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Treatment Methods for Meat Waste Management

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Abstract

The meat industries produce a large amount of waste that because of economic and ecological reasons should be reused. Aerobic and anaerobic digestions are number of treatments. Thermal treatment is away to reproduce fuel energy. Composting is another way to reuse the meat wastes and it has three ways however it has ecological and energy disadvantages. Livestock feed is another solution. Blood and bone meal are full of essential materials for feed and should be decontaminated.at the last bone meal is a cheap cost source of hydroxyapatite that it has adsorption capacity of heavy metal.

Keywords: meat waste, reuse, treatment

Introduction

Animal waste may be defined as carcasses or parts of animals, including products of animal origin not intended for direct human consumption **(Commission of the European Communities, 1990)**. In the meat industry, the slaughtering process is the largest contributor to liquid waste **(Benka-Coker and Ojioro, 1995).**
Another aspect is energy consumption that ther is an increase in both energy demand and specific energy consumption in the meat industry in this time. Furthermore, **Salminen and Rintala (2002)** reported that, because of legal restrictions, rising treatment costs and environmentally conscious consumers, the treatment of some solid residues and wastes and, particularly, residues from wastewater treatment processes emerged as a major concern in meat industries.

In an early work, the waste originating from Danish farm production amounted to 40–50 × 10^6 metric tonnes of solid and fluid manure. Moreover, the water used in dairy plants and slaughterhouses amounts to approximately 40 _ 106m3 per year, which equals the amount of water used by 500 000 people. However, the wastewater from these plants was so heavily contaminated with organic matter and chemicals that it required a purifying capacity matching 1.8–2.0 _ 106 person equivalents to render this water acceptable for streams and lakes (**Andersen and Aalund, 1975**).

Aerobic and anaerobic digestion

With the increasing costs of pollution abatement and high cost municipal surcharges, food processors are forced to look into alternative methods for pretreatment of wastewater prior to discharge for secondary treatment or other treatment systems **(Sistrunk, 1984).**

Aerobic digestion

Physicochemical methods are being increasingly used for the preliminary treatment of wastewater before its biochemical purification. This is due to stricter requirements with regard to the degree of purification of wastewater and the need to remove all organic admixtures before it is discharged **(Radoiu *et al.*, 2004)**.
In wastewater treatment, coagulation/flocculation processes are mainly used for the removal of colloidal material, which causes colors and turbidity. An essential feature of wastewater flocculation is the elimination of suspended solids (SS) and as much of the organic material as possible. To remove SS and organics, a floc forming chemical is needed which can be separated from water by flotation, settling or adsorption **(Al-Mutairi *et al.*, 2004)**.
The rate and effectiveness of the flocculation process employed depended on the composition of the wastewater, its temperature, the rate of mixing and the order in which coagulants and flocculants are introduced into the wastewater. When dissolved in wastewater, flocculants may be in a non-ionized or ionized state. When they are ionized, they are called soluble polyelectrolytes **(Radoiu *et al.*, 2004)**.

PAX-18, Al2(SO4)3 _ PA polyelectrolyte and Fe2(SO4)3 _ anionic polyacrylamide appear to be the most effective in COD removal rates, while the results obtained for the other compounds varied with pH.
conducted studies using alkaline or enzymatic treatments towards hydrolyzing or reducing the size of fat particles in a slaughterhouse wastewater.
One of the best chemicals that is used is pancreatic lipase which resulted in a reduction in particle size to 60% with an attendant increase in free long-chain fatty acids. In this way, **Masse *et al.***
(2001, 2003) reported that pancreatic lipase, PL-250, proved to be the most efficient in reducing pork fat particle size and increasing free long-chain fatty acid (LCFA) concentration.Number of aerobic methods seems in table 1-1.

Type of reactor	COD removal %	References
AFBR	73	Nikolaeva *et al*., 2002
LAR	82	Montalvo, 1995
UASB	77-91	Caixeta *et al*., 2002
MBRs	97	Fuchs *et al*., 2003
AFFR	85-95	Del Pozo *et al*., 2000
Fluidized bed	85	Borja *et al*., 1995
Anaerobic filter	30-85	Tritt, 1992
Two-stage UASB	90	Sayed *et al*., 1993
Anaerobic baffled reactor	75	Polprasert *et al*., 1992
Anaerobic filter	37-75	Viraraghavan and Varadarajan, 1996

Table1-1- Number of aerobic methods and efficiencies

Anaerobic digestion

the anaerobic digestion process is a promising solution to the problem from both energy conservation and pollution control considerations, since it can reduce the BOD5 considerably with the production of fuel in the form of methane **(Clanton *et al.*, 1985; Yan *et al.*, 1988)**. Besides generating biogas for energy use, the process also kills pathogens and produces stabilized material which can be used as fertilizer in land applications **(Salminen and Rintala, 2002)**.

During anaerobic digestion of meat wastes, the concentration of ammonia-nitrogen rises considerably as protein breakdown occurs. The excess of ammonium can inhibit the decomposition of organic compounds, the production of volatile fatty acids (VFAs) and methanogenesis **(Krylova *et al.*, 1997; Kayhanian, 1999)**.

Lipids may also cause problems in anaerobic digestion because of their tendency to form floating scum and accumulated long-chain fatty acids (LCFA) **(Angelidaki and Ahring, 1993; Hansen *et al.*, 1998)**.

Aerobic digestion

The goal of wastewater treatment is to remove the suspended materials and to eliminate the soluble organic contaminants. Biological degradation is the main technology that makes use of adsorption of microbes in activated sludge to oxidize and decompose the solute or suspended protein, fat and lard and other carbohydrates **(Spencer and Watson, 1997; Jian and Zhang, 1999)**. Aerobically treated excrement contains much less soluble organic material than fresh or anaerobically stored excrement and thus its application is less likely to lead to organic pollution of water courses **(Owens *et al.*, 1973)**.

Aeration is a highly effective and simple method for degradation of organic pollutants, including odorants, but its running cost is high. Because it is an exothermic process, the recovery and utilization of heat can help support the treatment cost **(Svoboda and Evans, 1987)**. Furthermore, aerobic treatments are very effective at reducing odors and pathogens **(Skjelhaugen and Donantoni, 1998)**.

Heating

As a general trend, MBM gives low polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/F) values ,compared with incineration of other wastes. Maximum yield of pollutants is observed at a nominal temperature between 700 and 800°C. In relation to the temperature behavior, the maximum production of PCDD/F was found between 700 and 800°C.

Among the different processes studied, valorization of MBM can be realized with a thermal degradation treatment (incineration or pyrolysis) **(McDonnell *et al.*, 2001; Chaala and Roy, 2003)**, as they are a readily flammable fuel (approximately 17 000 kJ/kg) **(McDonnell *et al.*, 2001)**.

Among the different processes studied, valorization of MBM can be realized with a thermal degradation treatment (incineration or pyrolysis) **(McDonnell *et al.*, 2001; Chaala and Roy, 2003)**, as they are a readily flammable fuel (approximately 17 000 kJ/kg) **(McDonnell *et al.*, 2001)**. During high temperature combustion (over 800°C), thermal energy is recovered and proteins such as prions are destroyed (as all organic matter is converted to CO_2, H_2O, etc.) **(Riesner, 1997; Dormont, 2002; Taylor, 2002)**.

A complex gas turbine engine, named IFGT (indirectly fired gas turbine), integrated with a rendering plant was evaluated for poultry industry waste. The rendering plant is composed of two lines: one for meat and the other for feathers.This energy resource can be used as fuel in order to supply the required thermal energy. A CHP (combined heat and power) system is a promising solution in order to meet the need to dispose of the metals, at the same time producing the thermal energy demanded by the process plant and an electric power surplus. In general terms, a gas turbine is a power generator capable of high CHP performance in terms of heat to electric power ratio.

The presented results revealed that energy recovery from poultry industry by-products becomes very attractive if the disposal of these wastes implies a cost to be sustained. In particular, the electric energy production can be a feasible and remunerative investment especially in a deregulated energy market.

Compost production

Composting is a widely used method for organic waste disposal **(Cambardella *et al.*, 2003)**, while it also has potential as an effective method of treating waste prior to land application **(Imbeah, 1998)**. It is an aerobic, biological process employing naturally occurring microorganisms to convert biodegradable organic matter into a humus-like product **(Lau *et al.*, 1992; Liao *et al.*, 1993; Imbeah, 1998)**.

Mesophilic and thermophilic microorganisms are involved in composting and their succession is important in the effective management of the process **(Beffa *et al.*, 1996; Ishii *et al.*, 2000; Goyal *et al.*, 2005)**. This process kills pathogens, converts nitrogen from unstable ammonia to stable organic forms, reduces the volume of waste and improves the nature of the waste **(Imbeah, 1998)**.

The acceptance of composting, however, depends on how well the operating strategies employed are developed for both product quality and environmental protection **(Tiquia and Tam, 2002)**. In this way, composting provides an inexpensive alternative for disposal of all dead animals.

Three methods of composting are commonly used: windrows (method used at Illinois State), aerated static piles (windrows with perforated pipe laid within the pile) and bins or aerated chambers.however, has ecological disadvantages in terms of an apparent energy loss and the production of a large amount of carbon dioxide. Thus, an innovative solution to these problems is urgently required.

Thermophilic bacteria are used in the decomposition of these hard-to-degrade animal proteins because, in the elevated temperature range where thermophilic bacteria grow, such proteins tend to gain plasticity, resulting in more susceptibility to protease attack **(Suriyama *et al.*, 2005)**.

Livestock feed

The most effective way of reducing the negative environmental impact on the accumulation of waste is the incorporation of the waste into productive processes **(Sancho *et al.*, 2004)**. The feeding of biological waste to livestock is currently an accepted practice in modern day society and has arisen mainly because of the necessity to reduce costs both in terms of disposal of wastes and in production of meat etc. from livestock **(Adel *et al.*, 2002)**.

Animal blood is the largest source of potentially edible material. About 100 000 tonnes of blood, which represents approximately 20 000 tonnes of protein are available every year in the UK. Blood has several functional and nutritional attributes which make it a useful ingredient in many food items and markets for hygienically collected and separated blood could be numerous **(Fallows and Wheelock, 1982)**.

Spray-dried blood plasma has the greatest potential use in the food industry due to its wide range of desirable functional properties **(Gault and Lawrie, 1980)**.

Meat and bone meal (MBM) was widely recommended and used in animal nutrition as a protein source in place of proteinaceous feeds because of its content of available essential amino acids (EAA) **(Cozzi *et***

***al.*, 1995)**, minerals and vitamin B12 in monogastric nutrition and rumen escape proteins in ruminant nutrition **(Piva *et al.*, 2001)**.

Obviously, decontamination of the sludge is mandatory when it is to be applied as a feed constituent, to prevent bacterial cycles from occurring in livestock, as well as the spread of human pathogenic zoonoses like *Campylobacter*, *Salmonella* and *Yersinia*, to minimize loss of protein quality by the microbial breakdown of amino acids and the formation of possible toxic metabolites in sludge during storage **(Fransen *et al.*, 1994)**.

Kargi *et al.* (1980) investigated the feasibility of using by single-stage aerobic continuous process for treating poultry waste in order to produce a single-cell protein useful as feedstuff.

Heavy metal adsorption

The pollution of the environment with toxic metals is a result of many human activities, such as mining and metallurgy, and the effects of these metals on the ecosystems are of large economic and public health significance.

Animal bones consist of 65–70% inorganic substances, mainly calcium hydroxyapatite **(Samuel *et al.*, 1985)**. **Deydier *et al.* (2003)** reported that calcium hydroxyapatite (CaHA) is the major inorganic constituent of bones and teeth. The chemical composition of calcium hydroxyapatite is Ca10(PO4)6(OH)2. This material removes the metal ions by means of adsorption and ion exchange from the solutions **(Samuel *et al.*, 1985)**.

Abdel-Halim *et al.* (2003) investigated the adsorption capacity of some natural materials such as animal bone powder for lead. The adsorption process was affected by various parameters such as contact time, pH and lead solution concentration.

Cheung *et al.* (2002) studied the sorption rate of copper and zinc ions onto bone char around pH 5 using a batch agitation system.

Chojnacka (2005) reported absorption of Cr (III) ions from aqueous solutions by animal bones. Furthermore, it was found that sorption capacity increased with increase in Cr (III) concentration, temperature and initial pH of metal solution.

Deydier *et al.* (2003) evaluated meat and bone meal (MBM) combustion residues, a natural apatite-rich substance, as a low cost substitute for hydroxy-apatite in lead sequestration from water effluents. The lead uptake by MBM combustion residues involved at least three successive steps: surface complexation of lead, Ca10(PO4)6(OH)2 dissolution followed by precipitation of Pb10(PO4)6(OH)2 and slow Pb diffusion/substitution of Ca. The above results showed that animal bones and MBM combustion residues are calcium hydroxyapatite rich, thus making them a promising adsorption heavy metals substrate for contaminated wastewaters.

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