Alkaline Hydrolysis of Mortalities and Disposition of the Sterile Remains

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Abstract. *Alkaline hydrolysis has become one of the preferred methods of processing diseased animal mortalities and remains. Today it is making its way into the funeral and pet industries as an alternative to flame cremation. Energy consumption is 1/20 that of flame cremation and overall carbon footprint is 1/10. The technology is inherently desirable for handling of disease emergencies for carcasses that are contaminated with any and all pathogens, including prions. These systems have evolved into portable forms that are suitable for emergency disease prevention and response at the site of the situation. The end product is sterile and is excellent fertilizer, allowing immediate land application at the emergency site after the process has been completed. This is an exceptional feature of the technology and we will show photos of the end product being applied to land. This presentation will address the efficacy of the process, discuss available forms, and look forward to new forms that could be developed. Costs and ideas for applications will be examined, as well as future planning ideas to ensure that the technology is available where needed.*

Keywords. Alkaline Hydrolysis, Tissue Digester, BioLiquidator, M-2500, M-4000, Cremation Alternative, Incineration Alternative, Bone Shadows, Sterile Effluent, Hydrolysate, Alkali, Sodium Hydroxide, NaOH, Potassium Hydroxide, KOH, Prions, TSEs, Transmissible Spongiform Encephalopathies, TDEs, Transmissible Degenerative Encephalopathies, CWD, Chronic Wasting Disease, BSE, Bovine Spongiform Encephalopathy, Tuberculosis, Rabies, Pseudo-Rabies, Virus,

Pathogens, Select Agents, FMD, Foot and Mouth Disease, Disinfection, Decontamination, Sterilization, Land Application, Slurry, Fertilizer, Calcium Phosphate, Bones, Teeth, SRM, Specified Risk Material, LP Gas, Natural Gas, Propane, Potable Water, Non-Potable Water, CO2, Carbon Dioxide, Citric Acid, Acid, Virkon-S, Quaternary Ammonium Compounds, Quats, Halogens, Peracetic Acid, Disposition, Dissolution, Sewage Treatment, Aerobic Digestion, Anaerobic Digestion, Avian Influenza, E. Coli, Animal Diseases, Zoonotic Diseases, Air Curtain Incinerator, Flame Incineration, Flame Cremation, Civil Service, Outbreaks, Response, On-Site Disease Response, Disease Containment, SRM Treatment, SRM Destruction, Denature SRM, Slaughterhouse Waste, Abattoir Waste, Best Available Technology

Introduction

Alkaline hydrolysis has emerged over the past 20 years as a preferred method of animal mortality disposal for universities, veterinary diagnostic institutions, research facilities, and agricultural operations as both a sterilization method and alternative to incineration. Today this technology is also widely available as a final method of disposition for humans and pets as an alternative to cremation, employed at medical schools for willed body programs, funeral homes, pet and human crematories, and veterinary clinics.

Alkaline hydrolysis can be performed at high temperature (above 100°C which requires a pressure vessel), or low temperature (below boiling temperature in an atmospheric tank or vessel). Alkaline hydrolysis uses as little as 1/20th the energy of flame incineration, and exhibits a carbon footprint approximately 1/10 that of flame incineration.

Some alkaline hydrolysis systems are specifically equipped for rapid, on-site response to animal disease outbreaks. On-site processing reduces any risks of disease transmission caused by transporting mortalities to off-site incinerators or processing plants. These mobile systems allow rapid deployment for timely response, cost effective sterilization, and are the best available technology with respect to other on-site sterilization or treatment options. Unlike air curtain incinerators, alkaline hydrolysis processes will not disseminate disease organisms into the atmosphere, thus allowing better containment particularly of airborne disease organisms. The end product from alkaline hydrolysis is a sterile, nutrient rich, true solution consisting of water, amino acids, small peptides, soaps, sugars, salts, and minerals. This end product may be disposed of by land application as a fertilizer, in an aerobic sewage treatment facility, or by anaerobic digestion depending on the facilities that are available for final disposition.

The resulting solids, including grasses from the digestive system (undigested cellulose), and the calcium phosphate mineral ash of the bones and teeth - are sterile. This resolves all concerns about end product disposal. Systems are available in many different configurations. We will concentrate on mobile systems that are available to be set up for field operations at the site of the disease emergency.

Introducing the BioLiquidator: Capacities and Capabilities

The BioLiquidator is a reliable and practical alkaline hydrolysis system available in portable and stationary models; these units have been in the field for over seven years. The M-Series BioLiquidators are mobile systems that are available as standard or highly custom units. The standard models M-2500 and M-4000 (the numbers refer to the maximum tissue weight capacity per cycle) are completely self-contained on a trailer that can be pulled by any standard ¾ ton pickup truck. The trailer houses the processing tank, boiler, generator, and propane tank. The onboard components allow the unit to operate in remote locations, such as in the middle of a pasture. The unit can also be plugged in directly to an on-site electrical supply to bypass the generator and conserve propane. Any fresh water source can be used to feed the units (water supply via standard garden hose, or water from lake, stream, river, etc. via pump and hose). These systems are built with significant ground clearance and mobility to be able to access and operate at off-road sites where the disease outbreak is located.

Extended Capability of System in Emergency Situations:

For large animal processing the standard cycle is 20 hours, however for emergency operations the liquefaction and sterilization of large animal carcasses can be as fast as an 8 hour turn

around (3 cycles per 24 hours). Cycle speed can be further enhanced by fast fill and fast discharge upgrades.

Any custom variation of this system can be built specific to the application. For example, two S-4000 units mounted to a semi-trailer with high speed fill and discharge pumps, and an energy recovery apparatus for rapid turn-around. For small animals such as chickens and turkeys, the process can be dramatically faster. As little as 3 hours turn around per cycle can be accommodated with a standard unit, and if equipped with energy recovery equipment (such as the large double unit on a trailer) the equipment could turn around in as little as 2 hours per cycle. In the case of this double unit, 24 cycles per day (over 75,000 pounds of chickens/turkeys per day) could be accommodated. Poultry in particular dissolves very rapidly in alkaline hydrolysis.

Testing Results of the Effluent (Hydrolysate/Digestate)

Most of the world has accepted the process of alkaline hydrolysis as a method to destroy Transmissible Degenerative Encephalopathy (TDE) agents, also known as Prions.

USDA FSIS recognizes alkaline hydrolysis as an effective treatment for SRM (specified risk material). SRMs include any tissues from bovine animals that are known to be areas where prions/BSE concentrate; in 2009 the FDA began full enforcement of a feed ban rule that requires the denaturing and destruction of all high-risk cattle material to prevent its use as food for all animal species. This is a more stringent rule that expanded from the 1997 rule which prohibited SRM entry into ruminant feed only. Canada has very strict SRM rules as governed by the CFIA, of which alkaline hydrolysis is an accepted treatment method with some restriction.

The U.S. Government employed alkaline hydrolysis to destroy carcasses with scrapie and chronic wasting disease (University of Wisconsin, 2004-present; Devitt 2003), BSE-contaminated sheep and cattle at Auburn, 2005 (Dr. Fred Hoerr, University of Auburn, personal communication), and Ames, 2001 (Mark Muth, USDA, Ames, IA, personal communication).

Alkaline hydrolysis has been shown to destroy the infectivity of prions in a study performed by the Institute of Neuropathogenesis, University of Edinburgh. These results fed the approval process in the European Union (EU) for category 1 waste, including bovine spongiform encephalopathy (BSE)-contaminated carcass materials.

Part of the EU approval process involved the acceptance of combined matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) and amino acid assay analyses of the hydrolysate as evidence of the degree of hydrolysis and proof of protein destruction. Dr. David Taylor, a leading authority on prion destruction, advised that this type of analysis would be the best way to determine the degree of hydrolysis from a specific system, and that it could be correlated with a high degree of probability of complete Prion destruction in an alkaline hydrolysis process (Taylor, 2008). MALDI and amino acid test data for low-temperature alkaline hydrolysis in challenged, real-life applications have been analyzed to show complete protein destruction and an equivalent degree of hydrolysis to the high-temperature process. All data was reviewed by Dr. David Taylor (Taylor, 2009).

Possible Scenario Yielding Availability for Emergencies

Required Resources:

Equipment needs to be available to respond to regional emergencies. The capability for this equipment to be pulled by any standard ¾ ton pickup truck makes deployment a feasible task.

In addition to machines, supplies are needed such as propane to fire the boiler and generator, water, alkali, and equipment to spread the effluent after it is emptied.

Propane is available from any local fill station. Water from almost any source can be utilized. Water from the site supply can be used via garden hose connection or tank with pump. A specialized pump can feed the unit using water from a nearby natural water source such as a pond or creek. If on-site water cannot sustain the operation of the unit, water can be transported to the site in standard agricultural tanks which should be available from nearby farms, co-ops, pool water companies, fire departments, or other industries.

Alkali is available in liquid or dry form; for mobile disease response the dry form would be recommended. Anhydrous alkali is available across the country. It is provided in 50 and 55 pound bags, each in a plastic lined bag, which are stored with the unit in plastic storage containers. For a large scale emergency plan, a large reserve of alkali should be kept; the volume would be calculated by forecasted need. Dry alkali can be stored on pallets in a reasonable indoor environment for very long periods of time. Cost of alkali is very reasonable/minimal considering the cost of not containing a disease outbreak.

Effluent/hydrolysate from this process has been directly land applied as fertilizer for over 10 years. Any local agricultural operation or supplier would have liquid storage tanks or liquid spreading equipment to accept the effluent from the completed process. Any liquid spreading technique is acceptable, including top dressing or knifing at agronomic rates. The effluent can also be discharged into a manure pit or lagoon to be later spread with the manure during normal application. Alternatively, a septic hauler can be used to transport the effluent to an anaerobic digester or wastewater treatment facility.

The final bone remains and any plant materials that have been through the process are sterile and ready for final disposal. These can be crushed and used as calcium phosphate fertilizer, or they can be properly buried or hauled to a landfill.

Civil Service Use:

For the systems to be available during an emergency outbreak, it would make sense for the equipment to be located where it could provide valuable civil services during the time it is not employed for emergency operations. Some options include use by local municipalities to dispose of road kill, animal shelter mortalities, localized livestock downers, and diseased animal mortalities (i.e. as part of a CWD control and surveillance program). These systems could be provided by the U.S. Government as part of a contractual condition that they become deployed in the event of emergencies as requested. The civil service use can support the cost of the equipment, and provide storage location and supply rotation for alkali.

Ongoing Maintenance and Condition of Equipment:

If the equipment is used routinely then the maintenance and condition would be maintained in operating order by the routine users. If the equipment is stockpiled it will need to be checked annually and the motors, boiler, etc. cycled to be sure it is in operating condition. This is why the first scenario, routine civil service with the equipment makes the most sense. Little maintenance is required since the units are primarily stainless steel construction, however it is highly recommended that the unit be located indoors or at least under a covered area.

Manpower:

If the equipment is employed in civil service, then trained operators and pickup trucks to transport the equipment would be already available. Contractual obligation by those provided the equipment could be that they show up at the emergency site with a tow vehicle and a trained operator. The personnel would be paid sufficiently during the emergency to make this commitment attractive to both the operators and to the Government. Alternatively, the equipment manufacturer can deploy on-site training or an annual training course can be held to train selected individuals. There are numerous options for selection of individuals to receive the training. Some options include representatives from the local agricultural community, municipal personnel, military personnel, extension office personnel, veterinary professionals, highway department personnel, DNR personnel, or a group assembled by the local board of animal health and/or department of homeland security.

Other Possible Forms of Alkaline Hydrolysis Technology:

As mentioned before, larger forms of the technology can be developed using either multiple low temperature systems (such as two or three S4000 units mounted on a flatbed semi-trailer), or a larger custom system either low or high pressure could be designed and developed. Work has been done conceptually for both options and still the S-4000 variants come in as the most economical vs. processing capacity and safety.

Site Decontamination and Emergency Response

Hotsies and BioLiquidators for Decontamination:

Any time a site is used to handle and process contaminated animals, the site needs to be decontaminated during and after the waste processing. Some tools are commonly available that can be employed in these decontamination processes including chemicals such as hot alkali or Virkon-S which can be stockpiled; these can be used with Hotsie equipment to provide heated disinfectant capabilities. Some disinfectants are environmentally compatible and will not contaminate groundwater. An example would be alkali (KOH or NaOH) at elevated temperature for treating the soil on the ground. A large amount (1,200 gallons) of hot alkali solution can be provided and spread by a BioLiquidator after the processing at the site is complete.

For vehicle and equipment decontamination Virkon-S or Quaternary compound fed warm or hot through a Hotsie type device can be used without damaging the equipment. The elevated temperature potentiates the decontaminant by orders of magnitude making it much more effective, much faster. Hot water alone is a good disinfectant for viruses where chemical concerns exist.

Some chemical formulations work well cold, simply sprayed on equipment or machinery. Virkon-S is one very good broad-spectrum chemical that would be safe for people working around the area while it is being used. It is proven effective even at cold temperatures. Other chemicals are available depending on the nature of the contamination.

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