Impact of total solids concentrations on release of organic compounds via mechanical disintegration of sewage sludge

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Treatment of municipal wastewater by means of the activated sludge method is broadly applied around the globe, although the primary drawback of the process is the production of considerable amounts of excess sludge. The costs of transformation of sewage sludge constitute a considerable share of operating costs of wastewater treatment plants, and can reach even 50-60% (Sahinkaya, 2015). Due to this, minimisation of production of sewage sludge is attempted, or its use in the place of its production. Disintegration of sewage sludge facilitates the implementation of these objectives. The process involves the destruction of the structure of sludge and change of its physicochemical properties as a result of application of additional energy, expressed as energy density (E_L) or specific energy (E_S). Depending on the quantity of energy introduced to the disintegrated medium, disintegration leads to: (i) destruction of the flocks structure of activated sludge; (ii) decomposition of extracellular polymeric substances (EPS); and further to: (iii) damage of cells, and (iv) lysis of cells (Kampas *et al.*, 2007). Organic substrates released from activated sludge flocks in the disintegration process can constitute a source of organic carbon for microorganisms conducting the process of anaerobic digestion or responsible for the removal of nutrients from wastewater (Kampas *et al.*, 2007). Because the primary source of organic substrates obtained as a result of sludge disintegration is its solid phase, total solids concentration (TS) of the disintegrated medium is also of importance. This indicator also affects the propagation of forces responsible for the destruction of the structure of activated sludge. According to Sorys and Zielewicz (2007), sludge characterised by TS of approximately 4% and flocks with a loose structure and small sizes is more susceptible to the effect of the ultrasound field than sludge with higher TS and large flocks, often obtained through an increase in the dose of polyelectrolyte, applied in the process of sludge thickening which in turn increases the resistance to shearing and may inhibit obtaining effective disintegration of such sludge. According to Jeong *et al* (2019), for thermal disintegration, the best effects in the form of an increase in SCOD are obtained for TS = 7%, whereas the authors emphasise that an increase in TS is accompanied by an increase in its viscosity, causing a necessity of supply of a higher amount of energy for pumping and mixing the sludge. According to other sources, e.g. for high pressure disintegration, an increase in TS from 0.96% to 2.46% causes a decrease in the degree of disintegration of sewage sludge (Zhang *et al.*, 2012). The literature provides scarce information concerning the effect of TS on the efficiency of release of organic substrates (SCOD and VFA) in the case of application of hydrodynamic disintegration (HD). Therefore, the objective of the study was the assessment of the effect of total solids concentration of thickened excess sludge and sludge not subject to thickening on the efficiency of release of organic substrates to the sludge liquid.

Three series were conducted, designated as: A, B, and C. Each series was composed of four batch disintegration tests, including three series conducted for the same sample of thickened excess sludge, but initially diluted to different levels of TS concentration (they were assumed to be approximately 2.5%, 3.5%, and 4.5%), and one for a sample of recirculated sludge with TS of approximately 1%. The HD process was conducted in accordance with the methodology presented in the paper by Walczak *et al* (2017).

The results presented the Fig. 1 document that the effect of total solids concentration of disintegrated sludge on the efficiency of release of organic compounds (ΔSCOD) was dependent on the amount of energy "supplied" for the disintegration process (E_S). In the case of the same specific energy and different total solids concentration in disintegrated sludge, hydrodynamic disintegration resulted in obtaining different amounts of organic compounds. In the disintegration process conducted at specific energy higher than approximately 3,000 kJ/kg TS, an increase in the concentration of total solids in disintegrated sludge in a range 2.39-4.56% was accompanied by a considerable increase in the intensity of release of dissolved organic compounds. For disintegrated sludge recirculated with the lowest total solids concentration, the threshold value of specific energy the exceedance of which caused intensification of release of dissolved organic compounds was approximately 16,000 kJ/kg TS in series B and C, where total solids concentration was 1.33% and 1.31%, respectively, and in series A (TS=0.93%) the value reached approximately 23,000 kJ/kg TS. It should be emphasised that after exceeding these threshold values, the dependency of ΔSCOD on E_S was a linear function (the observation refers to the analysed scope of specific energy values). Analysis of data presented in Fig. 2 shows that the determined threshold of specific energy values the exceedance of which caused an increase in the intensity of release of organic compounds were closely related to the total solids concentration in disintegrated sludge. It was determined that an increase in TS caused a decrease in the threshold value of specific energy.

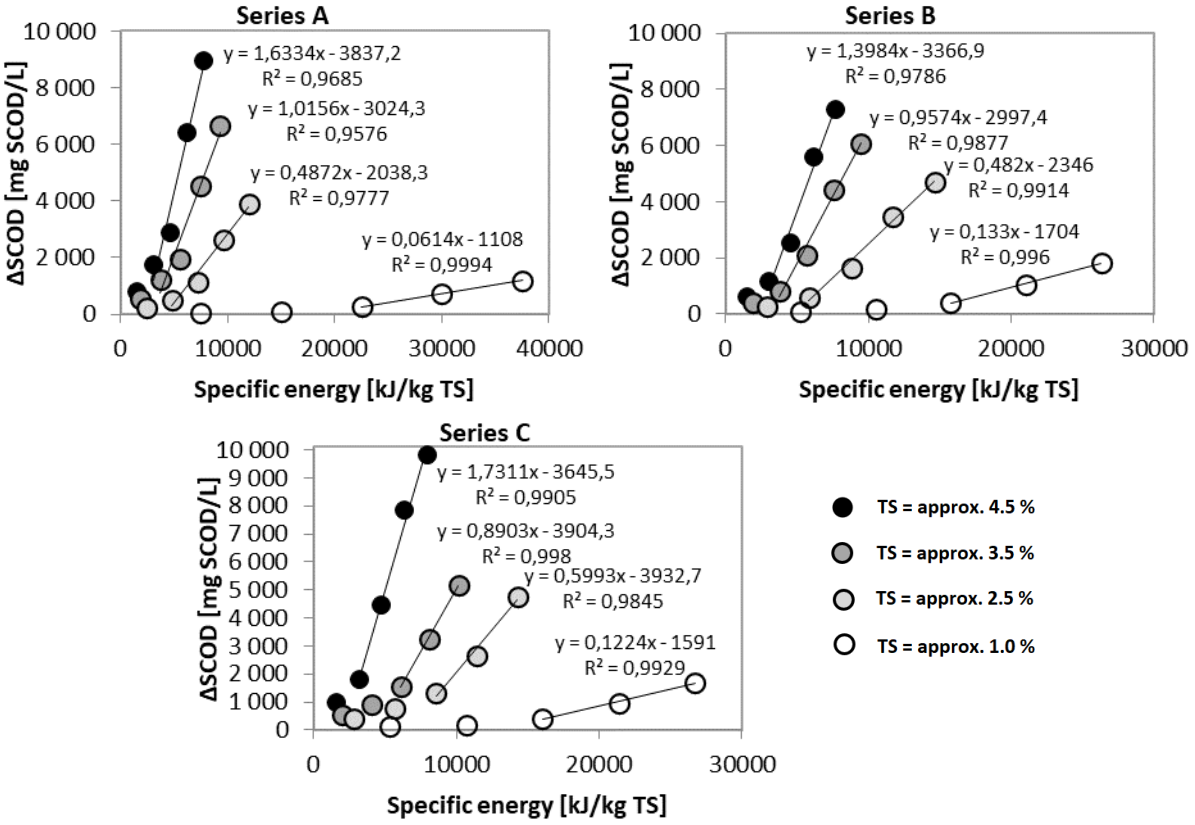

Figure 1. ΔSCOD depending on the total solids concentration of disintegration sludge.

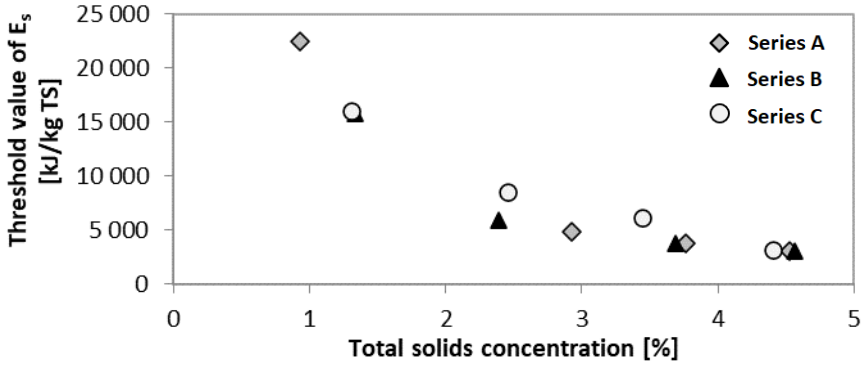

Figure 2. Threshold value of specific energy (Es) exceeding of which caused an increase in the intensity of release of organic compounds in the function of total solids concentration of disintegration sludge.

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