Sludge drying from water treatment plants using microwaves

Wagner, L. G.*, Possetti, G.R.C*, Fedalto, L**., Jahn, V**., Souza, S. E. de**

*Water and Sanitation Company of Paraná State - Sanepar, 1376 Engenheiros Rebouças St., Rebouças, Curitiba, Paraná State, Brazil - Zip Code 80215-900 – Phone: + 55 (41) 3330-3000 – e-mail: luizgw@sanepar.com.br; gustavorcp@sanepar.com.br

**Brook Intertech Equipamentos Ambientais S/A, 729 Ivo Luchi St., GP 02 SL 02 – Brejaru, Palhoça, Santa Catarina State, Brazil, Zip Code 88133-510 – Phone: + 55 (48) 3344-1515 – e-mail: fedalto@gmail.com; vannerjahn@gmail.com; sergio@booksambiental.com.br

Highlights:

- Large volumes of sludge are generated in the water treatment process.
- Drying is a process aimed at reducing the volume of sludge to be disposed of.
- Microwave energy can be an alternative for drying processes.

Keywords: Sludge from water treatment plants, Microwaves, Drying.

INTRODUCTION

The conventional water treatment process produces a residue during the sedimentation and filtration phase, composed of concentrated materials present in raw water, along with coagulants (aluminum or iron salts) and carbonates[1]. According to NBR 10.004:2004, sludges from water treatment plants (WTPs) are classified as solid waste and must be treated and disposed of accordingly. In the State of Paraná - Brazil, it is estimated that the amount of sludge can reach 22,000 tons of dry matter per year. All this volume must be managed and disposed of in accordance with applicable environmental legislation, including the sludge from small systems. The impact of these residues on water quality depends on the characteristics of the sludge and the relationship between the discharged volume and the self-purification capacity of the receiving body[2]. Although these impacts are not fully understood, there is a consensus today about the need for proper water sludge management, especially for small systems. However, the question remains: how to make the various stages feasible, including waste reduction, dewatering, and final disposal?

For the purpose of volume reduction, different processes can be applied, among which thermal drying processes stand out. These processes remove moisture through the application of heat. In the case of microwave processes, a valve called a magnetron converts electrical energy into microwaves at a frequency of 2,450 MHz. When these microwaves reach the material's surface, they generate heat due to molecular friction[3]. The amount of heat generated by this process is directly proportional to the molecules ability to align with the frequency of the applied field. One important advantage of this dryer technology is the use of only electricity as source of energy to dry the sludge. It is simply and replicable in small water systems.

In that context, the present study aimed to demonstrate the moisture reduction capacity of sludges from WTP after the mechanical dewatering stage, utilizing an innovative small dryer based on microwave generated by electricity. It was determined the energy consumption for that. It is a disruptive and useful solution to treat sludge for small water treatment systems, producing a material with properties appropriated for pavers manufacture.

METHODOLOGY

A small dryer system features 20 magnetrons, each with a power output of 3 kW, generating electromagnetic energy in the microwave range (2,450 MHz) has been installed at a treatment plant (Figure 1). The WTP sludge was conveyed through preheated cavities, where it was exposed to microwave action. An exhaust system and a charcoal filter have been added to allow for the emission of evaporated water resulting from the process. System peripherals include a reservoir, sludge pumps, a screw conveyor, and a cooling system for the magnetrons. The entire setup was powered by electricity, with an installed capacity of 150 kW.

Figure 1: Small microwave dryer able to process WTP sludge

The masses of sludge were measured at the inlet and outlet of the dryer. Samples of wet and dry sludge underwent moisture content analysis using the loss-on-drying method, assisted by a Marte Científica brand balance, model ID200.

Finally, electricity consumption was verified using a WEG brand electrical multimeter, model MMW02.

The equipment was configured to process a flow rate of 100 kg/h of wet sludge, operating continuously for a period of 6 to 7 hours daily, during 05 days.

RESULTS AND CONCLUSIONS

Table 1 presents the mass and energy balance results for STP sludge drying using microwaves. The total mass of wet sludge subjected to drying was 3,622.58 kg. The average flow rate was 103.5 kg/h of wet sludge with an average solids content of 20.5%. After processing in the microwave equipment, the measured average solids content was 89.3% (Figure 2). The final sludge mass was 855.87 kg, representing a mass reduction of approximately 76%.

The total energy consumed was 3.68 MWh or 3,166,349.28 kcal. Therefore, a specific energy of 1,152.27 kcal per kg of removed water was verified.

Table 1: Mass and energy balances of the small microwave dryer.

Total weight 3.622,58 (kg)	Flow rate (kg/h)	Initial dry solids (%)	Final dry solids (%)	Energy consumption (kCal/h)	Specific energy (kCal/kgH2O removed)
Average	103,50	20,50	89,32	90.467,12	1.152,27
Standard deviation	29,22	0,31	11,69	9.647,25	93,23
Maximum	178,00	20,80	99,00	111.854,73	1.237,80
Minimum	28,00	20,00	60,60	68.833,68	1.001,45

These results demonstrate that the equipment was capable of removing moisture from WTP sludge after previous mechanical dewatering, significantly reducing the mass of wet sludge when subjected to the microwave drying process within the presented flow range. It is an alternative and disruptive solution for small water systems, focus only in electricity demand, that can improve the treatment of water sludge, reducing the operational costs inherent to the final disposal of the material. It is important to highlight that the dry sludge has physical and chemical properties for manufacturing new products such as pavers, contributing for the circular economy approach.

Compared to other methods used in small plants, such as conventional drying beds, the use of microwave equipment has some advantages, such as: smaller area; not affected by weather conditions; shorter drying time; no need for manual removal of dry material; the dry material can be easily packed into bags for final disposal.

However, specialized maintenance is required for electromechanical systems and processing depends on a prior dewatering step to increase the total solids content to approximately 20%. Therefore, its use is recommended for plants that have dewatering systems, such as sludge dewatering centrifuges, for example. The cost of electricity can be a barrier, but reducing the volume can avoid transportation and final disposal costs. In addition, final disposal alternatives that add value to the dry material, such as use in construction products4, can increase viability. Therefore, research aimed at reusing dry WTP sludge needs to be developed.

(a) (b)

Figure 2: Both WTP sludge (a) Wet and; (b) Dry

ACKNOWLEDGMENTS

The authors thank both Sanepar and Brooks Intertech teams engaged in the partnership project.

REFERENCES

[1] DI BERNARDO, L. Methods and techniques of water treatment. In: DI BERNARDO, A. Second Edition. São Carlos: RiMa, 2005.

[2] CORDEIRO, J.S. The importance of proper treatment and disposal of sludge from Water Treatment Plants (WTP). In: REALI, M. A. P. (coord.) General notions of treatment and final disposal of WTP sludge. Rio de Janeiro: ABES, 1993.

[3] TONUCI, L. R. da. Disinfection of healthcare waste by dielectric heating using microwaves. 2006. 108 p. Dissertation (Master's in Environmental Technology) – University of Ribeirão Preto, Ribeirão Preto. 2006.

[4] LAURINDO, S. S.; ANTUNES, E. G. P.; SAVI, A. E.; SPECK, J. A.; PIVA, J. H. Study of the addiction of WTP sludge – Water Treatment Plant to coating mortars. MIX Sustentável, [S.l.], v. 6, n. 4, p. 19-28, ago. 2020. ISSN 24473073