Analysis of thermal disposal techniques for wastewater sludge

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Abstract

Sludge management has become a source of important discussions in Québec province. The environmental authority, MDDEP, is planning to ban organic matter elimination by 2020. In this context, agricultural spreading receives increasing attention. However, incineration is used to dispose of more than 50% of the province total sludge production. In order to prevent contaminated sludge spreading on fields, MDDEP has developed a system to categorize fertilizing residuals. In order to determine sludge field valorization limitations, a grade is given according to the levels of chemical contaminants, pathogens and odor potential. When limits are exceeded, other disposal approaches must be used. In order to improve thermal disposal techniques, anaerobic digestion and gasification will be compared to a combination of both technologies. The objective is to determine if biomethanation followed by gasification of digestate could be more efficient than any of the two techniques taken individually. The three approaches are evaluated on a financial and energetic point of view. The research is currently underway and results will be presented at the conference.

Keywords: Wastewater, sludge, combustion, gasification, biomethanation, anaerobic digestion.

1. Introduction

Quebec province generates about 245 000 dry tons of municipal sludge. Incineration is by far the most important treatment used. In 2007, 52% of total sludge dry weight was incinerated and 30% was landfilled [1]. Agricultural sludge spreading has a very low volume and this can be partly explained by the apprehensions of soil contamination. Figure 1 shows the repartition of sludge disposition.

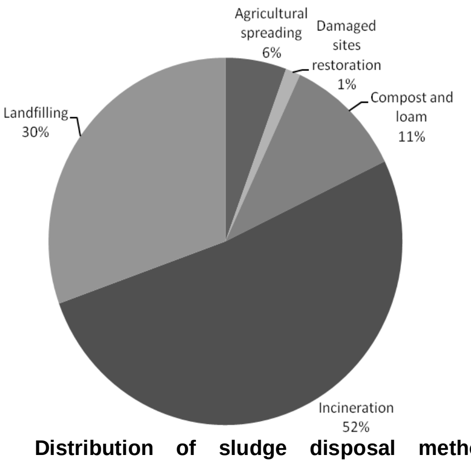

Fig. 1. Distribution of sludge disposal methods in Québec province (2007, MDDEP)

Sludge use on agricultural land is regulated by the provincial environmental authority, MDDEP. Sludge is part of what is called fertilizing residuals (FR). Agricultural use is restricted according to the grade the sludge receives. This grade is calculated according specific criteria and is composed of three categories. The first one is chemical contaminants that are regulated (C1 or C2). Second is pathogen levels (P1 or P2) and last is odor potential (O1, O2 or O3). Higher the score is, the more restrictions will apply. As an example, a FR such as municipal sludge that received a score of C1-P1-O1 will face none of little limitations for spreading on fields while one that received C2-P2-O3 will be highly limited. If the limit of any of the three categories is exceeded, the residual is then considered "out of category". Agricultural and silvicultural uses are then forbidden. Therefore, the land application is not suitable for every situation. In addition, the regulation focuses only on elements involved in biology, heavy metals and dioxins/furans. Limitations for non-regulated substances are much less explicit and rely partly on declarations from industrials. This contributes to the majors concerns about agricultural use of sludge in Québec. In the end, some sources of FR must not return to the environment without treatment. Also, it is generally accepted that municipal sludge must not return into the food chain by direct growing of crops for animal or human consumption. That mainly explains why the thermal approach is still very important.

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2. New technologies

2.1. Gazeification

Following that, improvement can be done on actual combustion systems. New technologies, like gasification could potentially phase out incineration. Attempts have already been done but remain limited to specific installations. A lot of hope has been put into gasification especially to help reduce emission levels. During this process, most of the carbon content of sludge ends up released as CO_2. One major advantage of gasification is the great potential for destruction of complex toxic substances. Non-volatile solids (NVS) are concentrated into ashes or vitrified residue. The NVS portion of the total mass that escapes through flue gas depends on the filtration efficiency. The part of NVS that is not collected by the filtration system is mostly fine particulate matter which carries the toxic substances that may have been reformed during combustion. From that process, energy can be recovered but because of the high water content in sludge, additional energy input may be required. Unless flue gas is condensed, an important portion of the energy escapes as water vapor. Generally, raw sludge is dewatered to a level of dryness between 15-30% (70-85% of water). However, the biggest interest lays in money and energy savings on transportation and disposal. A 90% of volume reduction can be achieved once thermally treated [2].

2.2. Biomethanation

Another approach that is being put forward is biomethanation, also known as anaerobic digestion. This approach uses bacteria in an oxygen depleted environment to induce methanogenesis. Then, methane, a valuable gas with similar properties to natural gas, is produced. Also, the digestate, the portion that is not converted to biogas, is stabilized and the rejections are sanitized. Some volume reduction occurs but it far from being as important as for gasification, mainly because the water content stays high. The digestate can be disposed of by the same ways the sludge is. However, if the incoming source is contaminated, it is very likely that the solid products resulting from biomethanation will be too. In addition, some contaminants have been found to affect negatively the digestion [3], so special care should be taken about the control of the process. An advantage of this approach is the possibility to purify the biogas in order to make it suitable for injection in existing distribution network. In this way, the production does not need to be exactly synchronous with the demand.

2.3. Combined technologies

That leads to an attempt for combining the two technologies together in order to benefit from the strengths of each one. It will be achieved by analyzing a hypothetical process that includes biomethanation of sludge followed by gasification of the digestate. This third approach will be put in contrast with biomethanation and gasification taken separately. The three options will be studied from an economical and energetic point of view in conjunction with mass balance.

To achieve this goal, data will be taken from existing installations that are currently in use and will be compared to different balance models. Strengths and weaknesses will be highlighted. Advanced technologies will be discussed. Those include thermal hydrolysis in order to reduce the biogas process time and supercritical water gasification. These improvements present a great potential to enhance efficiency of the thermal approaches. On one side, biomethanation is strongly limited by the hydrolysis duration. On the other side, gasification invests most of its energy to evaporate water.

The main outcome of this research will be to provide information for municipal decision makers in order to limit the environmental effects of sludge treatment and generate savings in operation costs. The potential of benefits is very high as municipalities spend large fraction of their budget on wastewater treatment and disposal of biosolids. A clear orientation from MDDEP has been given toward land application of sludge but huge work has to be done to convince the population of the benefits and to implement the modification in the actual disposal methods. In the meantime, improvement has to be applied to actual incinerators to enhance their performance. Simultaneously, sludge that is not suitable for land application still has to be treated and landfilling is the least preferred solution.

3. Conclusion

The research is currently under way and the results will be presented at the conference in terms of thermo-economic performance.

Acknowledgments

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