Technology solutions: Accelerators for sludge treatment

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Biosolids Management

Consistency
Applicability
Legal responsibility

Environment

Affordability
Technical feasibility
Viability

Economy

Desirability
Cultural Acceptability
Psychological Acceptability

Society
SEWAGE SLUDGE IRRADIATION PLANT IN GEISELBUHLACH, GERMANY

- Gamma ray: Co-60, Cs-137;
- Liquid sewage: 145 m$^3$/day;
- Dose: 2-3 kGy;
- Batch mode;
- Demo plant: 1973-1980
- Commercial plant.

Lessel, 1990
Hygienisation of Sewage Sludge Using Radiation – Integrated with Conventional Plant

Kumar, 2013
Radiation Treatment Process

Commercial plant, (1989)

Gamma ray
Co-60; 0.5 MCi

Liquid sewage sludge; 3 kGy
110 m³/day; 4 % SS
Dried sludge being despatched for field trials

Sludge after drying ready for use in agriculture
SLUDGE CAKE IRRADIATION SYSTEM

Reservoir for raw sludge

Flat nozzle

Feed pump

Grinder

Stainless conveyor

Scan horn

Reservoir for irradiated sludge

Hashimoto et al., 1991
Irradiation-composting system of sewage sludge
Sewage treatment with electron beams
Proposals, City of Edmonton, Canada (1993)

Electron energy 10 MeV; Beam power 50 kW;
Dewatered sludge 63 t/d; Dose 5-15 kGy
DISINFECTION OF MUNICIPAL SEWAGE SLUDGES IN INSTALLATION EQUIPED WITH ELECTRON ACCELERATOR

A.G. Chmielewski, Z. Zimek, T. Bryl-Sandalewska, W. Kosmal, L. Kalisz, M. Kaźmierczuk
Radiat. Phys. Chem. V. 46, 4-6, 1071-1074, 1995

Capacity 70 t/day
Dose 5-6 kGy
10 MeV, 10 kW

1 - electron accelerator, 2 - conveyor, 3 - shielding, 4 - feeder
Transport equipment for sewage sludge irradiation

Sewage sludge from piston pump

Electron accelerator

Irradiated sewage sludge

Transport towards irradiated sewage sludge loading zone

Full section roller-less worm conveyor
## Economics of Current Technologies

<table>
<thead>
<tr>
<th>Process</th>
<th>Cost per Dry Ton (2005 US$)</th>
<th>Cost per Dry Ton as VA Product (2005 US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incineration/Co-generation</td>
<td>600 to 1100</td>
<td>3 to 30 as Ash Reuse</td>
</tr>
<tr>
<td>Thermal Treatment</td>
<td>500 to 1200</td>
<td>30 to 150 Usage as a Fuel or Fertilizer</td>
</tr>
<tr>
<td>Biological Anaerobic Digestion</td>
<td>350 to 650</td>
<td>30 to 200 as Natural Gas/Residual Soil Amender</td>
</tr>
<tr>
<td>Biological Aerobic Digestion</td>
<td>350 to 700</td>
<td>30 to 70 as a Residual Soil Amender</td>
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<tr>
<td>Advanced Alkaline Stabilization</td>
<td>350 to 550</td>
<td>80 to 120 as a Ag Lime Agent</td>
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<tr>
<td>Acid Stabilization/Disinfection</td>
<td>350 to 550</td>
<td>30 to 70 as a Residual Soil Amender</td>
</tr>
<tr>
<td>E-Beam Disinfection/Stabilization</td>
<td>100 to 250</td>
<td>30 to 70 as a Residual Soil Amender</td>
</tr>
</tbody>
</table>

*Reimers et al, 2013*
Survival of micro-organism population vs dose (beam energy: 1MeV, thickness of sludge: 3mm)

Kim et al., 2009
Design assumptions

- Application: land application of disinfected digesting sludge;
- Flow rate of dewatered sludge: 7,000 m³/month (22 m³/h);
- Absorbed dose: 2~10 kGy (depend on removal efficiency of total coliforms bacteria (dewatered sludge - 18% SS));
- Electron beam utilisation efficiency: 70% (min. 60% ~ max. 80%);
- Electron Energy: 2.5 MeV; Beam power: 100 kW;
- Operating time: based on 16 hrs/day (20 days/month);
- Nozzle width: 1.8 m; Speed of conveyor: 30 m/min;
Electron Beam Sludge Hygienization Plant

Economy of sewage sludge e-beam treatment (results of calculations)

Electron accelerator (2.5 MeV, 100 kW) 960 k$
Investment 1020 k$
Total capital requirements 1980 k$
Fixed cost (6%; 20 years) 218 k$
Variable costs (5 c$/kWh, 2 shifts) 150 k$
Total operation cost 368 k$
Unit cost for sludge cake 4.4 $/m$^3$
E-Beam is unable to achieve stabilization of treated solids. There is a need to couple E-Beam with one or more technologies to achieve sludge stabilization:

- composting of dewatered sludge pretreated by electron beam,
- lime application (amount 30-40 kg/t of dewatered sludge - 2.3-3.2 $/t).
E-beam sludge treatment process steps:

1. Sludge dewatering: (volume reduction);
2. EB Irradiation (disinfection);
3. Sludge stabilisation (lime or composting; smell reduction);
4. Agriculture Use (fertilizer).
Summary

- E-Beam Process is a quick and credible method of hygienization of municipal sewage sludge.
- Sludge hygienized with e-beam can be used as soil fertilizer immediately after treatment and no large land areas are needed to their disposal for long time.
- The operation cost of e-beam sludge plant can be reduced for larger facility.
- More convenient and competitive to compare with other technologies.