Chapter 3

LAYING WASTES TO LAND:

Problems and Future Outlook of Land Application of Composted Sewage Sludge

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Introduction

> "All statements on treatment and disposal of sludge must not neglect the fact that one has to get rid of the sludge of sewage purification definitely and by all means."
>
> K.R. Imhoff (Moller, 1983)

Indeed we must get rid of the sludge, but how? The East Bay Municipal Utility District Special District 1 (EBMUD SD1), encompasses Alameda, Albany, Berkeley, El Cerrito, Oakland, Piedmont and Emeryville. The amount of sewage sludge produced by this district is enormous, upwards of 125,000 cu yds per year (Shastid, 1984, pers. comm.). This ammount of sludge creates several problems: finding an economical method of disposal, and one that minimizes hazards to public health and impacts on the environment.

What were considered acceptable measures in the past are now recognized as unsatisfactory solutions to the sludge disposal problem. Incineration and ocean dumping befoul air and water. The Ocean Dumping Act of 1977 and clean air regulations have curtailed these methods of removal (Epstein et al., 1983). EBMUD presently disposes of 93% of its sludge by landfilling (Shastid, 1984, pers. comm.). However, landfills have limited life spans, and as the most convenient and suitable sites are filled, less economical and less safe sites must then be utilized. Also important to water-conscious Californians is the realization that landfills may be contaminating our groundwater supplies (Epstein et al., 1983).

The remaining 7% of EBMUD's sludge is composted (Shastid, 1984, pers. comm.) and then utilized as a soil conditioner. Unfortunately, this procedure also has its faults. An article entitled Gardeners Beware published by Citizens for a Better Environment (CBE) focused on the extensive amounts of heavy metals, PCBs and pesticides which were turning up in Milorganite and Nu-Earth, composts produced by sewages in Illinois and Wisconsin (Davoli, 1978). CBE warned that use of these products might expose the public to a needless health risk.

This paper explores the present risks of using CompGro, EBMUD's composted sewage sludge, and examines steps to be taken to enhance its safe use and greater utilization.

Why Land Application of Compost?

Generally, the disposal of sewage sludge is regarded as the disposal of an unwanted waste. Money and energy are expended, land, water and air are contaminated, in trying to make a problem disappear. The land application of sewage sludge and compost is the only approach to disposal that recognizes the basic fact which every farmer knows: animal wastes (man's included) are not "wastes" at all, but precious inputs to depleted soils.

Landfilling of sludge interrupts the cycling of organic material back into our humus-deprived soils (Spohn, 1977). Organic material is necessary for proper soil structure, which in turn enhances crop growth and lessens erosion (Sterritt and Lester, 1980). Current intensive agricultural techniques speed decay of organic matter. Heavy dependence upon chemical fertilizers and the minimal return of organics through tilling in crop residues does little to alleviate what might be termed a "humus crisis" in U.S. agriculture (Coker and Mathews, 1983). Land application of compost channels organic materials to precisely where they are needed. The problem of sludge disposal becomes a remedy for our ailing soils.

Composting Sewage Sludge

Composting is a controlled process utilizing soil microbes and fungi to stabilize organic matter (Golueke et al., 1980). EBMUD uses the "extended aerated static pile" method (EBMUD, 1984c). Sewage sludge is bulked with woodchips and then placed on aeration piping, obviating the need to turn the piles. The next day's mix is butted to the previous day's, forming an "extended pile." The natural action of microbes raises the temperature of the piles to in excess of 55°C, which is maintained for at least three days. Within 2-3 weeks composting is complete and the sludge has been transformed into a rich, earthy material.

Compost has four advantages over untreated sludge: (1) compost is inoffensive and dry, thus easier to handle; (2) nutrients are stabilized against excessive microbial action, but remain available to plants; (3) high temperatures developed in composting kill off human pathogens; and (4) the bulking agent dilutes the concentration of contaminants found in the sludge (Shastid, 1984, pers. comm.).

The composting program at EBMUD is in its pilot stage, which means that the real costs have yet to be tabulated. Furthermore, as composting is stepped up to a projected 18% of the total sludge (and perhaps beyond), economies of scale should reduce expenditures. Projected costs run $20-25 per cu yd of compost, though presently the figure is several times that amount (Shastid, 1984, pers. comm.).

EBMUD currently pays approximately $14 per cu yd to have sludge transported and landfilled. At a projected market price for CompGro of $10 per cu yd (wholesale), composting will equal or undercut the cost of landfilling sludge. Presently, though, CompGro is selling wholesale for $7 per cu yd; EBMUD hopes the higher price will be attained when the desirability and acceptability of the product is realized (Shastid, 1984, pers. comm.).

CompGro retails through a local nursery for $17.95 per cu yd or $1.39 per cu ft bag. Milorganite is three times as expensive. Thus, CompGro is priced well below the competition. Were EBMUD to consider retailing CompGro, composting could pay for itself.

If EBMUD is to expand its composting program, it must have a market. Land reclamation projects could absorb large amounts of compost, as could Parks and Recreation maintenance services. Long-term, extended use is intimately tied with several factors, including the level of contaminants in the compost and its consequent suitability for backyard and large scale agricultural usage.

PTEs in Compost: Human Health Effects

Some heavy metals, in trace amounts, are essential for life; at higher concentrations they may become toxic. Such metals are referred to as Potentially Toxic Elements (PTEs) (Coker and Mathews, 1983). Toxic effects from PTEs generally result from disruption of protein structure and function, manifested in enzymic and metabolic disorders. Acute health effects can occur in cases of gross pollution, but because of widespread knowledge these occurrences are easily avoidable. Chronic effects can arise from bioaccumulation and long-term environmental exposure, both of which are the greatest causes for concern (Sterritt and Lester, 1980).

Zn, Cu and Ni are found at much higher levels in CompGro than in typical uncontaminated soils (Table 1). Even so, they pose little threat to human health as a consequence of land application of the compost. Humans are protected from excessive intake of these PTEs by the "soil-plant barrier." Accumulations in plant tissue are lethal to plants at concentrations well below those harmful to humans (Decrosta, 1981). CompGro was tested for PCBs and pesticides at the outset, but levels were undetectable (Shastid, 1984, pers. comm.).

Two PTEs arousing the most apprehension among scientists are Pb and Cd. Plants do not translocate Pb from the soil appreciably; danger lies not in consuming lead-tainted vegetables, but in consuming lead-tainted soil in which the vegetables have been grown. Care in washing vegetables alleviates this problem. Children playing in soils with high levels of lead are at risk as they are likely to breathe in dust or stick dirty fingers in their mouths. Chronic exposure to soil with 500-1000 ppm Pb can lead to impairment of auditory and language development, and cause brain damage (DeCrosta, 1981).

PTE	Soil	CompGro	CG/S
Cd	0.06	28	467
Cu	20	354	18
Ni	40	52	1.3
Pb	10	197	20
Zn	50	1540	31

Table 1. PTEs in soil and CompGro (ppm). CG/S = ratio of CompGro to soil concentrations.

Source: Lepp, 1981; EBMUD, 1984b.

Plants can translocate and accumulate considerable amounts of Cd from the soil and yet show no outward signs of distress. Human health effects of Cd intake have been extensively researched, but its toxicity is still not clearly defined. There is little evidence to indicate that Cd is a carcinogen at relevant environmental exposure levels. Bone disorders and hypertension can be traced to exceptionally high body burdens of Cd (Ryan et al., 1982).

The major non-occupational routes of Cd exposure are through food and from tobacco smoke (Ryan et al., 1982). When ingested or inhaled, Cd accumulates primarily in the liver and the kidney, and over long periods of exposure may finally reach toxic levels. The current ingestion rate of 25-50 µg Cd/day poses no human health threat. A safe limit is 100 µg Cd/day. At ingestion rates of 200-340 µg Cd/day an individual would be likely to incur critical amounts of Cd in the renal cortex.

Fear of elevating the body burden of Cd is one of the major obstacles restraining more widespread use of composted sludge. Nevertheless, " . . . there have been no documented occurrences of Cd toxicity in animals or man attributable to direct consumption of vegetation grown on land treated with municipal sewage sludge" (Ryan et al., 1982, p. 253).

Plants, Soil and PTEs

Presently EBMUD recommends that CompGro not be used as an amendment to soils where food chain crops are to be grown. Elevated levels of Cd in the compost form the basis for this recommendation. But how much is known about plant uptake of Cd? What are the risks involved, and are there other considerations?

Extensive study has shown that many factors influence the plant uptake of Cd. These factors complexly interact, making predictions of the amount of Cd translocation tenuous at best. The amounts of organic matter and clay in the soil, soil cation exchange capacity, moisture and temperature all modulate the availability of Cd to plants (Jastrow and Koeppe, 1980). Of overriding importance, though, is the soil pH. Study after study confirms that acid soils favor plant uptake of Cd (Pickering, 1980). Minimal translocation occurs if soils are maintained at pH 6.5-7.0, which is also optimal for plant growth for many cultivars (Decrosta, 1981). Scientists have searched for chemical extractants to indicate the amount of plant-available Cd in soils, but with little success (Symenoides and McRae, 1977).

Uptake of Cd also varies greatly from plant to plant. Tobacco, beets, spinach, chard and lettuce all consistently translocate high levels of Cd. Cereals, grasses, grains, tubers and the edible portions of beans and peas accumulate little Cd (Coker and Mathews, 1982). Different varieties of the same species can show substantial genetic variability in their capability to translocate Cd, a finding of note that has yet to be exploited (Jastrow and Koeppe, 1980).

The sum of the research has yielded few practical results for those farmers and gardeners wishing to utilize sludge compost. There are guidelines for acceptable loading rates of PTEs on agricultural lands, but the variance among accepted rates often exceeds the mean. The most up-to-date guidelines for Cd suggest a limit of 1.7 kg Cd/ha on acid soils and 5.0 kg Cd/ha on neutral soils. They also propose that 17 kg Cd/ha is acceptable for growing grains. These figures are based on a maximum safe consumption rate of 100 µg Cd/day and assume that the individual is obtaining the whole vegetable portion of his diet from his garden (Ryan et al., 1982). However, a recent USDA study may amend these guidelines. It was found that if the concentration of Cd in the compost is low, then plant uptake is low, even if the total loading of Cd to the soil is relatively high (BioCycle, 1982).

Using the 5.0 kg Cd/ha loading rate for neutral soils, and assuming Cd is the only limiting factor, I have calculated that CompGro could be safely utilized for vegetable gardening at a covering of about three inches. If one were to apply CompGro at this rate consistently, though, another problem would arise. Pb is essentially immobile in soil and would build up through repeated applications (Doner, 1984, pers. comm.).

Even if spread thinly, at EBMUD's recommended application rate for maintenance of lawns and ornamentals, soil lead levels would exceed 500 ppm in about 18 years if applied annually--a worrisome level. Perhaps 18 years is a long time, but there is no reason to take any risk. A consumer information circular produced by EBMUD (EBMUD, 1984a) is enclosed with each purchase (Ciardella, 1984, pers. comm.), detailing application rates and noting that CompGro should not be utilized for vegetable gardening. However, EBMUD does recommend the use of CompGro for maintaining soils. Given the short time that CompGro has been available and its limited distribution, the chances are slim that any dangers associated with its use have arisen to date. EBMUD's circular should note the presence of Pb in CompGro, though, and discourage its repeated use at the same site.

PTEs in Compost: Sources and Reduction

Of four important PTEs found at high concentrations in CompGro (Table 1), four, Cd, Pb, Ni and Zn come mainly from industry, whereas Cu comes mainly from household and commercial sources (Table 2). Cu plumbing, as well as a wide variety of household products containing CU, are sources

Source	Cd	Cu	Pb	Zn	Ni
Comm./House.	20	65	37	44	24
Industrial	80	35	63	56	76
Major Indus. Contributor	EP 53	EP 26	PM 30	EP 43	EP 66

Table 2. Contribution of selected PTEs to the wastestream from Commercial/Household (Comm./House.) and Industrial sources (in %), and major industrial contributors. EP = electroplaters; PM = primary metals mfg.

Source: Hathaway, 1980; EBMUD, 1978.

of Cu in the wastestream (Hathaway, 1980). Of the polluting industries, electroplaters consistently account for the largest influxes of PTEs to the wastestream (Table 2).

Given the uncertainties, complexities and apparent risks involved in utilizing contaminated compost, the safest route to fullest possible use of the product is to lower the amount of PTEs to levels concommitant with unrestricted use.

One approach is to further treat the sludge, yielding a "clean" sludge to be utilized in compost, and a highly concentrated sludge of small volume that would be disposed of by landfilling. In this manner, the life of the landfills are extended, and a thoroughly useful, worry-free compost is obtained.

Hot acid treatment (McNulty, 1980) is an effective means of achieving this goal, but to my knowledge has yet to be employed in other than an experimental basis. The process removes over 80% of the Cd, Cu and Zn in the sludge, without excessive loss of nutrients. In 1980 dollars, the total cost was estimated at $24/dry metric ton of sludge, which comes to about $4/cu yd of compost produced, a price that may be prohibitive.

A relatively low cost approach to reducing PTEs is to add bentonite, montmorillonite or basalt dust to the compost mixture. These materials adsorb PTEs, rendering them insoluble, that is, unavailable for plant uptake (Spohn, 1980). If Cd remains a problem, then this method may become useful.

Any extra treatment required at the sewage plant to produce usable compost is paid for by the public. The public, then, is subsidizing polluting industries. The direct approach to reducing PTEs in the sludge is to control them at the source. In 1972 Congress passed amendments to the Water Pollution Control Act, which charges the EPA with the responsibility for establishing pretreatment standards for the introduction of pollutants to publicly owned treatment works (O'dette, 1978). This was an attempt to make the polluters pay for the cleanup.

It is twelve years later, and the EPA has proposed standards, but has yet to implement them. The problems in creating blanket standards are manifold, though, and of course there has been much balking by industry (O'dette, 1978). The proposed standards are expected to be implemented in April 1984 for various point-source categories (Goldstein, 1983). A source control program started by EBMUD in 1972 produced significant drops in the amount of Cd, Cu, Pb and Zn entering the treatment plant (Table 3). This program was initiated to protect the functioning of the treatment plant. Since proposed EPA standards are designed specifically to ensure cleaner sludge, they are even more stringent (Shastid, 1984, pers. comm.).

Electroplaters are the single major source of PTEs in EBMUD sludge (Table 2). The concentration of PTEs in the wastestream of electroplaters may presently be 100-1000 times the levels required by the proposed regulations (Table 3). As the EPA regulations will also affect other polluting

	EBMUD Influent (Kg/day)			Wastestream (mg/l)	
PTE	Before	After	% Drop	EPA	Typical Conc.
Cd	7	2.5	64	.05	.01-21.6
Cu	318	29	91	2.0	.03-272.5
Pb	106	15	86	.4	.66-25.4
Ni	N/A	N/A	--	1.8	.02-2954
An	495	134	73	1.5	.11-252

Table 3. Effects of EBMUD source control program, and comparison of proposed EPA standards for electroplaters to concentrations in typical electroplater's wastestream, for selected PTEs.

Source: EBMUD, 1983; Wollan and Becket, 1979; Kreye et al., 1978.

industries, it seems that a further substantial reduction of PTEs in CompGro is in the offing.

A look through the Yellow Pages turned up over 30 electroplaters within EBMUD SD1. What are their prospects for coping with the new EPA regulations? Examples abound to show that if companies are willing, effective means of control are available and affordable. The first step is in water conservation, for it is easier to remove contaminants from a concentrated solution. Allied Metals of Baltimore, MD spent $7000 in consulting fees to this end; their costs were recouped the first year in water savings. Then they installed a Cd electro-chemical reactor for $50,000. The reactor recycles Cd from the wastestream and funnels it right back to the rinse tanks. In three years this investment will be making the owners money (Goldstein, 1982). A nickel-chrome plating operation in Milwaukee is having similar success. They reduced their water flow from 14,000 to 200 gal/day. An ion-transfer recovery system has reduced their chrome purchases from 1,400 lb/mo to 150 lb/mo (Goldstein, 1982).

For companies without the capacity for large capital outlays, a creative alternative is being investigated by Cleveland. The city hired a firm to study the feasibility of a central pretreatment facility. The study concluded that a central plant, financed by the industry, would save each electroplater from $15,000-40,000 as opposed to implementing individual pretreatment devices (Goldstein, 1983).

As strict pretreatment standards may soon become a reality, one might wonder about EBMUD's enforcement capabilities. EBMUD regularly monitors industrial effluent. If the standards are not being met, EBMUD may take action by persuasion, shutting off the water or taking the violator to court (Shastid, 1984, pers. comm.).

Summary

Were it not for the presence of Cd and Pb in CompGro, composting would be a feasible and ecologically sound approach to sewage sludge disposal. Proposed EPA pretreatment standards may bring about a sizeable reduction in the amounts of PTEs in CompGro, which would allow for its safe, widespread use.

Presently, use of CompGro is recommended only for horticultural purposes. Given its limited distribution and time of availability, the likelihood is small that hazards associated with the use of CompGro have arisen. Due to high Pb levels in CompGro, though, repeated use of the product can lead to dangerously high concentrations of Pb in the soil. With this in mind, I propose that CompGro should not be used for regularly maintaining soils.

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