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Biosolids Technology Fact Sheet
Alkaline Stabilization of Biosolids

DESCRIPTION

Biosolids are primarily organic materials produced during wastewater treatment which may be put to beneficial use. Biosolids are used in home gardening, commercial agriculture, silviculture, greenways, recreational areas and reclamation of drastically disturbed sites such as those subjected to surface mining. Biosolids are often rich in nutrients such as nitrogen and phosphorus, and contain valuable micro nutrients. The Environmental Protection Agency's (EPA) 40 CFR Part 503, *Standards for the Use and Disposal of Sewage Sludge*, (the Part 503 Rule) requires that wastewater solids be processed before they can be beneficially used. The processing is described in this fact sheet as stabilization. Stabilization helps to minimize the potential for odor generation, destroys pathogens (disease causing organisms), and reduces the material's vector attraction potential. One method of stabilization is to add alkaline materials to raise the pH level to make conditions unfavorable for the growth of organisms (such as pathogens). Figure 1 is a picture of alkaline stabilized biosolids being dropped from an overhead conveyor into windrow curing piles at Middlesex County Utility Authority's facility in New Jersey.

The Part 503 Rule defines two types of biosolids with respect to pathogen reduction: Class A (no detectable pathogens) and Class B (a reduced level of pathogens). Both classes are safe, but additional requirements are necessary with Class B materials. These requirements are detailed in the Part 503 Rule and include such things as limiting public access to the site of application, limiting livestock grazing, and controlling crop harvesting schedules. Class A biosolids are not subject to these use restrictions and can generally be used like any commercial fertilizer.

Alkaline stabilization can achieve the minimum requirements for both Class A and Class B biosolids with respect to pathogens, depending on the amount

Source: Parsons Engineering Science, Inc., 1999.

FIGURE 1 ALKALINE STABILIZED BIOSOLIDS

of alkaline material added and other processes employed. Generally, alkaline stabilization meets the Class B requirements when the pH of the mixture of wastewater solids and alkaline material is at 12 or above after 2 hours of contact.

Class A requirements can be achieved when the pH of the mixture is maintained at or above 12 for at least 72 hours, with a temperature of 52°C maintained for at least 12 hours during this time. In one process, the mixture is air dried to over 50 percent solids after the 72-hour period of elevated pH. Alternately, the process may be manipulated to maintain temperatures at or above 70°C for 30 or more minutes, while maintaining the pH requirement of 12. This higher temperature can be achieved by overdosing with lime (that is, adding more than is needed to reach a pH of 12), by using a supplemental heat source, or by using a combination of the two. Monitoring for fecal coliforms or *Salmonella* sp. is required prior to release by the generator for use.

The Part 503 Rule also allows for meeting Class A pathogen reduction requirements through monitoring for pathogens before and after processing. For example, Class A Alternative 3 requires that the unprocessed wastewater solids be monitored for enteric viruses and helminth ova. The process is monitored for lime dosage and pH and the final product must have no detectable levels of enteric viruses or helminth ova.

For more specific details on the requirements for achieving Class A or B, please refer to the Part 503 Rule.

Materials that may be used for alkaline stabilization include hydrated lime, quicklime (calcium oxide), fly ash, lime and cement kiln dust, and carbide lime. Quicklime is commonly used because it has a high heat of hydrolysis (491 British thermal units) and can significantly enhance pathogen destruction. Fly ash, lime kiln dust, or cement kiln dust are often used for alkaline stabilization because of their availability and relatively low cost.

The alkaline stabilized product is suitable for application in many situations, such as landscaping, agriculture, and mine reclamation. The product serves as a lime substitute, source of organic matter, and a speciality fertilizer. The addition of alkaline stabilized biosolids results in more favorable conditions for vegetative growth by improving soil properties such as pH, texture, and water holding capacity. Appropriate applications depend on the needs of the soil and crops that will be grown and the pathogen classification. For example, a Class B material would not be suitable for blending in a top soil mix intended for use in home landscaping but is suitable for agriculture, mine reclamation, and landfill cover where the potential for contact with the public is lower and access can be restricted. Class A alkaline stabilized biosolids are useful in agriculture and as a topsoil blend ingredient. Alkaline stabilized biosolids provide pH adjustment, nutrients, and organic matter, reducing reliance on other fertilizers.

Alkaline stabilized biosolids are also useful as daily landfill cover. They satisfy the federal requirement that landfills must be covered with soil or soil-like material at the end of each day (40 CFR 258). In most cases, lime stabilized biosolids are blended with other soil to achieve the proper consistency for daily cover.

As previously mentioned, alkaline stabilized biosolids are excellent for land reclamation in degraded areas, including acid mine spoils or mine tailings. Soil conditions at such sites are very unfavorable for vegetative growth often due to acid content, lack of nutrients, elevated levels of heavy metals, and poor soil texture. Alkaline stabilized biosolids help to remedy these problems, making conditions more favorable for plant growth and reducing erosion potential. In addition, once a vegetative cover is established, the quality of mine drainage improves.

APPLICABILITY

Where lime or another alkaline additive (for example, recycled kiln dust), is relatively inexpensive, alkaline stabilization is often the most cost-effective process for wastewater solids stabilization. This is particularly true where dependable markets for the alkaline product can be developed, such as in areas where alkaline materials are routinely applied to agricultural soils to maximize crop yields.

Alkaline stabilization is practical at small wastewater treatment plants that store wastewater solids for later transportation to larger facilities for further treatment. It is also applicable as an expansion of existing facilities or as a new facility to reduce odors and pathogens. The technology is especially useful at wastewater treatment facilities with flows that vary greatly since the process adjusts easily to changing flows. This adaptability also makes alkaline stabilization an appropriate choice as a secondary or backup stabilization method because these facilities can be started and stopped relatively quickly and easily. Facilities can also be designed to handle either liquid or dewatered wastewater solids.

In general, alkaline stabilization is not a proprietary process, meaning that no fee is required to be paid to a patent holder to use the process. However, several variations on the basic process are proprietary, such as:

- BioFIX Process (marketed by Bio Gro Division of Wheelabrator Clean Water Systems, Inc.)
- RDP En-Vessel Pasteurization System (marketed by RDP Company.)
- N-Viro Advanced Alkaline Stabilization with Drying (marketed by N-Viro International Corporation.)

ADVANTAGES AND DISADVANTAGES

Alkaline stabilization offers several advantages, including:

- Consistency with the EPA's national beneficial reuse policy. Results in a product suitable for a variety of uses and is usually able to be sold.
- Simple technology requiring few special skills for reliable operation.
- Easy to construct of readily available parts.
- Small land area required.
- Flexible operation, easily started and stopped.

Several possible disadvantages should be considered in evaluating this technology:

- The resulting product is not suitable for use on all soil. For example, alkaline soils common in southwestern states will not benefit from the addition of a high pH material.
- The volume of material to be managed and moved off-site is increased by approximately 15 to 50 percent in comparison with other stabilization techniques, such as digestion. This increased volume results in higher transportation costs when material is moved off-site.
- There is potential for odor generation both at the processing and end use site.
- There is a potential for dust production.
- There is a potential for pathogen regrowth if the pH drops below 9.5 while the material is stored prior to use (U.S. EPA, 1992.)
- The nitrogen content in the final product is lower than that in several other biosolids products. During processing, nitrogen is converted to ammonia, which is lost to the atmosphere through volatilization. In addition, plant available phosphorous can be reduced through the formation of calcium phosphate.
- There are fees associated with proprietary processes (Class A stabilization.)

Environmental Impacts

There are several potential environmental impacts associated with alkaline stabilization of wastewater solids. Odor problems may occur at the point of processing or use due to the release of ammonia and ammonia related compounds and amines. These are generally considered nuisance issues without long-term environmental impact. Handling of the material, such as loading, unloading, or spreading, all potentially cause release of ammonia and amines. The amount of ammonia released from the alkaline stabilized product depends on the nitrogen content of the wastewater solids and the pH and temperature achieved through the process. The extent of amine released will depend in part on the nature of the dewatering chemicals used.

In addition, small amounts of particulate matter may be emitted by the processing facility, but these are easily mitigated.

Land application of any biosolid product can increase the concentrations of trace elements in the soil. Alkaline stabilized biosolids help to create soil pH conditions in which metals are insoluble, minimizing plant uptake and movement of metals to groundwater.

Soils which have a low pH will benefit greatly from the alkaline material and will be more fertile. Lime is usually low in metals and, when blended with wastewater solids, can improve the quality of the product with respect to metals.

DESIGN CRITERIA

There are many factors that must be considered in designing an alkaline stabilization facility for biosolids. The most critical are:

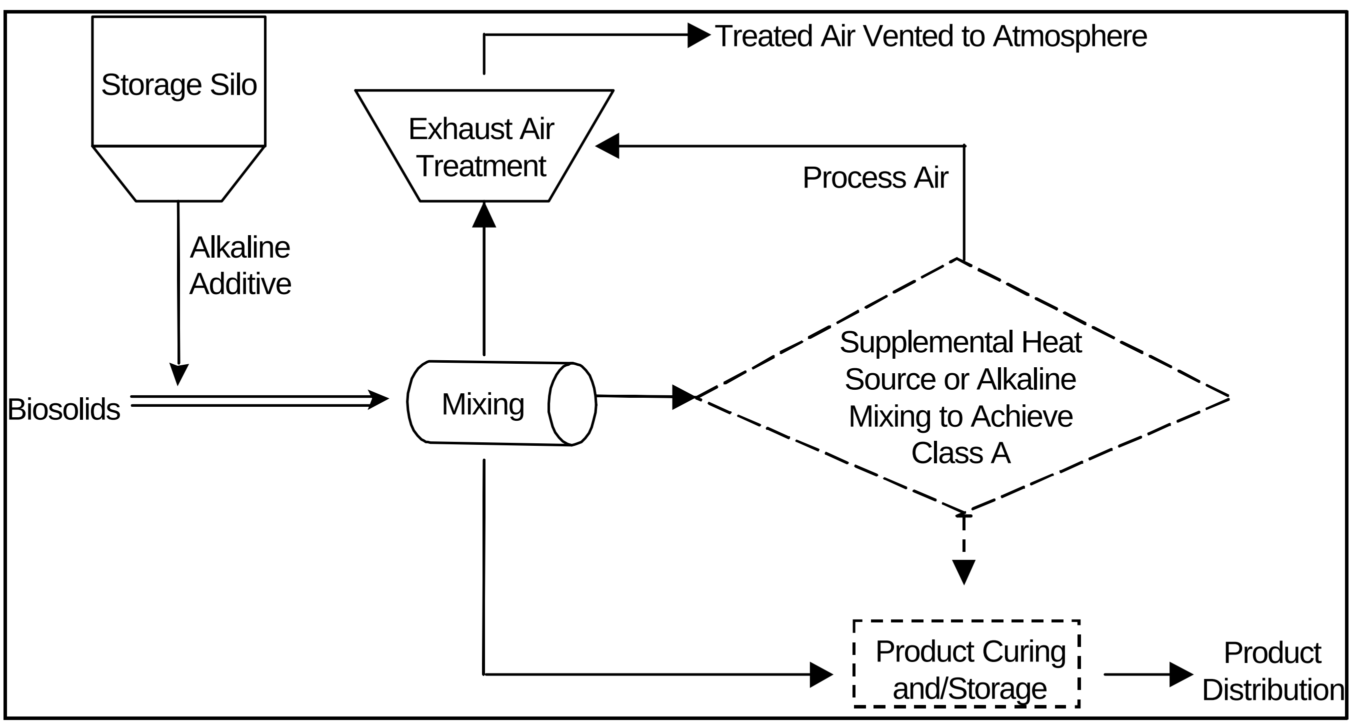
- Percent solids of infeed wastewater solids.
- Desired results (Class A versus Class B) which affect the amount of alkaline material needed and mixing time, which, in turn, impacts equipment size.
- Source and volume of alkaline material to be used.
- Odor control equipment at the processing facility.
- Storage and curing areas.

The equipment necessary for alkaline stabilization is relatively easy to install and operate. Typical equipment includes the following:

- Wastewater solids feed/conveyance mechanism.
- Lime storage (silo, 1000 or 50 pound bags, etc.)
- Lime transfer conveyor.
- Mixer.
- Air emission control equipment to minimize odors and dust.

Figure 2 presents a typical flow diagram for alkaline stabilization. A list of general design parameters and criterion for Class B alkaline stabilization is found in Table 1.

Designing a facility to meet Class A stabilization requirements may require additional lime storage to allow an increased lime dose, additional curing capacity, and/or the provision of supplemental heat.



Source: Parsons Engineering Science, Inc., 1999.

Note: Dashed lines indicate optional equipment.

FIGURE 2 FLOW DIAGRAM OF A TYPICAL ALKALINE STABILIZATION OPERATION

TABLE 1 TYPICAL DESIGN CRITERIA FOR CLASS B ALKALINE STABILIZATION

Parameter	Design Criterion
Alkaline dose	0.25 pound per pound of wastewater solids at 20 percent solids
Retention time in mixer	1 minute
Retention time in curing vessel	30 minutes

Source: National Lime Association, undated.

The end use of the material is another important factor when designing a biosolids management program, including alkaline stabilization. The resulting material is suitable for many uses, including agricultural application, mine reclamation and landfill cover. The amount of land that must be available differs with the use. Alkaline stabilized biosolids are generally lower in nitrogen than other biosolids products because nitrogen is converted to ammonia during processing. The material contains approximately one to two percent nitrogen; one percent phosphorus; and negligible potassium, nutrients of primary importance for vegetative growth. In agricultural application, alkaline stabilized biosolids are often applied more for their pH adjusting characteristics at a typical application rate of two to five tons per acre. Nutrients supplied to the crop are a secondary benefit. In reclamation applications, the material is often applied only once rather than annually or periodically as in agricultural applications. Therefore, the material is usually applied at a higher rate of between 60 to 100 dry tons per acre. In landfill cover applications, the amount of material used is dictated more by regulatory requirements than nutrient content. Alkaline stabilized biosolids can be used as daily cover, or to amend the final cover, in accordance with federal regulations which require material to enhance conditions for vegetative growth. For daily cover, a minimum of six inches of soil is required. Equivalent thickness of alkaline stabilized material must be approved on a case by case basis. Typical application rates for incorporation into final cover material are similar to those at mine reclamation sites.

PERFORMANCE

Alkaline stabilization is frequently selected by wastewater treatment facilities in regions where soils have a tendency to be acidic and where low cost alkaline materials are readily available. In areas where soils are acidic, the end product has greater value. Table 2 shows location, size, and end use for representative alkaline stabilization facilities.

Alkaline stabilization systems are generally quite reliable and flexible. The same equipment can often be used to produce either Class A or B biosolids with minor process modifications, such as a larger dosage of alkaline material or the addition of supplemental heating (pasteurization.)

With respect to pathogen reduction, Class B alkaline stabilization has been demonstrated to reduce total coliform, fecal coliform, and fecal streptococci bacterial concentrations by more than 99.9 percent. Concentrations of *Salmonella* and *Pseudomonas aeruginosa* have been shown to be reduced below the level of detection. Pathogen concentrations in Class B alkaline stabilized biosolids range from 10 to 1,000 times less than those in anaerobically digested sludge (U.S. EPA, 1979.) Alkaline stabilization can result in an exceptional quality product when it meets Class A pathogen reduction, vector attraction reduction and the highest standards for metal concentrations. This higher level of processing can result in a more valuable product because there are no restrictions on end use. The high level of disinfection achieved in Class A products makes them easier to handle and apply. For example, if a farmer purchases an exceptional quality product, he will not have to restrict access or limit grazing and harvesting times.

The appearance, odor causing potential, and handling characteristics can vary greatly depending on the type of alkaline stabilization process used. Processes that add larger amounts of alkaline material or include added heat, drying, or curing will produce a drier product that resembles topsoil. Other alkaline stabilization processes that simply

TABLE 2 REPRESENTATIVE LIME STABILIZATION FACILITIES

Location	Solids Production (dry tons/day)	Disposal/End Use	Pathogen Reduction	Process Employed
Hampton Road, VA	8	Land Application	Class A	Bio*Fix
Reedsville, WI	1-2	Land Application	Class A	EnVessel Pasteurization™
Lancaster, OH	3	Land Application	Class A & B	Bio*Fix
Raleigh, NC	20	Land Application	Class A	N-Viro AASAD
Howard Co., MD	20	Land Application	Class A & B	Bio*Fix
Cookeville, TN	<1	Land Application	Class A	EnVessel
Charlotte, NC	20	Agricultural Liming Agent	Class A	Bio*Fix
Washington, DC	270	Land Application	Class B	Post-Lime Stabilization
Middlesex, NJ	146	Landfill Cover Agricultural Liming Agent	Class A	N-Viro AASAD
Toledo, OH	63	Agricultural Liming Agent	Class A	N-Viro AASAD
Greenville, SC	10	Landfill Cover	Class A	N-Viro AASAD
Tarpon Springs, FL	3	Land Application	Class A	N-Viro AASAD
Syracuse, NY	30	Agricultural Liming Agent	Class A	N-Viro AASAD
Urbana-Champagne, IL	5	Land Application	Class B	N-Viro
Upper Gwynedd, PA	2-3	Land Application	Class B	Generic
Bergen County, NJ	45	Landfill Cover	Class A	Bio*Fix

Source: National Lime Association, 1995; RDP Technologies, Inc. web site, 1999; N-Viro International Corp. web site, 1999, and personal communication with facility operators.

add enough lime to increase pH to 12 for 2 hours may still resemble biosolids cake from the dewatering equipment. The characteristics of the end product should be considered when evaluating the methods and feasibility of storage. Drier alkaline stabilized products tend to have fewer odors after 30 days or more of storage. On the other hand, cake-like products should be used as soon as possible to minimize odor complaints at the application sites.

The odors associated with alkaline stabilized products are also dependent on the characteristics of the wastewater solids. Plant operators who minimize sludge age in the their wastewater treatment facility will also minimize odor generation both at the processing facility and at the end use site. In addition, 25 percent total solids cake is easier to process and requires less lime than 20 percent total solids cake. The odors also result from the dewatering chemicals used.

OPERATION AND MAINTENANCE

Alkaline stabilization systems are relatively uncomplicated facilities operated with the skills found in typical wastewater treatment plant personnel. Labor requirements include heavy equipment operators, maintenance personnel, and instrumentation/computer operators.

The caustic nature of the alkaline additive requires higher maintenance on these systems than on stabilization systems that do not involve caustic materials. Proper design and operation of the mixing equipment is necessary to ensure a consistent, homogeneous product.

COSTS

It is difficult to estimate the costs of stabilizing biosolids with alkaline materials without specific details, such as wastewater solids characteristics and quantities. One study estimated costs for Class A alkaline stabilization ranging from $139 to $312 per dry ton of wastewater solids processed by facilities designed to serve wastewater treatment plants ranging in capacity from 10 to 60 million gallons per day. This estimated range demonstrates the economy of scale associated with larger systems. The capital costs cited in this same study ranged from $1.5 to $4.0 million and annual costs were estimated to range from $1 million and $4 million. This study concluded that alkaline stabilization was less expensive than composting or thermal drying (Sullivan, 1996.)

Although exact costs for alkaline stabilization cannot be provided, the following items must be considered in estimating costs for any alkaline stabilization facility:

- Processing equipment purchase and installation.
- Product curing and storage facilities.
- Loading facilities.
- Transport of product to point of use.
- Royalty and operating fees for proprietary processes.
- Equipment maintenance and fuel.
- Alkaline additive.
- Labor.
- Odor control equipment and chemicals.
- Marketing costs/revenues.
- Regulatory compliance, such as permit applications, site monitoring, biosolids analyses, and regulatory record keeping and reporting.

The incremental capital cost for meeting Class A requirements through alkaline stabilization is the lowest among stabilization alternatives such as thermal drying and anaerobic and aerobic digestion. The incremental unit cost (including capital and operation and maintenance) associated with creating a Class A product from a system currently making a Class B product and serving a 5 million gallon per day wastewater treatment facility was estimated to be $39 per dry ton. Again, this is significantly less than the unit costs to increase pathogen treatment through aerobic or anaerobic digestion, which were cited as $88 and $103 per dry ton, respectively (National Lime Association, 1998.)

Some generators of alkaline stabilized biosolids sell the product for approximately $3 to $5 per wet ton.

REFERENCES

Other Related Fact Sheets

Odor Management in Biosolids Management
EPA 832-F-00-067
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Centrifugal Dewatering/Thickening
EPA 832-F-00-053
September 2000

Belt Filter Press
EPA 832-F-00-057
September 2000

Land Application of Biosolids
EPA 832-F-00-064
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Other EPA Fact Sheets can be found at the following web address:
http://www.epa.gov/owmitnet/mtbfact.htm

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