

Aerosol Transmissions From Land Applied Sewage Sludge

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Please note: The size of the H1N1 virus is 0.1 micron. The size of E. coli bacteria as an indicator of fecal contamination (Class B sewage sludge allows up to 2 million colony forming units of coliform for E. coli bacteria (from 1.0 to 3.0 microns) per gram of dry sewage or the amount of bacteria alive on an area the size of a sugar cube.

Size of the pathogens is significant. **Any virus or bacteria less than 3.0 micron in size will not settle and will become part of the ambient air for everyone to breathe.** These particles and biological pathogens can become deposited in the soil, grass, trees, etc. The air can carry aerosol pathogens many miles and their ability to live is largely dependent upon temperature and humidity of the area.

Sewage treatments will not kill all the H1N1 viruses nor does it destroy the Tamiflu medication used as treatment. In fact, Tamiflu medication has been found in municipal water supplies nationwide (per USGS).

The "shedding" of the H1N1 Swine Flue virus can take as long as two weeks for children and teenagers. Since gastrointestinal problems are a part of the H1N1 influenza; municipal WWTPs have additional reasons for concern. The airborne method of spraying the Class B sewage sludge opens the door to transmission of any H1N1 viruses or chemical irritants present in the mixture that could make the children more likely to become ill from the aerosol pathogens/chemical irritant combinations.

There is no safe distance from a school to spray Class B sewage sludge. This waste disposal process exposes children to whatever may be in the sewage sludge. Children at play touch the ground, get dust on clothing, have contact with playground equipment where the pathogens can live on solid hard surfaces for up to 48 hours, and most active children practice hand/mouth contact routinely.

Dr. McGowan made these comments at my request regarding the article: "The Health Hazards of Treated Sewage Sludge Applied to Land" He is a physician, surgeon, and a medical geo-hydrologist with 40 years experience with the World Health Organization and the US State Department in dealing with international problems with disease, water, soil and airborne transmission of pathogens. I have a list of references he sent if anyone wants to do further investigation and reading.

Re: Movement of pathogens and their genetic material from sewage sludge (land applied biosolids) to humans and consequent public health implications by Dr. McGowan:

I realize that some of these publications used come from the UK but the damage is not confined to the UK. The WHO and CDC (the latter has no solid program for tracking antimicrobial resistance in biosolids) both note that antimicrobial resistance is a major crisis. As noted by Selvaratnam and Kunberger in their paper "Increased frequency of drug-resistant bacteria and fecal coliforms in an Indiana Creek adjacent to farmland amended with treated sludge" we have a water transport problem. But water is not the only transport system.

With the vast farmland and forest areas that receive biosolids, the issue is broadened when one discusses the potential for the return of dust bowl days. Climatologists are predicting that major portions of this globe will see continuing droughts. If we are returning to droughts, then it seems reasonable that the lack of water will see large areas now under till going out of production and the soils will be left to the elements. I saw this in Africa when I was the State Dept's environmental advisor and see this here in the US when the ag-urban conflict gets too great for ag to continue. Actually, I see this a lot as growers spend down their soils preparatory to selling to impending development.

Dr Richard Seager of the Lamont-Doherty Earth Observatory (LDEO) of Columbia provides a map showing the projected drought area which can be Googled. The LDEO report indicates that drought conditions are expected to resemble the Dust Bowl years of the 1930s and Texas' worst-ever drought of the 1950s. The LDEO study found that unlike those former droughts, the new conditions will not be temporary.

With the trend for industry to recombine toxic and hazardous waste as well as sewage into "new" products and thus claim exemptions from liability in handling those hazardous materials, many are now being placed on American farmlands as biosolids under the rubric of fertilizer or soil amendment. In addition, we are seeing discarded tires shredded and added to sewage sludge which is composted, the tires being added as a bulking agent. There is insufficient research here as it is unclear that the composting operations are actually able to destroy the toxins and allergens. Latex is a major emerging allergen. If these materials are added to soils and these soils later abandoned, they may blow about.

Take these two scenarios and combine----drought and land contaminated by addition of heavy industrial waste (biosolids).

The soil that blew around in 1930s dust bowl days was relatively clean. Pesticides had not been developed to any extent and the use of sewage sludge and all its attendant industrial toxins and antibiotic resistant pathogens was something of the unknown future. But now we have soils that are heavily contaminated with various industrial wastes and antibiotic resistant pathogens. If they start to blow around as noted above, the human health impacts are going to be significant.

These bacteria when released by sewage treatment or contained within sewage byproducts are thus able to colonize environmental niches, and animals, including humans, through ingestion. Once ingested, the mobile genetic elements may be transferred to normal flora, and subsequently to pathogenic bacteria found in humans or animals, making later treatment with particular antibiotics ineffective. Thus, here we have two mechanisms that can see transfer to humans in the rural environment.

The first is straight human contamination; the second is secondary from livestock to humans----or pets and wildlife to humans. Stuart Levey in his book, the Antibiotic Paradox, discussed this train of transfer. It is also seen via soil organisms such as nematodes which feed on bacteria, the genetic information being transferred to their gut microbes, and then they (nematodes) infest crops. If those crops are consumed raw, then the genetic information is transferred to the human gut flora. Also one must consider transfer of genetic information from these microorganisms to more robust organisms as highlighted by Sjolund et al. (2005) [1] indicating that resistance in the normal flora, which may last up to four-years, might contribute to increased resistance in higher-grade pathogens through interspecies transfer.

Sjolund et al go on to note that since populations of the normal biota are large, this affords the chance for multiple and different resistant variants to develop. This thus enhances the risk for spread to populations of pathogens. Furthermore, there is crossed resistance. For example, vancomycin resistance may be maintained by using macrolides [2]. None of this seems to be considered within the risk assessment draft document.

The finger to mouth route is also necessary to discuss in any drift study as surfaces distant from the source can become contaminated.

AEROSOLS

How far are the nearest critical targets from the proposed biosolids application area or from the area receiving disking? **In the Caribbean, dust arising from Africa causes respiratory disease [12]. That is a transit of somewhere over 3,000 miles and during the 2 to 3 weeks the dust is in transit, it is subjected to intense UV at the very high altitudes it attains while crossing the Atlantic.**

In looking at local agriculture, what is the average wind speed and wind run in the area, then what are the upper ranges?

From Tellier's tables, I generated a small series of curves, the base data for which are noted below (R Tellier - Emerg Infect Dis, 2006 Nov;12(11):1657-62. ncbi.nlm.nih.gov)

These are for the drift of particulates in the following range: 10uM and 5uM. **Something smaller than 3uM will essentially not settle out and this is also the range in which pathogens and genetic fragments fall and also those that reach the deepest recesses of the respiratory system.**

The risk analysis needs to spend more time discussing this. Also, as previously mentioned elsewhere, the use of reclaimed water (see Joan B. Rose's work for WERF on this) which contains pathogens, genetic fragments, and antibiotic resistance can also confound the issue if these two sources of sewage byproduct are used within the same or overlapping areas. Because reclaimed water receives substantially more treatment than biosolids, yet we are finding resistant pathogens in it, there should be no doubt about finding resistance in biosolids, which is in fact the case.

The table below demonstrates the extent of pathogen drift. By definition, an aerosol is able to remain in suspension for prolonged periods because of its low settling velocity. The energy and disturbance supplied by tillage may see the dust rise several meters. [A meter is 3.2808 feet]

For spherical particles of unit density the settling time for a 3-M fall is noted in the table below. As we all know, the dust behind a tractor may rise several meters above this. Nonetheless, using the 3-meter fall and considering the size of both bacteria and viruses it will be noted that aerosol movement is considerable. Remember that the average bacteria is 1 uM and a virus about 1/100 of that. **[H1N1 is 0.1]**

TABLE*

Assumptions: 5 mph** average wind speed, laminar flow. In an open flat areas such as farmland laminar flow would need to be considered.

Particle Diameter.....	Settling Time.....	Distance at wind speed 5 mph**
100 uM.....	10 sec.....	44 ft
20 uM.....	4 minutes.....	1780 feet
10 uM.....	17 minutes.....	7480 feet (1.4 miles)
5 uM.....	62 minutes.....	approx 5 miles
< 3uM.....	These essentially will not settle.	

* Adapted from Tellier's work.

** 5 mph is about as fast as a rapid walk.

Note: The median diameters at which particles exhibit aerosol behavior also corresponds to the size range that will reach the deepest recesses of the respiratory tract (lungs).

Assume that a 10uM particle settles in 17 minutes from a drop height of 3 M; in a 5 mph wind with laminar flow it moves 7,480 ft from the release point (about 1.4 miles).

At 10 mph it will now move2.8 miles
 At 15 mph.....4.25 miles
 At 20 mph.....5.7
 At 25 mph.....7.1
 At 30 mph.....8.5
 At 35 mph.....9.9
 At 40 mph.....11.3
 At 45 mph.....12.7

Assume a 5uM particle that settles in 62 minutes from a fall of 3 meters.

At 10 mph.....10.3 miles
 At 15 mph.....15.5
 At 20 mph.....20.6
 At 25 mph.....25.7
 At 30 mph.....30.9
 At 35 mph.....41.2
 At 45 mph.....46.4

When particles get much smaller than 5uM; the distances go up almost exponentially.[**ALL VIRUS PATHOGENS**]

The manipulation of the soil through disking is perhaps the predominant generator of aerosols. After several seasons of application, there will likely be a shift in soil biota and the potential adaptation of pathogens and incorporation of genetic information into that soil. There are several papers on the persistence of viable genetic material within dry soils, long past the detection of their progenitors. When these soils are worked later in the season, the more robust microbes and genetic fragments may be surviving, especially the spore-formers. This is not well discussed if discussed at all. Please remember that during WW II, the Brits played about with Anthrax on a small island off Britain and subsequently were required to quarantine it for 50 years. I think more needs to be said here about the spore-formers and later tilling operations that may generate large clouds of dust.

Additionally friable soil can move with wind and disking is really not needed. As noted above, if the global climate shifts to a dryer system, the various climate agencies are predicting the return to dust bowl days and this needs to be considered, especially where there are years of accumulated biosolids.

(References and sources on request)