Wastewater Treatment Processes

SCHOOL OF PLANT AND ENVIRONMENTAL SCIENCES, VIRGINIA TECH

By: Odiney Alvarez-Campos and Dr. Gregory Evanylo

Biosolids are byproducts of wastewater treatment, whose processing permits safe and beneficial land application. Wastewater treatments plants (WWTP) receive sewage from household and industrial sources. The wastewater is subjected to physical, biological, and chemical processes that separate solids so that the effluent can be further treated for reuse (for example, irrigation) or returned to surface water. The solids are treated to reduce disease transfer risk and attraction by vectors in preparation for land application as "biosolids."

At the WWTP, wastewater solids are separated from the liquid fraction via primary and secondary sedimentation. Waste-activated sludge is biologically treated to reduce organic matter between primary and secondary sedimentation. The resulting effluent is often further treated via biological (enhanced microbial P removal) or chemical (P precipitation by Fe or Al compounds, chlorination) methods to remove potentially water-contaminating P and to destroy remaining microorganisms.

Combined primary and secondary sewage sludge are treated to reduce pathogens, odors, and disease vectors in order to permit their safe application to land as sources of essential plant nutrients and organic matter. Land applying biosolids prevents these potentially valuable soil amendments from being wasted via landfilling or incineration. The final quality of biosolids depends on the processes used to treat it and control of the quality of sewage accepted. Wastewater pretreatment regulations permit WWTP to accept only wastewater that does not contain excessive concentrations of certain pollutants, such as heavy metals, PCBs, dioxins, ensuring that the biosolids generated contain low concentrations of such pollutants.

There are two main types of processes for treating biosolids to reduce pathogens (U.S. EPA, 1994). These are:

1. Processes to Significantly Reduce Pathogens (PSRP) for production of Class B biosolids.
2. Processes to Further Reduce Pathogens (PFRP) for production of Class A biosolids.

Class B refers to biosolids that have been treated to reduce pathogens (Salmonella sp. bacteria, and viruses) to levels that do not pose a threat to public health and the environment. Because pathogens are still detectable, additional best management practices are used to further ensure public safety. Some of these practices include limiting the application of Class B biosolids to specific areas in order to prevent exposure, and allow sufficient time for natural degrading processes (microorganisms, moisture, sunlight, etc.) to reduce the remaining pathogens.

Class B biosolids are commonly used as soil amendments/fertilizers on agriculture lands, pastures, forests and for the reclamation of disturbed lands such as roadsides and mine lands. The U.S. Environmental Protection Agency (EPA) restricts access to these lands or harvesting of crops for various periods days after Class B biosolids application. For example, non-lactating cattle cannot graze on pastures and crops until 30 days after Class B biosolids application. A restriction of 60 days applies for lactating dairy cattle.

Some PSRPs used to create Class B biosolids are (U.S. EPA, 1994):

- Lime stabilization: use of lime to increase biosolids pH to 12 after 2 hours of contact.
- Aerobic digestion: biological process that occurs in the presence of oxygen, where microorganisms present help degrade organic matter and reduce pathogen density. Aerobic conditions must be kept for 40 days at 20°C or 60 days at 15°C.
- Anaerobic digestion: biological process that occurs in the absence of oxygen, where microorganisms degrade organic matter and reduce pathogens. Anaerobic conditions must be kept for 15 days at 35°C to 55°C or 60 days at 25°C.
- Air drying: biosolids are air-dried during for a minimum of 3 months at temperatures above 0°C.

Class A refers to biosolids whose pathogen densities have been reduced to below detection levels. Due to this intensive pathogen reduction, handling and application of Class A biosolids are less restricted than for Class B. Most Class A biosolids also contain low concentrations of U.S. EPA-designated "priority pollutants" (arsenic, As; cadmium, Cd; copper, Cu; lead, Pb; mercury, Hg; molybdenum, Mo; nickel, Ni; selenium, Se; and zinc, Zn) that permit their safe application to, even, residential landscapes. Biosolids that meet the strictest pollutant standards (see Inorganic Trace Element and Regulations fact sheets for more detailed information) and are treated to Class A by PFRP are termed "exceptional quality," or EQ, biosolids. Exceptional Quality biosolids can be safely handled and used by the general public, and can be applied like any other registered fertilizer on lawns, gardens, parks and golf courses in urban areas based on soil nutrient recommendations for plant growth.

Some PFRPs used to create Class A and EQ biosolids products are:

- Heat-drying: use of hot gases (>80°C) to reduce moisture content to 10% or lower.
- Pasteurization: maintaining biosolids temperature at 70°C or higher for at least 30 minutes.
- Radiation: biosolids are irradiated with either beta or gamma rays.
- Composting: the aerobic decomposition of organic material under controlled temperature, moisture, and oxygen can be used to produce either Class B or Class A biosolids depending on the time and temperature used in the process. However, composting is more commonly used to produce EQ biosolids by using within-vessel or static aerated pile composting methods where temperature is maintained at 55°C or higher for 3 consecutive days. Windrow composting can also be used, but temperature needs to be maintained at 55°C or higher for 15 consecutive days or longer (U.S. EPA, 2003).

Recent technology developments have resulted in new innovative processes to treat biosolids to produce EQ biosolids products. A list and description of these technologies can be found in the document "Emerging technologies for biosolids management" found at https://nepis.epa.gov (U.S. EPA, 2006). An example of a more recent technology is the CAMBI process which involves the use of thermal hydrolysis or the oxidation of sludge under very high temperature (~180 °C) and pressure (~100 psi) that destroys pathogens, followed by an anaerobic digestion to decrease volatile solids and volume of biosolids (U.S. EPA, 2006). This technology is currently used by DC Water at the Blue Plains Advanced Wastewater Treatment Plant, which is the largest thermal hydrolysis facility in the world.

To further prepare biosolids for land application, conditioning with flocculants and dewatering with filter and belt presses, centrifuges, and vacuum filters are used to remove water and improving ease of handling and transport (USEPA, 2003; USEPA, 2006).

Biosolids have generally been applied in the form of 1) dewatered "cake", 2) compost or 3) pellets. More recently, some EQ biosolids have been blended with organic materials, such as mulch or sawdust, and/or mineral byproducts, such as sand, to improve their handling and application. TAGRO™ is an example of an EQ biosolids blended product generated by the City of Tacoma, Washington (https://www.cityoftacoma.org/cms/one.aspx?objectId=16884) that has been used to improve urban soils for gardening (McIvor et al., 2012). DC Water has also developed an EQ biosolids called Bloom (http://bloomsoil.com/) that can be used in urban gardening and turfgrass establishment. As the number of WWTPs processing EQ biosolids continue to increase, new innovative biosolids byproducts will likely continue to proliferate.

References

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