

Article

Understanding the Influence of Diverse Non-Volatile Media on Rheological Properties of Thermophilic Biological Sludge and Evaluation of Its Thixotropic Behaviour

Maria Cristina Collivignarelli ^{1,2}, Sara Todeschini ^{1,2}, Stefano Bellazzi ¹, Marco Carnevale Miino ^{1,*}, Francesca Maria Caccamo ¹, Silvia Calatroni ¹, Marco Baldi ³, Sauro Manenti ^{1,2}

¹ Department of Civil Engineering and Architecture, University of Pavia, via Ferrata 3, 27100 Pavia, Italy; mcristina.collivignarelli@unipv.it (M.C.C.); sara.todeschini@unipv.it (S.T.); stefano.bellazzi01@universitadipavia.it (S.B.); francescamaria.caccamo01@universitadipavia.it (F.M.C.); silvia.calatroni01@universitadipavia.it (S.C.); sauro.manenti@unipv.it (S.M.)

² Interdepartmental Centre for Water Research, University of Pavia, via Ferrata 3, 27100 Pavia, Italy

³ Department of Chemistry, University of Pavia, viale Taramelli 12, 27100 Pavia, Italy; marco.baldi@unipv.it

* Correspondence: marco.carnevalemiino01@universitadipavia.it

Supplementary materials

Dependence of rheological parameters from the thermophilic sewage sludge composition

Preliminary tests allowed to highlight the strong dependence of the rheological parameters from the composition of the thermophilic biological sludge (TBS). Two sets of samples obtained by the two full-scale plants with similar conditions of feeding and operational temperature ($T=48$ C) have been analysed. Sludge samples differ in terms of TS (160 kg m^{-3} and 220 kg m^{-3} , respectively), and ratio NVS/TS (0.5 and 0.75 respectively). Figures S1a and S1b show the rheological behaviour of the sludge samples.

TBS collected in the first plant showed pseudoplastic behaviour since apparent viscosity decreases with increasing shear rate (Figure S1a). On the contrary, TBS collected in the second plant exhibited a dilatant behaviour (Figure S1b). Looking at the composition of the TS of two samples, Herschel-Buckley consistency coefficient (k) of the fluid was lower in the TBS sampled in higher TS conditions (second plant) (TS: 220 kg m^{-3} , k : 0.001 vs. TS: 160 kg m^{-3} , k : 0.093). Based on these results, TBS extracted from the second plant showed almost the same concentration of VS with respect to TBS sampled in the first plant but a stronger presence of NVS. The lower viscosity in second plant was probably due to diverse NVS concentration with respect to TBS sampled in first plant (165 kg m^{-3} vs. 80 kg m^{-3} , respectively) that could have influenced sludge consistency.

Therefore, in this work, the influence of non-volatile media concentration and type was considered and the relation between these factors and TBS rheology was deeply studied.

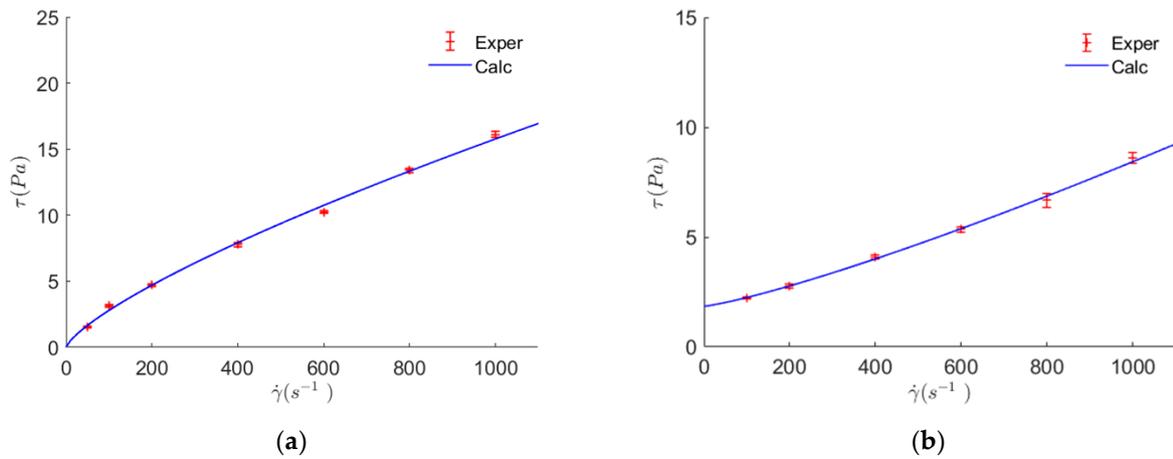
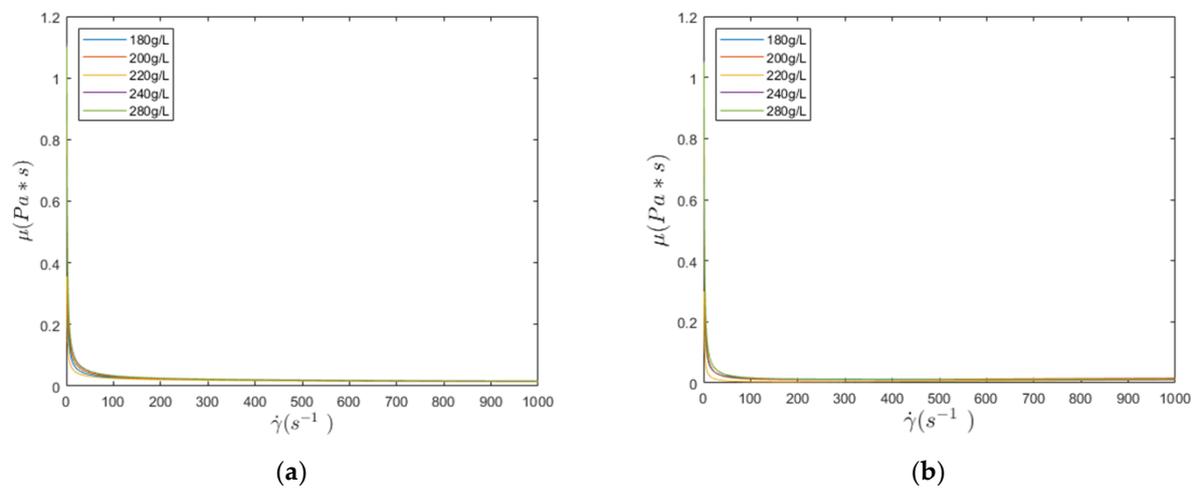


Figure S1: Shear stress of TBS sampled from (a) plant 1 and (b) plant 2 as a function of imposed shear rate.

Dependence of rheological parameters from the type of NVS

The following section presents the shear stress as a function of shear rate depending on concentration of TS and non-volatile media tested.



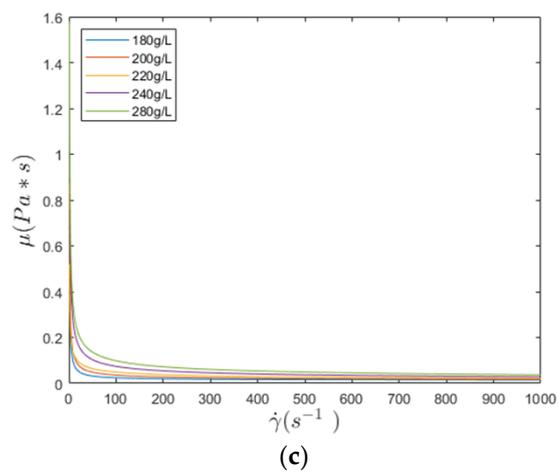


Figure S2: Viscosity as a function of shear rate during TBS conditioning with (a) calcium carbonate, (b) sand, and (c) sodium bentonite. Unconditioned situation is represented by 180 g L⁻¹ of TS concentration.