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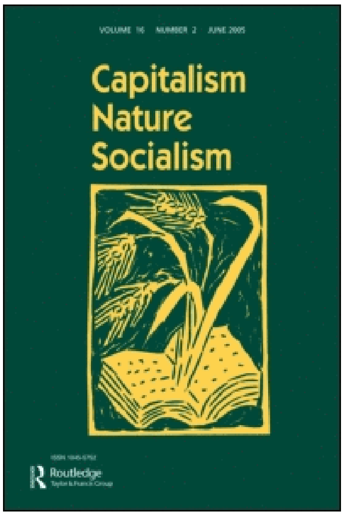

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Abby A. Rockefeller

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Civilization and Sludge: Notes on the History of the Management of Human Excreta*

By Abby A. Rockefeller

People have been "civilized" — have been settled as opposed to nomadic or hunting-and-gathering — for a mere ten thousand years. And most of us *Homo sapiens* remained "uncivilized," in this narrow sense of living without the advantages or constraints of a settled abode, for probably at least the first half of that ten thousand year period.

Before people became "citizens" living in "cities," these smartest alecks of the animal world deposited their excreta — their urine and feces — on the ground, here and there, widely dispersed, in the manner of all other land creatures. Some groups, such as the cats, bury their feces and urine in shallow holes. But the effect of surface deposit or shallow burial is the same: ready access by the decomposer creatures in the soil to the nutrients and stored energy in the excreta; ready cycling through life of the elements necessary to it, attended by an incremental enrichment and diversification of the forms of life.

This meant keeping the nutrients characteristic of excreta in the cycle of soil-to-bacteria-to-plants-to-animals-to-soil. The soil and its communities of life long ago grabbed hold, so to speak, of this major source of nutrients. Keeping these nutrients — especially the major, or "macro," ones such as nitrogen and phosphorus — locked up in the cycles of the land, besides making the land-based life cycles nutrient-

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rich, kept them out of the waters of the Earth. The lakes, rivers, streams, ponds, oceans, and aquifers were consequently relatively nutrient-poor — what we call "pure." Aquatic life forms evolved in precise relation to such pure waters, so that the characteristic of macro-nutrient scarcity has become, gradually but absolutely, crucial to the health of the species and the ecosystems of the aquatic environment.

When we speak of "healthy" eco-systems, we mean stable eco-systems: that is, tending toward diversity and not subject to cataclysmic drops in diversity. Such balanced conditions create relationships — ever more intricate relationships — that increasingly locate the inorganic elements necessary to life in cycles that make those inorganic elements increasingly available to life. The more extensive these relationships, the more consistently available the nutrient-elements will be to the life forms within those relationships. Expanding diversity of life forms is, relatively speaking, a low entropy enterprise. The more diverse the forms of life, the more matter and energy are kept available for use, or "work," and the less they are lost to use or work through either irretrievable dissipation or unresolvable mixing.

So, when we talk of "pure" water, we do not mean pure in the chemical sense. We mean, rather, a dynamic balance between the nonliving macro-nutrient-scarce matter and the living organisms in water; a balance whereby the relationships of life forms to one another, perhaps developed over the course of a couple of billions of years, are, though always changing, nevertheless (excepting cataclysmic events), always stable, expanding in diversity, and healthy.

It is not that life will disappear in waters suddenly enriched by an infusion of macro-nutrients. (Nitrogen and phosphorus, both called macro-nutrients because most plants need large quantities in order to grow, are also sometimes called "limiting factors" since, when they are scarce, the growth of plants — such as algae — not accustomed to nutrient-poor waters, is limited.) But the effect of sudden infusions of any of the macro-nutrients will be to reduce the diversity of life in any body of pure water. We call waters polluted that look like pea soup — so full are they with living algae — because we understand that even a very great abundance of a single form of life in, say, a lake doesn't mean that all's well with the life system in the waters of that lake.

And, indeed, all is not well — much is, in fact, dreadfully wrong — with most of the waters on Earth. What happened to make this so? In brief, there was a sudden infusion (sudden compared to the slow pace of evolution) of nutrients into the Earth's waters — in the form of water-borne human excreta. What follows touches on how water came

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to be used to transport human excreta, how bodies of water came to be used as the recipient dumps for the water-borne excreta, and what environmental effects have been associated with the chain of behavioral and technological developments resulting from these practices.

Much of the history of human behavior is before our eyes in living societies today, the history of our excretory practices not excepted. It is likely that all practices ever associated with the disposition of excreta continue in some societies still. The patterns of settled community behavior early split into two courses: one that unambiguously assumed there to be in human excreta a fertilizer value to agriculture, and one that did not regard it as having such a value or that was at least ambivalent about its value.

It was, to be sure, agriculture that "caused" civilization: In its simplest and in its most elaborate forms, civilization altogether depends on agriculture. This dependence, however, has not inspired all agricultural societies with reverence for the economy of the cycles on which agriculture is dependent. Especially uneven has been awareness of the economy of giving back to the soil in the form of excreta what has been taken out in the form of food. The cultures that did consistently employ their own manure in agriculture were primarily Asian. Much has been written about the longevity of these civilizations and the significance of the persistent use of human manure for that longevity.[1]

Those settled cultures that do not — and did not — connect human manure with sustainable agricultural productivity followed, and still follow, a fairly standard pattern of "development" of their "sanitation" habits. Urinating and defecating on the ground's surface in the manner of pre-civilized days, but in the immediate vicinity of their dwellings, is the first phase. This soon becomes unviable — that is, too unpleasant — due to the increasing density of the settlers, which leads to the creation of the community pit. When privacy of excretory functions comes to be deemed important, then comes the pit privy, the privacy structure on top of the hole in the ground.

This "outhouse," on account of the smell, is placed at a distance from the dwelling. The odor caused by concentrating excreta in one spot in the manner of the pit latrine — an olfactory offense that causes many to choose the bushes — is legendary for its unpleasantness. But stink aside, and contrary to what some people think, the pit latrine, with or without the privacy structure, is not, and never was, environmentally viable. The pit toilet causes two related troubles — waste and

[1]F.H. King, *Farmers of Forty Centuries* (London: Jonathan Cape, 1927; reprinted in 1972 by the Rodale Press).

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pollution: waste through loss of the unretrieved nutrients in the excreta, and pollution of the ground waters by those same wasted nutrients. The pit privy is not, from an environmental point of view, anywhere near as damaging as the flush toilet, but the kind of damage it caused — and still causes — is of a piece with the kind caused by the string of technologies, flush toilet included, that evolved in response to the pit privy's inadequacies.

European societies were for centuries ambivalent in their attitude toward their own excreta. Was it a fertilizer source for agriculture or a nuisance to be "got rid of"? Before the advent of piped-in water, human excreta was deposited in cesspools (lined pits with some drainage of liquids) or vault privies (tight tanks from which there is no drainage) in the backyards of European towns. The "night soil" — human manure collected at night — was removed by "scavengers" and either taken to farms or dumped into streams and rivers or in "dumps" on the land. In Europe there was, in other words, no consistent perception of the agricultural value of these materials, unlike in Asian cultures, where the husbanding of human excreta was (until very recently) unexceptional and routinized.

Five hundred years before Christ, Rome already had in place a system both for bringing in pure water through its famous aqueducts and for the removal via sewers of fouled water that included water-borne excreta from public toilets and from water closets in the homes of the rich.[2] But until the middle of the 19th century, most of Europe prohibited the use of sewers for the disposal of human excreta. Sewers consisting of open gutters or sometimes covered trenches in the center or sides of streets had long been in use in European cities, but only for the drainage of rain run-off and for city filth. Householding transgressors, however, used the sewers to dump their kitchen slop water, and — to save on the cost of paying scavengers — the contents of chamber pots and overflowing cesspools. When going all the way to the farm was an inconvenience or an extra expense for professional cesspool scavengers, they too took surreptitious advantage of the sewers to dump the product of their nightly labors. The putrefying matter in these stagnant ditches moved along only when it rained enough (hence the name "storm" sewers), and digging them out with shovels was the job of the "sewermen."[3]

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[2]Pliny the Elder, *Natural History* (London: Penguin Books Ltd., 1991); Lewis Mumford, *The City in History* (New York: Harcourt, Brace & World, Inc., 1961), pp. 214-217.
[3]Donald Reid, *Paris Sewers and Sewermen* (Cambridge: Harvard University Press, 1991), p. 161.

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The "water closet" (so-called to distinguish it from the "earth-closet," an early species of compost toilet much favored by 19th century environmentalists) afforded the enormous convenience of simultaneously putting the toilet in the house while getting the excreta out of the house. The so-named "flush" toilet had been known to the privileged at the height of the Roman era and since the 18th century in northern parts of Europe. But this pivotal technology, symbol of civilization still, came to widespread use only after piped-in water had been made available to the major cities in Europe and the United States. The first waterworks in the United States was installed in Philadelphia in 1802. By 1860 there were 136 systems in the U.S., and by 1880 the number was up to 598.[4] The convenience of a constant water supply stimulated the adoption of residential water fixtures — baths and kitchen sinks as well as flush toilets — dramatically increasing the per capita use of water on average from three to five gallons per person per day to 30 and even 100 gallons per person per day.

Of course, once water was in great quantities piped into homes, it had to be piped out again, and the first "logical" place to pipe it, including the flush water from water closets, was backyard cesspools. These cesspools, which hitherto had only received the contents of chamber pots — urine and feces now regularly overflowed with fecally polluted water, and a new level of horrendous odors and the spread of water-borne diseases was the immediate result.

Thus the system of cesspools and vault privies, which had been partially effective in both avoiding pollution of waterways through their periodic cleanout by scavengers returning human manure to farms, was overwhelmed by the pressure created by the new availability of running water. The next "natural" step in the solve-one-problem-at-a-time approach was to connect the cesspools to the sewers, thereby moving the sewage from overflowing cesspools into the open sewers of city streets. The result: epidemics of cholera. In 1832, 20,000 people died of cholera in Paris alone.[5] Wherever and whenever this combination of piped-in water, flush toilets, and open sewers has appeared in the world, epidemics of cholera have followed.

By the middle of the 19th century, the diseases spawned by the convenience of running water and the flush toilet gave rise to a demand for the construction of sewers that would carry the sewage not only out

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[4]Joel A. Tarr and Gabriel Dupuy, eds., *Technology and the Rise of the Networked City in Europe and America* (Philadelphia: Temple University Press, 1988).
[5]Reid, *op. cit.*

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of and away from the home, but away from the city as well. This demand entailed the evolution of the ditch-type storm sewer into the closed-pipe water-carriage system of sewerage. The wastewater itself was in this system the medium of transportation, so a large and regular supply of water was a built-in requirement to keep the wastes moving in the pipes.[6] (Today, efforts to conserve water by promoting the use of low-flush toilets — 1.6 gallons vs. five to seven gallons — have led to plugging of sewers engineered for a minimum hydraulic flow of five gallons per flush. To deal with this problem, owners of these "water-conserving" toilets have been instructed to flush two or three times per use.)

The water-carriage system of sewerage introduced a new set of problems and, about these problems, a new set of debates among sanitary engineers in Europe and the United States. The engineers were divided again between those who believed in the value of human excreta to agriculture and those who did not. The believers argued in favor of "sewage farming," the practice of irrigating neighboring farms with municipal sewage. The second group, arguing that "running water purifies itself" (the more current slogan among sanitary engineers: "the solution to pollution is dilution"), argued for piping sewage into lakes, rivers, and oceans. In the United States, the engineers who argued for direct disposal into water had, by the turn of the 19th century, won this debate. By 1909, untold miles of rivers had been turned functionally into open sewers, and 25,000 miles of sewer pipes had been laid to take the sewage to those rivers.[7]

In the cities with water-carriage sewers, cholera epidemics abated. In cities downstream from those dumping raw sewage into the river, however, death rates from typhoid soared. This led to the next debate: whether to treat the sewage before dumping it into the recipient bodies of water or whether to filter the drinking water downstream. Health authorities argued that sewage should be treated before disposal into any bodies of water, but the sanitary engineers preferred filtration by the next town down the river. The engineers prevailed, and indeed, in those cities with filtered water, deaths from typhoid then dropped dramatically.[8]

The practice of "purifying" water polluted with sewage from upstream in order to make drinking water safe downstream, rather than treating sewage where it is produced, persisted until the middle of the

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[6]Tarr and Dupuy, *op. cit.*
[7]*Ibid.*
[8]*Ibid.*

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20th century. By then, the growth of industrial development had been enormous, and every industry wanted cheap disposal of its wastes. Since the public was paying, this was cheap as could be. Industries' demand for more sewering to serve their own disposal needs stimulated the industrialized nations of the world to allocate vast sums of money for massive sewer construction programs.

To the nutrient burden on recipient waters from human excrement, then, was added a new and ever increasing flow of industrial waste, much of it toxic. Wherever on the globe there were sewers, the recipient rivers, lakes, and streams were discovered to have become unacceptably filthy, and in response came pressure to treat the sewage before it entered those waters. So began the "treatment" phase of the get-rid-of-it approach to dealing with wastewater now consisting of human excrement mingled with all industrial wastes transported by water.

The first step in the effort to clean up the sewage before sending the effluent into the river is termed "primary treatment." From the point of view of improving water quality, it is a crude method, consisting of little more than settling and screening the sewage to remove the largest and most aesthetically offensive objects: All nutrients and chemicals not tied up in dead cats and intact feces remain in the water.

The next stage, called "secondary treatment," includes some biological stabilization through forced aeration of the sewage, and chemical flocculation and precipitation of some of the phosphates from laundry detergents. But in spite of the great energy and financial cost of this form of treatment, the effluent reaching the recipient bodies of water continues to be rich in nitrates and phosphates. (These nutrients, as noted above, are called limiting factors. When they are present in water, they cause an explosive growth of algae, which in turn causes lakes to die of eutrophication as the decaying algae robs the water of its oxygen.) Industrial pollutants, such as toxic chemicals and heavy metals, are not addressed by this level of treatment.

So engineering ingenuity developed another, more complex, yet more energy intensive and expensive form called "tertiary" or "advanced wastewater treatment." Because of its enormous cost it has been difficult to get U.S. taxpayers to fund this level to any great extent. But even where funded, treatment remains incomplete: Some nitrates, some heavy metals, and many toxic chemicals continue to evade tertiary treatment and remain in the water.

Central collection and treatment of sewage cannot be said to have succeeded in solving the underlying problem of water pollution caused by using water to transport wastes. The problem is deeper and systemic.

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The trouble with the treatment approach to managing the pollution caused by water carriage of excreta and the by-products of industry lies only partly in the inadequacy of even the most advanced processes. Although the trouble may seem to have been ameliorated because this bay or that river is less polluted than it was without wastewater treatment, the pollutants in the water have simply been reorganized and concentrated in a new form: sludge.

Sludge is the dewatered, sticky black "cake" consisting of every waste material capable of being sent down the drains of homes and industries and into the sewers, and which the treatment process is able to get back out again. If sewage can be said to perfectly exemplify a high entropy process of matter lost through irretrievable dissipation, sludge is the quintessential example of disparate matter lost to use through unresolvable homogenization.

In the *United States Federal Register*, the United States Environmental Protection Agency (EPA) says of sludge:

> The chemical composition and biological constituents of the sludge depend upon the composition of the wastewater entering the treatment facilities and the subsequent treatment processes. Typically, these constituents may include volatiles, organic solids, nutrients, disease-causing pathogenic organisms (e.g., bacteria, viruses, etc.), heavy metals and inorganic ions, and toxic organic chemicals from industrial wastes, household chemicals, and pesticides.[9]

This short list of what sludge "may include" is shorthand for the enormous list of constituents that can actually be present in it. For instance, of the 100,000 or so organic and inorganic chemicals produced and used in industrialized nations, a huge number will end up in the sewers. One thousand new ones are produced every year and are added to the cocktail of synthetic substances affecting life processes. Those pollutants that are put in the sewers — and that are removed from the wastewater by the treatment process — will end up in the sludge. There are the heavy metals which, though they are micro-nutrients crucially needed in tiny amounts for growth of life, are toxic to life when they cross the threshold firmly established in the cells of life. There are organochlorine estrogen mimickers, the best known of which are DDT, chlordane, alpha-hexachlorocyclohexane, 2,4,D, PCBs, and dioxin. There are halogenated aliphatic (chain) hydrocarbons, aromatic (ring) hydrocarbons, chloro- and nitro-aromatic hydrocarbons, phthalates,

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[9] *United States Federal Register*, 55, 218, November 9, 1990.

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halogenated ethers, and phenols. There is radioactive matter from hospitals. All of these are destructive of life processes.[10]

Attitudes toward sludge — this heterogeneous product of wastewater treatment processes — and the disposition of it have a convoluted history of their own. Clearly, sludge contains constituents that are hazardous to life. If we persist in producing sludge, something must be done with it. What to do with it is the subject of intense debate. To understand this debate, one must know something of the interplay among the following forces: the environmental movement that began in the early 1970s; the organic food movement that began decades earlier; the traditional sanitary engineering/regulatory posture; and the exigencies of the prevailing economic/industrial arrangement. The character of the debate taking place in the United States is illustrative of the way these forces interact regarding the technical and management patterns in all the sewered, and about-to-be-sewered, parts of the world.

To begin, it may be clarifying to focus this history on the question of why decentralized solutions to water pollution were not developed and promoted over sewering, since, environmental considerations aside for the moment, they would have saved taxpayers immense amounts of money. The answer is in part the engineering/regulatory bias in favor of top-down, centrally controlled solutions. Health authorities are traditionally skeptical of people's ability to manage problems themselves. The regulatory and sanitary engineering community (very much one body, in general) also feels that troubles are safer in its hands. Moreover, there has been a widespread conviction on the part of environmental groups that treatment at the "end of the pipe" is the surest way of cleaning up polluted water. The environmental movement in the United States played a large part in creating the pressure that resulted in the Clean Water Act of 1977. This Act was effectively a sewering act. Enormous sums of money were allocated exclusively for the laying of sewer pipes and the construction of treatment plants. The Clean Water Act funded virtually no on-site, site specific, decentralized systems — either for remediation or for new construction.

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[10]Lars Reutergårdh, "An overview on organic contaminants, focusing on the monitoring of a few chlorinated organic pollutants, through emission studies," *Resources, Conservation and Recycling* 16, 1996. (This analysis of the pollutants deriving from sewage that can be found in recipient bodies of water gives a good indication, not only of the damage done to aquatic ecosystems, but of what can end up in sludge through wastewater treatment with consequent effects on land ecosystems.)

But the greatest force behind the drive to sewer has been the interests of industry: first, because public sewers are the cheapest place for industries to put their wastes, and second, because it is the enormously expensive system of central collection that generates the highest profits for engineering and construction firms. For example, 80 percent of the total cost of sewering and treatment is in the laying of pipes, and engineering and construction firms get a flat 20 percent profit on the total project cost. Fixing the 5-10 percent of septic systems that are failing (i.e., polluting or overflowing) would never generate the profits associated with sewering 100 percent of these communities' central collection and treatment works.

This powerful coincidence of seemingly disparate interests — regulatory, environmental, and industrial — overwhelmed any popular opposition to the tax burden required to fund this massive public project, which in cost is second only to that of the U.S. highway construction program. When environmentalists are for it, and the governments are for it, corporate interests can just lay low, for who but a philistine would object to tax increases for so good a cause? Thus, town after town, each, as noted above, with typically 5-10 percent of on-site wastewater systems (mostly old cesspools and "modern" septic tank/leach fields) deemed to be failing, has been herded down the sewer path, and so has come to have 100 percent of its sewage centrally collected and treated. Since it is treatment of sewage that creates sludge — and since, therefore, the more extensive the treatment, the more and the worse the sludge — the issue of how to dispose of it became for municipalities a major and growing problem.

What was being done with it? In some places sludge was dumped in "sanitary" landfills, where it caused serious groundwater pollution. In other places it was incinerated, causing serious air pollution. And, remarkable as it may seem (given the stated objective of removing pollutants from the water), during the first phase of the sewage treatment era, cities built on ocean shores saw fit to dump the sludge into the ocean — that is, back into the water. As early as 1924, New York City, whose new treatment plant was a striking case in point, began dumping its sludge 12 miles outside New York Harbor. Sixty years later, the U.S. EPA determined that the coastal waters had been unacceptably damaged and ordered that the sludge be barged farther out — to a site 106 miles offshore. Although this strategy seems to suggest a failure of imagination, it remained an acceptable solution in the eyes of the federal authorities until the 1980s, when hypodermic needles and other medical debris from hospitals started washing up on the beaches. (These needles actually came from "solid waste," or trash,

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which was also routinely dumped into the ocean.) The barren moonscape on the ocean floor created by the unwonted concentrations of heavy metals and other toxins present in the sludge had been of little concern to the public (who couldn't see it and for the most part didn't know about it), but the AIDS epidemic and its attendant focus on hypodermic needles caused a public and media commotion sufficient to cause Congress to ban ocean dumping altogether in 1988.

This was a triumph for many environmental groups who had fought ocean dumping because of its toxic effects on marine ecosystems. But the ban on ocean dumping only moved the sludge problem to other grounds. What to do with it now? Although not a conflict known to many, including environmentalists, there was a disagreement within and among the groups in the environmental movement over what should be done with the sludge. It seemed that the old debate had reappeared, only this time about sludge: Is it a nuisance — or worse, a hazard — that must be "disposed of"; or is it, like the old "night soil," a valuable fertilizer?

Some of the major environmental organizations — including the Environmental Defense Fund (EDF) and the National Resources Defense Council (NRDC) — struck a deal with the EPA, which agreed to shut down ocean dumping if they would join in promoting land application as the long-term solution to the disposition of sludge. Both EDF and NRDC were among the signers of the "consent decree," the legal document mandating land application in place of ocean dumping. To many in these organizations, this must have seemed a very good arrangement: In one fell swoop it ended a poisonous process (ocean dumping) and, it seemed, began a very good one. Wasn't this a promise to "recycle"? Wasn't it "sewage farming" at last?

The organic farming and natural food movement developed in response to the post-World War II period when agriculture was turning to chemical fertilizers and synthetic pesticides. By the 1970s the movement had attracted a diverse, passionate, and international following. Organic gardeners and farmers were "environmentalists" before the emergence of the more encompassing environmental movement in the 1970s. Fundamental to the organic movement's philosophy is the belief that human health depends on food grown on healthy soil — soil alive with humus, the partly decomposed residue of organic matter. Feeding the soil — rather than feeding the plants "intravenously" with soluble synthetic chemical fertilizers, as is the practice in agribusiness — is, according to this view, the way to support the health of the soil. And humus is the "food" for soil. Hence, compost, the managed creation of humus, is the essential ingredient of

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the organic method. Crucial to this orientation, also, has been the belief that, since all life is related, the pesticides, herbicides, and fungicides routinely employed in chemical agribusiness will damage human health at least as much as they will damage the smaller and rapidly multiplying creatures they were designed to destroy. It is logical to expect that using sludge in agriculture would be abhorrent to the organic movement.

The organic food and agriculture movement gained in strength in spite of the silent but monumental opposing interests of the agro-industry, whose economic health has depended on the petrochemical-based fertilizers and, given vertical integration of the chemical and agriculture industries, on pesticides of every sort. The organic food and agriculture movement also gained strength in spite of the ruling view of the EPA, which to a large extent is composed of engineers who have little respect for ideas associated with anything "organic." Indeed, the U.S. Department of Agriculture and the EPA regarded the practice of composting, the organic farmers' means of achieving soil health and fertility, as being unscientific — until, that is, the late 1980s when, soon after the signing of the consent decree stopping ocean dumping of sludge, "land application" of sewage sludge came into its own.

In 1992, the ocean dumping ban went into effect, and then, with the full fanfare and pomp of a formidable public relations campaign, sewage sludge was rechristened "beneficial biosolids." Thus the EPA's classification of sludge as a hazardous material evaporated and then was reconstituted with the trappings of the recently despised word "compost." Sludge would be composted, and the word "compost" would achieve official dignity. Environmental groups such as EDF and NRDC blessed this conversion.

At the same time, industry and the big environmental organizations were forging a new kind of relationship. These groups believed they could modify the behavior of industry for the sake of the environment by sitting at the same table in a spirit of negotiation. Industry on its part began to fund these organizations. EDF and NRDC both received funding from the waste handling industries, and subsequently were notably silent when questions were raised about the toxic constituents of sludge and the likely dangers of its application to the land. Within the organic movement, *Compost Science*, a spinoff of Rodale's very popular *Organic Gardening and Farming* magazine, became the prime publicist of land application of sludge, not only through its articles, but also through its copious advertisements for sludge hauling and sludge spreading equipment.

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This sanction by the most respectable environmental organizations was key to getting public and regulatory acceptance for what would be for the waste industry the most profitable sludge disposal method among all the alternatives. Land filling is expensive for them because of tipping fees. Incineration is expensive because of unabated environmental opposition. Land application, on the other hand, is profitable. Municipalities pay waste haulers to take the sludge away and then dump it — for free (hence no tipping fees) — on farms. But beyond free dumping, through high-powered public relations expropriation of the words "natural" and "organic" and "compost," this same sludge, neatly pelletized and bagged, could be sold retail to gardeners. As long as there were environmentalists who condoned it, gardeners would buy it.

For every municipality with a sewer system and some kind of sewage treatment, the growing mounds of sludge are becoming an increasingly serious problem. This problem gives them a compelling interest to support land application: Every town and city needs a way — a cheap way, if possible — to dispose of this sludge. The public, already burdened by taxes, first for sewering and then for treatment of sewage, will not easily take on the further cost of the treatment of sludge. Land application isn't treatment. It's "beneficial reuse" that costs taxpayers nothing. Waste haulers began offering sludge as a "free fertilizer" to the farmers along with free spreading of lime, which was a bonus of thousands of dollars to small and middle sized farms, in those parts of the country with acid soils in need of liming. This offer has made advocates of many of those farmers.

The claim that "biosolids" are beneficial is based on the presence in the sewage sludge of nutrients deriving from human excreta. But the benefit of this content compared to the dangers of the toxic matter in it is a key point in the debate about land application of sludge. It is the view of this writer that the menace of toxic and otherwise non-life-compatible substances that can be found in sludge so greatly outweigh the potential nutrient benefit as to make that potential benefit irrelevant. Let me now present the reasoning on which my position is based.

Nitrogen is the main nutrient promoted to farmers as the "free fertilizer" in sludge. The land application wing of EPA (primarily the wastewater division) claims that the total nitrogen fertilizer requirement of agriculture can be met by using sewage sludge. Most of the nitrogen in excreta, however, derives from the urine, and the forms of nitrogen in urine are highly soluble and, once mixed with water, are not easily removed from it. Therefore, sewage treatment processes allow most of

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the nitrogen to remain in the wastewater, transferring correspondingly little to the sludge. Since the concentrations of nitrogen are so relatively low, and the concentrations of heavy metals (e.g., lead, cadmium, zinc, copper, mercury, chromium, and arsenic) are, relative to ambient levels in soils, so high, it follows that massive quantities of sludge must be spread on farmland to attain the levels of nitrogen needed to act as fertilizer. This means heavy metals will accumulate in the soil. Or they will move. Where? Into bacteria, into plants, into the chain of life.

The offers of free lime, besides serving as an inducement to farmers to accept sludge on their land, serves another purpose. The regulations governing land application of sludge require the maintenance of a pH above 6.5 in soils on which sludge is spread. This 6.5 pH is needed in order to bind up the heavy metals — precisely to prevent them from moving, either up, causing "bio-accumulation" in life chains, or down, causing pollution of groundwater. There is an active debate between soil scientists and advocates of land application about this effort to "bind up" the heavy metals. This debate has two questions: Whether or not liming works on all the metals from a strictly chemical point of view, and whether or not it matters if it works, since the monitoring and enforcement of pH levels on farms is a virtual impossibility.

There are many problems surrounded by intense controversy over the issue of land application of sludge. Its noxious odor is the first if the least threatening to life. Disease — from viability and regrowth of human pathogens in raw sludge, and other diseases caused by the sludge composting processes — is of major concern. But, serious as these concerns are, serious as is the danger of heavy metals' toxicity due to land application, sludge has another yet more threatening characteristic. Far more dangerous to all life is the fact that combinations of some chemicals can cause levels of life process disruptions many times in excess of the effects of any chemical alone. For example, recent research has demonstrated dramatic increases in the estrogenic effects of common pesticides when they act in combination. Whereas the endocrine disrupting effect is 1:1 in the case of the doubling of one single compound, where two or more are combined, their destructive effects are not just doubled but, rather, multiplied and magnified to the order of 600 or even 1600 times. Sludge provides perfectly the conditions for combinations of thousands of chemicals to cause a cataclysmic devastation of life.[11]

[11]Theo Colborn, Frederick S. vom Saal, and Ana M. Soto, "Developmental Effects of Endocrine-Disrupting Chemicals in Wildlife and Humans,"

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What is to be done with sludge, then? This question has two parts. The first is immediate: Is there a safe way to deal with the sludge that the world is now producing? The second is a policy question: Should we continue to commit resources to a sewering-and-treatment-of-sewage system which creates so unresolvable a problem as is embodied in sludge?

In answer to the immediate question, the sludge that is still being produced by existing treatment plants should be treated as the hazardous waste that it is. It should either be isolated in secure storage, as nuclear waste is, or it should be processed by means of emerging technologies such as gasification which, through high-heat oxidation, avoids the creation of dioxins in the stack gases and reduces the sludge to a mineral ash. Both these strategies have the advantage of making possible the minimizing of the contact of sludge with life, rather than the maximizing of it as is currently the case with land-application.

The answer to the second part — the policy part — is prevention. Prevention rather than inevitably futile attempts at "cure" is the form any positive change must take. Prevention in this case means not creating sludge in the first place. Communities that are not already sewered should practice sewer avoidance. Sewering is the most expensive technology. It degrades the environment more than protects it, and it unceasingly produces sludge in overwhelming quantities. Communities need to take the political initiative to insist that substandard or failing on-site systems (e.g., pit latrines, cesspools, septic tank/leach fields) must be remediated by on-site technologies that solve, instead of merely move, the problem. Many options now exist for on-site remediation of failing or polluting septic systems. There are waterless composting toilets, greywater purification-by-use systems, and reed beds and other water-based biological systems for cleaning organically polluted wastewater from industrial processes. The key to preventing the trouble caused by this homogenized mess of mixed matter is separation at the source.

No society in the world today deals well with human excreta. At all levels of technical sophistication, damage is done to water, soil, and human health — whether by the pit latrine, the flush toilet, the septic tank/leach field, or, most insidiously and destructively, by the central

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Environmental Health Perspectives, 101, 5, October, 1993, pp. 378-384; Steven F. Arnold, Diane M. Klotz, Bridgette M. Collins, Peter M. Vonier, Louis J. Guillotte Jr., John A McLachlan, "Synergistic Activation of Estrogen Receptor with Combinations of Environmental Chemicals," *Science*, 272, June 7, 1996, pp. 1489-1492.

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sewage collection and treatment plant, which creates an unpredictably toxic, and therefore unrecyclable, sludge. The only principle by which we can simultaneously protect the soil, the water, and human health is through technologies and management systems that systematically segregate human "wastes" and recycle them to agriculture, from where for the past 10,000 years, they have come.

The sheer number of dangers associated with treating sludge as if it were a fertilizer is so great, so various, and so serious that it would be the life work of thousands of professionals to divide up and respond to the categories of problems that will arise from this practice. The real significance of all this — of the names and numbers, of the long list of "anecdotes" about human illness, about cows and horses dying after eating hay grown on sludge and of people who live next to agricultural lands to which sludge has been applied developing strange illnesses — lies in the unknowability of it all: What goes down the drains is unpredictable; what goes into the sewer — from hour to hour, from week to week, from month to month — is unpredictable; what is extracted from the wastewater can neither be predicted nor monitored to an extent even remotely adequate. No system of regulations can be either designed or enforced in such a way as to protect life chains from the potential of devastation by the constituents of sludge.

Collecting our "wastes" in sewage, then "treating" them so as to disentangle them again, then distributing the residue, the sludge, on agricultural land, can be made to look like "recycling," for some of the sludge did come from food growth and food use processes. But much of it did not come from such processes, and when those materials, foreign to the cycles of life, are insinuated into these cycles through the food chain, the consequences for life can be terrible. Because we cannot find a certain way either to keep all the toxics out of the sludge or to get all the toxics out of the sludge, we must say, I think, that the consequences of dumping sludge on agricultural land *will* be terrible.

To entertain the view that the benefits of application of sewage sludge to agriculture will outweigh the harm is either sentimental evasion or shortsighted greed. Uncertainty because of unpredictability is the unavoidable character of sewage sludge. And when uncertainty risks damage to all life of the order that industrial society's toxic chemicals certainly involve, gambling on the dangerous route is absurd.

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