USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Development of a Simple Combustion Process for Disposal of Waste from Livestock Operations

Focus Categories:

Treatment	TRT
Nonpoint Pollution	NPP
Agriculture	AG

Keywords: Animal Waste, Wastewater, Agriculture, Treatment, Pollution Control

Duration: 03/01/99 - 02/28/01

Federal Funds Requested: $44,000

Non-Federal (matching) Funds Pledged: $91,699

Principal Investigator(s):

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Congressional District: 8

Statement of Critical Regional or State Water Problems:

The recent statements emanating from Federal and State environmental agencies show a growing concern for the adverse effects of run-off from large livestock operations,[1] particularly in the midwestern states. There is ample data to show that unprotected waste from livestock operations washes into streams as non-point source (NPS) pollution. The United States Environmental Protection Agency (US EPA) estimates that 41 percent of the total NPS pollution results from agricultural sources, and a third of that is attributable to livestock operations.[2] In addition, water quality concerns such as noxious odors and the spread of pathogens and weeds are becoming serious. Clearly, alternative treatment technologies for livestock waste are required to:

- reduce the volume of the waste
- reduce the odor
- destroy pathogens and other undesired components such as residual pesticides

Statement of Results or Benefits:

According to Stephen Mahfood, the newly-appointed director of the Missouri Department of Natural Resources, the impact of swine production on the water and air quality is one of the most pressing environmental issues in the state.[3]

The proposed drying and combustion system would provide an economical solution to the environmental problems faced by large swine and other livestock operations. A preliminary cost analysis shows that treatment with the proposed process will cost approximately $3.80 per ton. This is competitive with treatments such as composting or oxidative and anaerobic digestion.

The research will be carried out in laboratories affiliated with the Center for Environmental Science and Technology (CEST) on the UMR campus. It will involve both graduate and undergraduate students, affording them an opportunity to work on and solve real world environmental problems. Furthermore, the close association between CEST and Missouri industry would enhance implementation probabilities for the technique. The proposed system is highly relevant to major swine producing regions such as southern Iowa and northwestern Missouri.

Nature, Scope and Objectives of Research

An abundant supply of clean water is essential for sustaining human health and the environment.

Recent statements issued by the US Environmental Protection Agency (US EPA) state that rural and urban runoff accounts for more than one-half of all water pollution. Runoff from animal feeding operations in particular has been associated with threats to human health and the environment. In a draft plan issued March 5, 1996, by the US EPA, the EPA plans to regulate runoff from factory farms with large numbers of cattle, pigs, and chickens. The draft plan calls for an aggressive enforcement of the Clean Water Act permit requirements. It is estimated that these requirements will affect approximately 450,000 animal feeding operations in the United States.[4] In Missouri alone, approximately 3.3 million head of swine are raised every year. The annual waste resulting from these operations is estimated to be 19,500 tons.

It is anticipated that reduction in animal waste runoff would reduce or eliminate the excess nutrients which are contaminating lakes and streams in states with large livestock feed operations. This pollution has been blamed for drinking water contamination, fish kills, noxious odors, and a host of other deleterious environmental effects. In Missouri, the runoff situation is particularly acute with the swine feedlots. These operations are centered in northwestern Missouri, and similar situations exist in other states. The estimated volume of wet solid waste resulting from these operations is approximately 1 million tons. These wastes are rich in carbonaceous materials, urea, and related ammoniacal compounds and noxious sulfurous volatiles. Advanced combustion processes hold potential for rendering all these chemicals harmless.

The overall objective of the proposed research is to develop and evaluate a simple drying/combustion process to eliminate pollutant runoff from livestock production operations. The specific objectives are:

- Design and build a laboratory scale combustion system.
- Evaluate the combustion efficiency.
- Evaluate a modular configuration.
- Carry out a preliminary economic evaluation.

This study should provide scientific and engineering data to submit a proposal for construction of a pilot scale combustion system and evaluate the potential of an industrial scale operation.

Methods, Procedures, and Facilities

The objective of the proposed research is to develop and evaluate a simple combustion technique for disposal of livestock production waste streams. The proposed research will use an integrated high-efficiency fluidized combustion/drive system. The system will be conceptually similar to a process that our group has developed for treatment of industrial waste streams.[5,6] The combustion system will integrate the following tasks:

- Concentrate the solid content
- Combust a portion of the dry material
- Oxidize odiferous volatiles

A schematic of the proposed system is shown in Figure 1. The system will consist of an 8000 BTU/pound solid fuel burner.

The fuel for the burner will be derived from the livestock (swine) waste slurry (9-20% solids). The slurry will be fed into the fluidized bed dryer maintained at approximately 650ºC (1200ºF). The hot combustion gases will be used to rework excess moisture from the waste stream in a fluidized bed dryer. The dry solids from the fluidized bed will be apportioned into the solid fuel burner and pathogen and odor-free solids. These solids would be useable for feed, fertilizer, and fuel. The flue gases from the fluidized bed will be combusted in a secondary burner. The odor-free exhaust will be released through a stack.

The efficiency of the proposed system will first be tested with a bench scale set-up. Parameters of interest include the following:

- BTU value of the livestock waste
- Pathogen concentration of waste
- Pathogen concentration of treated solids
- Concentration of residual pesticides

- Volatile sulfurous organics in livestock waste
- Volatile sulfurous organic concentration of the off gas
- Concentration of nutrients in the treated solids

The Center for Environmental Science and Technology (CEST) and associated laboratories, occupying approximately 20,000 square feet of laboratory space, are well equipped to determine these parameters. A partial list of available instrumentation is provided in Appendix A.

The off gases from the fluidized bed will be mixed with air supply for the solid burner. The odor free (due to the sterilization temperature) flue gases will be released from the exhaust.

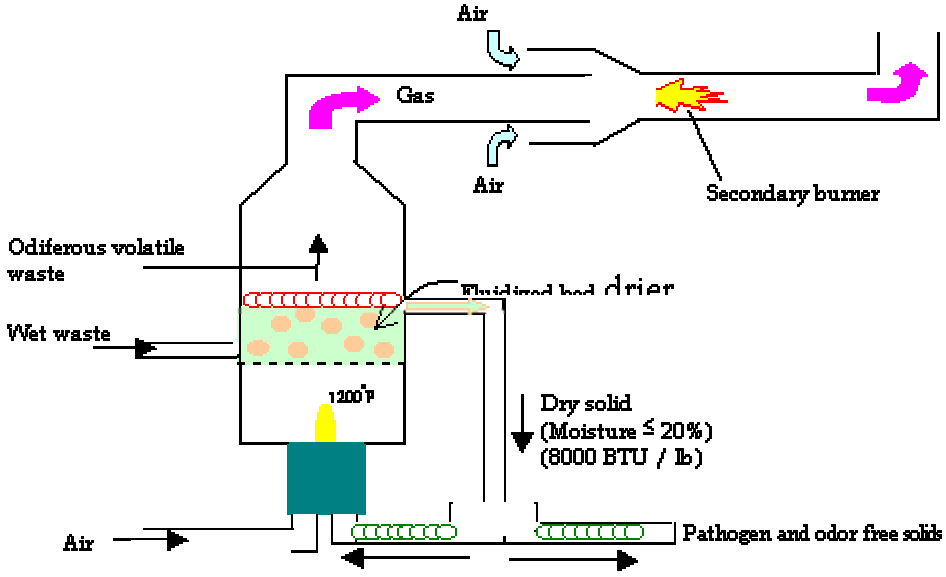

Figure 1. Livestock Waste Dryer/Combustor and Deodorizer System

The flue gas sample will be analyzed with an on-line gas chromatograph equipped with a thermal conductivity detector (TCD) and a tandem flame photometric detector (FPD). This instrumentation will be interfaced to a PC-based data system. Concentrations of selected flue gas components such as SO_2 and NO_X will be monitored with an on-line combustion gas analyzer (Bacharach Model 300). A preliminary analysis of treatment cost with the proposed system is provided in the following section.

Preliminary Cost Analysis
Livestock Waste Dryer/Combustor and Deodorizer System

Capacity: 2 tons/hour required for 7600 head of swine (13.9 lbs/day/head)

Total Annual Waste: 17,526 tons

	Annual Cost	Cost/Ton
Capital Equipment Costs (amortized over 5 years)		
Materials and Construction	$4,182	$0.24
Operating Costs		$0.46
Operator, semi-skilled	$6,900	
Supervisor	$1,200	
Maintenance Costs	$1,300	$0.07
Miscellaneous Costs	$ 500	$0.03
Electric Power Costs; 100 kwh; $0.06/kwh		$3.00
Total Cost Per Ton		**$3.80**

Related Research

Advanced combustion processes are being evaluated on bench scale in our laboratory for incineration of high-ammonium-containing industrial waste streams. Results of ammonium bisulfate containing waste streams (50% ammonium bisulfate w/w basis) have shown that sulfur in the waste stream are completely converted to sulfur dioxide (SO_2). Ammonia in the waste stream was completely oxidized to nitrogen. The nitrogen oxide (No_x) emissions were minimal. Clearly, such a process holds potential for rendering pollutants harmless and with added potential for energy recovery.

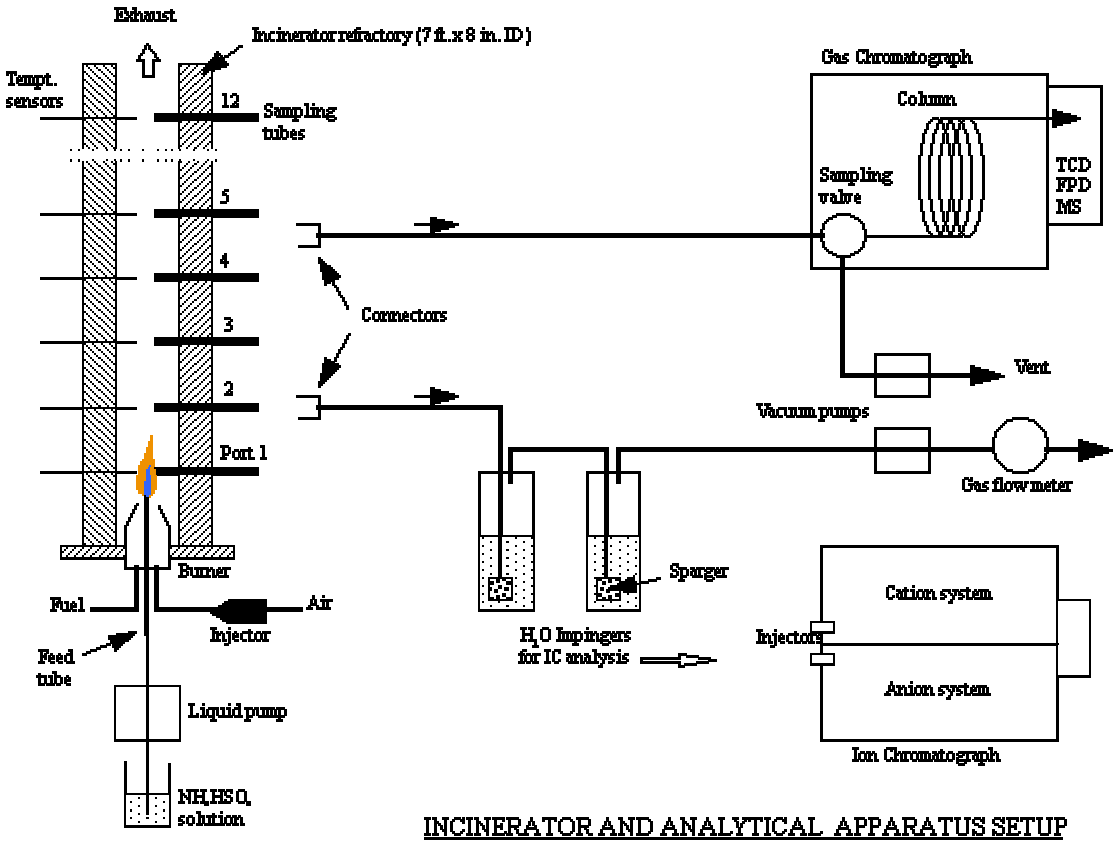

Figure 2. Industrial Waste Combustor and Ancillary Analytical Apparatus

The combustor consists of a nozzle burner with designed heat yield of 150,000 BTU/hour with hydrocarbon fuel (Figure 2). The aqueous waste is fed through a nozzle located in the center of the burner. The burner is enclosed in a combustion chamber consisting of a steel pipe 210 cm x 35 cm i.d. lined with a 7.5 cm thick layer of refractory material. The chamber is lined with sampling ports 15 cm apart. The ports are used for flue gas sampling and temperature measurements.