient cycles! We just don't give a damn. Compost making is unglamorous and you can't get rich doing it. So why bother?!

MS: You're right on one point - Americans will never stop shitting. But don't be so hasty. In 1988 in the United States alone, there were 49 operating municipal sludge composting facilities.[3] In Duisberg, Germany, a decades-old plant composts 100 tons of domestic refuse daily. Another plant at Bad Kreuznach handles twice that amount. Many European composting plants compost a mixture of refuse and sewage sludge. A solid waste composting plant in Oregon is designed to handle 800 tons of refuse daily. There are at least three composting plants in Egypt. In Munich, a scheme was being developed in 1990 to provide 40,000 households with "biobins" for the collection of compostable refuse.[4]

It's only a matter of time before the biobin concept is advanced to collect humanure as well. As it is today, much of the compost being produced by the big plants is contaminated with such things as batteries, metal shards, wine bottle caps, paints, heavy metals and the like. As a result, much of it isn't useful for agriculture and has to be used for filler or for other non-agricultural applications, which, to me, is absurd. The way to keep the junk out of the compost is to value the compostable organic refuse enough to collect it separately from the other trash, and to keep the humanure out of the sewers. A household biobin would do the trick. The biobin could be collected regularly, emptied, its contents composted, and the compost sold to farmers and gardeners as a financially self-supporting service provided by independent businesses.

Some entrepreneurs have already got into the sewage composting business in the United States. In 1989, the town of Fairfield, Connecticut contracted to have its yard refuse and sewage sludge composted. The town is said to have saved at least $100,000 in waste disposal costs in its first year of composting alone. The Fairfield operation, which is just one quarter mile from half million dollar houses, is reported to smell no worse than wet leaves from only a few yards away.[5]

Some say that as much as 50% of all municipal refuse could be converted into compost. However, the problem remains the same: contamination of the compost, largely due to sewage sludge contamination and inadequate or improper collection systems for organic refuse. Americans put someone on the moon in 1969, surely we can figure out the solution to making good compost today.

M: But still, there's the fear of humanure and its capability of causing disease and harboring parasites.

MS: That's right. But y'know, according to the literature, a temperature of 122°F for a period of twenty-four hours is sufficient to kill all of the human pathogens potentially in humanure. When my humanure compost pile thawed out last spring, I put two thermometers in it, one with a long (20") probe and one with a short (8") probe to see what happened with the temperature. Now this was a pile of human manure, urine, sawdust, kitchen food scraps, and some weeds and hay. This was a pile that I never turned or worked manually in any way, except to occasionally rake the exposed outer surfaces of the pile on to the top of the pile to ensure inclusion of all the compost in the thermophilic process. I also occasionally raked the top of the pile flat, but I never manually aerated the compost. Nor did I add any compost starters or anything else. The pile was outside, exposed to the air and rain in a three sided wooden bin with an earth bottom. As soon as the pile thawed it began to heat. In a few weeks, the entire pile reached and maintained a temperature of over 120°F and stayed there for eight days. Parts of the pile stayed over 120°F for over two weeks. This spring I monitored my compost pile temperature again, after it thawed. This time it stayed above 122° for 25 days. I'm not worried about diseases or parasites in my compost at all. It doesn't seem to me that creating thermophilic compost is difficult or complicated, and that's what we need to do in order to sanitize human excrement without excessive technology and energy consumption. Thermophilic composting is something simple humans all over the world can do whether they have money or technology or not.

M: Why would the heat of a compost pile kill human pathogens anyway? I don't understand that.

MS: Human disease-causing organisms thrive in the human body, which has a temperature of about 98.6°F. They like this temperature. The natural way the body tries to destroy the pathogens is by elevating its own body temperature. That's called a fever, and the temperature rarely exceeds 104°F. Now I understand that the body raises its temperature not only to retard the growth of pathogens, but also to accelerate the growth of disease fighting components of the human bloodstream, such as white blood cells. However, the higher the temperature, the harder it is for human pathogens to survive. Not only does a high compost temperature destroy the pathogens, but it also indicates prolific microbial activity in the compost, and thereby a level of microbial competition that thwarts the growth and reproduction of microscopic animals that would rather be in someone's body than in an over-populated compost pile. When the temperature climbs to 110 or 120°F, the pathogens start rapidly dying off. Our bodies can't achieve that kind of temperature elevation, but thermophilic microorganisms can. A compost pile is like a mass of life that is having a huge fever. Pathogens are comfortable in the human body, but they can't take the heat of the compost. It's a harsh and unnatural environment for them. A killer.

Furthermore, just leaving a compost pile sit for a year will kill off almost all pathogens, Ascaris (roundworm) eggs being the exception. They're tough buggers, but heat will do them in. That's why I recommend letting compost heat, like a fever, then letting it sit and age. That's the one-two punch.

M: But how do you know that *all* parts of the compost pile are being subjected to temperatures sufficient to kill potential pathogens? If the pathogens are microscopic and a little piece of fecal material rolls off the pile, why wouldn't billions of pathogens in that little piece then escape the thermophilic process and live on to cause trouble another day?

MS: That's one of the most common questions I'm asked. Frankly, you *don't* know that *all* parts of the compost pile have elevated in temperature sufficiently to kill all pathogens. And you will never know for sure that every cubic centimeter of your finished compost is pathogen-free unless you analyze every cubic centimeter in a laboratory. Which few people can afford to do, and even fewer want to do. There will always be people who will not be convinced that thermophilically composted humanure is pathogen-free unless every tiny scrap of it is analyzed in a laboratory first, with negative results. On the other hand, there will always be people, like myself, who conscientiously compost humanure by maintaining a well-managed compost pile, and who feel that their compost has been rendered hygienically safe as a result. A layer of straw covering the finished compost pile, for example, will insulate the pile and help keep the outer surfaces from cooling prematurely. It's common sense, really. The true test comes with living with the thermophilic composting system for long periods of time. I don't know anyone who has done so besides myself, but after fifteen years I've found that the simple system I use works quite well for me. And I don't do anything special or go to any great lengths to make thermophilic compost other than the simple things I've outlined in this book.*

Perhaps Gotaas (<u>Composting</u>, 1956, p.101) hits the nail on the head when he says, "*The farm, the garden, or the small village compost operator usually will not be concerned with detailed tests other than those to confirm that the material is safe from a health standpoint, <u>which will be judged from the temperature</u>, and that it is satisfactory for the soil, which will be judged by appearance. The temperature of the compost can be checked by: a) digging into the stack and feeling the temperature of the material; b) feeling the temperature of a rod after insertion into the material; or c) using a thermometer. Digging into the stack will give an approximate idea of the temperature. The material should feel very hot to the hand and be too hot to permit holding the hand in the pile for very long. Steam should emerge from the pile when opened. A metal or wooden rod inserted two feet (.5 m) into the pile for a period of five to ten minutes for metal and 10-15 minutes for wood should be quite hot to the touch, in fact, too hot to hold. These temperature testing techniques are satisfactory for the smaller village and farm composting operations.*" [Emphasis mine.] In other words, humanure composting can remain a simple process achievable by anyone, and need not become a complicated, hi-tech, expensive process controlled and regulated by nervous, bespectacled academics in white coats bending over your compost pile shaking their heads and wringing their hands while making nerdy clucking sounds.

I want to make it clear though, that I can't be responsible for what other people do with their compost. If someone who reads this book decides that s/he wants to compost humanure, but wants to go about it in an irresponsible manner, then s/he could run into problems. My guess is that the worst thing that could happen is that the person would end up with a mouldered compost pile instead of a thermophilic one (I see this happen a lot), and the remedy to that would be to let the mouldered pile age for a few years before using it agriculturally, or to use the mouldered compost horticulturally instead.

I can't fault someone for being fecophobic, and I believe that fecophobia lies at the root of most of the concerns about composting humanure. What fecophobes may not understand is that those of us who aren't fecophobes understand the human nutrient cycle and the importance of recycling organic refuse materials. We recycle organic refuse because we know it's the right thing to do, and we aren't hampered by irrational fears. We also make compost because we need it for fortifying our food-producing soil, and we consequently exercise a high degree of responsibility when making the compost. It's for our own good.

Then, of course, there's the composter's challenge to fecophobes: *show me a better way to deal with human excrement.*

M: Sounds to me like you have the final word on the topic of humanure.

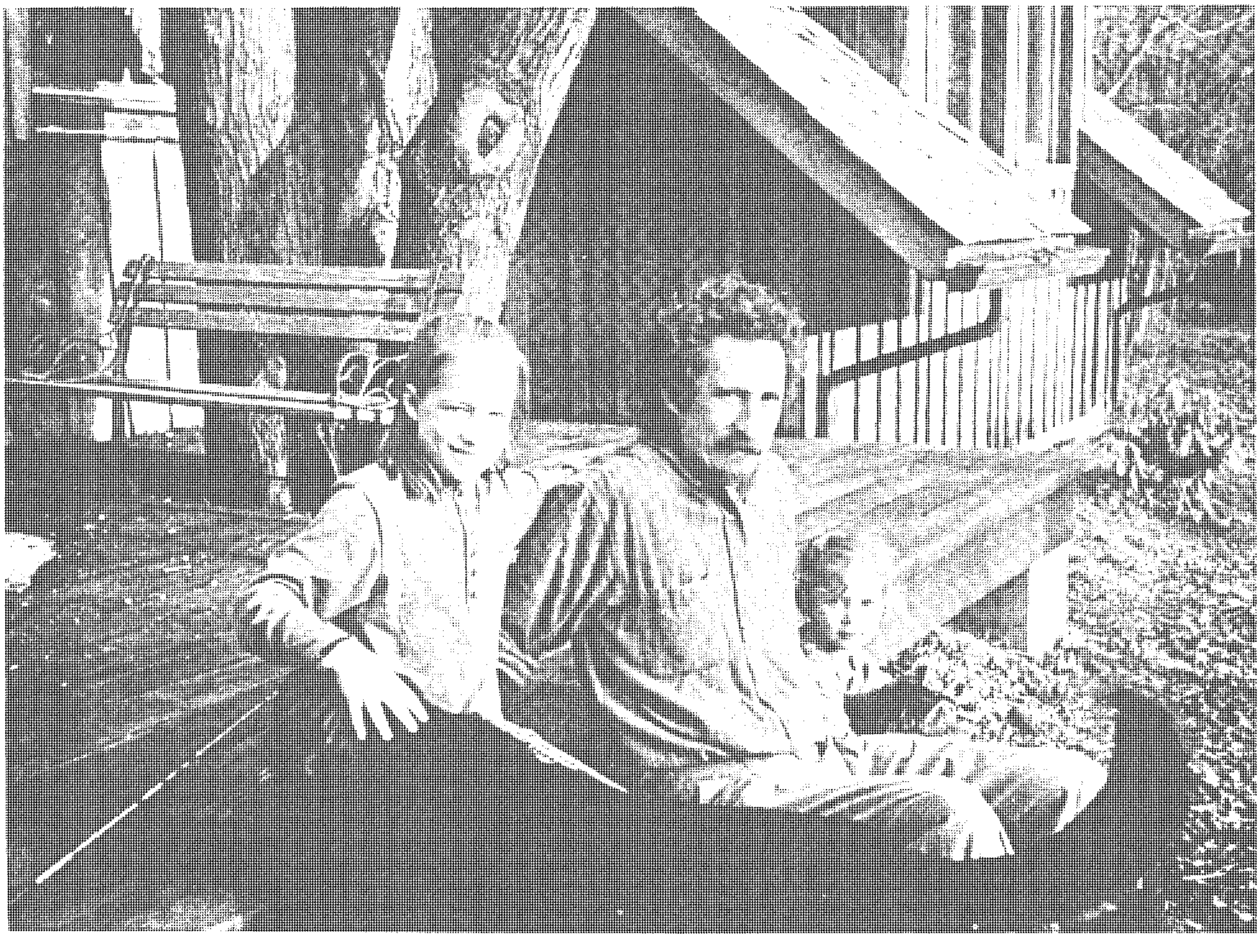
MS: Hardly. The *Humanure Handbook* is only a tiny beginning in the dialogue about human nutrient recycling.

M: Well sir, this is starting to get boring and our time is running out so we'll have to wrap up this interview. Besides, I've heard enough talk about the world's most notorious *"end"* product. So let's focus a little on the end itself, which has now arrived.

MS: And this is it. This is the end?

M: *"This is the end,"* (sung like Jim Morrison). Whatd'ya say folks? [Wild applause, stamping of feet, frenzied whistling, audience members jumping up and down, yanking at their hair, rolls of toilet paper thrown confetti-like through the air, clothes being torn off, cheering and screaming. What's this!? The audience is charging the stage! The interviewee is being carried out over the heads of the crowd! Hot dang and hallelujah!]

THE END



THE AUTHOR RELAXING AT THE END OF THE DAY WITH TWO OF HIS CHILDREN (AND A DOG).
Photo by Jeanine Jenkins

REFERENCES - CHAPTER 8

1 - Rybczynski, W. et. al. (1982). Appropriate Technology for Water Supply and Sanitation - Low Cost Technology Options for Sanitation, A State of the Art Review and Annotated Bibliography. World Bank, Geneva. (p. 20).

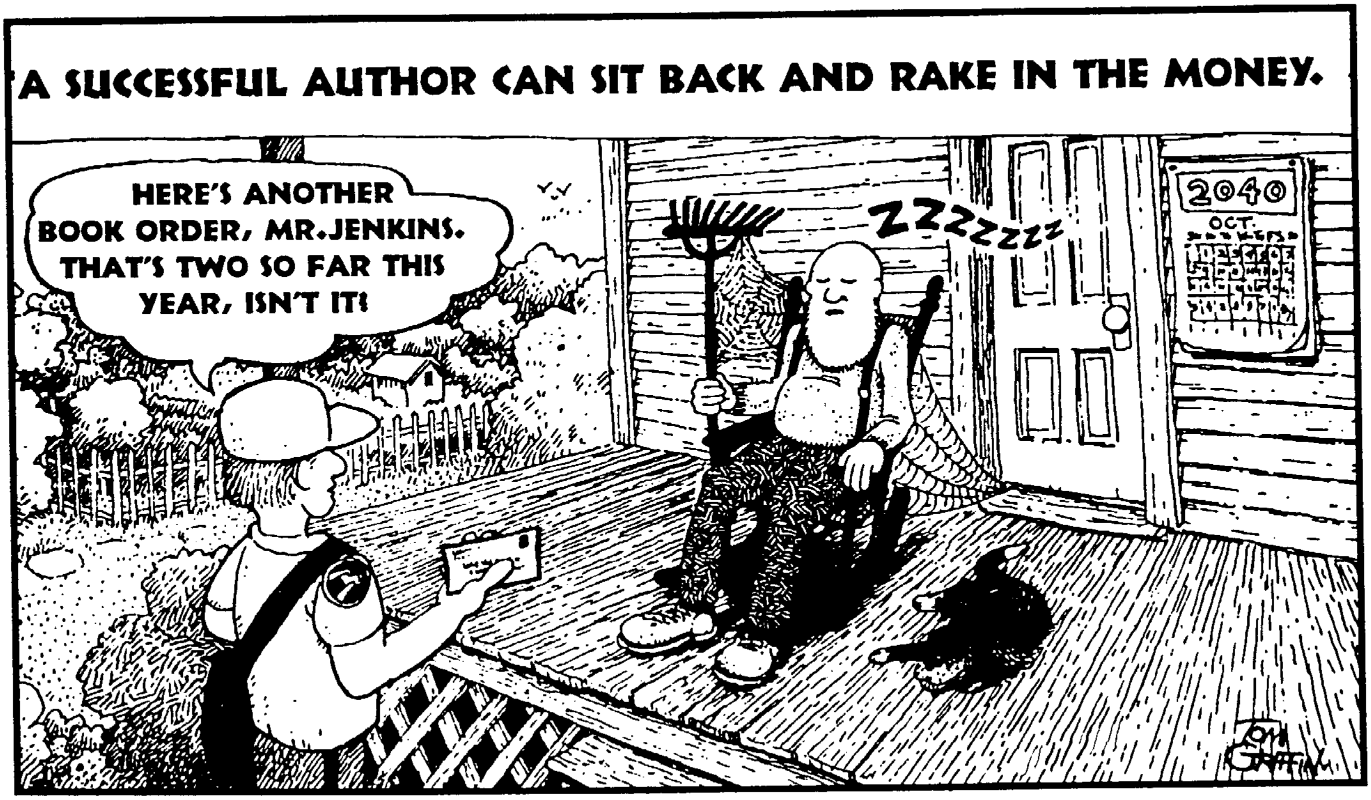
2 - Johnson, Julie. (1990). "Waste That No One Wants". *New Scientist.* 9/8/90, Vol. 127, Issue 1733. (p.50).

3 - Benedict, Arthur H. et. al. (1988). "Composting Municipal Sludge: A Technology Evaluation". Appendix A. Noyes Data Corporation.

4 - Johnson, Julie. (1990). "Waste That No One Wants". (p. 53) see above.

5 - Simon, Ruth. (1990). "The Whole Earth Compost Pile?" *Forbes*. 5/28/90, Vol. 145, Issue 11. (p. 136).

* For laboratory analyses of compost contact Woods End Research Laboratory, Inc., Old Rome Road, Rt. #2, Box 1850, Mt. Vernon, Maine 04352; Phone: (207) 293-2457.



Appendix 1: Sources of Compost Thermometers

Real Goods - 966 Mazzoni St., Ukiah, CA 95482-9486 USA, (800)762-7325. [They offer a thermometer with a 20" probe.]

Pinetree Garden Seeds - Box 300, New Gloucester, ME 04260 USA, (207)926-3400. [20" probe.]

The Natural Gardening Co. - 217 San Anselmo Ave., San Anselmo, CA 94960 USA. (707)766-9303. [20" probe.]

Harris Seeds - 60 Saginaw Drive, P.O. Box 22960, Rochester, NY 14692-2960, USA, (716)442-0100. [12 1/2" long probe.]

Johnny's Selected Seeds - Foss Hill Road, Albion, Maine 04910-9731 USA, (207)437-4301. [12" probe.]

W. Atlee Burpee Co. - Warminster, PA 18974 USA, (800)888-1447. [5" probe.]

Edmund Scientific Co. - 101 East Gloucester Pike, Barrington, NJ 08007-1380 USA, (609)547-8880. [8" and 5" probes.]

A. M. Leonard Co. - 241 Fox Dr., P.O. Box 816, Piqua, Ohio 45356 USA. (800)543-8955. [13 1/2" probe.]

Appendix 2: Table of Linear Measures

1 meter = ...39.37 inches = ...3.2808 feet

1 foot (12 inches) = ...0.3048 meter

1 centimeter = ...1/100 (or 10^{-2}) meters = ...0.3937 inch

1 millimeter = ...1/1000 (10^{-3}) meters = ...0.03937 inch

1 micrometer = ...1/1,000,000 (10^{-6}) meters

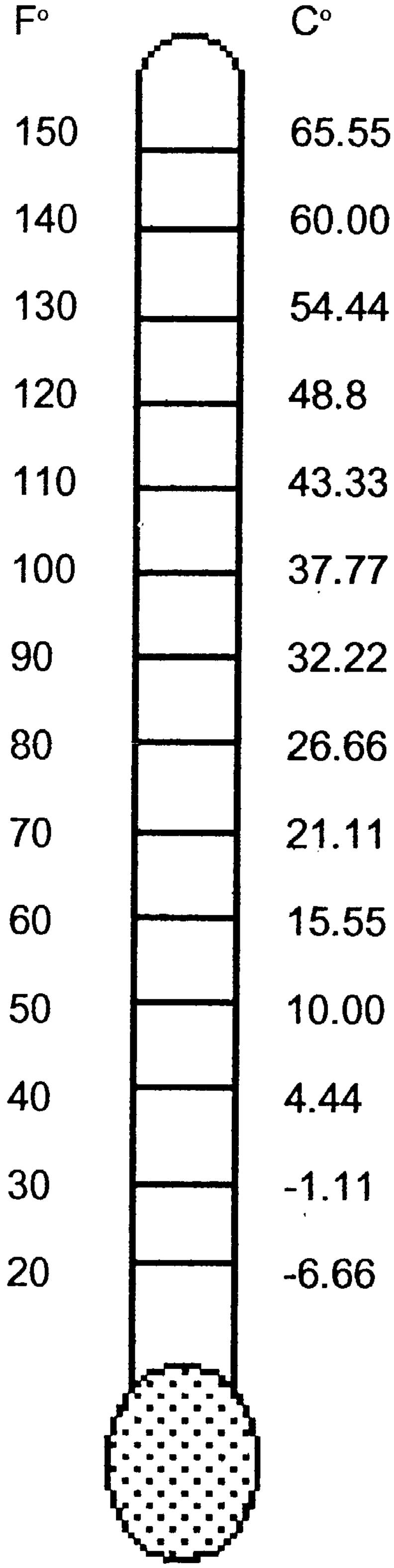
1 mil = ...001 inch = ...0.0254 millimeters

1 inch = ...2.54 centimeters

1 yard (3 feet) = ...0.9144 meter

Appendix 3: Temperature Conversions

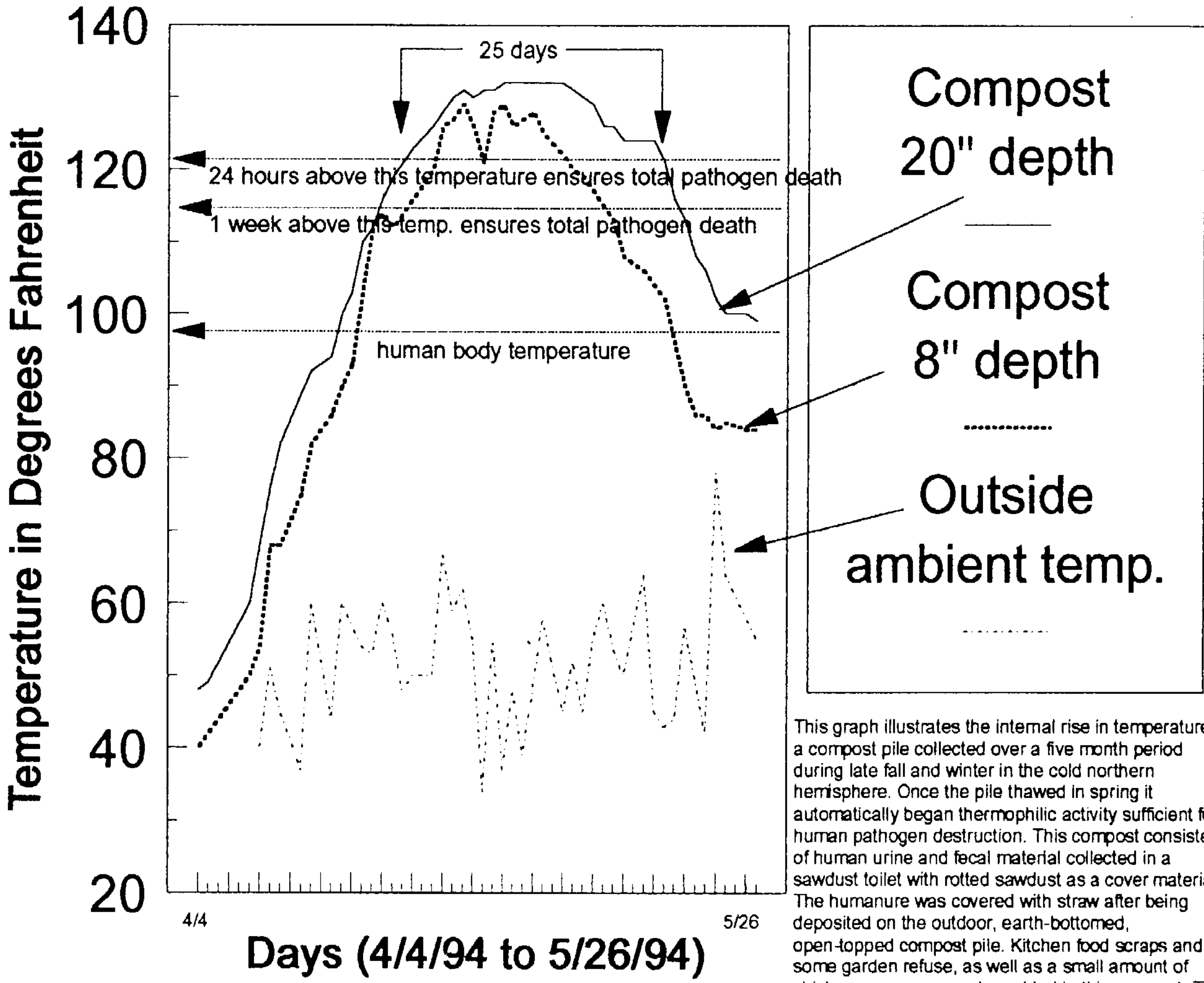
Fahrenheit	Celsius
-40	-40
-30	-34.44
-20	-28.88
-10	-23.33
0	-17.77
5	-15.00
10	-12.22
15	-9.44
20	-6.66
25	-3.88
30	-1.11
35	1.66
40	4.44
45	7.22
50	10.00
55	12.77
60	15.55
65	18.33
70	21.11
75	23.88
80	26.66
85	29.44
90	32.22
95	35.00
98.6	36.99
100	37.77
105	40.55
110	43.33
115	46.11
120	48.88
125	51.66
130	54.44
135	57.22
140	60.00
145	62.77
150	65.55
155	68.33
160	71.11
165	73.88



$$F = 9/5\ C + 32$$

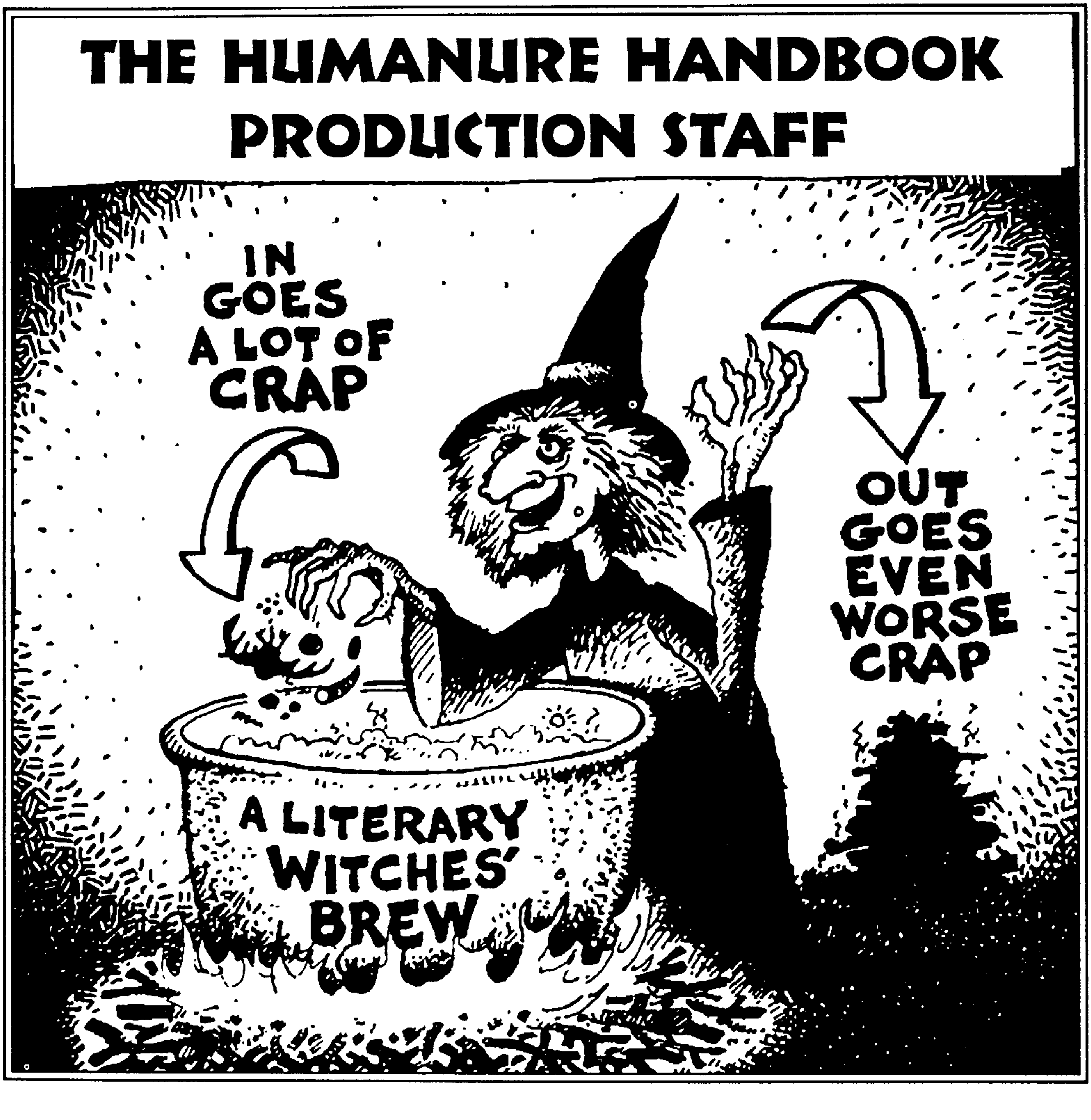
Celsius	Fahrenheit
0	32.00°
5	41.00°
10	50.00°
15	59.00°
20	68.00°
25	77.00°
30	86.00°
35	95.00°
40	104.00°
45	113.00°
50	122.00°
55	131.00°
60	140.00°
65	149.00°
70	158.00°
75	167.00°
80	176.00°
85	185.00°
90	194.00°
95	203.00°
100	212.00°

Temperature Curve of Humanure Compost After Spring Thaw



This graph illustrates the internal rise in temperature of a compost pile collected over a five month period during late fall and winter in the cold northern hemisphere. Once the pile thawed in spring it automatically began thermophilic activity sufficient for human pathogen destruction. This compost consisted of human urine and fecal material collected in a sawdust toilet with rotted sawdust as a cover material. The humanure was covered with straw after being deposited on the outdoor, earth-bottomed, open-topped compost pile. Kitchen food scraps and some garden refuse, as well as a small amount of chicken manure were also added to this compost. This pile was not turned or manually aerated in any way. No compost starters whatsoever were used.

The above graph provides an illustration that human fecal material and urine when collected in a sawdust toilet and layered on an outdoor, earth-bottomed, wooden compost bin open to the rain, covered with straw and additional food scraps, a small amount of garden refuse, and a small amount of chicken manure, will undergo thermophilic composting automatically, even after being frozen for months. No turning is necessary, although the pile should be covered with a layer of insulating material after it has thawed, such as straw, animal manures, or earth, to hold in heat. According to Gotaas (Composting, 1956, p. 20), disease causing bacteria are unable to survive temperatures of 55-60 degrees C (130-140F) for longer than thirty miniutes to one hour. Dr. T. Gibson (Complete Book of Composting, J. I. Rodale, 1960, p. 650) states, *"All the evidence shows that a few hours at 120 degrees Fahrenheit [approx. 50C] would eliminate [disease causing microorganisms] completely. There should be a wide margin of safety if that temperature were maintained for 24 hours."* Franceys, et. al. (A Guide to the Development of On-site Sanitation, 1992, p.214) state, *"All fecal [pathogenic] microorganisms, including enteric viruses and roundworm eggs, will die if the temperature exceeds 46 degrees C [115F] for one week. Fly eggs, larvae and pupae are also killed at these temperatures."* According to Feachem, et. al. (Appropriate Technology for Water Supply and Sanitation, 1980), complete pathogen destruction is guaranteed by arriving at a temperature of 62 degrees C [144F] for one hour, 50 degrees C [122F] for one day, 46 degrees C [115F] for one week, or 43 degrees C [110 F] for one month. Westerberg and Wiley (Applied Microbiology, December, 1969) found that three days at 116 to 130 degrees Fahrenheit killed all of the polio virus, salmonella, roundworm eggs and Candida albicans in infected compost.


THE HUMANURE HANDBOOK
PRODUCTION STAFF
IN GOES A LOT OF CRAP
OUT GOES EVEN WORSE CRAP
A LITERARY WITCHES' BREW

GLOSSARY OF TERMS

activated sludge
Sewage sludge that is treated by forcing air through it in order to activate the beneficial microbial populations resident in the sludge.

aerobic
Able to live, grow, or take place only where free oxygen is present, such as *aerobic* bacteria.

anaerobic
Able to live and grow where there is no oxygen.

Ascaris
A genus of roundworm parasitic to humans.

bacteria
One-celled microscopic organisms. Some are capable of causing disease in humans, others are capable of elevating the temperature of a pile of decomposing refuse sufficiently to destroy human pathogens.

carbonaceous
Consisting of or containing carbon.

C/N ratio
The ratio of carbon to nitrogen in an organic material.

combined sewers
Sewers that collect both sewage and rain water runoff.

compost
A mixture of decomposing vegetable refuse, manure, etc., for fertilizing and conditioning soil.

continuous composting
A system of composting in which organic refuse material is continuously or daily added to the compost bin or pit.

cryptosporidia
A pathogenic protozoa which causes diarrhea in humans.

enteric
Intestinal

fecophobia
Fear of fecal material, especially in regard to the use of human fecal material for agricultural purposes.

green manure
Vegetation grown to be used as fertilizer for the soil, either by direct application of the vegetation to the soil, by composting it before soil application, or by the leguminous fixing of nitrogen in the root nodules of the vegetation.

heavy metal
Metals such as gold, platinum, lead, mercury, cadmium, etc., having more than five times the weight of water. Some heavy metals, when unnaturally concentrated in the environment, pose a significant health risk to humans.

helminth
A worm or worm-like animal, especially parasitic worms of the human digestive system, such as the roundworm or hookworm.

human nutrient cycle
The endlessly repeating cyclical movement of nutrients from soil to plants and animals, to humans, and back to soil.

humanure
Human feces and urine used for agriculture purposes.

humus
A dark, loamy, organic material resulting from the decay of plant and animal refuse.

hygiene
Sanitary practices, cleanliness.

indicator pathogen
A pathogen whose occurrence serves as evidence that certain environmental conditions, such as pollution, exist.

latrine
A toilet, often for the use of a large number of people.

macroorganism
An organism which, unlike a microorganism, can be seen by the naked eye, such as an earthworm.

mesophile
Microorganisms which thrive at medium temperatures (20-37C or 68-98.6F).

metric ton
A measure of weight equal to 1,000 kilograms or 2,204.62 pounds.

microhusbandry
The cultivation of microscopic organisms for the purpose of benefiting humanity, such as in the production of fermented foods, or in the decomposition of organic refuse materials.

moulder (also molder)
To slowly decay, generally at temperatures below that of the human body.

mulch
Organic material such as leaves or straw spread on the ground around plants to hold in moisture, smother weeds, and feed the soil.

naturalchemy
The transformation of seemingly value-

less materials into materials of high value using only natural processes, such as the conversion of humanure into humus by means of microbial activity.

night soil
Human excrement used raw as a soil fertilizer.

nitrates
A salt or ester of nitric acid, such as potassium nitrate or sodium nitrate, both used as fertilizers, and which show up in water supplies as pollution.

organic
Referring to a material from an animal or vegetable source, such as refuse in the form of manure or food scraps; also a form of agriculture which employs fertilizers and soil conditioners that are primarily derived from animal or vegetable sources as opposed to mineral or petrochemical sources.

pathogen
A disease-causing microorganism.

pH
A symbol for the degree of acidity or alkalinity in a solution, ranging in value from 1 to 14, below 7 is acidic, above 7 is alkaline, 7 is neutral.

pit latrine
A latrine consisting of a hole or pit in the ground, into which human excrement is deposited. Known as an outhouse or privy when sheltered by a small building.

protozoa
Tiny, mostly microscopic animals each consisting of a single cell or a group of more or less identical cells, and living primarily in water. Some are human pathogens.

psychrophile
Microorganism which thrives at low temperatures [as low as -10°C (14°F), but optimally above 20°C (68°F)]

schistosome
Any of a genus of flukes that live as parasites in the blood vessels of mammals, including humans.

septic
Causing or resulting from putrefaction (foul-smelling decomposition).

shigella
Rod shaped bacteria, certain species of which cause dysentery.

sludge
The heavy sediment in a sewage or septic tank.

sustainable
Able to be continued

indefinitely without a significant negative impact on the environment or its inhabitants.

thermophilic
Characterized by having an affinity for high temperatures, or for being able to generate high temperatures, such as in regard to thermophilic microorganisms.

virus
Any of a group of submicroscopic pathogens which multiply only in connection with living cells.

waste
A substance or material with no inherent value or usefulness, or a substance or material discarded despite its inherent value or usefulness.

wastewater
Water discarded as waste, often polluted with human excrements or other human pollutants, and discharged into any of various wastewater treatment systems, if not directly into the environment.

Western
Of or pertaining to the Western hemisphere (which includes North and South America and Europe) or its human inhabitants.

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