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Microwave enhanced biodegradability of food industry sludge

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Abstract— **Compared to other industrial sectors, a great amount of wastewater occurs in the food technologies, because of the high water content of the raw materials processed, the commonly used dehydration operations and, additionally, the high water demand of flushing and cleaning procedures. Wastewater originated from food operations contains a great amount of organic matter, and due to frequently cleaning and disinfecting procedures effluents can be characterized by a high content of surfactants and disinfecting agents, respectively. Dosed cations in wastewater purification technology are also contributed to form more resistant sludge flocks via the stronger polymeric network.**

Therefore disruption of extracellular polymeric substances (EPS) and sludge condition for enhanced biodegradation has been an important factor in the efficiency and economy of sludge handling technology. Microwave irradiation has been successfully adopted as pre-treatment method via the high energy dissipation of polar compounds of sludge. There are several studies concluding that the MW method has advantages over the pre-treatment process operating by conventional heating. Energy transfer carried by microwaves affect the biodegradability in two ways. Thermal effect is expressed in the increase of internal pressure of intracellular liquor caused by internal heating and rapid evaporation, which altogether can lead to cell wall disruption. The non-thermal effect of high frequency electromagnetic field contributes to alter the structure of macromolecules with polarization of side chains and breaking of hydrogen bounds.

These microwave specific effects can be suitable to alter the sludge structure for enhanced biodegradation. In recent years numerous papers have dealt with the efficiency of microwave sludge pre-treatments, but the microwave sludge conditioning experiments were carried out by using municipal wastewater sludge. Therefore, our aim was to verify the applicability of the microwave process for primary sludge originating from food processing. In our work the irradiated MW energy (IMWE) and intensity of MW pre-treatment given by the specific MW power level (MWPL) were used for optimization. To quantify the change in sludge structure and in the degree of biodegradability novel control, parameters, namely the solubilization index (SLI) and the biodegradation index (BDI), were developed.

Microwave (MW) pre-treatments were performed in a tailor-made microwave system; containing a continuously irradiating magnetron with changeable power in the range of 50 W to 700 W operating at a frequency of 2450 MHz. To investigate the efficiency of the MW pretreatment process parameters studied were the microwave power level (MWPL), and the irradiated microwave energy (IMWE). MWPL (Wg^{-1}) was defined as the ratio of magnetron power to the quantity of treated sludge. In order to vary the MWPL, weight of sludge samples were kept constant at 100 g in every experiment. IMWE (kJ) was calculated by the magnetron power and the irradiation time. Thickened primary meat processing wastewater sludge (MPWS) came from the sedimentation tank of wastewater treatment plant of a local meat processing factory (Szeged, Hungary). By applying SLI and BDI as control parameters to characterize the change in physicochemical structure of sludge was verified that beside the irradiated microwave energy (IMWE) the specific microwave power level (MWPL) has also significant effect on the change of organic matter solubility related to disintegration of sludge structure and the aerobic and anaerobic biodegradability of food industry wastewater sludge.

Based on the results obtained from response surface analysis it was concluded that increasing of IMWE and MWPL has a positive effect on solubilization, but over a certain value of them the value of BDI was worsened. Maximal SLI was obtained for meat processing wastewater sludge if the IMWE reach the value of 650 kJ and MW intensity was over MWPL of 2 Wg^{-1}, higher value of irradiated energy or higher intensity of MW treatment caused any further increment in the SLI. To achieve the maximum biodegradability IMWE of 550-700 kJ, and MWPL of 1.75-3.5 Wg^{-1} can be considered as optimum region. Applying IMWE and MWPL at optimum level, the initial BDI of raw sludge (0.21) increased to above 0.8 due to the microwave treatment. On the contrary to the results related to SLI, if the MW pre-treatment was carried out with higher intensity than the optimum region, or the irradiated energy was higher than that of it, a decreasing of BDI occurred.

Results of batch mesophilic anaerobic digestion (AD) tests confirmed that microwave pre-treatments are suitable to shorten the initial lag phase of anaerobic decomposition, and to accelerate of biogas production with higher biogas yield. In order to examine the energy efficiency of MW process the net energy products of pre-treated sludge were also calculated from the power of magnetron, time of irradiation and the volume of produced methane.

Keywords— **sludge, biodegradability, solubility, anaerobic digestion**

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