WATER CONSERVATION, WASTEWATER REDUCTION, AND WATER QUALITY PROTECTION THROUGH HUMANURE COMPOSTING

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ABSTRACT

Flush toilets are the main source of domestic water use and account for nearly 30 percent of an average home's indoor water consumption. Compost toilets are an inexpensive alternative to conventional flush toilets. A compost toilet is a water-free device for the collection of human wastes, which are thermophilically composted to create soil fertilizer. A compost toilet is easy to construct, and a bathroom can be easily retrofitted with one. Use of compost toilets is an effective way to conserve water resources, reduce wastewater generation, and preserve water quality.

CONVENTIONAL SANITATION

Many people view human excreta, including fecal material and urine, as a waste. Conventional sanitation uses flush toilets to make excreta "disappear." The use of flush toilets is a major source of water consumption and may lead to water contamination.

Water Consumption

In 1995, domestic water use was 740 million gallons per day (MGD) in Pennsylvania (Clemens and others, 2009). Flush toilets are the main source of domestic water use and account for approximately 27 percent of an average home's indoor water consumption (EPA, 2008). On average, Americans use about 18.5 gallons of water per day to flush toilets (Clemens and others, 2009). A leaky toilet may waste more than 200 gallons every day (EPA, 2008).

Water Contamination

When people defecate or urinate into flush toilets, they are fouling water that may naturally, or by means of treatment, meet or exceed drinking water standards. Flushed materials are either wasted to septic systems or processed at wastewater treatment plants, often along with wastes from other sources.

Septic Systems. Septic systems are used for on-site disposal of sewage where public sewer systems are unavailable. Public water supply is often unavailable in these areas,

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so residents may obtain their drinking water from wells or springs on the same parcel of land. One-fourth of U.S. homes use septic systems, and more than 4 billion gallons of wastewater per day is dispersed below the ground's surface (EPA, March 2005). Typical pollutants in household wastewater are nitrogen, phosphorus, and disease-causing bacteria and viruses.

Inadequately treated sewage from septic systems can cause surface and groundwater contamination. Consumption of contaminated groundwater from wells can cause diseases and infections in people and animals. Swimming in contaminated surface water increases the chance of contracting a variety of infectious diseases including eye and ear infections, acute gastrointestinal illness, and diseases like hepatitis (EPA, March 2005).

Septic systems can contribute to elevated nitrate (NO_3^-) levels in groundwater, especially in areas of dense development or poor groundwater recharge. According to PADEP (1997), "Essentially all nitrogenous materials entering subsurface disposal systems ultimately convert into nitrate nitrogen. This nitrate nitrogen does not break down in normal groundwater."

Sewage Treatment Plants. According to PADEP (October 2009), NPDES permits are held by 1,078 municipal sewage facilities, which have an aggregate total approximate design flow of more than 2.3 billion gallons per day, and 1,855 non-municipal sewage facilities, which have an aggregate total approximate design flow of more than 64 MGD. In addition, thirty municipalities or authorities in Pennsylvania have NPDES permits for wet weather overflow discharges from combined sewer systems.

Sanitary sewer overflows (SSOs) occur when untreated sewage from municipal sanitary sewer systems is discharged as a result of broken pipes, equipment failure, or system overload. The EPA (July 2001) estimates that there are at least 40,000 SSOs each year. According to the EPA (April 2009a), "the untreated sewage from these overflows can contaminate our waters, causing serious water quality problems. It can also back-up into basements, causing property damage and threatening public health."

The wastewater leaving sewage treatment plants is often treated with chlorine to kill disease-causing microorganisms before being discharged to the environment (e.g., streams, rivers, and lakes). Chlorine in water reacts with organic material in water to form harmful chlorinated organic chemicals (USEPA, April 2009b). Recently, concern has been raised about endocrine disrupting compounds, which may have been introduced to surface or ground waters used as drinking water sources from sewage treatment systems and wet-weather runoff (USEPA, April 2010). Concern has also been raised about pthalate contamination as a result of land application of sewage sludge (USEPA, December 2009).

HUMANURE SANITATION

Unlike conventional sanitation, which generally treats human excreta as a waste, humanure sanitation treats human excreta as a resource to be recovered and utilized.

The Human Nutrient Cycle

According to Jenkins (2005), "the human nutrient cycle goes like this: a) we grow food, b) we eat it, c) we collect and process the organic residues (feces, urine, food scraps and agricultural materials), and d) we then return the processed organic material back to the soil, thereby enriching the soil and enabling more food to be grown" (Figure 1). Conventional sanitation generally disrupts the human nutrient cycle by failing to return human nutrients back to the soil (Figure 2).

Methodology

Humanure sanitation is thoroughly addressed in *The Humanure Handbook* (Jenkins, 2005). Humanure sanitation requires three things: a compost toilet, cover materials, and a composting facility.

Compost Toilet. A compost toilet is used to collect human excrement (urine, feces, and paper) before it comes in contact with any soil or water. A compost toilet can be constructed from recycled materials such as a plastic 5-gallon bucket, scrap wood, and the toilet seat from the flush toilet being replaced (Photo 1). Plans for building a compost toilet are available in *The Humanure Handbook* (Jenkins, 2005).

A compost toilet should not be confused with *composting* toilets. The latter are usually directly connected to the composting facility, are relatively anaerobic and low temperature, and may not kill the eggs of intestinal parasites present. They can also be quite expensive and may require electricity to operate.

Cover Materials. Cover materials consist of carbon-based plant cellulose material (e.g., sawdust, peat moss, or rice hulls) and serve two purposes. First, they are used to cover material deposited in the compost toilet so as to prevent odors and flies. Second, the carbon balances the nitrogen and moisture in the human excrement so as to encourage reproduction of the thermophilic microorganisms that do the composting.

Cover materials are also used to cover the contents of the bucket after it is emptied into the compost bin. The cover materials used to cover the compost pile may be somewhat coarser and may include grasses, hay, straw, pine needles, weeds, leaves, or other organic plant materials that are odor-free and do not attract flies. The coarser materials are used to create air spaces in the compost pile so as to promote aerobic thermophilic microbial activity. Typical cover materials are shown in Photo 2.

Food scraps and other organic materials can be added to the compost bin. Wood ashes and lime should not be used as cover material since they inhibit microbial activity. Wood chips and shavings are not suitable cover materials since the carbon is not readily accessible to the microorganisms.

Composting Facility. The base of the compost bin should be covered with materials like straw, hay, weeds, or grasses, which serve as a biological sponge to absorb excess liquids that may collect during construction of the pile. The contents of the bucket from the compost toilet are emptied into a compost bin and covered with suitable material. The compost bin should be located and constructed to prevent access to the compost pile by children, animals or other vermin, or insect vectors. The sides of the bin may be built of new or used wood, masonry products, or straw or hay bales.

A two-bin compost facility constructed of wood logs, used wooden planks, and recycled metal roofing is shown in Photo 3. The roof covers an area used to store cover materials such as straw bales. Rain run-off from the roof is collected in a rain barrel and used to clean the compost buckets with a long-handled brush after they are emptied. A half-gallon of water is usually adequate to clean a bucket, and the rinse water is poured onto the compost pile to add moisture.

A two-bin facility is desirable since it permits one pile to rest for a period of about a year as the other bin is being filled. Human pathogens such as viruses, protozoa, intestinal worms, and bacteria are killed off during the thermophilic phase. After the thermophilic phase, other organisms (non-thermophilic microorganisms, earthworms, insects, and fungi) continue to convert the humanure into useable compost (Photo 4). Proper composting requires both heat and time. A compost thermometer should be used to monitor the temperature of the compost pile.

CONCLUSION

Humanure sanitation is more sustainable and earth-friendly than conventional sanitation. Practicing humanure sanitation conserves the water normally used by flush toilets, which are the main source of domestic water use. Only a minimal amount of water is required to clean the buckets, and most of this water may be obtained from a rain barrel. Use of a compost toilet to collect humanure reduces wastewater generation and the environmental, energy, and economic costs associated with wastewater collection and treatment.

Humanure composting destroys pathogens and produces a valuable, hygienically safe material that is less likely to degrade water quality than the effluents and sludges produced by septic systems and wastewater treatment plants. Additional benefits of humanure composting include replenishment of soil nutrients and cost savings due to reduced energy consumption and less use of chemical fertilizers.

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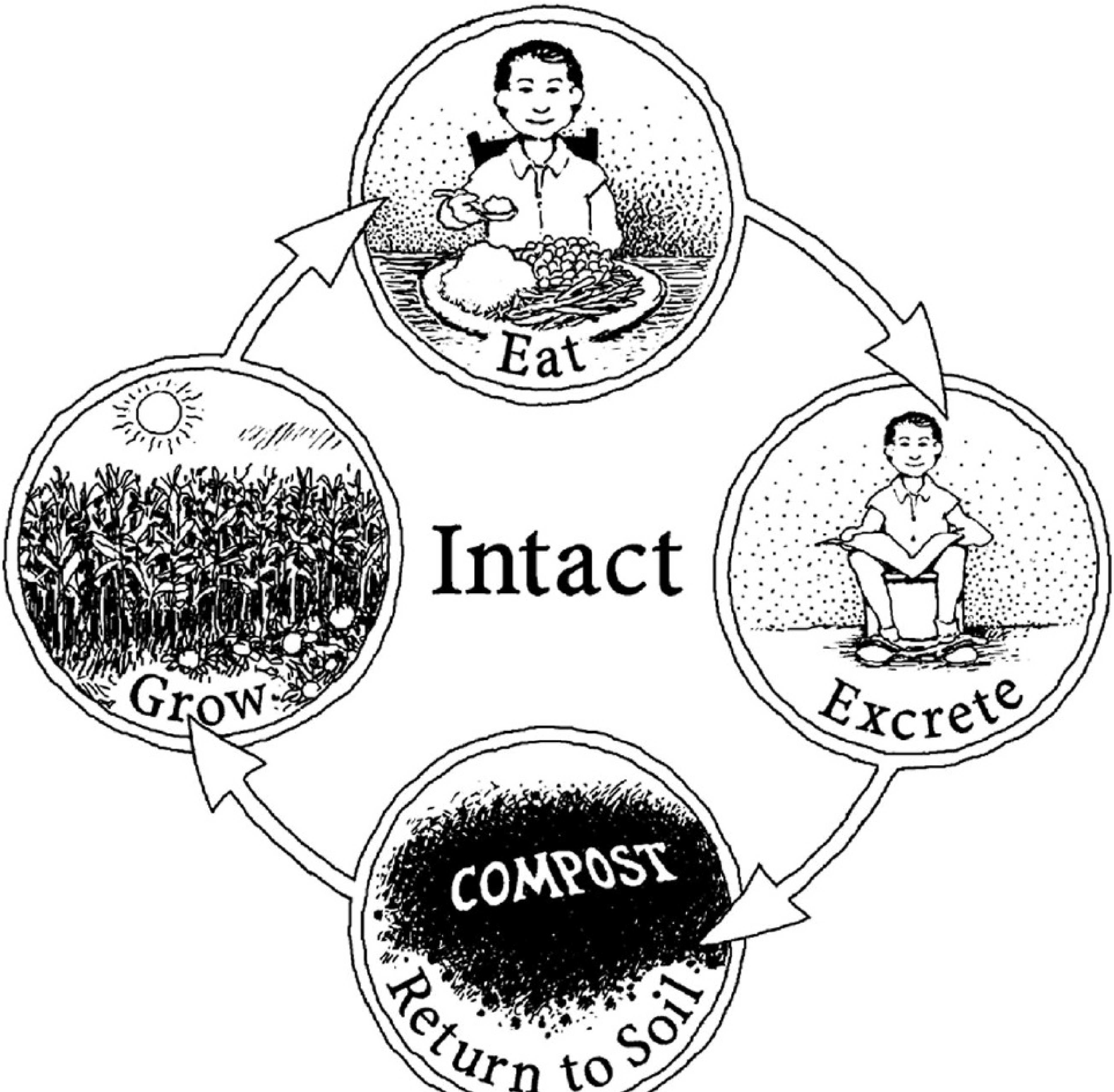
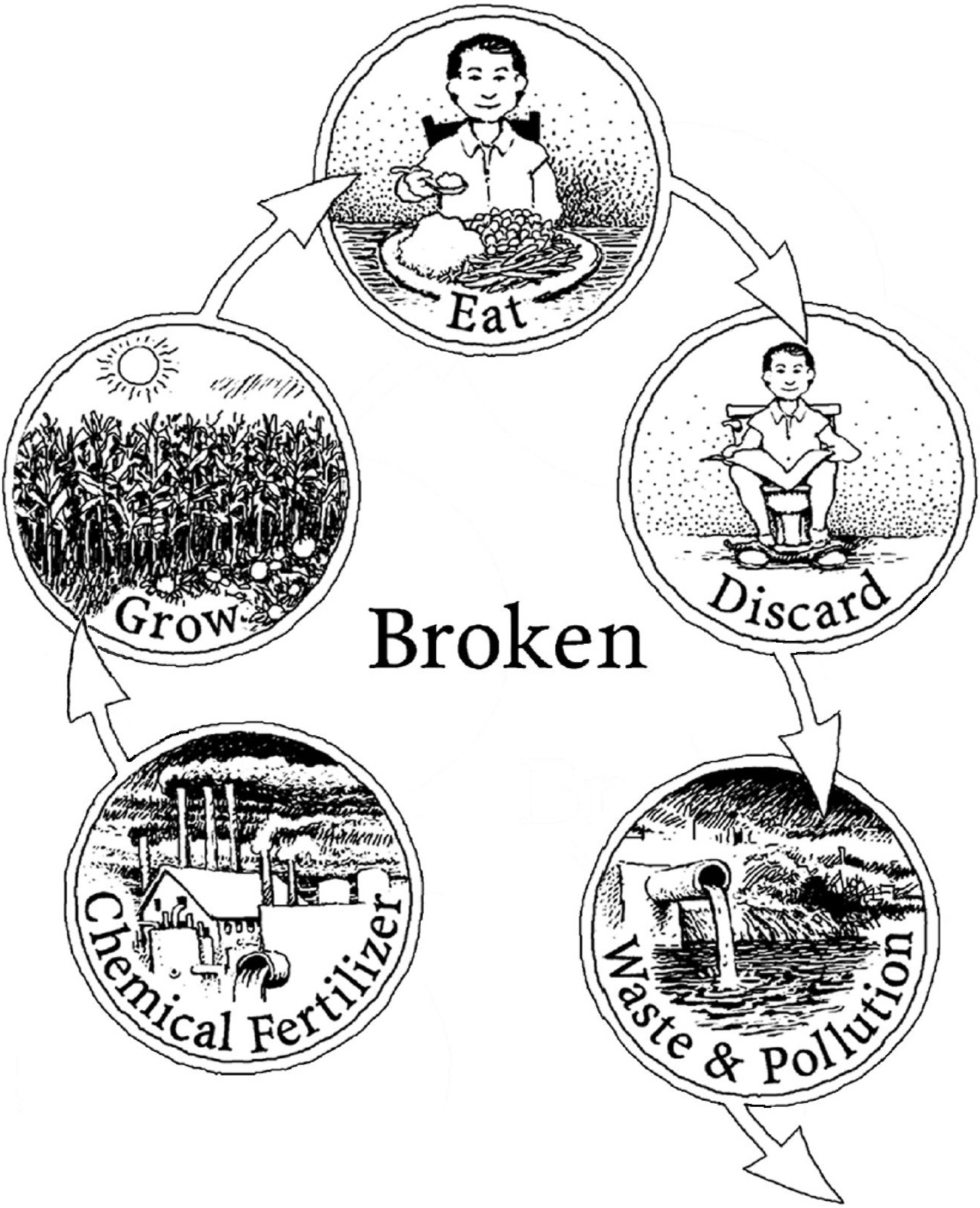
FIGURE 1



The Human Nutrient Cycle is an endless natural cycle. In order to keep the cycle intact, food for humans must be grown on soil that is enriched by the continuous addition of organic materials recycled by humans, such as humanure, food scraps and agricultural residues. 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.

Source: Jenkins, Joseph, 2005, The Humanure Handbook, 3rd ed.: Joseph Jenkins Inc., Grove City, PA.

FIGURE 2



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.

Source: Jenkins, Joseph, 2005, The Humanure Handbook, 3rd ed.: Joseph Jenkins Inc., Grove City, PA.

Photo 1. Compost toilet and bucket of sawdust used for cover material.

Photo 2. Sawdust and leaves stored for use as cover materials.

Photo 3. Double-bin composting facility with rain barrel for collecting water used to clean the buckets and storage area for cover materials.

Photo 4. Compost ready for placement in the garden.