DOWNLOAD PDF SLUDGE HEALTH RISKS OF LAND APPLICATIONS

Chapter 1 : Frequent Questions about Biosolids | Biosolids | US EPA

Introduction. Sewage sludge (also known as 'biosolids') refers to the semi-solids left over from municipal waste water treatment. Current legal disposal options include incineration, landfill, and land application to agricultural land, rangeland, or forests.

You can help by adding to it. June Ocean dumping[edit] It used to be common practice to dump sewage sludge into the ocean, however, this practice has stopped in many nations due to environmental concerns as well to domestic and international laws and treaties. Biosolids Biosolids is a term widely used to denote the byproduct of domestic and commercial sewage and wastewater treatment that is to be used in agriculture. National regulations that dictate the practice of land application of treated sewage sludge differ widely and e. Depending on their level of treatment and resultant pollutant content, biosolids can be used in regulated applications for non-food agriculture, food agriculture, [33] or distribution for unlimited use. Treated biosolids can be produced in cake, granular, pellet, or liquid form and are spread over land before being incorporated into the soil or injected directly into the soil by specialist contractors. Such use was pioneered by the production of Milorganite in Use of sewage sludge has shown an increase in level of soil available phosphorus and soil salinity. The impact of this persistence in soils is unknown, but the link to human and land animal health is likely tied to the capacity for plants to absorb and accumulate these chemicals in their consumed tissues. Studies of this kind are in early stages, but evidence of root uptake and translocation to leaves did occur for both triclosan and triclocarban in soybeans. Switzerland, Sweden, Austria, and others introduced a ban. Since the s there has been cooperative activity with industry to reduce the inputs of persistent substances from factories. Pyrolysis of the sludge to create syngas and potentially biochar is possible, as is combustion of biofuel produced from drying sewage sludge or incineration in a waste-to-energy facility for direct production of electricity and steam for district heating or industrial uses. Thermal processes can greatly reduce the volume of the sludge, as well as achieve remediation of all or some of the biological concerns. Direct waste-to-energy incineration and complete combustion systems such as the Gate 5 Energy System will require multi-step cleaning of the exhaust gas, to ensure no hazardous substances are released. In addition, the ash produced by incineration or incomplete combustion processes such as fluidized-bed dryers may be difficult to use without subsequent treatment due to high heavy metal content; solutions to this include leaching of the ashes to remove heavy metals or in the case of ash produced in a complete-combustion process, or with biochar produced from a pyrolytic process, the heavy metals may be fixed in place and the ash material readily usable as a LEEDs preferred additive to concrete or asphalt. In both cases this allows for production of electricity with less carbon-dioxide emissions than conventional coal-fired power stations. The EC encourages the use of sewage sludge in agriculture because it conserves organic matter and completes nutrient cycles. Recycling of phosphate is regarded as especially important because the phosphate industry predicts that at the current rate of extraction the economic reserves will be exhausted in or at most years. The specific problem is: June Learn how and when to remove this template message According to the EPA, biosolids that meet treatment and pollutant content criteria of Part Biosolids that meet the Class B pathogen treatment and pollutant criteria, in accordance with the EPA "Standards for the use or disposal of sewage sludge" 40 CFR Part , can be land applied with formal site restrictions and strict record keeping. PFRPs include pasteurization , heat drying, thermophilic composting aerobic digestion, most common method , and beta or gamma ray irradiation. The follow-up report in documented that "the EPA cannot assure the public that current land application practices are protective of human health and the environment. This is probably the greatest issue with the practice: To some degree, this lack of oversight is a function of the perceived by the regulatory agencies benign nature of the practice. However, a greater underlying issue is funding. Few states and the US EPA have the discretionary funds necessary to establish and implement a full enforcement program for biosolids. In the case of New York City, at first the sludge was discharged directly along the banks of rivers surrounding the city, then later piped further into the rivers, and then further still out into the harbor. This was deemed a successful public health measure and not until the late s was there any examination

of its consequences to marine life or to humans. There was accumulation of sludge particles on the seafloor and consequent changes in the numbers and types of benthic organisms. In a large area around the site was closed to shellfishing. From then until to , the practice of dumping at the Mile Site came under increasing pressure stemming from a series of untoward environmental crises in the New York Bight that were attributed partly to sludge dumping. In , sludge dumping was moved still further seaward to a site over the deep ocean called the Mile Site. Then, again in response to political pressure arising from events unrelated to ocean dumping, the practice ended entirely in The wider question is whether or not changes on the sea floor caused by the portion of sludge that settles are severe enough to justify the added operational cost and human health concerns of applying sludge to land. Since [edit] After the Congressional ban on ocean dumping , the U. Environmental Protection Agency EPA instituted a policy of digested sludge reuse on agricultural land. The US EPA promulgated regulations â€" 40 CFR Part â€" that continued to allow the use of biosolids on land as fertilizers and soil amendments which had been previously allowed under Part The EPA promoted biosolids recycling throughout the s. The Part regulations became effective in Rosendall was the former president of Synagro of Michigan, a subsidiary of Synagro Technologies. Kern county passed an ordinance "Keep Kern Clean" ballot initiative which banned sludge from being applied in Kern County. Los Angeles sued and the case has yet to be decided, as of

Chapter 2 : Sewage sludge - Wikipedia

A more detailed report on the health risks from pathogens associated with land application of sewage sludge can be found in "Hazards from pathogenic microorganisms on landdisposed sewage sludge", which outlines the range of pathogens found in sludge and their longevity in the soil.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. Solutions to these environmental problems require an integrated program of research and development using input from a number of disciplines. The Health Effects Research Laboratory, Research Triangle Park, NC and Cincinnati, OH, conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using human volunteer subjects. Wide ranges of pollutants known or suspected to cause health problems are studied. The research focuses on air pollutants, water pollutants, toxic substances, hazardous wastes, pesticides, and non ionizing radiation. The laboratory participates in the develop- ment and revision of air and water quality criteria and health assessment documents on pollutants for which regulatory actions are being considered. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of environmental regulatory decisions involving the protection of the health and welfare of all U. This report provides information on the health effects of land application of municipal sludge. The results of this study suggest that the land application of sludge can be a safe practice, provided that the proper precautions are taken. The agents, or pollutants, of concern from a health effects viewpoint are divided into the categories of pathogens and toxic substances. The pathogens include bacteria, viruses, protozoa, and helminths; the toxic substances include organics, trace elements, and nitrates. For each agent of concern the types and levels commonly found in municipal wastewater and sludge are briefly reviewed. A discussion of the levels, behavior, and survival of the agent in the medium or route of potential human exposure, i. Infective dose, risk of infection, and epidemiology are then briefly reviewed. Finally, some general conclusions are presented. The practice has continued for millennia in the Far East. Sewage sludge or "municipal sludge" has characteristics that make it valuable as a fertilizer and a soil conditioner it contains fair amounts of nitrogen, phosphorus,and micronutrients, and it increases soil friability, tilth, pore space, and water-holding capacity. In the United States a mandate for the greater use of land application of both municipal wastewater and sludge has been provided by the Clean Water Act of PL , Title. Land application of sludge consists of the low-rate application compared with a purely disposal operation to agricultural, forest, or reclaimed land of municipal wastewater sludge which has been "stabilized" in some way, e. That land application of sludge is an important and probably growing practice in the U. With the application to land of large volumes of wastewater and sludge, it is evident that considerable potential for adverse health effects exists. The major health concerns with land treatment of wastewater and land application of sludge are somewhat different. Thus, the potential exposure of humans through the routes of aerosols and groundwater is frequently emphasized with wastewater, and through the food chain with sludge. Nevertheless, the agents, or pollutants, of concern from a health effects viewpoint are almost the same in wastewater and sludge. These agents can be divided into the two broad categories of pathogens and toxic substances. The pathogens include bacteria e. The protozoa and helminths are often grouped together under the term, "parasites," although in reality all the pathogens are parasites. The toxic substances1 include organics, trace elements or heavy metals, e. Nitrates are usually not viewed as "toxic" substances, but are here so considered because of their potential hematological effects when present in water supplies at high levels. These agents form the basis of the main sections of this report. The major health effects of these agents are listed in Figure 1. Health effects of pathogens and toxic substances. For each agent of concern the types and levels commonly found in municipal sludge are briefly reviewed. Runoff to surface water is not considered, since it is assumed that this will be prevented in a well-managed sludge land application operation. For the pathogens, infective dose, risk of infection, and epidemiology are then briefly reviewed. Since only a fraction

of the total viruses in wastewater and other environmental samples may actually be detected, the development of methods to recover and detect viruses needs to be continued. The occurrence of viruses in an environmental setting should probably be based on viral tests rather than bacterial indicators since failures in this indicator system have been reported. The tremendous number of organic chemicals possibly present in sludge, together with their myriad health effects and poorly understood behavior in the environment, represent a potential for public health risk when the sludge is applied to agricultural land. Among the trace elements, probably only cadmium, under ordinary circumstances, is likely to be of health concern to humans as a result of the land application of sludge, with the exposure being through food plants or organ meats. Minimizing of health risks can probably be accomplished by the monitoring of sludge composition, and the regulation of maximum concentrations and cumulative application of toxic substances in land-applied sludge. The complexity of the organics composition of sludges, however, might require the development and use of biological assays to screen for toxicity Babish et al. Aerosols Because of the potential exposure to aerosolized bacteria, and possibly viruses, at land application sites, it would be prudent to limit public access to a sludge spray source, such as an active spray gun or tank truck. Human exposure to pathogenic protozoa or helminth eggs through aerosols is unlikely. Surface Soil and Plants The survival times of pathogens on soil and plants are summarized in Table 1 after Feachem et al. Since pathogens survive for a much longer time on soil than on plants, recommended waiting periods before harvest are based upon probable contamination with soil. However, what is a safe waiting period before crop harvest for human consumption is really an unsettled issue. Survival Times of Pathogens on Soil and Plants Soil Plants Pathogen Bacteria Viruses Protozoa Helminths Absolute Maximum 1 year 6 months 1 0 days 7 years Common Maximum 2 months 3 months 2 days 2 years Absolute Maximum 6 months 2 months 5 days 5 months Common Maximum 1 month 1 month 2 days 1 month Aerial crops with little chance for contact with soil should probably not be harvested for human consumption for at least one month after the last sludge application; subsurface and low-growing crops for human consumption would probably require a six-month waiting period after last application. These waiting periods need not apply to the growth of crops for animal feed, however. The levels of toxic organics likely to be present in soils at land application sites will probably result in very low levels in above-ground portions of plants, but levels in roots, tubers, and bulbs may present a health hazard. The potential increase in cadmium levels in human food due to land application of sludge is still an unsettled question. Present levels of total dietary intake of cadmium for most people appear to be fairly safe. However, in view of human variability in sensitivity and the variability in food supply, these levels probably should not be allowed to rise greatly. Movement in Soil and Groundwater Properly designed sludge application sites may pose little threat of bacterial or viral contamination of groundwater. Human exposure to pathogenic protozoa or helminths through groundwater is unlikely. Groundwater is unlikely to represent a significant organic or trace element threat. This can be prevented, however, by proper siting and management practice, e. Animals The literature to date suggests little danger of bacterial, viral, or protozoan disease to animals grazing at land application sites if grazing does not resume until four weeks after last application Yeager , but the need for complete inactivation of helminths in sludge before land application is still unsettled. The feeding of land- application-site-grown plants to animals is unlikely to pose a health problem, but grazing animals may accumulate significant levels of toxic organics. The issue of accumulation of organics from the soil by plants and animals particularly into milk , and into the human food supply, is poorly understood. Infective Dose, Risk of Infection, Epidemiology Because of the possibility of contracting an infection, it would be wise for humans to maintain a minimum amount of contact with an active land application site. Epidemiological studies to date suggest little effect of land application on disease incidence. However, many questions on the public health consequences of land application of wastewater and sludge remain Larkin All have symptomless infections and human carrier states, and many have important nonhuman reservoirs as well. The pathogenic bacteria of minor concern are listed in Table 3. This list is perforce somewhat arbitrary since almost any bacterium can become an opportunistic pathogen under appropriate circumstances, e. Recent reviews of pathogens in wastewater and sludge include those by Benarde , Burge and Marsh , Elliott and Ellis , Kristensen and Bonde , and Menzies Campylobacter jejuni formerly C. All produce acute diarrhea, but by different mechanisms. Outbreaks

occasionally occur in nurseries and institutions, and the disease is common among travelers to developing countries. Leptospirosis is a group of diseases caused by the bacteria, and may manifest itself through fever, headache, chills, severe malaise, vomiting, muscular aches, and conjunctivitis, and occasionally meningitis, jaundice, renal insufficiency, hemolytic anemia, and skin and mucous membrane hemorrhage. Fatality is low, but increases Table 2. Domestic and wild mammals, birds, turtles Shigella sonnei. Wild and domestic birds and mammals Y. Salmonella paratyphi A, S. Pathogenic Bacteria of Minor Concern Aeromonas spp. Bacillus aureus Brucella spp. Clostridium perfringens Coxiella burnetii Enterobacter spp. Legionella pneumophila Listeria monocytogenes Mycobacterium tuberculosis M. Pseudomonas aeruginosa Serratia spp. Staphylococcus aureus Streptococcus spp. Direct transmission from humans is rare, with most infection resulting from contact with urine of infected animals, e. Salmonella paratyphi A, B, C causes paratyphoid fever, a generalized enteric infection, often acute, with fever, spleen enlargement, diarrhea,and lymphoid tissue involvement. Fatality rate is low, and many mild attacks exhibit only fever or transient diarrhea. Paratyphoid fever is infrequent in the U. It occurs sporadically in the U. Death is uncommon except in the very young, very old, or debilitated Benenson There is negligible mortality associated with shigellosis Butler etal. Vibrio cholerae causes cholera, an acute enteritis characterized by sudden onset, profuse watery stools, vomiting, and rapid dehydration, acidosis, and circulatory collapse. Cholera is rare in the U. Yersinia enterocolitica and Y. Yersiniosis occurs only sporadically in the U. The term, "enteric bacteria," includes all those facultative bacteria whose natural habitat is the intestinal tract of humans and animals, including members of several families, particularly Enterobacteriaceae and Pseudomonadaceae e. They are all gram-negative, nonspore-forming rods Jawetz et al. The family Enterobacteriaceae includes the following tribes and genera Holt The terms, "total coliform" and "fecal coliform," are operationally defined entities used for indicator purposes. Their taxonomic composition is variable, but all are members of the Enterobacteriaceae. A recent study of fecally contaminated drinking water Lamka et al. The contribution from wash water, or "grey water," is probably relatively insignificant, except as it may contain opportunistic pathogens.

Chapter 3 : Land Application of Sewage Sludge | Biosolids | US EPA

Minimizing of health risks can probabl be accomplished by the monitoring c sludge composition, and the regulatio of maximum concentrations and curr ulative application of toxic substances! land-applied sludge.

This is an open access article distributed under the Creative Commons Attribution License , which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Abstract Land application of biosolids has proven a cost-effective method of waste disposal by beneficially recycling organic matter and nutrients and improving soil quality; however, it may also pose potential threat to the environment and human health. The purpose of this paper is to provide information on recent research progresses and regulation efforts regarding land application of biosolids, including forms and types and nutrient values of biosolids, environmental and health concerns, and related best management practices BMPs of biosolids application, with emphasis on its land application in agriculture. More research and regulations are expected to minimize potential risks of biosolids land application, especially its long-term impacts. These receiving water bodies became heavily polluted [1]. Since s, federal legislation has been strengthened to control water pollution. Municipal sewage treatment systems or publicly owned treatment works POTWs were built, although ocean disposal of residual solids was still permitted. The Federal Water Pollution Control Act Amendments of PL , placed further restrictions on the discharge of wastewater to waterways and encouraged other disposal methods such as land applications. Recent restrictions on ocean disposal Ocean Dumping Ban Act, and cost increase of incineration and landfill make land application an attractive option of disposal. Wastewater usually undergoes two processes in treatment factories. The primary step is a physical screening or settling process to remove sediment but with all the dissolved minerals still in the effluent. The secondary step is a biological process where dissolved biological matter is progressively converted into a solid mass using a cultivated culture of indigenous, water-borne bacteria, thereby large amount of biological oxygen demand BOD is removed from the wastewater. After the tertiary step, the effluent may be suitable for discharge into a stream, river, lagoon, or wetland or used for irrigation of public area such as golf courses, greenways, or park or injection to groundwater. To meet the regulatory requirements 40 CFR Part , described below for land application, the wastewater treatment residuals sewage sludge have to undergo treatments to reduce pathogens and attractiveness to vectors. Treatments include aerobic digestion, anaerobic digestion, composting, alkaline stabilization, and thermal drying. They may be also used to control odor and inactivate heavy metals. Regulations Regulations that ensure the safe and responsible management of sludge have been in effect since s. As a result, sludge quality has dramatically improved since then. The Rule is based on the results of risk assessments for chemicals that began in the mids, was more extensive than any previous federal rulemaking effort for sludge, and established biosolids quality requirements for its land application. These requirements address pathogen and vector attractiveness reduction, metal loading and concentration limits, and nutrient limits [4]. Pathogens and Vector Attractiveness As pathogens e. There are two classes of pathogen reduction: Class A and Class B. Class A pathogen reduction is necessary if biosolids are to be applied to lawns, home gardens, or other types of land, or bagged for sale, or land application and requires pathogen densities be reduced to below detection limits: There are 6 alternative methods for meeting Class A pathogen reduction requirement: Class B pathogen reduction is necessary for any other application and requires a fecal coliform density in the treated sewage sludge biosolids of 2 million MPN or CFU per gram total solids biosolids dry weight basis [5]. Viable helminth ova are not necessarily reduced in Class B biosolids. There are 3 alternatives for achieving Class B pathogen reduction: Public access is not restricted for biosolids that meet Class A requirements. Since Class B sewage sludge still contains considerable pathogens, site restrictions that limit crop harvesting, animal grazing, and public access for a certain period of time are required. Part regulation contains 12 options for demonstrating a reduction in vector attraction of sewage sludge: Options 1 through 8 and Option 12 are designed to reduce the attractiveness of sewage sludge to vectors, while Options 9 through 11 are to prevent the vectors from coming in contact with the sewage sludge. Trace Elements Trace elements in biosolids are of particular concern in regard to their effects on human and

animal health. The US EPA [8] analyzed their risks to humans, animals, plants, and soil organisms from exposure to pollutants in biosolids via 14 different pathways for land-applied biosolids. Land application of biosolids must meet the ceiling concentrations and cumulative loading rates for these 9 trace elements set in the Rule Table 1. If the concentration limit of any one of these elements is exceeded, the biosolids cannot be land-applied. The application of biosolids will also be required to cease, if it is estimated that the cumulative loading limit is being approached. Pollutant ceiling concentrations and cumulative loading amounts for biosolids adapted from [6] and mean concentrations measured in biosolids from the National Sewage Sludge Survey [7]. Exceptional quality biosolids can be used with few site restrictions except following normal agronomic practices. For biosolids that do not meet EQ standards, certain management practices are required: Nutrients Although maximum nutrient application rates in federal biosolids regulations are not well defined, the Rule stipulates that agronomic rates cannot be exceeded. To protect groundwater or surface water quality, nitrogen is regulated through an agronomic rate approach, requiring an estimate of crop N need and biosolids N availability [8]. Biosolids P applications are not regulated by the US EPA, but increasing numbers of states are introducing regulations, because of concerns about the effects of repeated manure or biosolids applications on soil P and risk of P loss to surface water. And Shober and Sims in [10] recommended a national biosolids P risk assessment be conducted to develop scientifically based national standards for P management. Forms and Types There are a large number of different forms of biosolids products including liquid, cake, and pellet form. Cake biosolids with the texture of a wet sponge can be created with digested liquid sludge or undigested liquid sludge alkali-stabilized with quicklime calcium oxide or hydrated lime calcium hydroxide. From liquid to cake to pellet form, both volume and weight of biosolids are subsequently reduced, increasing economic value by reducing transportation or storage costs. Pellet biosolids can be easily handled and spread with conventional agricultural equipments. Since soluble anions and cations are left in the liquid phase, nutrient composition can be changed in the dewatering processes during the production of cake and pellet biosolids. For instance, ammonium dominates the inorganic N in dewatered biosolids. Many nutrients may be dominated by less bioavailable forms in dewatered biosolids therefore, the loss of nutrients would be less from a dewatered biosolids than from a liquid biosolids when applied to soils [12]. Dewatered biosolids are more persistent but slower in nutrient release, while liquid biosolids are faster in providing nutrients for plant uptake. A survey of nutrient levels in biosolids conducted by Stehouwer et al. These biosolids were aerobically digested, anaerobically digested, or alkali-treated. Means and variability of nutrient concentrationsa in biosolids collected and analyzed in Pennsylvania between and [12]. Processes such as digestion or composting result in the loss of organic N because the readily degradable organic matter undergoes mineralization during digestion or composting. For instance, a loss of N by Phosphorus is largely present as inorganic phosphates of Fe, Al, and Ca. The relatively small content of H2O-extractable P may be due to the Fe, Al, and Ca in biosolids which are added during the treatment processes as metal salts and lime [20]. Compared to manures, biosolids have a lower N-to-P ratio, around 3. Biosolids have limited amount of K [21], which is partitioned into the aqueous fraction or effluent at the wastewater treatment plant. Biosolids contain several essential micronutrients for plants e. Therefore, biosolids can be applied on micronutrient-deficient soils e. Nutrient values of biosolids vary with sources of wastewater and wastewater treatment processes. Processes such as digestion or composting result in the loss of organic matter through decomposition, increase concentrations of P and trace metals, decrease ammonia-N by volatilization, and decrease K by leaching. Lime-stabilized biosolids contain lower N, P, and metal concentrations, but higher Ca concentration than digested biosolids, due to the large amount of lime added to the material. However, nutrient composition of biosolids is significantly altered by stabilization processes. The rate of nutrient release or mineralization is also affected by the processes. Mineralization of N from aerobically digested biosolids e. Besides, soil type [26], temperature [28], soil moisture content, aeration, and species and number of soil microorganisms play a role in organic matter mineralization in biosolids. More N in municipal biosolids was mineralized in a Dystrochrept soil, whereas more N in pulp and paper industrial biosolids mineralized in a Typic Udivitrand soil [27]. Mineralization rate is also closely related to C: The higher the C: N ratio, the lower the N mineralization rate. In some cases, the mineralization process was more influenced by soil type

than by rate and type of sludge applied [26]. The primary nutrients in biosolids are in organic forms, not as soluble as those in chemical fertilizers, and released more slowly. Therefore biosolids can nourish the plants at a slower rate over a longer period of time with higher use efficiency and a lower likelihood of polluting groundwater when applied rate is appropriate. Although maximum nutrient application rates in federal biosolids regulations are not well defined, the Rule stipulates that agronomic rates cannot be exceeded. Also groundwater or surface water is not permitted to be contaminated by biosolids applications. Land Application of Biosolids: Benefits Due to population increase and urbanization, biosolids production has been on the rise. And land application is generally considered the most economical and beneficial way of biosolids disposal [29]. The most recent national biosolids survey indicated that about 6. US EPA estimates that biosolids are applied to approximately 0. Therefore, biosolids can be utilized as a soil conditioner to improve physical, chemical, and biological properties of soils, especially those degraded or disturbed soils. Besides acting as a food source for microorganisms, organic materials are the major binding agents for aggregate formation and stabilization [32]. Optimum soil structure, in turn, improves many other important soil physical and chemical properties such as bulk density, porosity, water and cation exchange capacity, aeration and drainage, microbial communities and soil fauna, thus contributing to disease suppression, and reduced soil erosion [33]. Bulk density significantly decreased, and porosity, moisture retention, percentage of water-stable aggregates, mean weight diameter of aggregates, and liquid and plastic limits increased in the surface soils 0â€”15 cm with biosolids application. Increase in aggregate stability was related to the increased organic C in the soil incorporated with biosolids [36]. Improved pore size distribution by long term application of biosolids in soil may be linked to the increased volume of macropores or micropores, depending on the texture of the soil [38 , 39]. Biosolids-treated soil was less sensitive to compaction than untreated soil due to the improved pore volume [34]. Improvements in soil physical properties after biosolids application coincided with an increase in soil organic C [34 , 35 , 38]. Many of the soil physical properties differences were associated with addition of organic matter, and these effects persisted for at least 4 years according to Lindsay and Logan [35]. Biosolids have the advantage of high organic matter content and have been used to remediate sites previously contaminated with trace metals by binding and converting the metals to less soluble fractions [42 , 43]. Soil degradation mainly involves damage to soil structure [44]. Due to the beneficial effects of biosolids on soil structure, interest in using biosolids on degraded soils, such as metal-contaminated mine tailings, disturbed urban soils, landfill cover soils, and eroded land to reestablish the vegetation and the ecosystem, is on the rise. Turf grass establishment on a disturbed urban soil with low organic matter and nutrient contents was significantly enhanced by biosolids application [45]. Other similarly beneficial effects of biosolids application on degraded soils, such as increased aboveground plant biomass yield [46], restored vegetative cover [37 , 43], and reestablished ecosystem viability with active microbial communities [47] were also reported. Besides improving soil quality, biosolids application can supplement or replace commercial fertilizer.

Chapter 4 : Sewage Biosolids Land Application: Reported Health Incidents

Land application of biosolids results in enhancement of soil health by improving physical, chemical, and biological properties of soil, nutrient recycling, carbon.

However, additional scientific work is needed to reduce persistent uncertainty about the potential for adverse human health effects from exposure to biosolids. Biosolids may have their own distinctive odor depending on the type of treatment it has been through. Some biosolids may have only a slight musty, ammonia odor. Others have a stronger odor that may be offensive to some people. Much of the odor is caused by compounds containing sulfur and ammonia, both of which are plant nutrients. The federal biosolids rule is contained in 40 CFR Part Biosolids that are to be land applied must meet these strict regulations and quality standards. The Part rule governing the use and disposal of biosolids contain numerical limits, for metals in biosolids, pathogen reduction standards, site restriction, crop harvesting restrictions and monitoring, record keeping and reporting requirements for land applied biosolids as well as similar requirements for biosolids that are surface disposed or incinerated. This guide states and interprets the Part rule for the general reader. This guide is also available in hard copy. Biosolids are used to fertilize fields for raising crops. Agricultural use of biosolids, that meet strict quality criteria and application rates, have been shown to produce significant improvements in crop growth and yield. Nutrients found in biosolids, such as nitrogen, phosphorus and potassium and trace elements such as calcium, copper, iron, magnesium, manganese, sulfur and zinc, are necessary for crop production and growth. The organic nitrogen and phosphorous found in biosolids are used very efficiently by crops because these plant nutrients are released slowly throughout the growing season. This enables the crop to absorb these nutrients as the crop grows. This efficiency lessens the likelihood of groundwater pollution of nitrogen and phosphorous. Biosolids have been used successfully at mine sites to establish sustainable vegetation. Not only does the organic matter, inorganic matrix and nutrients present in the biosolids reduce the bioavailability of toxic substances often found in highly disturbed mine soils, but also regenerate the soil layer. This regeneration is very important for reclaiming abandoned mine sites with little or no topsoil. The biosolids application rate for mine reclamation is generally higher than the agronomic rate which cannot be exceeded for use of agricultural soils.

Chapter 5 : Information for Biosolids Managers | Biosolids | US EPA

Land application is defined by EPA as "the spreading, spraying, injection, or incorporation of sewage sludge, including a material derived from sewage sludge (e.g., compost and pelletized sewage sludge), onto or below the surface of the land to take.

Kowal The potential health effects arising from the land application of munici- pal sludge are examined, and an ap- praisal of these effects made. The agents, or pollutants, of concern from a health effects viewpoint are divided into the categories of pathogens and toxic substances. The pathogens in- clude bacteria, viruses, protozoa, and helminths; the toxic substances include organics, trace elements, and nitrates. For each agent of concern the types and levels commonly found in munici- pal wastewater and sludge are briefly reviewed. A discussion of the levels, be- havior, and survival of the agent in the medium or route of potential human exposure, i. Infective dose, risk of infection, and epidemiology are then briefly re- viewed. Finally, some general conclu- sions are presented. Introduction For centuries Western man has been conscious of the potential value of the application of human wastes to the land. The practice has continued for millennia in the Far East. Sewage sludge or "municipal sludge" has characteristics that make it valuable as a fertilizer and a soil condi- tioner: That land application of sludge is an important and probably growing practice in the U. With the application to land of large volumes of wastewater and sludge, it is evident that considerable potential for adverse health effects exists. The major health concerns with land treatment of wastewater and land application of sludge are somewhat different. Thus, the potential exposure of humans through the routes of aerosols and groundwater is frequently emphasized with wastewater, and through the food chain with sludge. Nevertheless, the agents, or pollutants, of concern from a health effects viewpoint are almost the same in wastewater and sludge. These agents can be divided into the two broad categories of pathogens and toxic substances. The pathogens in- clude bacteria e. The protozoa and helminths are often grouped together under the term, "parasites," although in reality all the pathogens are parasites. The toxic sub- stances include organics, trace ele- ments or heavy metals, e. Nitrates are usually not viewed as "toxic" sub- stances, but are here so considered be- cause of their potential hematological effects when present in water supplies at high levels. These agents form the basis of the main sections of this report. The major health effects of these agents are listed in Figure 1. For each agent of concern the types and levels commonly found in munici- pal sludge are briefly reviewed. A dis- cussion of the levels, behavior, and sur- 2 vival of the agent in the medium or route of potential human exposure, i. Runoff to surface water is not considered, since it is assumed that this will be prevented in a well-managed sludge land application operation. For the pathogens, infective dose, risk of infection, and epidemiol- ogy are then briefly reviewed. General Conclusions Types and Levels of Agents in Wastewater and Sludge The types of levels in wastewater and sludge of most pathogens are fairly well understood, with the exception of viruses. Since only a fraction of the total viruses in wastewater and other envi- ronmental samples may actually be de- tected, the development of methods to recover and detect viruses needs to be continued. The occurrence of viruses in an environmental setting should proba- bly be based on viral tests rather than bacterial indicators since failures in this indicator system have been reported. The tremendous number of organic chemicals possibly present in sludge, together with their myriad health effects and poorly understood behavior in the environment, represent a potential for public health risk when the sludge is ap- plied to agricultural land. Minimizing of health risks can probabl be accomplished by the monitoring c sludge composition, and the regulatio of maximum concentrations and curr ulative application of toxic substances! The complexity c the organics composition of sludge; however, might require the developmer and use of biological assays to screen fc toxicity. Humai exposure to pathogenic protozoa o helminth eggs through aerosols is un likely. Surface Soil and Plants The survival times of pathogens or soil and plants are summarized ir Table 1. However, what is i safe waiting period before crop harves for human consumption is really ar unsettled issue. Health effects of pathogens and toxic substances. Survival Times of Pathogens on Soil and Plants Soil Plants Pathogen Bacteria Viruses Protozoa Helminths Absolute Maximum t year 6 months 10 days 7 years Common Maximum 2 months 3 months 2 days 2 years Absolute Maximum 6

months 2 months 5 days 5 months Common Maximum 1 month 1 month 2 days 1 month Aerial crops with little chance for con- tact with soil should probably not be harvested for human consumption for at least one month after the last sludge application; subsurface and low- growing crops for human consumption would probably require a six-month waiting period after last application. These waiting periods need not apply to the growth of crops for animal feed, however. The levels of toxic organics likely to be present in soils at land application sites will probably result in very low levels in above-ground portions of plants, but levels in roots, tubers, and bulbs may present a health hazard. The potential increase in cadmium levels in human food due to land appli- cation of sludge is still an unsettled question. Present levels of total dietary intake of cadmium for most people ap- pear to be fairly safe. However, in view of human variability in sensitivity and the variability in food supply, these levels probably should not be allowed to rise greatly. Movement in Soil and Ground-water Properly designed sludge application sites may pose little threat of bacterial or viral contamination of groundwater. Human exposure to pathogenic proto- zoa or helminths through groundwater is unlikely. Groundwater is unlikely to represent a significant organic or trace element threat. This can be prevented, however, by proper siting and management prac- tice, e. Animals The literature to date suggests little danger of bacterial, viral, or protozoan disease to animals grazing at land appli- cation sites if grazing does not resume until four weeks after last application but the need for complete inactivation of helminths in sludge before land appli- cation is still unsettled. The feeding of land-application-site-grown plants to animals is unlikely to pose a health problem, but grazing animals may ac- cumulate significant levels of toxic or- ganics. The issue of accumulation of organics from the soil by plants and animals particularly into milk , and into the human food supply, is poorly under- stood. Infective Dose, Risk of Infec- tion, Epidemiology Because of the possibility of contract- ing an infection, it would be wise for humans to maintain a minimum amount of contact with an active land application site. Epidemiological studies to date sug- gest little effect of land application on disease incidence. However, many questions on the public health conse- quences of land application of waste- water and sludge remain. Health Effects Research Laboratory U.

Chapter 6 : Itâ€™s Time to Talk (Again) about Sewage Sludge on Farmland

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Source Tracking Aerosols Release. This is a formal request for answers, see below. Sat, 5 Dec The answers back have generally been that little activity exists in this area by the former agency and for the latter, the subject seems to be off limits for discussion. The question that comes to mind is why this may be the case? CDC considers the spread of antibiotic resistance to be a high priority subject. If we also fold into this the work by Mark Meckes done back in the early s, the question becomes a very compelling and the answer thus profound, see: The case for an answer becomes yet more interesting when we look at the work in , via the American Society for Microbiology. The interesting thing here is the distance traveled by critical aerosols. How far can these aerosols move and cause damage? I worked with the Ag Engineering staff at UC Davis when we tracked Propanil for 50 miles to confirm tissue damage in distant orchards. Veterinarians in the UK have noted foot and mouth in isolated herds that were several miles distant from any source. Considering the ability for the gut flora to take in merely a single bit of genetic information, by the next day the numbers are very impressive. Is it wise to continue ignoring this issue? Thus, I wrote Jordan Peccia, the corresponding author as noted below. A previous request was sent to these agencies but no usable answers were forthcomingin fact most did not answeragain why? The salient point of the Baertsch et al paper is that off-site movement of aerololized sewage sludge. This then also means that antibiotic resistant genes ARGs are capable of aerosol movement to off-site targets. Since these are very small but very robust fragments their settling rate is almost nill. Jaydeep Ghosh, of Bowling Green State University, Geology, in looked at aerosol generation from land applied sewage sludge. He noted that "compared to the data collected on the day of application, total bacteria, Staphylococcus aureus, and gram-negative bacteria were elevated 2 days after biosolids application. Levels decreased to control level 13 days after application, except for Staphylococcus aureus, which was highest 13 days after application. It can be concluded that pathogenically nontreated class B biosolids are capable of generating potential pathogens in the air. This increased content might be responsible for reported health problems in nearby residents during the post-application period", see: The largest source of aerosol generation is not the application of sewage sludge but its tillage. 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. That is a transit of somewhere over 3, 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. How do these types of studies on areosols correlate to setback distances suggested for the application of sewage sludge? 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 formal questions, then what governmental agency has been working along these lines, i. Based on wastewater industry dogma and its controlling standards, sewage sludge is a benign soil amendment for farmland. If, however, one reviews the current medical and scientific literature, a different picture emerges, one that raises serious questions about the benevolence of these activities and the efficacy of the underlying standards. Thus, the issue takes on aspects of a political and not a scientific argument. Many regulatory agencies refer back to EPA but do not receive a factual response. The issue is passed on to ill-prepared state and local authorities Office of Inspector General, Status Report, Land Application of Biosolids , March 28, ; www. In discussions with CDC, I was informed that there was no particular focus on these issues. Who then watches the chickens, the fox? Dr Edo McGowan Jordan, this is interesting and aerosols may well act as a mechanism to spread antibiotic resistance to down-wind, off site targets. Also, note the paper by the Canadian authors who looked at Sugar Creek http: Thus, there may be large off-site movement of antibiotic resistant genes and pathogens by both air and water. A more complex situation may be regional dust storms. How does information in your paper along with the carriage of antibiotic resistance affect dust and dust storms? It is

estimated that three tons of sewage sludge is generated for each million gallons of sewage entering a treatment plant. Land application of sewage sludge has been going on for some years and thus there is a build-up within the soil profile of pathogens, heavy metals and contaminants of emerging concern. Once contaminated, stopping the application of pollutants such as metals and many organic chemicals that are in sewage biosolids will not correct the problem. The contamination will remain for decades or centuries. It is also important to consider the synergistic effect on the barrier protection of fragile respiratory tissues by mechanical or chemical irritants and the entry of pathogens and thus antibiotic resistant genetic information through disrupted barriers. The climate scientists are estimating a return to dust bowl days on a permanent basis. With thousands of acres of farmland in the drought-prone areas and with multiple-year sludge application and a dust storm, very large, regional areas may be impacted lifting tons of sluged soils, their contained pathogens and toxins into the air. Unfortunately, US EPA , although promoting the land application of sewage sludge has no comprehensive data base on where and how much sewage sludge has been applied. Thus it may be difficult to do strategic planning. As the droughts hit and the water availability is reduced. The costs of bringing ground water to the surface in numerous areas may no longer be economically supportable and crops will be abandoned. I saw this through out Africa and it will happen here. Also farmers will, in anticipation of converting ag land to urban, spend down their soils so those soils may have an increased tendency to blow. As to pathogens, for the long-lived spore formers, as well as dried yet viable DNA containing virulence and antibiotic resistance data, this combination of pathogen and chemical-mechanical irritation of the respiratory tract may overwhelm the capacity of health care centers to deal with the incoming ill. Because of the levels of antibiotic resistant pathogens within sludge and the transfer of that information to the soil bacteria, inhalation of dust may see many of these respiratory infections that will be difficult to treat. Where, a rhetorical question with the above in mind, is the discussion and preparedness? Thanks for doing the paper, CheersEdo Increased frequency of drug-resistant bacteria and fecal coliforms in an Indiana Creek adjacent to farmland amended with treated sludge Authors: Shivi Selvaratnam; J D. Since one of the main methods of treated sewage disposal is by application to agricultural land, the presence of these organisms is of concern to human health. The goal of this study was to determine whether the frequency of drug-resistant and indicator bacteria in Sugar Creek, which is used for recreational purposes, was influenced by proximity to a farmland routinely amended with treated sludge site E. Surface water from 3 sites along Sugar Creek site E, 1 upstream site site C and 1 downstream site site K were tested for the presence of ampicillin-resistant AmpR bacteria, fecal and total coliforms over a period of 40 d. Site E consistently had higher frequencies of AmpR bacteria and fecal coliforms compared with the other 2 sites. All of the tested AmpR isolates were resistant to at least 1 other antibiotic. However, no isolate was resistant to more than 4 classes of antimicrobials. These results suggest that surface runoff from the farmland is strongly correlated with higher incidence of AmpR and fecal coliforms at site E. Published online May Abstract DNA-based microbial source tracking MST methods were developed and used to specifically and sensitively track the unintended aerosolization of land-applied, anaerobically digested sewage sludge biosolids during high-wind events. Culture and phylogenetic analyses of bulk biosolids provided a basis for the development of three different MST methods. They included i culture- and 16S rRNA gene-based identification of Clostridium bifermentans, ii direct PCR amplification and sequencing of the 16S rRNA gene for an uncultured bacterium of the class Chloroflexi that is commonly present in anaerobically digested biosolids, and iii direct PCR amplification of a 16S rRNA gene of the phylum Euryarchaeota coupled with terminal restriction fragment length polymorphism to distinguish terminal fragments that are unique to biosolid-specific microorganisms. Next, a sampling campaign was conducted in which all three methods were applied to aerosol samples taken upwind and downwind of fields that had recently been land applied with biosolids. During these high-wind events, the biosolid concentration in downwind aerosols was between 0. The application of DNA-based source tracking to aerosol samples has confirmed that wind is a possible mechanism for the aerosolization and off-site transport of land-applied biosolids. Please support the work of the Sewage Sludge Action Network. Be as generous as you can. Mailing List To receive alerts, news and information from the Sewage Sludge Action Network, please join our mailing list.

Chapter 7 : Health Effects Of Land Application Of Municipal Sludge

The potential for human health problems associated with land disposal of municipal sludge is reviewed. Migration of heavy metals from the sludge through soil into drinking water supplies and into the human food chain is surveyed. Health effects and bioaccumulation of cadmium are examined. Bacteria.

Reported Health Incidents CWMI has compiled a matrix that includes information on the reported health incidents that citizens associate with the application of sewage sludges to land. The matrix includes the locations, the number of persons and the symptoms reported. A wide array of sources provided the information contained in this matrix including newspaper articles, government reports and other sources. It has not been confirmed by scientific investigation that these persons became ill due to land application of sludges. We hope that the information may be useful to the full range of stakeholders concerned about the reported illnesses. CWMI invites those with additional information on these or other incidents to send it to us at cwmi cornell. It calls for their investigation and for a system to keep track of them. No such system is in place. This matrix is provided as a first step in tracking reported health incidents. It was compiled as part of a research project gathering information on what governmental investigations were undertaken of the reported incidents Harrison and Oakes, To date there is only one study that has been published that examines any of these cases Lewis et al, In that study, interviews were conducted at 10 of the sites where neighbors reported symptoms. Land application data and medical records were reviewed. Approximately half of the 48 residents surveyed at those sites reported symptoms consistent with endotoxin exposure and half reported infections. At one site, symptoms decreased linearly with distance from the treated field and increased linearly with duration of exposure to winds blowing from the field. That study also suggests that chemical contaminants in sludges may be responsible for an increased host susceptibility to infection. The charge to the committee was to review the current standards and the risk-assessment upon which the rules are based. The committee did not review the reported health incidents such as those included in Lewis et al. It did, however, review the epidemiologic literature which was very sparse see Chapter 3, NRC, At the time the report was drafted, the Lewis article had not yet been published. Only one published prospective epidemiological study of health effects of land application Dorn, et al. A number of factors made the authors of that study urge that their finding not be generalized. The study did not use sludges associated with health complaints, sludges were applied at a low application rate, any odorous sludge was eliminated from the study, and only a small percentage of persons remained in the study over the course of the work. It has been suggested that sludge is unlikely to cause illness in individuals adjacent to land application sites because it has been reported that workers handling sludges, who therefore have high levels of exposure, do not get sick. The NRC report states the fallacy of this assertion. This reasoning is problematic for several reasons. First, as described earlier in this chapter [Chapter 3], the knowledge base regarding wastewater treatment workers is thin and contradictory. Second, the exposure characteristics will be quite different in the wastewater treatment industry compared with biosolids land-application. For example, potential exposure to airborne contaminants from wet sewage sludge are quite different from those of dried biosolids. Third, the routes of exposure may be different. Fourth, the populations exposed to biosolids may not be equivalentâ€¦community residents will include subpopulations unlikely to be found in the work place, such as children and individuals with respiratory diseases. The risk assessment performed by EPA in support of the Part rules addressed a range of chemical contaminants and a number of exposure pathways. It is important to recognize that the EPA sludge rules 40 CFR Part are not based on an assessment of risks posed by pathogens or biological agents such as endotoxins. Nor are the risks posed by airborne or water runoff transport of sludge constituents or those resulting from any combination of pollutants or of biological and chemical contaminants addressed. Thus, as the NRC has stated, there is a need for research to address these and related issues and for a revised risk assessment. Biosolids Applied to Land.

Chapter 8 : EPA Sludge Cover Up and Denial of Human Health Risks | Sewage Sludge Action Network

DOWNLOAD PDF SLUDGE HEALTH RISKS OF LAND APPLICATIONS

The second basic surveillance activity for evaluating the effects of land application of sludge on the health of North Carolina residents involves tracking reports of symptoms, illness, and diminished quality of life.

Chapter 9 : Land Application of Biosolids in the USA: A Review

the risks to human health posed by many microbiological enti- ties within biosolids have been shown to be low if current EPA regulatory guidelines are followed.