

# **Researched Risk Factors of Food Chain 2018**

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## 2.2. COMPARISON OF THE EFFICIENCY OF MICROWAVE ASSISTED ACIDIC- AND ALKALINE PRETREATMENT ON THE AEROBIC AND ANAEROBIC BIODEGRADABILITY OF SLUDGE

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### **Abstract**

Beside the unambiguously advantageous effect of microwave (MW) irradiation on biodegradability, there can be found just very few study on comparison of the efficiency of microwave assisted alkaline and acidic pre-treatments. Therefore, the main aim of our research was to investigate the effects of microwave irradiation coupled by alkaline and acidic treatment on the biodegradability of food industry sludge under aerobic and anaerobic condition. Our results show that although the microwave irradiation using it alone was suitable to increase the organic matter solubility and biodegradability of dairy sludge, but the disintegration degree enhanced when combined it by alkali or acid dosage. Microwave-alkali pre-treatment (in the pH range of 10-12) was the most favourable to increase the organic matter solubility. SCOD/TCOD achievable by microwave intensified alkaline treatment was 34% higher than that of it observed for acidified sludge. However, using acidic condition (pH range of 2-4) was more suitable to increase the shorter time aerobic biodegradability.

*Keywords: microwave, sludge, biodegradability*

### **Introduction**

Nowadays, the amount of sludge produced from municipal and industrial wastewater is continuously increasing. Therefore sludge handling has become one of the key issue of research and development activities. Biological treatments and utilization considered as one of the most popular method, but to achieve higher biodegradation degree pre-treatment step is needed (Yang et al., 2010). Applicability of microwave irradiation before the anaerobic digestion has

been investigated in the last years. Microwave irradiation is an alternative method for the commonly used thermal treatment, in many times is reported to be more effective than conventional heating processes (Tyagi and Lo, 2013).

Existence of so called non-thermal effects of microwave is disputable yet. In material processing apply the conventionally used higher power ranges, the thermal effects dominate, investigation and verification of

existence of non-thermal effects need special methods (Géczi et al., 2013).

By microwave irradiation the volumetric heating and low loss of power transmission led to rapid heating directly in the irradiated material. Dipolar orientation of side chains of macromolecules subjected to electromagnetic field can be manifested in refolding of complex molecules, or alteration of hydrogen bonds (Afolabi and Sohail, 2017).

Chemical sludge treatment methods have also advantageous effect on the efficiency of biodegradation, therefore the combination of them with microwave could be promising pre-treatment procedure. Among the chemical pre-treatment processes alkaline method reported as an effective method to disintegrate the complex physicochemical structure of sludge. But it can be noticed, that high alkalinity (over pH of 10) can inhibit the activity of methanogen bacteria resulted in higher volatile fatty acid production, which manifested in lower biogas and methane production, and decreased initial and overall organic matter degradation rate during anaerobic digestion.

### Materials and methods

Microwave pre-treatment was carried out in a tailor made microwave unit equipped with variable power magnetron (from 100W to 700W) operating at a stable frequency of 2450 MHz. In the continuously flow operation mode the volumetric flow rate of irradiated samples can be varied by the speed of peristaltic pump in the range of 6-35 L/h. The specific irradiated microwave energy was determined as the product of magnetron power and residence time of processed material. During the pre-treatments the pH of sludge was adjusted by sodium hydroxyde and hydrochloric acid, respectively.

Sludge samples originated from a dairy work. Sludge has a total solid (TS) and chemical

Efficiency of acidic treatment coupled by microwave irradiation is not investigated in details. Devlin et al. (2011) reported that pre-treatment of municipal sludge under acidic condition resulted 4 times increment of protein and carbohydrate solubility compared it to control sample. Acidic agents dosed in pre-treatment stage reduce the negative charge of sludge particles, therefore the ratio of strongly bounded water decrease.

Combination of thermal sludge treatment with chemical methods could be effective mainly at lower temperature ranges. It is verified that sodium ions concentration above a certain value inhibit the anaerobic degradation, because the sodium is toxic to the bacteria utilizing the propionic acid (Kim et al., 2000). Recent studies reported that a quite effective method is to combine microwave irradiation with other various processes and materials, such as oxidants, or coupled with advanced oxidation processes, like catalysis, photocatalysis or Fenton-like reaction (Remya and Lin, 2011).

oxygen demand (COD) of  $6.1 \pm 0.2$  w%, and  $18900 \pm 680$  mg/L, respectively. The pH of fresh collected dairy sludge was measured as  $6.3 \pm 0.3$ .

COD was measured by colorimetric standard method. Biochemical oxygen demand (BOD) measurements were carried out in a respirometric BOD system (BOD Oxidirect, Lovibond, Germany) at 20°C for 5 days.

Anaerobic digestion (AD) tests were carried out triplicated in a labortaory scaled stirred reactors with volume of 250 mL equipped by Oxitop-C measuring head (WTW GmbH, Germany).

## Results and Discussion

In the first stage of our experiments the effect of specific irradiated energy (kJ/L) and pH of sludge adjusted before MW irradiation was examined on the organic matter solubility and the ratio of biodegradable to total organic matters. The change of organic matter solubility was expressed as the soluble to total chemical oxygen demand (SCOD/TCOD). Biodegradable fraction of sludge was determined by 5 days BOD measurement.

Our results show that irradiated MW energy and pH of irradiated sludge has also effect on organic matter solubility. In general, the alkaline condition (pH range of 10-12) applied during MW heating helped the disintegration process, which is manifested in higher SCOD/TCOD ratio (Fig. 1.). Acid dosage, especially at higher irradiated energy level was suitable to achieve higher SCOD/TCOD compared to the neutral samples. It has been revealed, that despite of higher SCOD/TCOD, the strong alkaline condition applied it by higher MW energy irradiation led to form soluble but less biodegradable components.

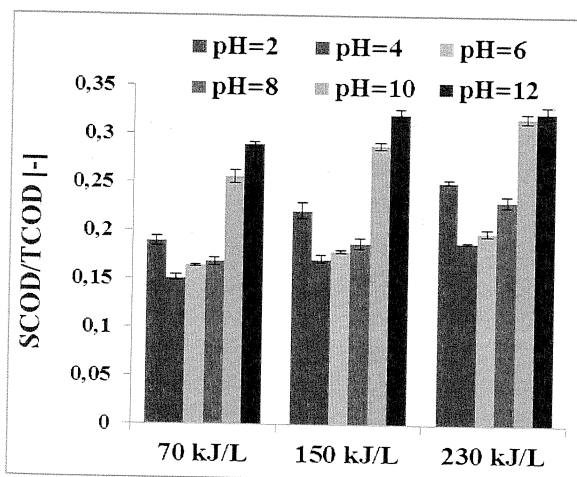


Figure 1. SCOD/TCOD for pre-treated sludge

At MW energy level of 150 kJ/L and 230 kJ/L the acidic condition during the continuously flow microwave irradiation of sludge resulted higher BOD/TCOD ratio than observed for alkaline pre-treated samples (Fig.2). It can be summarized, that for higher disintegration degree the MW assisted alkaline pre-treatment proved more efficiently, which suitable to apply the method followed by dehydration processes. But to achieve higher aerobic biodegradability (composting, for instance) the acidic condition is favourable.

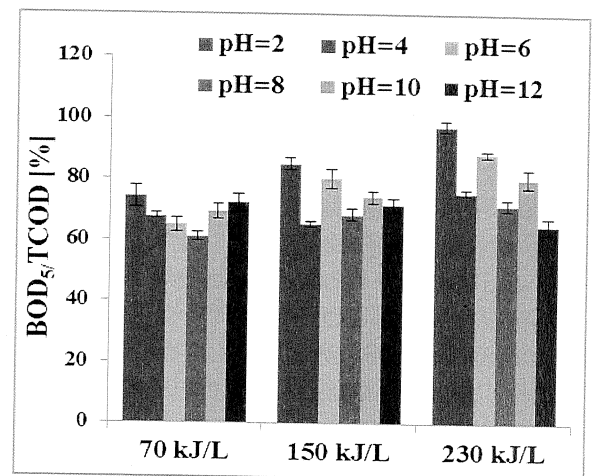


Figure 2. BOD/TCOD for pre-treated sludge

Effects of MW energy and pH of sludge exposed to MW irradiation was investigated by using the MW treatment followed by mesophilic anaerobic digestion (AD). Our results verified that considering the efficiency of AD process expressed by biogas yield (volume of biogas produced/TS content of sample) the MW assisted alkaline pre-treatment method was more favourable than acidic pre-treatment. By adjusting the pH of sample to the range of 10-12 the biogas yield was 80-95% higher than that of obtained from near neutral and acidified samples (Fig. 3.).

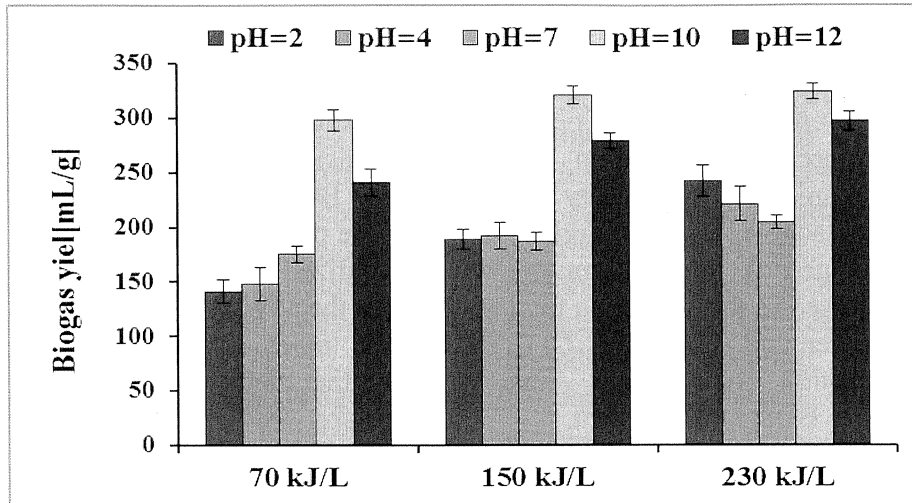


Figure 3. Biogas yield of pre-treated sludge

**Conclusion**

Our results verified that continuously flow MW pre-treatment is suitable to increase the aerobic and anaerobic biodegradability of sludge. It is concluded that MW assisted acidic treatment has higher efficiency for enhanced aerobic biodegradability, but using alkaline condition during MW irradiation led to increased biogas yield, respectively. Further experiments need to analyse the

efficiency of MW assisted acidic/alkaline pre-treatment method for different originated sludge. From the aspects of scale-up, it is necessitated to investigate the AD kinetic for different pre-treated sludge, because they determine the capacity parameters, organic matter removal efficiency, and overall economy of the technology, as well.

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