

Getting a Handle on Biosolids New Model Estimates Microbial Exposure Risk

Each year several million tons of treated sewage sludge (“biosolids”) are applied to crop land, reclaimed surface mines, forests, parks, and various other land areas in the United States. Yet the public health risk from exposure to pathogens in biosolids has never been quantitatively assessed because of the lack of an appropriate model and a paucity of exposure data. Now researchers have developed a model that can estimate microbial exposure, starting with data on the content of certain pathogens in raw sewage sludge, through the treatment process, and ending with exposure to humans [EHP 116:727–733; Eisenberg et al.].

Untreated sewage sludge contains a wide variety of microbes and parasitic worms. Current federal standards for pathogen reduction in sewage sludge are based on levels of a few indicator organisms, such as

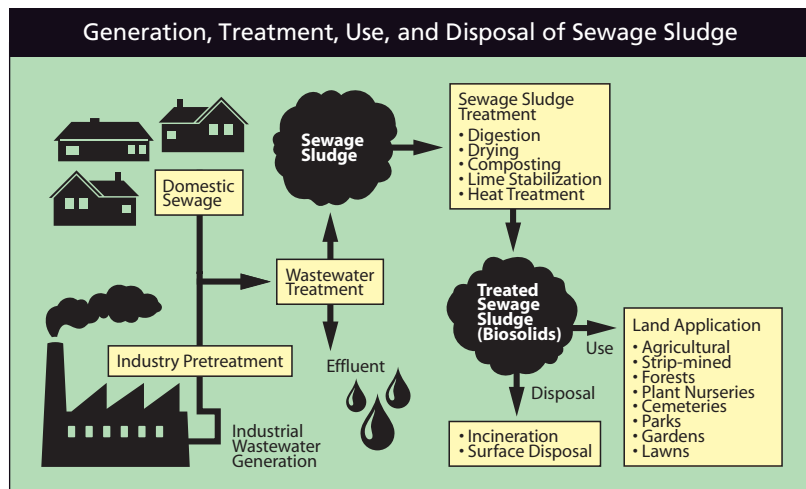
Escherichia coli and enteroviruses. A National Research Council committee concluded in 2002 that while there was no evidence that the standards had failed to protect public health, there also had been no concerted effort to investigate health complaints and the potential for adverse human health effects from exposure to biosolids.

In the current proof-of-concept article, the model was used to examine three pathogen exposure pathways—ingestion, drinking contaminated groundwater, and inhalation—using data for Class A biosolids, one of two EPA-designated categories of biosolids. Class A sludges have no detectible indicator organisms; low levels of indicator pathogens are permitted in class B sludges. The team used Class A biosolids data for testing.

The authors demonstrated the model’s utility by calculating human exposure in different settings. Using enterovirus concentration as a proxy for pathogens in general and beginning with data on raw sludge, they calculated the attenuation that resulted from anaerobic digestion with or without the use of lime to control the growth of pathogens. They also considered natural attenuation.

The modeling suggests that treatment systems using two anaerobic digesters substantially reduce pathogen loads. The most hazardous exposure was seen with contaminated groundwater. Ingesting a 100-mg speck of treated sludge was the next-riskiest exposure, and aerosol exposure was the least risky. Although the new model was not developed with the intention of examining specific disease outcomes, it lays the foundation for future models that could address end points such as irritation of the skin, mucous membranes, and respiratory tract.

The authors conclude that risk assessments for biosolids exposure are practical, even for Class A biosolids for which post-treatment monitoring data are below detectable limits. They also believe pathogens in biosolids can now be regulated similarly to water-related risks. —Rebecca Renner



Source: Adapted from *Environmental Regulations and Technology Report: Control of Pathogens and Vector Attraction in Sewage Sludge*. EPA/625/R-92/013. Washington, DC: U.S. EPA, 2003: p. 1. (Matthew Ray/EHP)

Brain Effects Stick Around PFCs and Neural Cell Development

Although some perfluorinated chemicals—manmade compounds used in such goods as nonstick cookware and stain protectors—are no longer manufactured, decoding the ways in which these chemicals affect humans and wildlife is important because of the stability of the compounds, their persistence in the environment, and their long retention times in living organisms. To date, the biological mechanisms through which these chemicals cause damage have not been well understood. Now, however, researchers have shown that four common perfluorinated chemicals—perfluorooctane sulfonamide (PFOSA), perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutane sulfonic acid (PFBS)—affect developing PC12 cells in ways that suggest a variety of mechanisms of action [EHP 116:716–722; Slotkin et al.].

The team studied whether the chemicals affected the cells’ ability to synthesize DNA, the growth of the cells and their ability to reproduce, cell viability, and the tendency of the cells to manufacture dopamine and acetylcholine neurotransmitters as they differentiated into neural cells. The investigators also assessed the abilities of the chemicals to induce oxidative stress that can damage or kill cells.

For a benchmark comparison, the research team compared the effects of PFOSA, PFOS, PFOA, and PFBS to those of chlorpyrifos, an insecticide and known developmental neurotoxicant. The PC12

cells, a model of neuronal development, were exposed to the chemicals in five concentrations ranging from 10 μM to 250 μM. The effects were assessed over six days—long enough for the cells to differentiate into neuronlike structures.

The researchers demonstrated that all four perfluorinated chemicals affected the PC12 cells. PFOSA had the strongest effects on the health of the cells. Next most significant was PFOS, with PFBS and PFOA tied for third place. Despite similarities in their chemical structures, each chemical had a different effect on neurodevelopment, which suggests the adverse effects are likely mediated by different mechanisms.

PFOSA behaved very differently from PFOA and PFOS. At all concentrations, PFOSA suppressed the production of DNA. At the highest concentration, almost all DNA production was prevented. In addition to PFOSA preventing the production of new cells, existing cells appeared to have been destroyed. Even at the lowest concentration, PFOSA caused more oxidative stress than that seen with a five-fold higher concentration of chlorpyrifos. At the highest PFOSA concentration, cell viability plummeted.

The researchers offer one possible explanation for PFOSA being more toxic than the other perfluorinated chemicals—it is more hydrophobic and therefore crosses cell membranes more easily. This ability to enter cells could indicate that PFOSA and perfluorinated chemicals with similar properties are better able to cross the barriers that guard the placenta and developing brain tissues. Hence, these chemicals may warrant particular research attention. —Scott Fields

Methylmercury Pause Study Suggests Long Latency for Neurotoxicity

Methylmercury (MeHg) easily crosses the blood–brain barrier and accumulates in the central nervous system, where it is demethylated to inorganic mercury. Chronic perinatal exposure to environmentally relevant levels of MeHg is associated with the occurrence later in childhood of neurobehavioral problems such as impaired attention and fine motor function. Animal studies confirm this association, but epidemiologic evidence is mixed despite extensive study. Moreover, MeHg toxicity and the period of time before effects appear are not completely understood, as few studies have been conducted beyond the first months or years of life in either animals or humans. Researchers now demonstrate in a mouse model that effects from early exposure to methylmercury can occur years after early-life mercury levels in the brain have declined [*EHP* 116:746–751; Yoshida et al.].

In the current study, investigators used two strains of mice—the wild-type C57BL strain and the genetically manipulated metallothionein (MT)-null strain. The latter was used to examine potential genetic susceptibility to the toxic effects of MeHg exposure, as MT-null mice do not produce metallothionein-I and II proteins that can bind metals and protect against their toxic effects. Mice were exposed through diet to low levels of MeHg (5 µg/g diet) from the first day of pregnancy through the tenth day after birth. Offspring of the treated

mice were weaned at 28 days. At 12 and 52 weeks (roughly comparable to young adulthood and middle age in humans), the offspring underwent behavioral tests of their locomotor activity and learning ability. All animals were weighed biweekly, and mercury concentrations in the brains, livers, and kidneys were measured for 10-day-old mice and for the group tested at 12 weeks.

In 10-day-old exposed mice, mercury concentrations in the brain were 0.5 µg Hg/g body weight or lower, with no significant differences observed between exposed wild-type mice and MT-null mice. At 13 weeks, concentrations of mercury in the brain of exposed groups were similar to those of the unexposed groups. Except for one activity measure in female MT-null mice, exposure to MeHg did not significantly affect behavioral test responses at 12 weeks. At 52 weeks, however, investigators observed significant effects in all behavioral test responses, with MT-null mice being slightly more affected. After 28 weeks, wild-type male and all MT-null mice exposed to MeHg weighed significantly less than control mice, which may signal an emerging toxic effect.

The authors demonstrate a long latency period after perinatal exposure to low levels of MeHg and show that this period may be influenced by genetic susceptibility, given the stronger effect of MeHg exposure in MT-null mice. The existence of a latency period suggests that a slow process, such as aging, plays a role in MeHg toxicity, although the actual damage occurs much earlier in life. —Julia R. Barrett

Toxicants and Teen Health Pollutant Effects on Adolescent Thyroid Function

Persistent organic pollutants (POPs), as their name suggests, persist in the environment, contributing to the burden of toxicants threatening human health. The evidence to date strongly suggests these chemicals contribute to endocrine disruption, including altered thyroid function. Many studies have looked at health outcomes of POP exposure in infants and adults, but few have analyzed the effects in the age group in between: older children and adolescents. A new study now confirms a relationship in adolescents between altered thyroid function and prenatal exposure to certain POPs as well as to other common pollutants [*EHP* 116:806–813; Schell et al.].

Researchers in the current study examined the effect of POPs including polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), and *p,p'*-DDE (a metabolite of DDT), as well as lead, mirex, and mercury, on thyroid function. Study participants included 232 mother–youth pairs of the Akwesasne Mohawk Nation, who lived near an area with a history of local environmental pollution from neighboring industrial complexes. Between 1996 and 2000, trained Mohawk staff collected fasting blood samples from the youths (aged 10–17 years) and provided material for serum level analyses of the six toxicants as well as cholesterol, triglycerides, and the thyroid hormones triiodothyronine (T_3), thyroxine (T_4), and thyroid-stimulating hormone (TSH). The mothers provided socio-demographic and breastfeeding history information.

Serum PCB levels were consistent with chronic exposure to multiple toxicants. Levels for 16 congeners—including 8 persistent (with long physiologic half-lives) and 8 non-persistent—indicated both cumulative and recent exposures. Controlling for other toxicants, the investigators used multivariate regression analysis to examine the effects of PCB exposure on TSH, T_3 , and T_4 . They found that breastfed adolescents had higher levels of persistent PCBs and *p,p'*-DDE than non-breastfed adolescents. However, despite having lower levels of persistent PCBs, the non-breastfed

adolescents displayed a significant positive relationship between persistent PCBs and TSH and a significant negative one between persistent PCBs and free T_4 , whereas breastfed adolescents did not.

The highest level of lead measured in the study population was less than half the Centers for Disease Control and Prevention action level of 10 mg/dL (lead was positively associated with T_3). Mercury levels were well below the Environmental Protection Agency reference dose of 5.8 mg/L in all but one adolescent. More than 50% of the study population had mirex levels below the method detection limit of 0.02 ppb as well as a negative association of HCB with T_4 levels.

Thyroid hormones are important because they regulate metabolic rate, growth, cognitive development, and many other important functions. These findings support the hypothesis that prenatal exposure to PCBs and other toxicants alters long-term thyroid function. Postnatal exposure cannot be excluded as an influence, but exposure from breastfeeding was not linked to an effect on thyroid hormones. —Tanya Tillett

A fishing boat navigates the St. Lawrence River off the Akwesasne Mohawk Nation

