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(56) Documents Cited:
EP 0179234 A2 **WO 2003/040047 A1**
US 6521133 B1 **US 4983298 A**
US 20070209997 A1 **US 20020168288 A1**

(58) Field of Search:
INT CL **A61L, C02F, C05F**
Other: **WPI, EPODOC**

(54) Title of the Invention: **Sludge treatment process**
Abstract Title: **Sludge treatment process using hydrolysis and pasteurisation**

(57) A method for treating sludge comprises: (i) heating the sludge, for a predetermined amount of time, to a temperature sufficient to enable hydrolysis of the sludge to begin; (ii) heating the sludge, for a second predetermined period of time, to increase the temperature and enable pasteurisation of the sludge to occur; and (iii) allowing the temperature of the sludge to decrease and holding the sludge at the decreased temperature for a third predetermined period of time, to enable further hydrolysis of the sludge to occur. Preferably, the temperature in steps (i) and (iii) is from 30 to 52°C, whilst the temperature in step (ii) can be greater than 55 °C. The predetermined amount of time in steps (i) and (ii) may be from 12 to 24 hours, whilst the predetermined amount of time in step (iii) is suitably from 2 to 4 days.

Figure 1 - **Diagram of HpH**

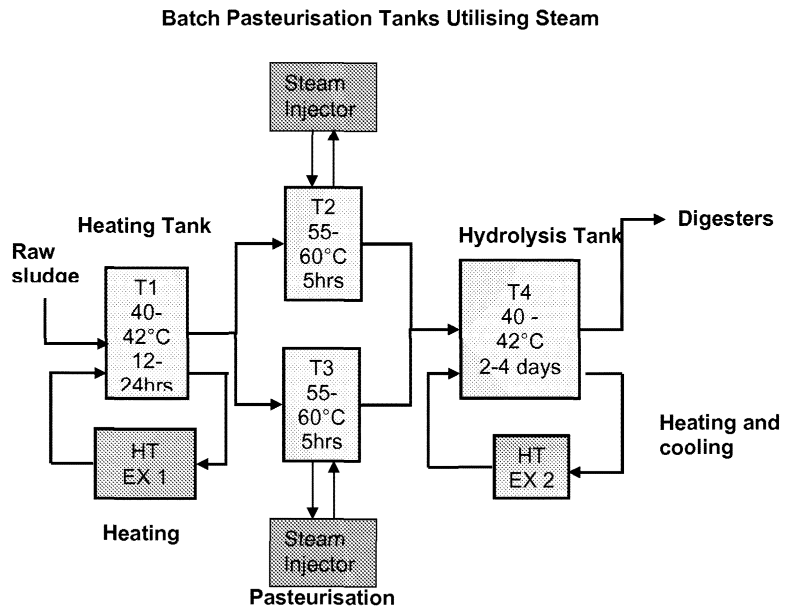

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Figure 1 - **Diagram of HpH**

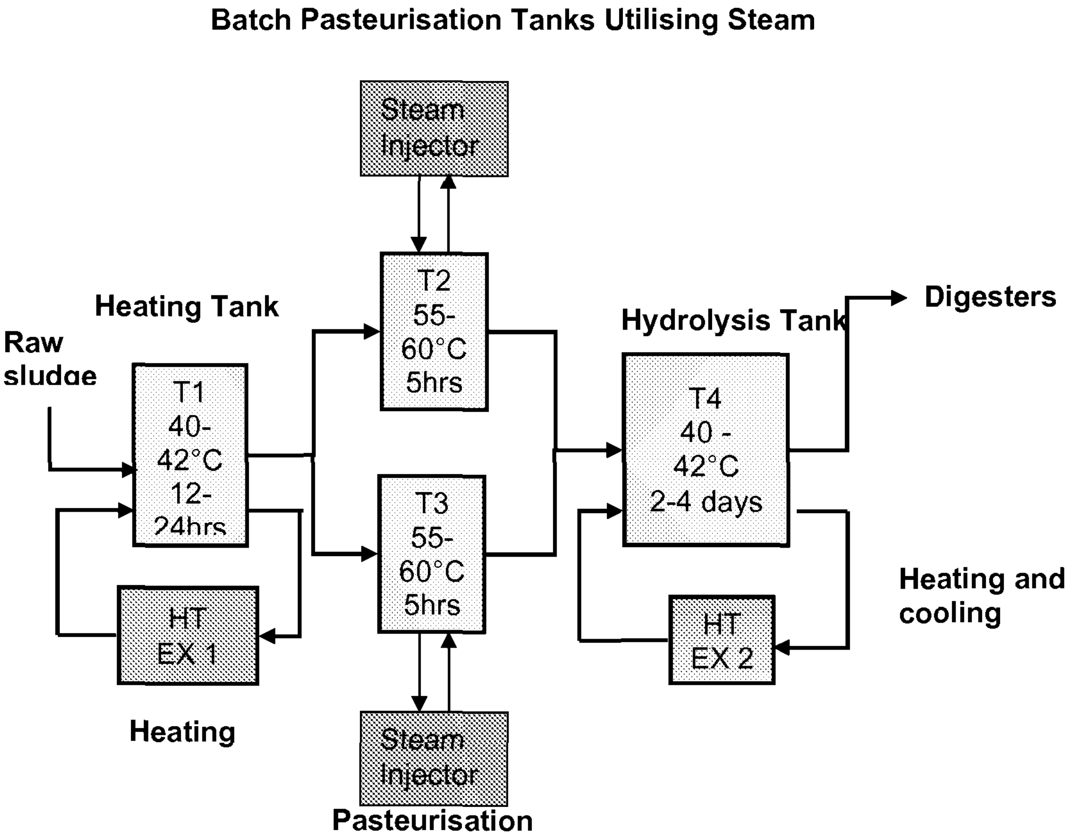
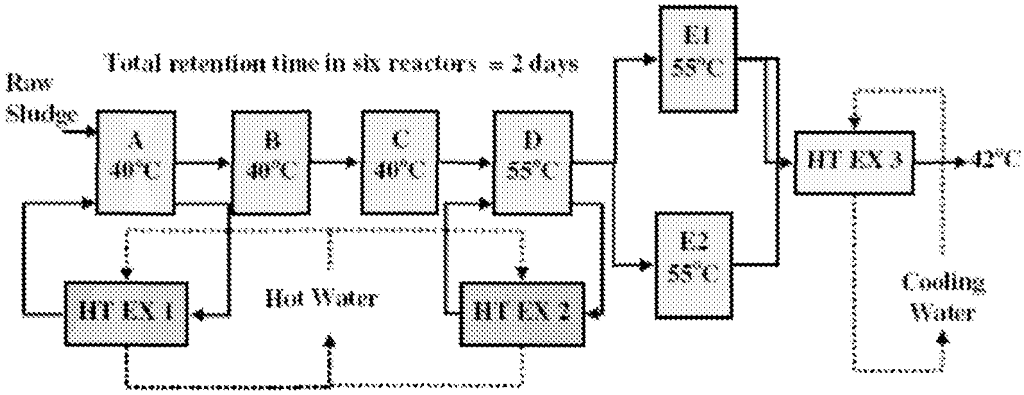


Figure 2 – **Diagram of EEH**



SLUDGE TREATMENT PROCESS

Field of the Invention

This invention relates to the treatment of sludge, i.e., the solid waste resulting from waste-water treatment.

Background of the Invention

Waste-water treatment leads to the production of sludge. In industry, this sludge is treated by mesophilic anaerobic digestion (MAD). The MAD process converts sludge to biogas, which can be used to generate heat and electricity. However, this process is inefficient, and not all the sludge can be converted. This sludge must be disposed of correctly, which creates an environmental burden.

MAD reduces the organic content of sewage sludge by conversion to methane through the actions of micro-organisms. The processes which occur in a traditional MAD process are well documented. Essentially the digestion process is considered to involve three steps: a first step of solubilisation of solids by enzymes; a second step of bacterial synthesis of fatty acids (acidogenesis); and finally a third step of gasification by the methane bacteria. A temperature of 30°-35°C provides the best rate of conversion and stability with a typical retention time of at least 12 days and typically of the order of 18-20 days.

It was previously thought that sufficient pathogen reduction could be achieved by treating the sludge in a MAD process at a temperature of around 30°-35°C. However, in more recent times, particularly due to increasing concern over well-known sewage-borne diseases such as *E.coli*, the level of pathogen reduction that can be achieved in such MAD processes alone is no longer considered sufficient to meet health requirements.

Upstream treatment of the sludge before MAD is therefore advisable. One known method is to hydrolyse then pasteurise the raw sludge before MAD. This is known as "Enhanced Enzymic Hydrolysis" ("EEH") as shown in Figure 2. Another method is pasteurisation of the sludge. A third method is hydrolysis of the sludge, which is known as acid-phase digestion. These pre-treatment processes have two main advantages. Firstly, a "safe sludge" can be produced, which is safe to use in agriculture as it is free of harmful pathogens. Secondly, the pre-treatment results in increased biogas production and therefore a reduced amount of sludge requiring disposal. However, even with this pre-treatment, conversion to biogas is still reasonably inefficient, and there is still a relatively large amount of sludge requiring disposal. Therefore, there exists a need for an alternative MAD pre-treatment process.

Summary of the Invention

It has surprisingly been found that a pre-treatment process comprising an initial hydrolysis step followed by pasteurisation and then a further hydrolysis step, results in high amounts of biogas production, high amounts volatile solids destruction and efficient heat balance of the process. This results in low amounts of waste, and therefore has environmental benefits.

The present invention therefore comprises a method for treating sludge, comprising:

(i) heating the sludge, for a predetermined amount of time, to a temperature sufficient to enable hydrolysis of the sludge to begin and preheat sludge prior to pasteurisation;

(ii) heating the sludge, for a second predetermined period of time, to increase the temperature and enable pasteurisation of the sludge *to occur; and*

(iii) allowing the temperature of the sludge to decrease and holding the sludge at the decreased temperature for a third predetermined period of time, to enable further hydrolysis of the sludge to occur.

Description of the Drawing

Figure 1 illustrates a process of the invention.

Figure 2 illustrates EEH, a process of the prior art.

Description of the Invention

As used herein, raw sludge means sewage sludge having a high organic content, which has not previously been subject to a treatment process to reduce the organic content/pathogen content. Typically this will be sludge having a total Chemical Oxygen Demand (COD) greater than about 10,000mg/L, more preferably 30,000. The raw sludge should have a BOD (5 day) in the range 8,000 to 250,000 mg/l (the BOD indicating the biodegradability of the sludge).

The method of the invention is a method for treating sludge, prior to sludge digestion, preferably prior to mesophilic anaerobic digestion.

In stage (i), the raw sludge is heated to start the hydrolysis process. Preferably, the raw sludge is heated to a temperature of 30-52˚C, more preferably, 40-42˚C. In a preferred embodiment, this step is carried out for a period of 12 to 24 hours. This raises the temperature of the sludge, via hot water, for efficient heat balance. It also begins to hydrolyse the sludge, and therefore starts to increase volatile fatty acid (VFA) concentration. Preferably, the heating is carried out using low grade heat recovered from the CHP engine, to ensure energy efficiency.

In stage (ii), the sludge is further heated, preferably with steam, in order to increase the temperature and therefore thermally condition and pasteurise the organic material. Preferably, the temperature of this step is greater than 55˚C, more preferably from 55 to 60˚C. In a preferred embodiment, stage (ii) comprises of 6 hours of filling and heating of the sludge, followed by 5 hours of further heating of sludge and subsequent emptying of the tank. The steam is added on the feed to stage (ii) such that at the end of the filling and heating cycle the desired temperature is achieved. This ensures pathogens are killed and causes an increase in VFA concentration. Pasteurisation also acts as a pre-treatment stage for stage (iii).

In stage (iii), the sludge is cooled in order to further hydrolyse the organic material and produce volatile acids. Preferably, the temperature of this step is from 30-52˚C, more preferably from 40-42˚C. The retention period within this stage is preferably from 2 to 4 days. This ensures hydrolysis is carried out, and also acidogenesis and acetogenesis, to increase the VFA concentration, prior to optional methanogensis.

Each of the stages should be carried out in separate tanks. Stage (ii), i.e. the pasteurisation stage, may be carried out in two separate tanks in parallel.

Optionally, the pre-treated sludge is then transferred to a conventional anaerobic digester, with a retention time of 12-25 days, and an operating temperature of 33-41˚C. These operating conditions allow optimum anaerobic biological digestion of readily degradable organic material, producing the useful by-product of biogas. This gas is typically 60-70% methane, with the balance mainly carbon dioxide, and is a suitable fuel for combined heat and power units and boilers.

In a preferred embodiment, each stage has a variable liquid level control, to allow optimum retention time independent of feed rate achieved by incorporating a pump mixing and transfer system. In a further preferred embodiment, the available headspace could be used for the periodic jetting of liquid into the gas space to treat potential foaming in the tank.

The key benefits of this process are that the pre-treatment, in particular the presence of step (ii) of the process, leads to enhanced quality “safe sludge” (class A sludge), which is suitable for use in agriculture. The process also means that there is a high rate of solid destruction, and rate of biogas production. This biogas can be used to provide the energy to heat the process, meaning that the whole process is energy self-sufficient. This means that the process is commercially viable and economically attractive, compared to conventional anaerobic digestion and other commercial technologies.

Step (ii), i.e. the pasteurisation step, is responsible for reducing the pathogen content of the sludge.

As the process is energy self-sufficient, this leads to the whole process having a lower carbon footprint, which is beneficial to the environment.

Figure 1 illustrates a process according to the invention.

The following examples illustrate the invention.

Example 1

A pilot plant was constructed in accordance with the claimed invention to process 1 m^3 of thickened sludge per day in a semi-batch process using two parallel streams. The pilot plant includes 7 m^3 of storage capacity for untreated and treated sludge tanks. The filling and emptying of these tanks were manually controlled.

The automated process consists of two parallel streams of two tanks; each tank has a working capacity of 2.5 m^3. Sludge was batch fed alternatively between the two streams automatically. The pasteurisation tanks operated at between 55°C and 75°C, with direct steam heating. The third stage hydrolysis tanks were cooled indirectly with final effluent from a hydrant. All tanks included a side stream mixing loop with pump for recirculation, heating or cooling and transfer to the next tank.

Both streams combined and fed into the digester which had a working capacity of 20 m^3.

The pasteurisation and hydrolysis tanks continuously produced biogas which was held in a floating gas bell. The controlled release of biogas was vented directly to atmosphere.

Example 2

In the pilot plant of Example 1, a study was conducted to compare the effects of either using a heated first hydrolysis tank according to the invention (i.e. for step (i) according to the invention), or using an unheated buffer tank in place of the first hydrolysis tank (comparative).

The results showed that the use of a heated hydrolysis tank produced sludge with mean volatile fatty acids (VFA) of 4064 mg/L compared with a mean of 3262 mg/L when an unheated buffer tank was used, demonstrating that the heated tank begins the hydrolysis process. This is beneficial to the overall pre-treatment process.

CLAIMS

1. A method for treating sludge, comprising:

(i) heating the sludge, for a predetermined amount of time, to a temperature sufficient to enable hydrolysis of the sludge to begin;

(ii) heating the sludge, for a second predetermined period of time, to increase the temperature and enable pasteurisation of the sludge to occur; and

(iii) allowing the temperature of the sludge to decrease and holding the sludge at the decreased temperature for a third predetermined period of time, to enable further hydrolysis of the sludge to occur.

2. A method according to claim 1, wherein the temperature of step (i) is 30 to 52˚C.

3. A method according to claim 1 or claim 2, wherein the increased temperature of step (ii) is greater than 55˚C.

4. A method according to any preceding claim, wherein the decreased temperature of step (iii) is 30 to 52˚C.

5. A method according to any preceding claim, comprising a further step (iv): transferring the sludge to an anaerobic digester.

6. A method according to any preceding claim, wherein the pre-determined amount of time in step (i) is 12 to 24 hours.

7. A method according to any preceding claim, wherein the pre-determined time in step (ii) is from 12 to 24 hours with a minimum of 5 hours.

8. A method according to any preceding claim, wherein the pre-determined time in step (iii) is from 2 to 4 days.

Application No:	GB1218016.2	**Examiner:**	Mr Alun Owen
Claims searched:	1-8	**Date of search:**	30 January 2013

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-4 and 6-8	US 4983298 A (FUCHS ET AL.) See whole document
X	1-5 and 7	US 2007/0209997 A1 (POPPE) See especially Figures 1-2 and paragraphs [0027]-[0040]
X	1-5 and 7	EP 0179234 A2 (UTB UMWELTTECHNIK BUCHS) See whole document, the EPODOC Abstract and WPI Abstract Accession Number 1986-114258 [18]
X	1-5	US 6521133 B1 (ROEDIGER) See especially column 5, lines 26-65
A	-	WO 03/040047 A1 (UNITED UTILITES) See whole document
A	-	US 2002/0168288 A1 (BRADE) See whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A61L; C02F; C05F

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
C02F	0011/18	01/01/2006
C02F	0011/04	01/01/2006