CHEMICAL ENGINEERING TRANSACTIONS Volume 17, 2009
Editor Sauro Pierucci

ISBN 978-88-95608-01-3 ISSN 1974-9791
DOI: 10.3303/CET0917117

Drying Process of a biological industrial sludge: experimental and process analysis

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This work is the result of a collaboration between the Department of Chemistry, Chemical engineering and Materials of the University of L'Aquila and the GSA plant, located in Civita Castellana (VT).
GSA consists in a wastewater treatment plant which regenerates wastewater effluents from organized industrial districts using a combination of different treatment types such as distillation, multiflash, drying, Fenton, biological treatment and physical-chemical processes, complied in an integrated way.
GSA plant produces four types of wastes with different CER codes, which are: sludge concentration FC, FB biological and chemical solvents and FCF.
Our attention turned to the three sludges, in particular the concentration one, being it a dangerous mud.
The objective of this work was to develop environmental technologies aimed at downgrading of solid waste is not hazardous and dangerous and their reduction in both quantitative and qualitative terms in order to have a heat recovery.
The process used to achieve these goals consisted in drying the sludge produced, at various temperatures, in particular breaking down the value of TOC and reducing the volumes of sludge themselves.
The drying sludge processes have been conducted in both pilot and laboratory-scale (Flashdryer).
The performance of the experiment was monitored by evaluating the reduction of dry weight, the total organic carbon TOC and the total dissolved solids TDS, at the optimum temperature of 150 ° C.
Dry sludge was obtained after a substantial weight loss for the three types of mud, being the significant reduction in dry weight due to the release into the atmosphere of volatile organic compounds (VOC), water vapour and ammonia in this characterized samples.
The decrease of the quantity of sludge (also due to the loss of water) determined both economically and environmentally benefits since a lower quantity of it has to be disposed in landfills. Moreover, after the process of drying the sludge, the final product can be subject to gasification or incineration, permitting a substantial energy saving.

Please cite this article as: Macolino P., Bianco B. and Veglio F., (2009), Drying process of a biological industrial sludges: experimental and process analysis, Chemical Engineering Transactions, 17, 699-704 DOI: 10.3303/CET0917117

1. Introduction

This work was born from a collaboration between the GSA Srl company and the Department of Chemistry, Chemical Engineering and Materials of the University of L'Aquila, with the main goal consisting in the reduction, by a drying process, of the TOC content of the sludges outgoing from the plant, so that they can be afterwards disposed in adequate landfills, in respect of the restraints imposed by law.
GSA is located in Civita Castellana (VT) and its plant provides a uniform treatment of different types of both dangerous and non dangerous industrial wastes such as leachate, inked water, water with solvents, etc.., resulting in a difference in the characteristics of both the incoming and outgoing currents.
The flow chart in Figure 1 shows the different sections of the plant, and then the different outgoing types of waste.

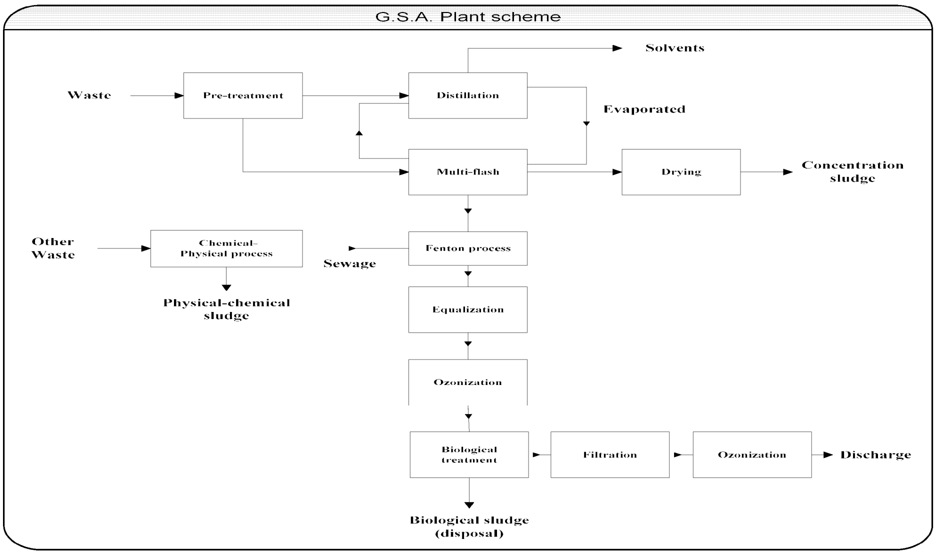

Figura 1. Flow chart of GSA treatment plant in Civita Castellana (VT), Italy.

The aim of this work consisted in improving the quality not only of the sludge concentration, coming from the drying section, but also of the sludge produced by the physical-chemical and biological sections of the plant.
The outgoing waste can be divided into dangerous and non dangerous waste, according to the classification given by Decreto Legislativo 3 aprile 2006, n. 152. Sludge concentration (black mud) is a dangerous waste, while biological and physical-chemical sludges are classified as non dangerous waste.

2. Materials and methods

The characterization of industrial wastes is based on the three types of outgoing currents: biological sludge, concentration sludge or "black sludge" and physical-chemical sludge.
- Biological sludge (FB).

Table 1. Average values for biological (FB), concentration (FC) and physical-chemical (FCF) sludges.

	PH	Humidity %	Flash Point [°C]	PCI MJ/kg	Chlorinated solvents [mg/kg]	Organic solvents [mg/kg]
FB	7,00	83,0	> 250	0,048	< 0,1	<0,1
FC	7,70	53,0	> 250	0,68	<0,1	<0,1
FCF	10,00	53,0	> 250	0,031	< 0,1	< 0,1

This type of sludge comes from the organic section of the plant. In this section wastes coming from the previous sections are homogenized and the mutation from anaerobic to aerobic conditions takes place, so that, after a process of dehydration, biological sludge is obtained and subsequently sent in appropriate disposal facilities.

- Concentration sludge or "black sludge"(FC)

Concentration sludge comes from the evaporation section, where, in addition to a current of low-BOD evaporated, a concentration of salts, metals and organic matter is subject to a drying treatment and after that it can be disposed in landfills.

- Physical-chemical sludge (FCF)

Physical-chemical sludge comes from the physical-chemical section, where after treatment on the physical-chemical reactor, the incoming waste is separated into a stream of sewage and a sludge, the latter being such that it can be sent to a filter press.
The average values, measured in laboratory, for the chemical parameters characterizing the three types of sludge are shown in Table 1.

2.1Experimental Procedure

In order to characterize the different kinds of sludge, their samples have been dried different temperatures.
The heat treatment was performed at different temperatures, with a duration of twenty-four hours, using the stove for treatments at 105 ° C and 150 ° C, while using the muffle furnace for treatment at 300 ° C and 550 ° C respectively.
After the drying process, the percentages of dry weight (method for the determination of the dry weight), the percentage of ammonia, the value of the TOC (Total organic carbon), TDS (total dissolved solids) and pH were measured.
The percentages of dry weight were measured by the weight loss, the TDS values were measured by cession test eluate, while the other parameters were measured by analytical methods.

2.2Analytical methods

The TOC measures were performed by using the Dr. Lange's kit cuvette-test LCK 380, the ammonia measures by the Kjeldahl's method and pH by a common pH-meter.

3. Results and discussion

One of the main goals of this work consisted in diminishing the percentage of TOC of the sludge coming out from the plant, which, without any treatment, is too high with respect to law terms and therefore it cannot be accepted in landfills.

To achieve this goal we performed on the sludge a heat treatment (drying), both on laboratory and pilot-scale.
In the following sections the results obtained on different samples of sludge, by laboratory-scale measures, are illustrated.

3.1 Percentages of dry weight

After having sent the sludge samples to a heat treatment (DRYER), we characterized them by drying the different kinds of sludge (biological sludge, concentration sludge and physical-chemical sludge) for twenty-four hours at four different temperatures (105 ° C, 150 ° C, 300 ° C, 550 ° C), in order to simulate a sample of dried sludge coming from the dryer plant.

Table 2. Percentages of the dry weight of three to four sludge temperatures.

Temperature heat treatment [°C]	% dry weight of biological sludge	% dry weight of concentration sludge	% dry weight of physical-chemical sludge
105	28,90	88,90	52,00
150	14,40	75,60	49,30
300	10,00	55,00	45,00
550	4,50	40,90	42,10

The percentage of dry weight reveals the weight loss by all the kinds of sludge as a result of the processing of heat treatment (Figure 2).
Table 2 illustrates the values of the percentages of dry weight obtained.
The evolution with temperature of the percentages of dry weight obtained is better shown in Figure 2 where the comparison among the three types of sludge is shown, where one can clearly see that as the temperature increases, there is a reduction in the percentage of dry weight for all the types of sludge, since increasing temperature means an increasing loss of water and volatile substances including ammonia.

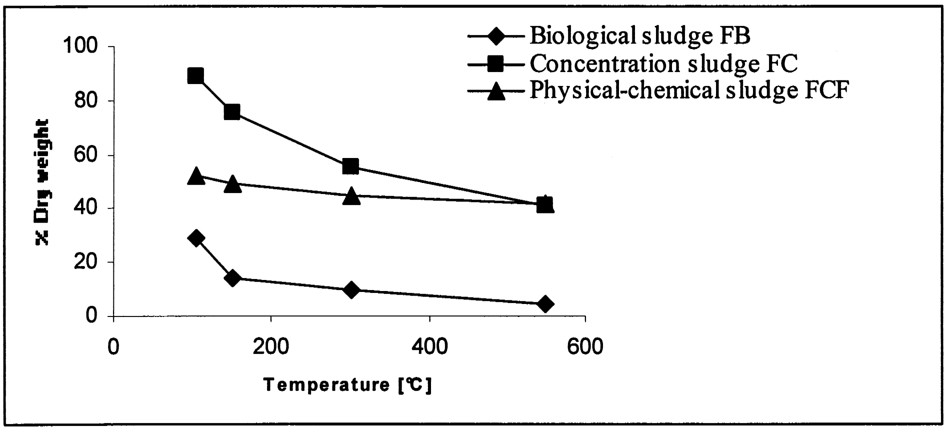

Figure 2.Comparison between the biological, concentration and physical-chemical sludge.

3.2 Percentage of ammonia in the dry

Table 3. Percentage of ammonia in the dry weight of the three sludges.

Temperature heat treatment [°C]	%NH_3 in the biological sludge	%NH_3 in the concentration sludge	%NH_3 in the physical-chemical sludge
105	1,00	3,43	0,05
150	0,78	3,16	0,00
300	0,20	0,24	0,01
550	0,00	0,00	0,00

The value of the percentage of ammonia in the dry weight, i.e. in the sludge sample after the drying process, is necessary to determine the admissibility of the sludge in a particular type of waste landfill, in respect of the criteria established by Decreto Legislativo 3 aprile 2006, n. 152.

In this case we measured the percentage of ammonia freed in atmosphere, as a result of the drying treatment of the three sludges. The measured values at four different temperatures are shown in Table 3 and the comparison among the different types of sludge for the ammonia percentage is more easily illustrated in Figure 3.

From Figure 3, in fact, one can see that the proportion of ammonia present in the sample dried tends to decrease with increasing temperature and that for very high temperatures (550 ° C) the ammonia content vanish.

Moreover increasing temperatures causes not only an ammonia decrease, but also a release of water vapor and volatile organic compounds (VOC) .

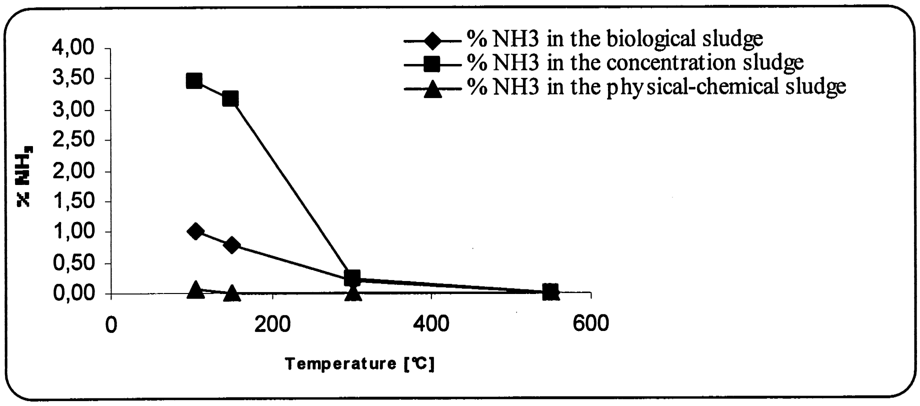

Figure 3. Percentages of ammonia versus temperature for the three sludges.

3.3 TOC, TDS and pH after drying

After the drying treatment at different temperatures, we chose the temperature of 150 ° for the TOC, TDS and pH measurements, shown in Table 6. At this relative low

Table 4. Measured values of TOC and TDS compared to the limit values permitted by law (Decreto Ministeriale 3 Agosto 2005).

	pH	TOC[mg/l]	D.M.3/08/05 TOC[mg/l]	TDS[mg/l]	D.M.3/08/05 TDS[mg/l]
FB	9,17	4560	80	6000	6000
FC	7,10	8080	100	72000	10000
FCF	11,20	748	80	0	6000

temperature in fact we already obtained a consistent volume reduction for the three sludges. Table 4 shows that the values of TOC obtained for the three types of mud are higher than those set by law, hence a further treatment for TOC reduction is required, for example by adding bonding materials as lime or concrete. Concerning the TDS values we see that biological sludge reaches a TDS value just equal to the limit value permitted by the law, while for concentration sludge the value obtained is well above the same limit. Finally the best result is achieved for the physical-chemical sludge where the level of dissolved solids is annulled.

4. Conclusion

The main goal of this work was to make the industrial sludges suitable for disposal in landfills, by reduction of their TOC content, otherwise resulting too high with respect to the values permitted by law. We therefore decided to implement a process of heat treatment (drying) at a temperature of 150 ° C on the three types of sludge (biological, concentration and physical-chemical sludge) produced by the GSA s.r.l. plant.
This resulted then in a reduction of the amount of waste sent to landfills and therefore in a decrease of the costs related to their disposal. The TOC values obtained are still too high with respects to the legal limits, hence a more stringent treatment is required. Finally good results have been obtained also for the TDS values, which are under the standard limits for biological and physical-chemical sludges.

Acknowledgements

The authors acknowledge the GSA s.r.l. company, that permitted us to carry out this work, and the technical staff of the Dept. of Chemistry, Chemical Engineering and Materials, University of L'Aquila.

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