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Sewage Sludge Disposal – Land Application - Environmental Problems – An Overview

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Abstract:

Approximately one half of the costs of operating secondary sewage treatment plants in Europe can be associated with sludge treatment and disposal. Land application of raw or treated sewage sludge can reduce significantly the sludge disposal cost component of sewage treatment as well as providing a large part of the nitrogen and phosphorus requirements of many crops. The numbers of pathogenic and parasitic organisms in sludge can be significantly reduced before application to the land by appropriate sludge treatment and the potential health risk is further reduced by the effects of climate, soil-microorganisms and time after the sludge is applied to the soil. The availability of the phosphorus content in the year of application is about 50% and is independent of any prior sludge treatment. Nitrogen availability is more dependent on sludge treatment, untreated liquid sludge and dewatered treated sludge releasing nitrogen slowly with the benefits to crops being realised over a relatively long period. Land applied sludge is required laws to have toxic levels below certain limits and it is treated with lime to reduce pathogen levels. The sources of contaminates in sludge are many, depending upon the specific water treatment facility and the community that it serves. In this article we have described various aspects of sewage sludge, their disposal; their application to land and the different environmental problems arises from tose activities.

Key Words: sewage, sludge, disposal, land application, environmental contamination, hazards, toxicological problems

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1. Introduction

Most wastewater treatment processes produce a sludge which has to be disposed of. Conventional secondary sewage treatment plants typically generate a primary sludge in the primary sedimentation stage of treatment and a secondary, biological, sludge in final sedimentation after the biological process. The characteristics of the secondary sludge vary with the type of biological process and, often, it is mixed with primary sludge before treatment and disposal. Approximately one half of the costs of operating secondary sewage treatment plants in Europe can be associated with sludge treatment and disposal. Land application of raw or treated sewage sludge can reduce significantly the sludge disposal cost component of sewage treatment as well as providing a large part of the nitrogen and phosphorus requirements of many crops. Very rarely do urban sewerage systems transport only domestic sewage to treatment plants; industrial effluents and storm-water runoff from roads and other paved areas are frequently discharged into sewers. Thus sewage sludge will contain, in addition to organic waste material, traces of many pollutants used in our modern society. Some of these substances can be phytotoxic and some toxic to humans and/or animals so it is necessary to control the concentrations in the soil of potentially toxic elements (PTE) and their rate of application to the soil. The risk to health of chemicals in sewage sludge applied to land has been reviewed by Dean and Suess[1]

Sewage sludge also contains pathogenic bacteria, viruses and protozoa along with other parasitic helminths which can give rise to potential hazards to the health of humans, animals and plants. The numbers of pathogenic and parasitic organisms in sludge can be significantly reduced before application to the land by appropriate sludge treatment and the potential health risk is further reduced by the effects of climate, soil-microorganisms and time after the sludge is applied to the soil. Nevertheless, in the case of certain crops, limitations on planting, grazing and harvesting are necessary.

Apart from those components of concern, sewage sludge also contains useful concentrations of nitrogen, phosphorus and organic matter. The availability of the phosphorus content in the year of application is about 50% and is independent of any prior sludge treatment. Nitrogen availability is more dependent on sludge treatment, untreated liquid sludge and dewatered treated sludge releasing nitrogen slowly with the benefits to crops being realised over a relatively long period. Liquid anaerobically-digested sludge has high ammonia-nitrogen content which is readily available to plants and can be of particular benefit to grassland. The organic matter in sludge can improve the water retaining capacity and structure of some soils, especially when applied in the form of dewatered sludge cake.

2. What is sludge?

Residuals, biosolids, septage, sewage, wastewater byproduct, compost: there are many names for sludge and sludge products. The term “sludge” is used as most people understand it: the sometimes solid, sometimes liquid material generated by wastewater treatment plants and used as fertilizer on fields, in gravel pits, and on forestry lots throughout the state. Sludge may classified as “Class A” if it has been treated to reduce germs to background levels (levels normally found in soils) and “Class B” if it has been treated so that germs are reduced by an estimated 90%.

3. Composition of sewage sludge:

The nature of the sewage sludge depends on the waste water treatment process and on the source of the sewage. In general it contains both toxic and non-toxic organic wastes. Of the two, non-toxic compounds are most prevalent comprising all materials of plant and animal origin, including proteins, amino acids, sugar and fats. Toxic organic compound comprises Poly-nuclear aromatic hydrocarbons (PAHs), alkyl phenols, polychlorinated biphenyls (PCBs) organo-chlorine pesticides, monocyclic aromatics, chloro-benzenes, aromatic and alkyl amines, polychlorinated dioxins, phenols etc. In addition to these organic waste material sewage sludge also contains traces of many pollutants like Copper, Zinc, Nickel, Cadmium, Lead, Arsenic, Chromium, Selenium etc. Some of these substances can be phytotoxic and some toxic to humans and / or animals, so it is necessary to control the concentrations in the soil of potentially toxic elements and their rate of application to the soil. Sewage sludge also contains pathogenic bacteria, viruses & protozoa along with other parasitic helminthes which can give rise to potential hazards to the health of humans, animals and plants. Apart from those components of concern sewage sludge also contains useful concentrations of N, P and organic matter. Each component of the sludge has its own environmental impact, which must be taken into account when choosing the disposal route.

4. Processing of sludge:

Increasing urbanization and Industrialisation have resulted in a dramatic increase in the volume of waste water produced around the world. The waste water treatment step concentrates the various pollutants (upto 90%) in the waste water into sludge, normally containing between 1% and 2% by weight dry solids. The waste water treatment commonly involves the following processes to process (Table-1) the sludge for the production of suitable end products for utilization or disposal.

5. Agricultural application

The application of sewage sludge as a “safe fertilizer “started in earnest after the 1988 ban on dumping sewage sludge into the ocean. When the Ocean Dumping Ban Act of 1988 went into effect, the municipalities & the Govts. left with a new problem – how to get rid of the tons of sludge they generate on a daily basis. The federal Environmental Protection Agency (EPA) stepped in with a plan to “solve” this problem by promoting sludge (sometimes called ‘biosolids’, a public relations term that is used interchangeably by EPA with the technical term “sewage sludge”) as fertilizer to be spread on land – where people live, work and play. Though, the viscous, black cake adds free Organic Matter & Fertilizer to poor soils, making them productive and profitable, the main limitations arising from such factors are: pathogens, heavy metals, toxic organics. Therefore, the plan of EPA has allowed toxic chemicals into air, water, soil, crops & into us. So, to call this sludge “ fertilizer” is tantamount to call a soup “food” which, though it contains some meat & vegetables, also contains a bit of lead, a little arsenic, and perhaps hundreds or even thousands of other toxic organic and inorganic materials whose impact ranges from carcinogenic to teratogenic (birth defect inducing). “Most people want a simple answer; is it good or is it bad. The answer is not that simple. It is not completely risk free, but it has benefits. Just like driving a car", Sanden said.

Table-1. Sludge processing methods.

Process	**Description**
Sludge pasteurization	Minimum of 30 minutes at 70ºC or minimum of 4 hours at 55ºC (or appropriate intermediate conditions), followed in all cases by primary mesophilic anaerobic digestion.
Mesophilic anaerobic digestion	Mean retention period of at least 12 days primary digestion in temperature range 35ºC ± 3ºC or of atleast 20 days primary digestion in temperature range 25ºC ± 3ºC followed in each case by a secondary stage which provides a mean retention period of at least 14 days.
Thermophilic aerobic digestion	Mean retention period of at least 7 days digestion. All sludge to be subjected to a minimum of 55ºC for a period of at least 4 hours.
Composting	The compost must be maintained at 40ºC for at least 5 days and for 4 hours during this period at a minimum of 55ºC within the body of the pile followed by a period of maturation adequate to ensure that the compost reaction process is substantially complete.
Lime stabilization of liquid sludge	Addition of lime to raise pH to greater than 12.0 and sufficient to ensure that the pH is not less than 12 for a minimum period of 2 hours. The sludges can then be used directly.
Liquid storage	Storage of untreated liquid sludge for a minimum period of 3 months.
Dewatering and storage	Conditioning of untreated sludge with lime or other coagulants followed by dewatering and storage of the cake for a minimum period of 3 months. If sludge has been subject to primary mesophilic anaerobic digestion storage to be for a minimum period of 14 days.

(Source: Dean and Suess ,1995)

The benefits of sewage sludge on agricultural land

- Valuable agricultural nutrients like Nitrogen, Phosphorus, Potassium and Sulphur can be returned to the land
- Soil organic matter levels have been increased to 12% – 15%
- Ground water and surface water quality are maintained
- Decrease bulk density and increase the non-capillary pore space
- Improve the aggregation of soil particles
- No significant health or nuisance problems occur

6. Problem of Sludge

Sludge contains measurable quantities of pollutants, such as heavy metals, dioxin, and other toxic chemicals. Sludge also contains pathogens--human germs, bacteria, viruses, and parasites. And sludge smells: sludge odor is more than just a nuisance; it is a public health threat, which has been linked to respiratory problems and death. The land application of sludge distributes pollutants from large towns and cities to rural areas, far from where they were originally produced. State and federal agencies of various countries regulate sludge spreading, but regulation of this waste is difficult and problematic. Many scientists agree that the current land application rules do not protect human health, agricultural productivity, or the environment. The lack of funding to provide proper regulatory oversight and the very nature of sewage allow for sludge spreading of an unknown quality to occur on our lands.

The problems with sludge include:

- Sludge contains heavy metals, toxic chemicals, and pathogens.
- The testing and regulation of sludge is inadequate and problematic.
- Sludge odors pose a public health threat and lower quality of life.

7. The trouble with sludge

7.1. How toxic sludge become fertilizer

In traditional agricultural societies, human waste was often used to enrich the soil. The Industrial Revolution caused increased urbanization and the need for cities to develop primitive sewer systems to remove human waste. Pipes and gutters were built to dump sewage directly into our lakes, rivers, and oceans. As industry increased in World, factories began using these primitive sewer systems to get rid of their waste. This practice continued well into 20th century, when industry began widely using toxic chemicals. Using the local sewer system as a dumping ground for toxic waste was an easy solution to their disposal problems and was cheaper than treating their waste on site. Sewage loaded with toxic chemicals created major public health and environmental disasters throughout the World: rivers caught fire, public drinking water supplies became polluted, and waste washed up on our beaches. Public outcry from the growing number of disasters led to the passage of the federal Clean Water Act in 1972. This act set water quality standards nationally and provided money to communities to improve sewer systems and create wastewater treatment facilities. Unfortunately, instead of addressing the root of the problem by stopping industrial use and disposal of toxic chemicals, the act instead regulated the amount of pollution large industries could release into sewer systems.

By the late 1970s, extensive sewage systems had been built across the country. Wastewater treatment plants were built to separate solid waste from water, and, following natural and chemical treatment, release water back into the environment, clean of human waste. Unfortunately, they were not built to treat toxic chemical waste. While these sewage systems and wastewater treatment plants improved public health standards and water quality, they have an ironic flaw. The treatment process creates cleaner water but also creates a toxic byproduct: sludge. In fact, the Clean Water Act rightly defines sludge as a pollutant. Like all waste, sludge must be disposed of in some way. What to do with sludge has been a source of controversy for the past three decades in the World. Through the 1970s and 80s, the federal Environmental Protection Agency (EPA) strictly regulated the land spreading of sludge, effectively prohibiting much of the waste from being used on agricultural land. Wastewater treatment facilities could only dispose of sludge in one of three ways: by sending it to a landfill, by incinerating it, or by dumping it 100 miles offshore into the ocean.[2]

Ocean dumping eventually created large under-sea dead areas. In response to public concern, Congress passed the Ocean Dumping Act, which banned ocean dumping of sludge in 1992.[3] Sludge disposals was then largely limited to landfills and incineration that became expensive for wastewater treatment plants. Municipal treatment facilities then pressured the EPA to relax its standards for the land spreading of sludge on agricultural fields. Following a number of draft rewrites of EPA regulations, corporate sludge marketing companies and municipal wastewater treatment facilities were successful in relaxing the limits of toxins in sludge for land spreading. What was once considered hazardous waste became a fertilizer? By classifying sludge as a fertilizer, it became exempted from several waste management regulations.

7.2. Marketing of toxic sludge

Municipal water treatment facilities depend upon corporate sludge brokers to dispose of their sludge. To dispose of it, these private corporations convince farmers and landowner across the country to spread sludge on their fields as a nutrient supplement for their crops. Sludge is marketed to landowners and consumers in two different ways. The first, and most obvious, is by offering them free sludge. By convincing individual property owners that sludge is of "agronomic benefit" to their land, sludge brokers are finding extremely cheap disposal sites for sludge that would otherwise have to be shipped to landfills or incinerators at a cost of approximately $70 a ton.[4]

Companies then claim that everyone wins: treatment plants have a cheap disposal option for their sludge, which gives taxpayers a break, and landowners get free nutrients for their fields. As an accurate result, the sludge brokers walk away with the disposal fees from the treatment facility. The sludge brokers also escape from potential liability, which is now assumed by the farmer or property owner. The second way sludge is marketed is by composting or palletizing it. Then it can be sold or given away as compost or fertilizer. Since the weakening of sludge regulations in the late 1980s, citizens cross the World have been fighting to keep sludge from being spread on fields and farmland in their communities. Activists fighting sludge are up against formidable opponents. Water treatment facilities and sludge brokers have formed powerful trade groups, such as the New England Biosolids & Residuals Association (NEBRA). NEBRA, in turn, is part of an even larger and more powerful group: the National Biosolids Partnership, which is a coalition of groups such as the EPA and Water Environment Federation, whose primary responsibility is to change "public perception" about sludge spreading.

7.3. Toxic secrets of sludge

Land applied sludge is required laws to have toxic levels below certain limits and it is treated with lime to reduce pathogen levels. However, no sludge in World is completely free of toxic chemicals or pathogens. In fact, after it is treated, Class B sludge still contains a significant amount of pathogens[5].

7.4. Toxic in sludge

A. Heavy Metals

All sludge in world contains heavy metals like arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc.[6] These metals are persistent—that is, they do not break down in the environment and therefore build up over time. As the Cornell Cooperative Extension states, “most heavy metals remain in the soil for long periods of time, ranging from several decades to many centuries.” The heavy metals in land spread sludge therefore become permanent additions to the total quantity in the soil. Even extremely small amounts of heavy metals in sludge, therefore, are dangerous.[7] High levels of arsenic in food or water can be fatal. Cadmium, chromium, nickel, and selenium have been linked to cancer. Cadmium has also been linked to kidney problems, miscarriages, and stillbirths. Copper, nickel, and zinc are known to cause growth problems in crops. Children exposed to lead can develop behavioral and learning problems. Mercury exposure at key moments in fetal development can cause learning disabilities and neurological disorders. Molybdenum bioaccumulates in grass eating livestock; ingested in excess, it can cause anemia, diarrhea, and growth problems.[8] These metals can be taken up by the plants that are grown on sludge and re-enter the human food chain via livestock feed. These metals can also leach into groundwater. Highly acidic soils, like those found in Maine, can exacerbate heavy metal leaching.[9]

B. Pathogens: Bacteria, Viruses, and Parasites

Sludge, by its very nature, contains human pathogens: germs such as bacteria, viruses, and parasites. Whereas exposure to heavy metals can cause problems over time, exposure to these germs is more acute and can cause health problems almost immediately. Because of the extremely large numbers of pathogens that exist in the world, it is impossible to test sludge for all types of pathogens. Some common pathogens in sludge include the bacteria E-coli and Salmonella, the virus Hepatitis A, and parasitic worms. Pathogens can cause intestinal problems, other serious illnesses, and death. Land spread sludge can be treated to nearly eliminate pathogens. By composting sludge, for example, pathogen levels can be reduced significantly. Unfortunately, federal and state laws allow “Class B” sludge, which has not been treated to the strictest pathogen reduction methods, to be spread. In other words, sludge with live pathogens is being spread throughout the state. Unfortunately for the residents and workers of Northern New England, wet and overcast climates encourage pathogen growth. Researchers have found that pathogens can survive in sludge for weeks, months, or even years after reduction treatment processes.

Humans can be exposed to sludge pathogens in a number of ways. We might consume vegetables that have pathogens on them. Children might accidentally gain access to a sludge field and become exposed to the germs. Pathogens can also be spread by pets or wildlife, such as deer, that walk through a sludge field.

C. Dioxin: "The Darth Vader of Chemicals"

Dioxin is the unwanted byproduct of chemical processes involving chlorine. According to the EPA, sludge spreading is the largest land distributor of dioxin nationally.[10] Dioxin is a known carcinogen and has been linked to reproductive problems, genetic damage, and endometriosis. Scientific evidence suggests there is no safe exposure level to dioxin.[11] As one well-known dioxin expert called it, dioxin is "the Darth Vader of chemicals," because you can't see or taste it, but it is deadly. The source of dioxin contamination in sludge is not known. It might be discharged into the sewer system by unknown industrial or residential sources. Dairy cattle grazing on sludged land may ingest dioxin and the chemical will then enter humans via milk and meat.

8. Source of toxic chemicals

Sludge contains heavy metals and other pollutants because industry and households use and release far too many toxic chemicals. The sources of contaminates in sludge are many, depending upon the specific water treatment facility and the community that it serves. Sources of contamination include industrial releases, small business discharges, hospital releases, household waste, leachates from landfills and Superfund sites, including nuclear waste dumps, and municipal water and sewer systems as a whole.[12] Everything that is discharged into a sewer that leads to a water treatment plant could potentially become part of the sludge that the facility produces. If a worker at an industrial facility accidentally dumps toxic chemicals down the drain instead of disposing of it properly, those chemicals could end up in the sludge. Likewise, if a home gardener rinses out a bottle containing toxic pesticides in the sink, those toxic pesticides could find their way to the sludge.

8.1. Industrial Hazards

As discussed earlier, many chemicals used by industry have not been properly tested and are not regulated or reported. Additionally, even at the safest facilities, accidents happen and toxic chemicals can be released into the waste stream. World requires wastewater treatment plants to work with large industries on reducing and monitoring their waste discharge. This "pretreatment process" is required of companies that discharge a large amount of waste into the sewer system or use a large amount of chemicals that could affect the operation of the sewer system. Unfortunately, once companies release heavy metals, or other toxins, into the sewer system, there is no process to remove these chemicals from the sludge. In addition, every industry in the country can discharge 33 pounds of hazardous waste *every month* into wastewater treatment plants, without penalty or reporting.[13]

8.2. Small Business Hazards

Many small businesses are not regulated for their toxic releases. Nor are they included in the pretreatment processes. While auto garages, dentist offices, photo developers, dry cleaners, and other small businesses may not individually release a large amount of toxic chemicals, taken as a whole their contribution to chemicals in sludge could be dangerous.

8.3. Hospital Hazards

All hospitals are required to dispose of toxic chemicals and biohazards in a state approved manner. Nevertheless, accidents do happen: from a broken mercury hermometer to additional human pathogens being washed down the drain, hospitals can contaminate sludge.

8.4. Contamination from Municipal Water and Sewer Systems

Many towns and cities have water and sewer systems made with lead and copper pipes. Lead, copper, and other metals often leach into the waste stream and contaminate sludge. Contamination of sludge can also occur if a town's reservoir is polluted with pesticides and other chemicals for which testing are not required.

8.5. Household Hazards

From pesticides (including flea shampoos), to heavy duty cleaning agents and hair coloring products, toxic chemical containing products abound. Any of these chemicals dumped down the drain could end up being spread on a farm field or in a forest.

9. Sludge regulation

It is nearly impossible to know the exact levels of toxic materials in each batch of sludge because what is released into the waste stream varies day to day. While sewage waste is treated at wastewater facilities for several days, not every batch of sludge is tested before it leaves the plant. It is more due to economics than to concerns for health protection, that sludge generators do not test the waste more frequently. For example, waste is often only tested for dioxin twice a year because of the cost of the test. A worker may accidentally spill pesticides into a sink or storm drain, or someone might illegally dump other toxic chemicals down the drain, and no matter how strict regulations are in the law books, testing could miss these sudden increases in contaminants. Regulations and testing cannot guarantee sludge safety until toxic chemicals are removed from industrial household use.

10. Sludge consequences

"Temporary odors are a necessary inconvenience in the practice of agriculture."[14] Sludge smells similar to manure and that the smell will dissipate "within several days." Despite industry propaganda, studies have shown that sludge odors are more than just a nuisance; they are a public health threat. Harmful gases, called organic amines, can develop from chemical reactions that occur in sludge. These gases are released when the pH of sludge is raised above 10, such as when lime is added. Studies suggest that sludge odor can cause health problems in humans as far as 1600 feet from a site.[15] A study performed by a former EPA sludge regulator linked sludge odors to "severe irritation to mucous membranes followed by respiratory infections" in residents living near a sludge site. Irritation of the eyes, throat and skin make infection from pathogens in sludge more likely. The study was conducted following the death of a New Hampshire man suffering from respiratory distress in the vicinity of a sludge site.[16] Residents near sludge sites have not been the only victims of sludge odor. Symptoms associated with organic amine poisoning frequently occur among waste treatment plant workers and drivers who haul sludge.

10.1. Deaths associated with sludges

At least two deaths have been associated with sludge spreading. In October 1994, an eleven-year-old boy, named Tony Behun, went dirt bike riding near his home in Osceola Mills, Pennsylvania. Unknowingly, the boy rode through a field covered in Class B sludge. He came home covered in dirt and grime. Two days later, he developed a sore throat, headache, and a boil on his left arm. Brenda Robertson, his mother, took him to the doctor, who prescribed flu antibiotics. The next day, Tony had trouble breathing. He died after being flown by helicopter to a hospital in Pittsburgh. The final diagnosis was that Tony had died from a bacterial infection. How her son contracted the infection remained a mystery to Brenda Robertson until five years later when she read about an investigation into her son's death by the Pennsylvania Department of Environmental Protection. Without consulting Brenda, the state published a report concluding that Tony died of a bee sting and that Class B Sludge *was not* spread on property that he went riding on.

Another sludge related death occurred in Greenland, New Hampshire. In late October of 1995, the Marshall family had their otherwise quiet lives tragically disrupted. Sludge was being dumped on a field in their rural neighborhood. This was just the beginning of the residents' problems. On Halloween, Joanne Marshall rushed home from work to take her little girl trick-or-treating. When she arrived home and jumped out of her car, she was "greeted by such a stench, it took her breath away."[17] The Marshalls and their neighbors began suffering from nausea, vomiting, stomach cramps, migraine headaches, flu-like symptoms, slowed reflexes and respiratory problems.

10.2. Environmental Assessment and some remedy:

Recycling sewage sludge to agricultural land to gain benefit from the essential plant nutrients and organic matter it contains, would seem a reasonable and rational method of managing a material which would otherwise need disposing of by some other non-beneficial route. But sludge also contains inorganic, organic and biological contaminants and so careful, management is required to avoid the potential environmental problems. The problems are listed in following Table (Table-2). Large application of sewage sludge can decrease the soil pH. This can be avoided, if the soil pH is increased by application of lime, or if sludge application rates are limited in some way.

The no. of bacteria of different genera in sludge varies. In general, a total coliform count of 10 to 10 can be found per gram of dry wt., while fecal coliform bacteria generally represent 10 to 10 per gram of dry wt. The pathogens should be reduced to levels that are unlikely to cause a threat to public health and the environment under specified use conditions processes to significantly reduce pathogens, such as digestion, drying, heating and high pH or their equivalent are the most commonly used one.

For the removal of OCs from sludge mainly two approaches ar there – physico chemical or microbiological which involves either high temperature oxidation (incineration) or reductive dechlorination (pyrolysis in an atmosphere of hydrogen). To achieve allow level of risk, presticide concentrations in the combined soil and sludge mixture must be less than 1.25 mg/kg dry wt.

Table-2. Environmental impact risk and benefit assessment for sewage sludge recycling to agricultural land (B= beneficial effect, L=Low risk, P=Possible risk, NA=Not applicable.)

Environm-ental parameter	**PTEs**	**Organic contaminants**	**Pathogens**	**Nitrogen**	**Phosphorus**	**Organic matter**
Human health	L	P	L	B	B	B
Crop yields	L	L	L	B	B	B
Animal health	L	L	L	B	B	B
Ground water quality	L	L	L	P	L	L
Surface water quality	L	L	L	P	P	B
Air quality	L	L	L	P	NA	NA
Soil fertility	P	L	L	B	B	B
Natural ecosystem	P	P	L	P	P	B

(Source: Gibbs, Lois Marie *et al.* 1995)

11. Sludge regulation

Sludge, by its very nature, is difficult to regulate. Depending upon what chemicals are being released into various sewer systems minute to minute, the toxicity of the state's sludge could vary day-to-day, minute-to-minute (Table-3,4 and 5). Regulations of sludge do not adequately protect public health and the environment.

11.1. Regulations problems:

- Have weak pollution standards;
- Allow for the spreading of sludge containing live pathogens;
- Discourage municipalities from being precautionary and public health oriented by not allowing them to make stricter standards than the state's; and
- Marginalize citizens' voices in the process as the sludge industry has greater access to state regulators than the average citizen.

Table-3. Heavy Metals Standards (in ppm)

Heavy Metal	Denmark	Sweden	Finland	Germany	Netherlands	Norway	European Union
Arsenic	25	N/A	N/A	N/A	0.15	N/A	N/A
Cadmium	0.8	2.0	1.5	5 or 10*	1.25	2.5	20
Chromium	100	100	N/A	900	75	100	N/A
Copper	1000	600	N/A	800	75	1000	1000
Lead	120	100	100	900	100	80	750
Mercury	0.8	2.5	1	8	0.75	3	16
Nickel	30	50	100	200	30	50	300
Zinc	4000	800	1500	2500	300	800	2500

(Source Harrison, et al. 1999)

12. The sludge solution

If spreading sludge in our communities is dangerous, where should it go? What are we supposed to do with this waste? The real question is, how can we eliminate the spreading of toxic pollutants on our land and how can we eliminate these contaminants from our wastewater treatment plant so that human waste becomes a truly useful and safe commodity? Because sludge contains toxic chemicals and other pollutants, the best solution to our sludge problem is reducing these contaminants at their source (see the above tables). By dramatically reducing the use and disposal of industrial and household toxic chemicals we can greatly cut the chemical levels in sludge. Until the long-term goal of eliminating the use and disposal of toxic chemicals is achieved, the state should:

1. Ban the use of sludge that contains industrial discharges.
2. Require the strictest level of pathogen reduction.
3. Broaden and strengthen sludge testing and toxic limits.

4. Allow municipalities to enact ordinances that are more stringent than the state's regulations through the town meeting or a town-wide vote process.
5. Provide for the long-term pH maintenance and metal monitoring of sludge sites.

In addition to statewide protections, municipalities should also enforce their own protections through strong ordinances controlling sludge. It is, after all, local communities that are most threatened by sludge spreading.

Table-4. Sludge vs. Natural soil

Heavy Metal	**Average Sludge (ppm)**	**Natural Soil (ppm)**	**Times Higher than Natural Soil**
Arsenic	5.6	7.4	1.3
Cadmium	2.4	0.37	6.4
Copper	388.0	23.3	16.6
Chromium	33.3	30	1.1
Lead	61.5	17	3.6
Mercury	1.2	0.003	400
Molybdenum	7.5	0.79	9.4
Nickel	22.8	18	1.2
Selenium	2.6	0.45	5.7
Zinc	468.5	68.5	6.8

(Source Harrison, et al. 1999)

13. Disposal of sludges

Sludge disposal is a worldwide problem and a wide variety of disposal routes have been adopted as directed by local conditions. The final resting place of the sludge must be either on the land, in the air or in the water. Disposal of sludge to the air largly employs high temperature incineration or pyrolysis. Although, this reduction is sufficient to "stabilise" the sludge, a large volume remains for disposal. Disposal of sewage sludge to the ocean in now banned because of its perceived environmental effects. The major sludge disposal methods employed by the waste water treatment plants are alienation or selling lagooning, used for municipal gardens, used for instant lawn cultivation, land application. The remaining of the sludge is either stockpiled or land filled.

Table-5. Standard values for organic compounds

Compounds	Concentration in sludge
PAHs	1-10 mg./Kg.
Alkyl phenols	100 – 3000 mg./Kg.
PCBs	1 - 20 mg./Kg.
Poly chlorinated dibenzo-p-dioxins	Very low < µg /Kg.
OC pesticides	< low mg./Kg.
Monocyclic aromatics	<1 – 10 mg./Kg.
Chloro benzenes	<0.1 – 50 mg./Kg.
Aromatic & alkyl amines	0 – 1mg./Kg.
Phenols	0 – 5mg./Kg.

(Source Harrison, et al. 1999)

Disposal and application of sludge's should involve the following

1. The application must contain a summary of the types of crops to be grown on the proposed site, the method of sludge application, and an anticipated spreading schedule. The application must also include a representative soil nutrient analysis for the site.[18]

2. The sludge must provide "agronomic benefit" to the crops grown on this soil--meaning the generator must show that the site has a need for the nutrients provided for by the sludge. Farms utilizing sludge are required to have a licensed nutrient management specialist develop a whole farm nutrient management plan. This plan is the basis for the above determination that additional nutrients are needed on the farm.[19]

3. The application must show that "the water of the state will be protected." In practice, state regulators assume that the waters of the state will be protected as long as certain setbacks and spreading requirements are provided for in the application.

4. To this end, sludge cannot be spread when soil is frozen, snow covered, and water logged. Sludge cannot be spread on land that favors the growth of water loving plants such as wetlands, swamps and others.

5. The soil of a proposed sludge site must have a six-inch soil cap and a minimum depth to bedrock of 10 inches for perennial crops (such as hay) and 20 inches for row crops (such as corn).

6. For Class B sludge, spreading may not occur within 25 feet of on-site waterways, including gullies, ravines, and swales. Sludge sites may not be located within 75 feet of a river, perennial stream, or great pond.

7. The application must include a statement as to whether or not the site is located on or next to a protected natural resource, a sensitive area, and/or a direct watershed to waters.

8. The generator must demonstrate that the sludge spreading activity will meet traffic standards for the site. This standard is assumed to be met if the sludge spreading activity will result in 16 or less vehicle trips a day.[20]

9. The application must include a site-specific odor control plan to prevent nuisance odors at neighboring properties. It assumes that odor, air quality, and nuisance standards will be met at the site if the site is 300 feet from occupied buildings, if there is a site specific odor control plan.[21]

10. The application must prove that the sludge is "non-hazardous". To prove this, the application must include an analysis of the heavy metal levels in the sludge. If the generator's sludge contains heavy metal concentrations above screening concentrations then the application must include a sampling and monitoring plan as well as demonstrate that the maximum heavy metal soil concentration will not be exceeded.

11. The application must also include an analysis of the dioxin level in the sludge. If a generator's sludge contains 27 parts per trillion of dioxin, then the application must include a statement signed by the generator, the landowner, and the operator acknowledging the dioxin in the sludge to be spread.

    The statement must also include an agreement to the following conditions:

    - The site will be tested for dioxin within 3 months of the last sludge spreading.
    - If the soil on the site contains 27 parts per trillion of dioxin, then livestock intended for human consumption may not be pastured on site, crops for human consumption may not be grown on the site, and the deed to the site must record this information.

12. The application must also include a sampling plan: how often and in what manner the sludge will be tested for heavy metals and other toxins.[22]

13. Sludge will be spread at a minimum of 15 inches above groundwater surfaces. Food crops grown on the site with harvested parts that touch the soil will not be harvested for 14 months after the last sludge spreading.

14. If the sludge remains on the land for four months or more before being incorporated into the soil, food crops that grow below the soil cannot be harvested for at least 20 months after the last sludge spreading.

15. Food crops, feed crops, and fiber crops grown on the site but do not have harvested parts that might touch the sludge cannot be harvested for at least 30 days after the last sludge spreading.

16. Domestic animals are not allowed to graze on the land for at least 30 days after the last sludge spreading.

17. Turf grown on the site cannot be harvested for one year after the last sludge spreading.

18. The application must contain site maps, including: a topographical map; a sketch of the site; a tax map; soils map (from U.S. Department of Agriculture); sand and gravel aquifer map; and a flood zone map.

19. The site sketch should include all the set backs and buffers that will be incorporated, as well as the location of onsite and abutting roads, wells, and buildings. The topographical maps are used to determine slopes at the site. The soils, sand and gravel aquifer, and flood zone maps are used to determine if the site is suitable, in a regulatory sense, for sludge spreading activities.[23]

14. Recommendation

14.1. Policy recommendation

- Prohibit sludge that contains industrial discharges from being land applied. The best way to ensure that our rural land is protected from industrial contamination is to ban the use of sludge that contains these toxins.

- Require land spread sludge to undergo the strictest pathogen reduction method available. Sludge with viruses, bacteria, and parasites above background levels should not be land applied.

- Broaden and strengthen sludge testing parameters. Sludge needs to be tested more frequently for more contaminants. In order to best protect public health and the environment, allowable pollutant levels should be guided not only by toxicology but also by natural background levels as well.

- Allow municipalities to enact ordinances that are more stringent than the state's through a town meeting or town-wide vote. The people who are most affected by sludge sites are local residents. It is important that these residents have a voice when it comes to decisions that affect their community.

- Provide for long-term maintenance of sludge sites. Sludge generators should be responsible for testing the pH of all sludge application sites, whether active or closed, and cover the costs of lime (or other amendments) to maintain safe soil pH. All large volume sludge activities should be recorded on deeds so that future potential buyers are aware of past use of the property.

14.2. Recommendation for municipalities

- Sludge is an especially important issue for municipalities to oversee: it is local residents that have the most to lose from the threat of sludge.

- In municipalities that are home to a wastewater treatment facility, local residents, town officials, and directors of the facility can work together to implement the above statewide recommendations at the local level.

- All towns have the authority to ban the use of sludge, or sludge materials (such as compost) on municipal property.

15. Conclusion

Citizens can protect themselves and their community from the dangers of sludge by being proactively engaged in sludge reform. Depending upon the needs of the community, citizens can reform sludge rules through engaging town officials, local and statewide public health and environmental groups. Municipalities should pass strict ordinances controlling sludge application. Although the state preempts local control on setting strict standards, there are several ways towns can discourage sludge spreading. Sludge contains toxic chemicals and other pollutants. The best solution to our sludge problem is reducing these contaminants at their source. By dramatically reducing the use and disposal of industrial and household toxic chemicals we can greatly cut the chemical levels in sludge. The long-term goal of eliminating the use and disposal of toxic chemicals should be achieved as soon as possible to protect our beautiful mother world.

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