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

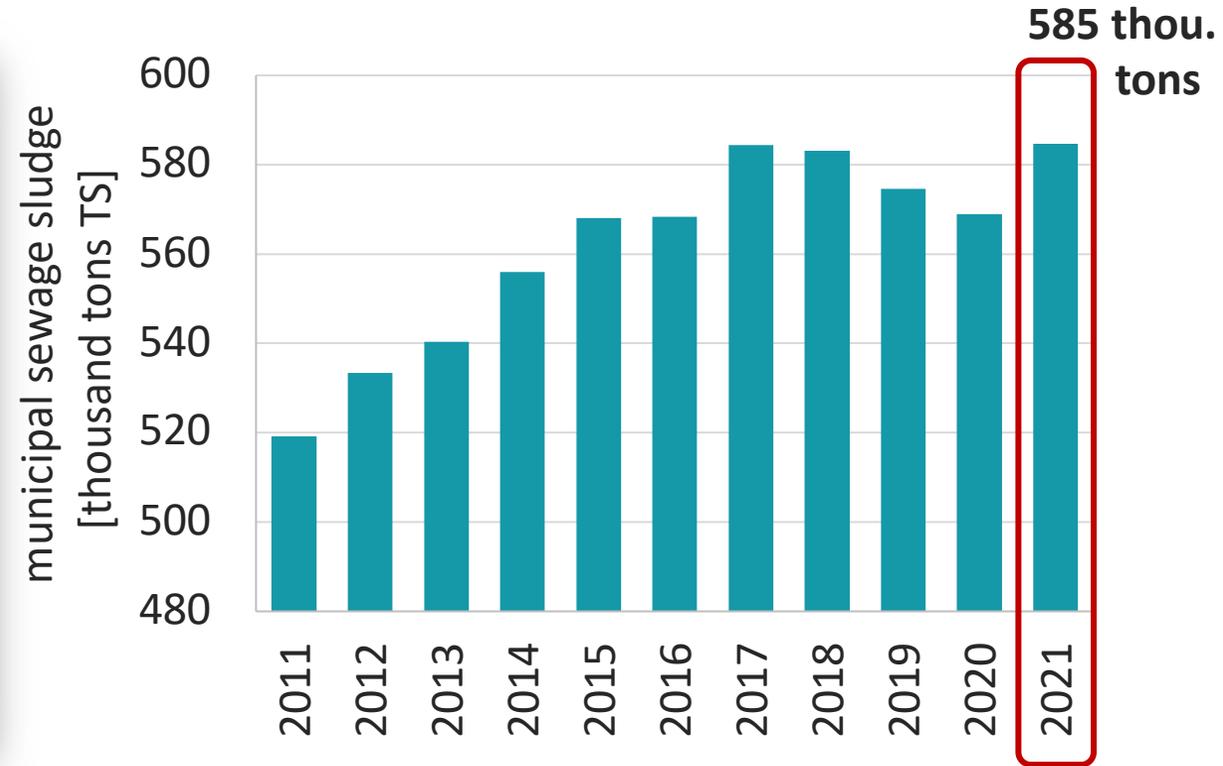
Justyna Walczak, Monika Żubrowska-Sudoł

**Warsaw University
of Technology**

TREATMENT OF MUNICIPAL WASTEWATER & SEWAGE SLUDGE



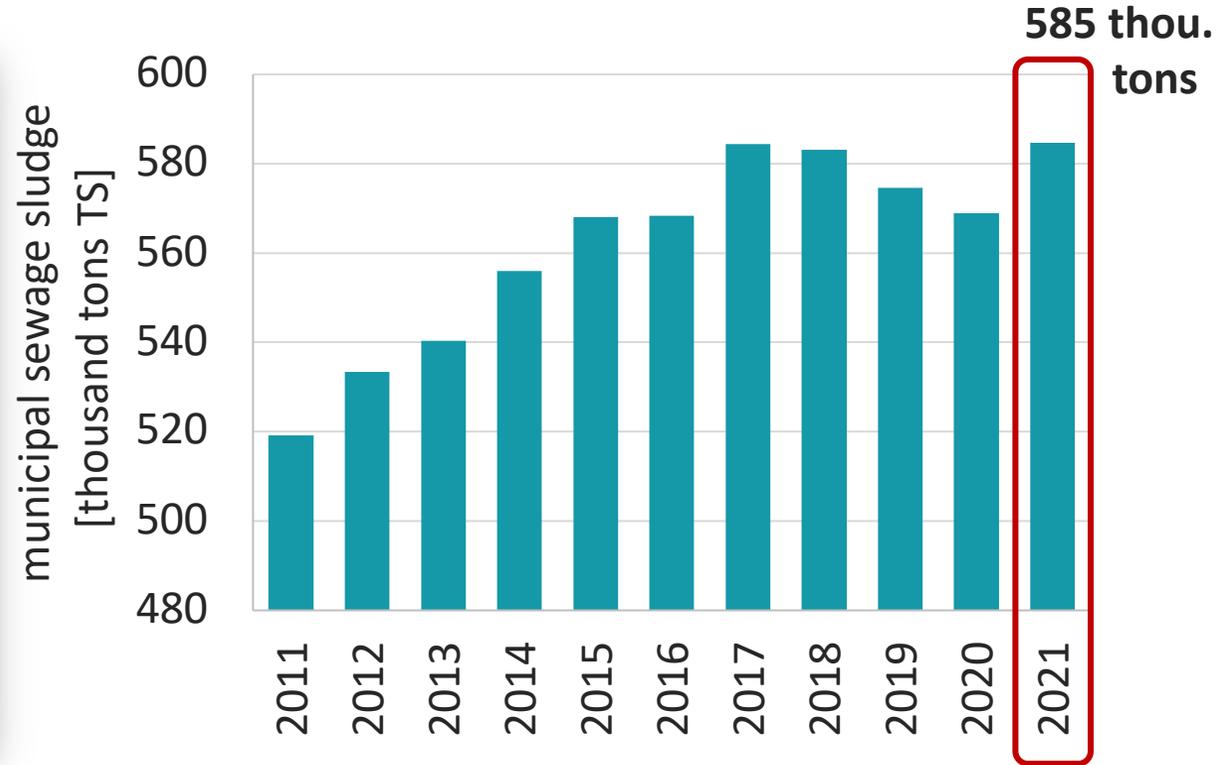
TREATMENT OF MUNICIPAL WASTEWATER & SEWAGE SLUDGE



TREATMENT OF MUNICIPAL WASTEWATER & SEWAGE SLUDGE



50-60%
of operating costs
of WWTPs

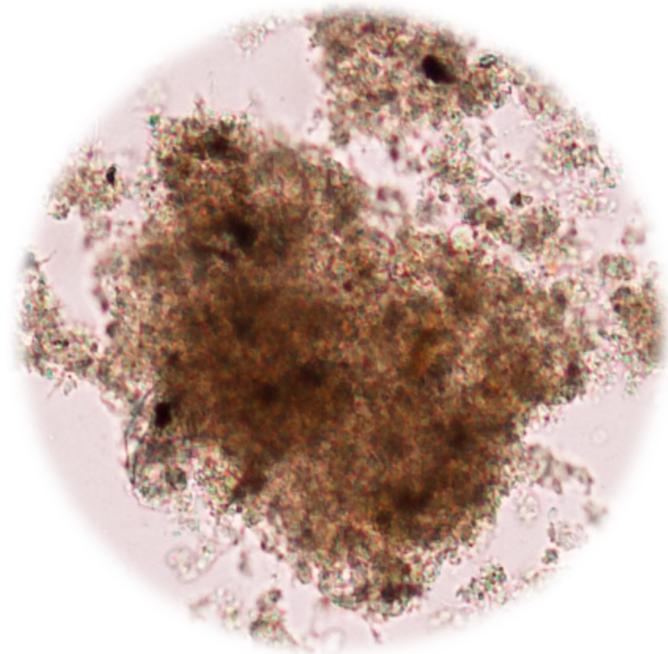


The costs of handling sewage sludge are estimated to account for a considerable share of the operating costs of wastewater treatment plants. It can reach up to 50-60%*.

*Sahinkaya S. (2015) Disintegration of municipal waste activated sludge by simultaneous combination of acid and ultrasonic pretreatment. Process Safety and Environmental Protection, 93, 201-205.

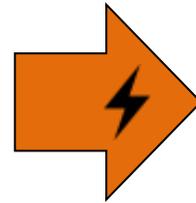
DISINTEGRATION OF SLUDGE

the disintegration process is a destruction of sludge flocs structure by added energy, which leads to changes in the physico-chemical properties of the sludge



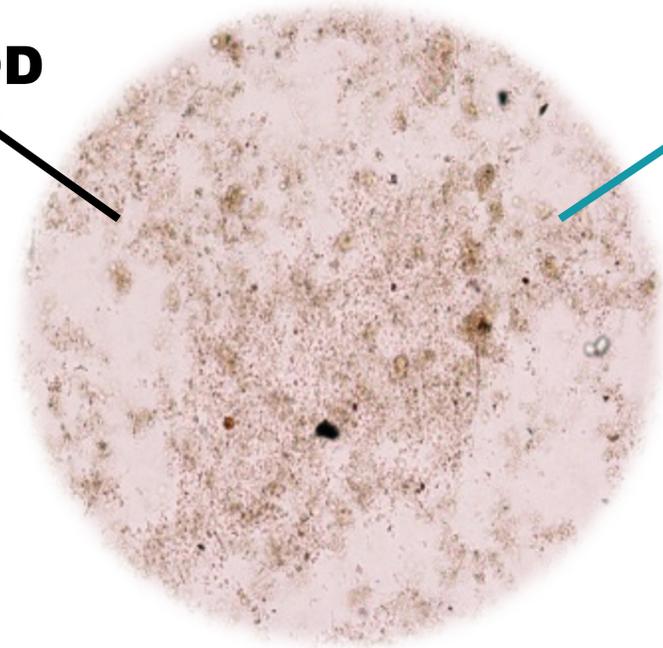
**BEFORE
DISINTEGRATION**

ENERGY



energy density (ϵ_L)
or
specific energy (SE)

SCOD



VFA



**AFTER
DISINTEGRATION**

DISINTEGRATION OF SLUDGE



WASTE

DISINTEGRATION OF SLUDGE



WASTE



PRODUCT

DISINTEGRATION METHODS

Mechanical disintegration methods are based on the destruction of flocs structure by mechanical interactions (including ultrasonic and hydrodynamic cavitation phenomena). They involve tearing, shearing, friction, or other stresses that change the structure of activated sludge and/or microbial cell wall.

Chemical disintegration is carried out with acids, bases, strong oxidants (e.g. ozone), or using advanced oxidation processes.

Biological disintegration involves autolytic hydrolysis under the influence of enzymes produced by microorganisms or enzymes dosed into the sludge from outside.

In **thermal** methods, the main factor is elevated temperature, usually in a range from 40°C to 180°C.

HYDRODYNAMIC DISINTEGRATOR



DEVICE: patent No 214335

TYPE: MECHANICAL

KIND: HYDRODYNAMIC CAVITATION



Chamber
Outlet
Sludge circulation
Multifunctional rotor
Inlet

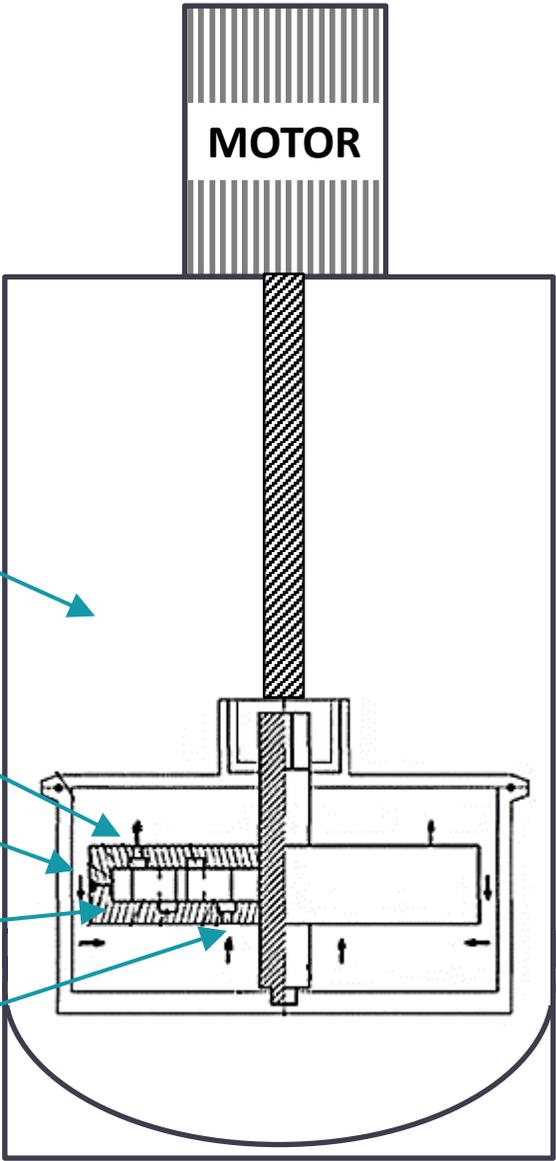


Fig. The laboratory hydrodynamic disintegration apparatus

TOTAL SOLIDS CONTENT



PURPOSE

the aim 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 liquid sludge



MATERIALS

Sewage sludge was obtained from the largest wastewater treatment plant with biological nutrient removal in POLAND

PE = 2 100 000



Fig. „Czajka” WWTP, Warsaw, Poland

DISINTEGRATION BATCH TESTS

THREE series were conducted in 4-week intervals, designated as: Serie A, Serie B, Serie C.

Each series was composed of four disintegration batch tests conducted for **three samples of thickened excess sludge** diluted to different levels of TS concentration, and one for a sample of **return activated sludge**.



thickened excess activated sludge

TS=2.5%

TS=3.5%

TS=4.5%

return activated sludge

TS=1.0%

The disintegration process was carried out at: 70, 140, 210, 280 and 350 kJ/L.

DISINTEGRATION BATCH TESTS

THE SCOPE OF THE ANALYSIS INCLUDED:

- TS concentrations of sludge before disintegration
- characteristics of liquid phase in the samples before and after disintegration:
 - soluble chemical oxygen demand (SCOD) [mg/L]
 - volatile fatty acids (VFA) [mg/L]
- specific energy (SE) [kJ/kgTS]

The sludge liquids were obtained by 30 min centrifugation at a speed of 15,000 rpm and filtration on filter paper with a pore diameter of 0.45 μm



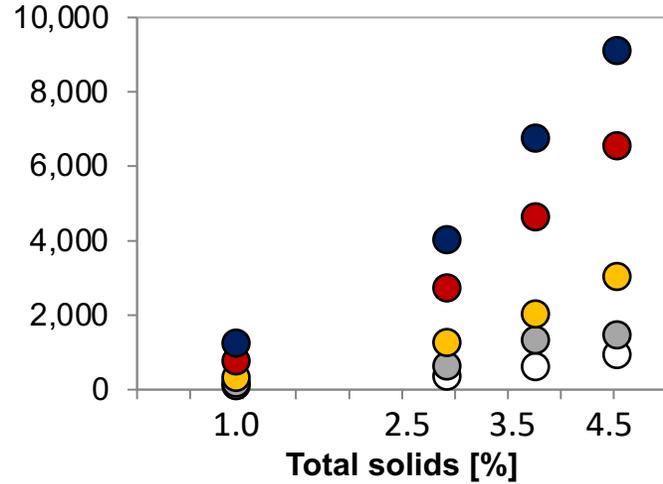
RESULTS



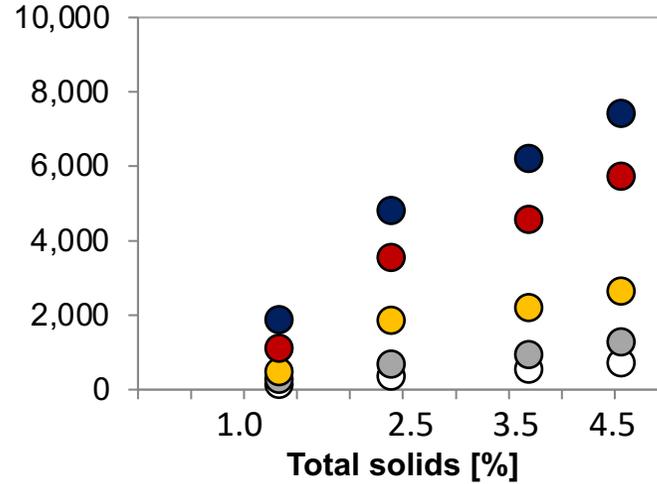
RELEASE of SCOD and VFA

SCOD [mg/L]

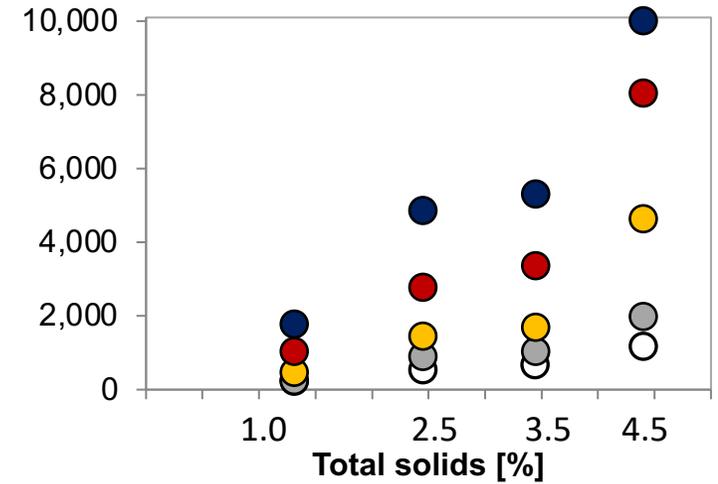
Serie A



Serie B



Serie C



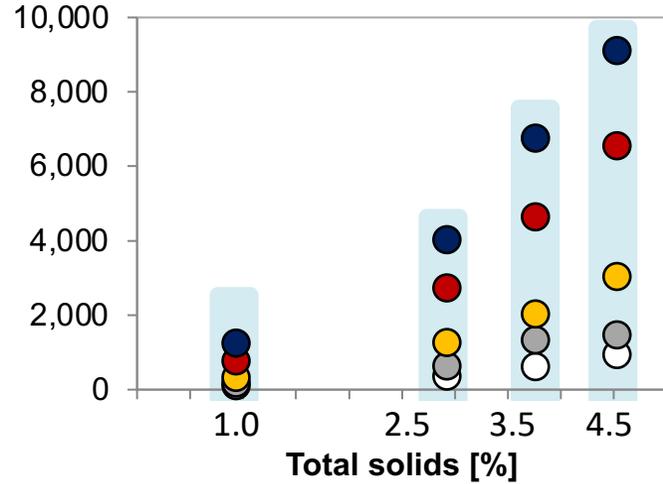
Energy density [kJ/L]:

- 350 kJ/L
- 280 kJ/L
- 210 kJ/L
- 140 kJ/L
- 70 kJ/L

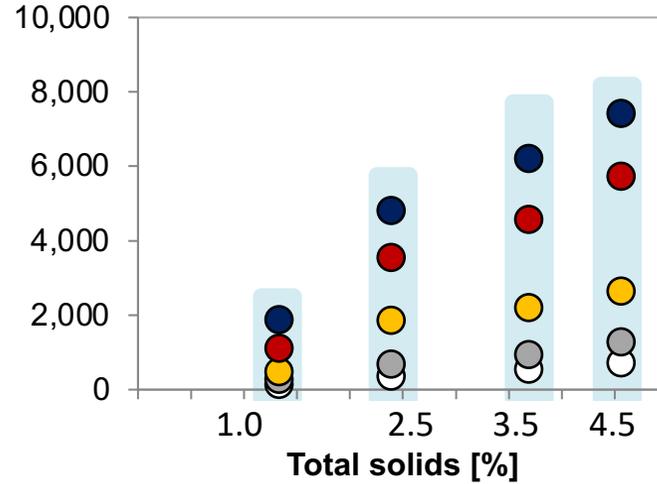
RELEASE of SCOD and VFA

SCOD [mg/L]

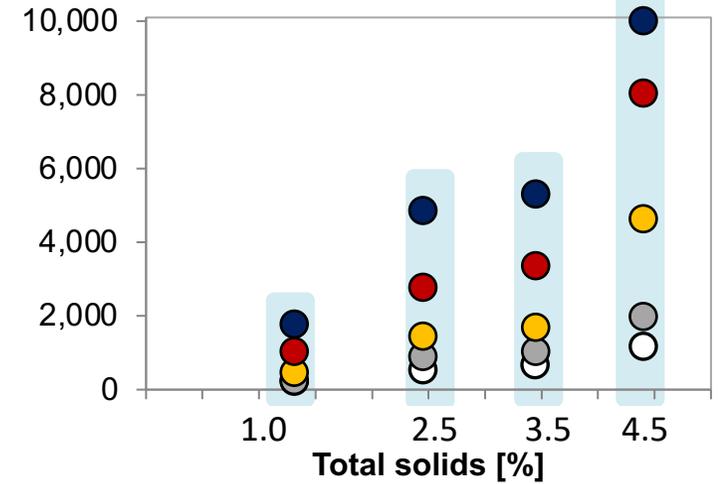
Serie A



Serie B



Serie C



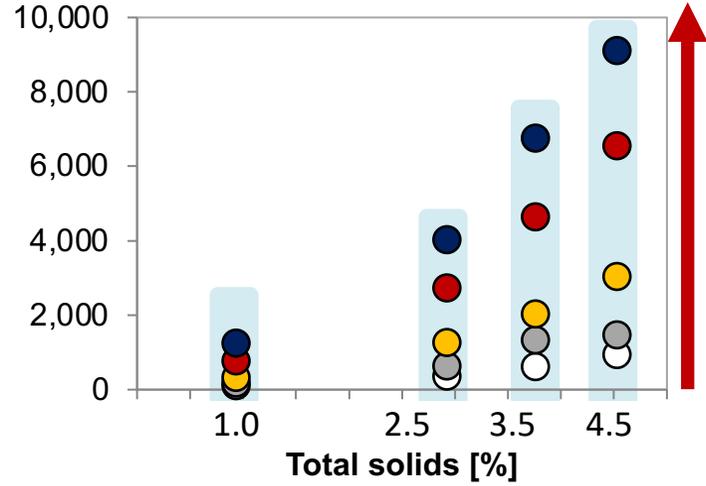
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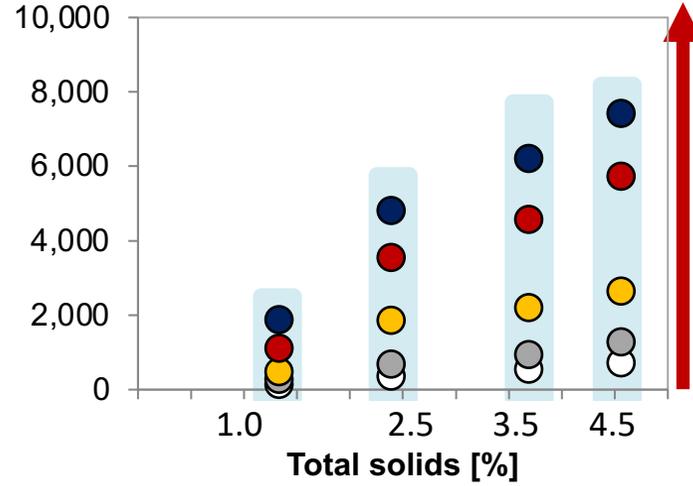
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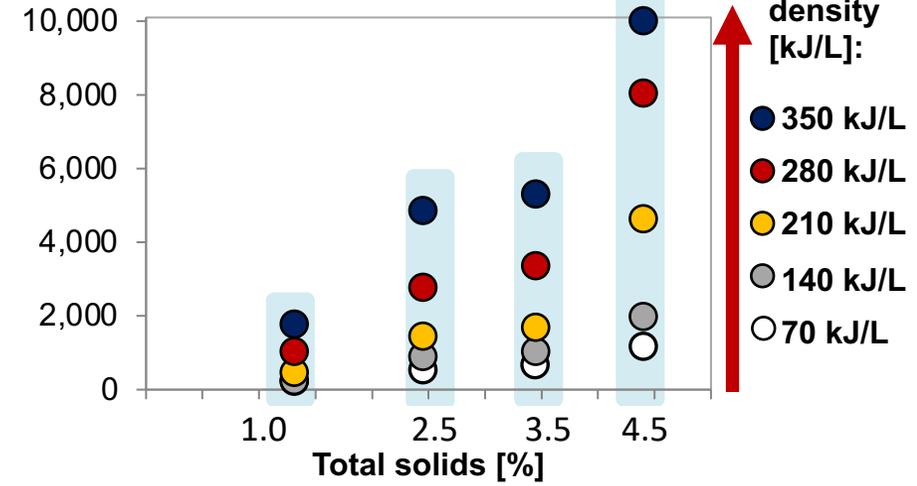
Serie A



Serie B



Serie C



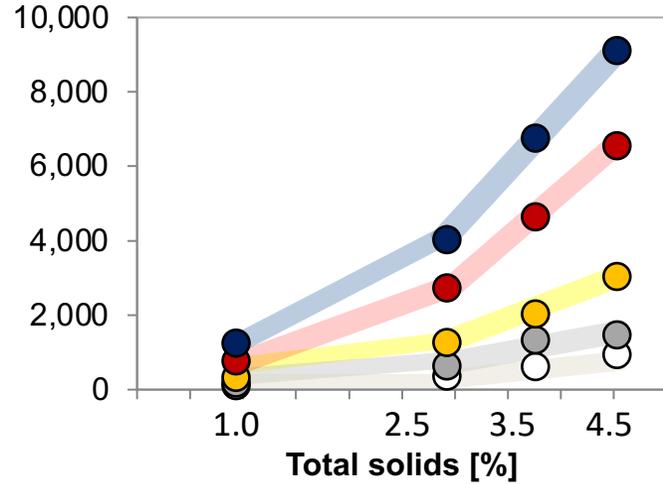
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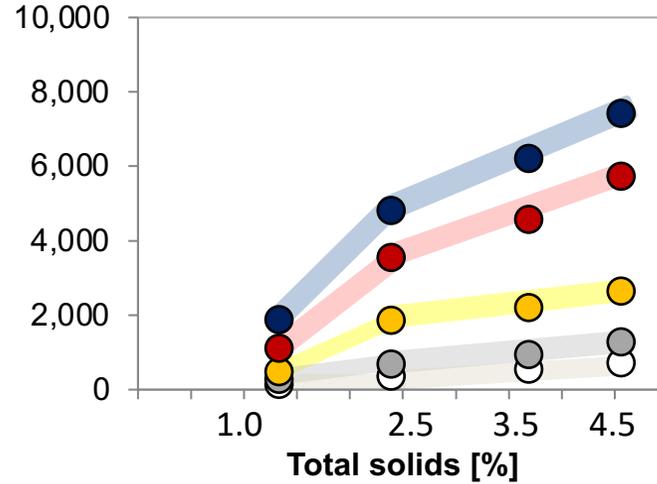
RELEASE of SCOD and VFA

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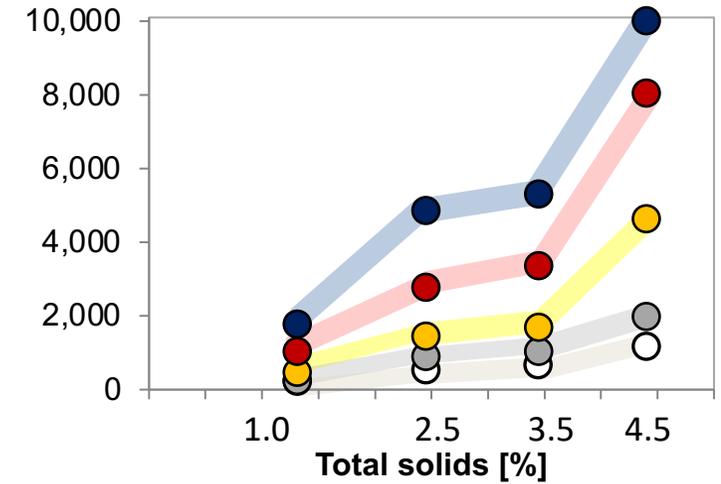
Serie A



Serie B



Serie C



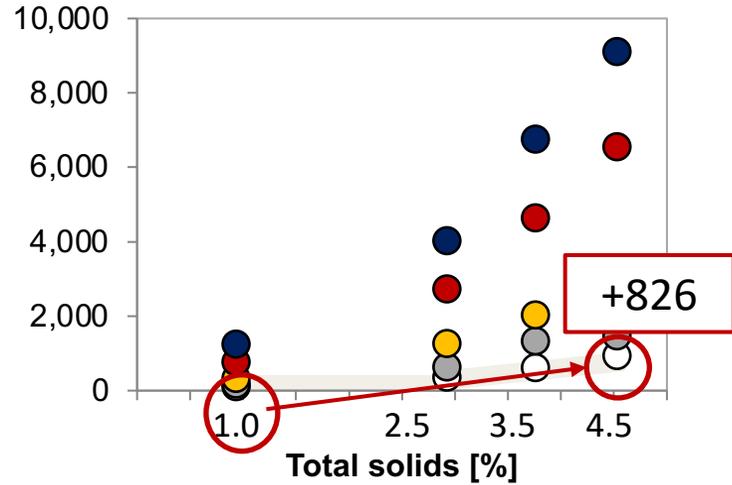
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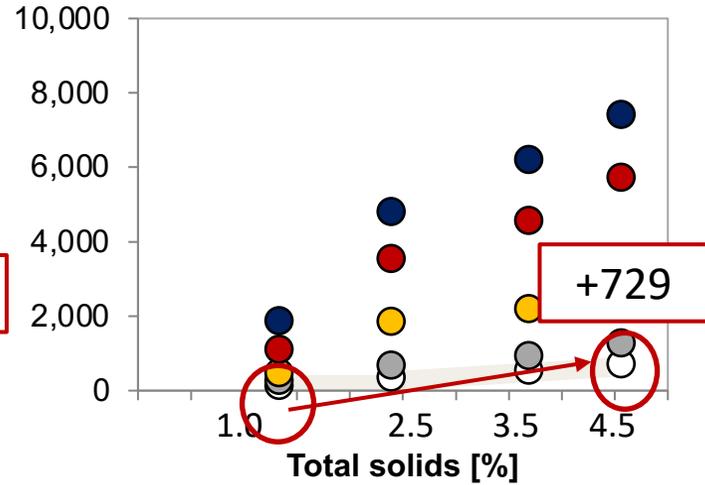
RELEASE of SCOD and VFA

SCOD [mg/L]

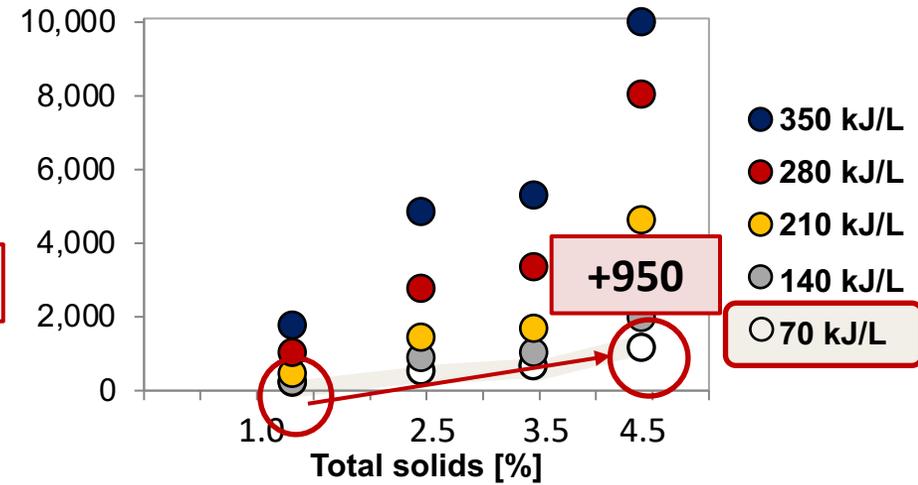
Serie A



Serie B



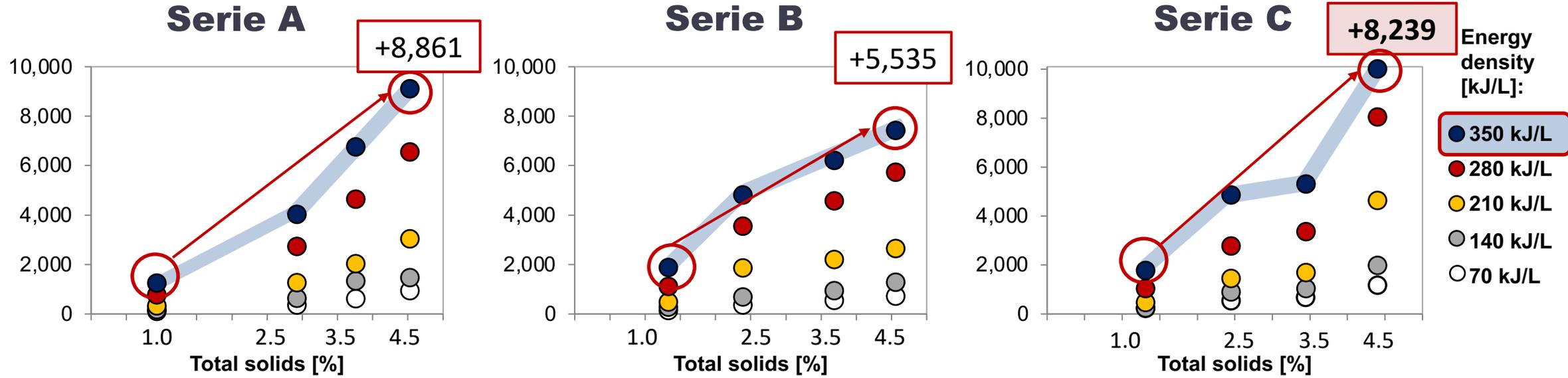
Serie C



- 350 kJ/L
- 280 kJ/L
- 210 kJ/L
- 140 kJ/L
- 70 kJ/L

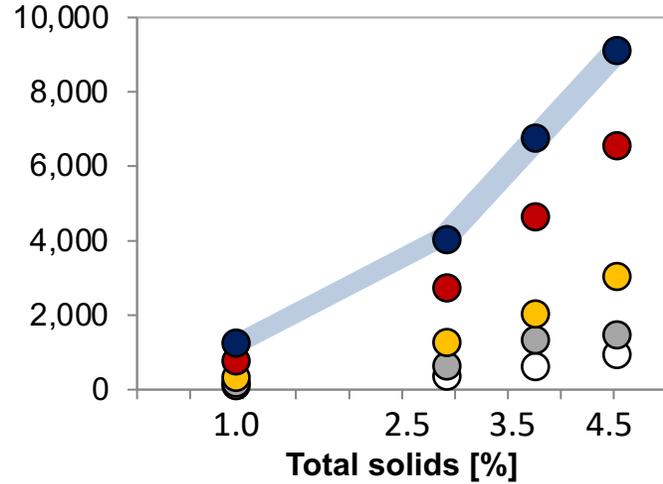
RELEASE of SCOD and VFA

SCOD [mg/L]

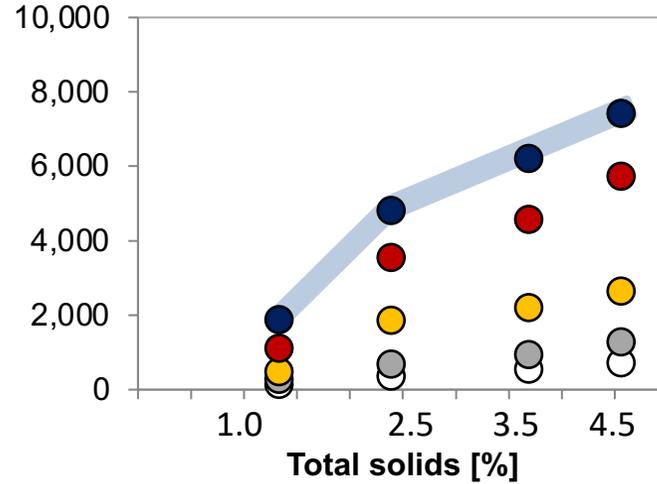


RELEASE of SCOD and VFA

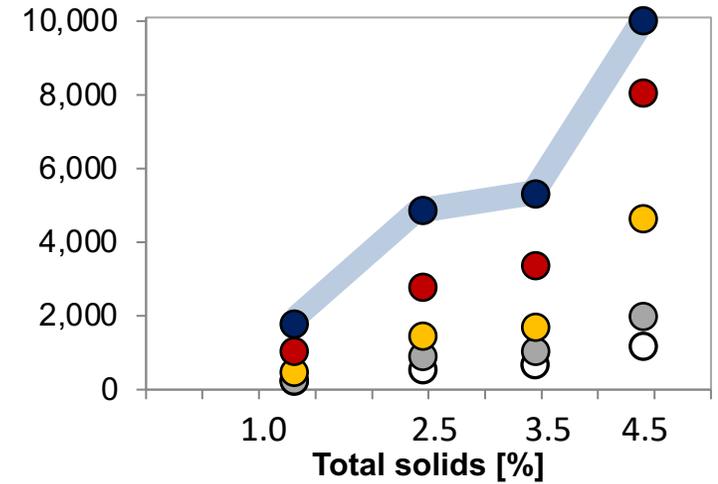
Serie A



Serie B



Serie C

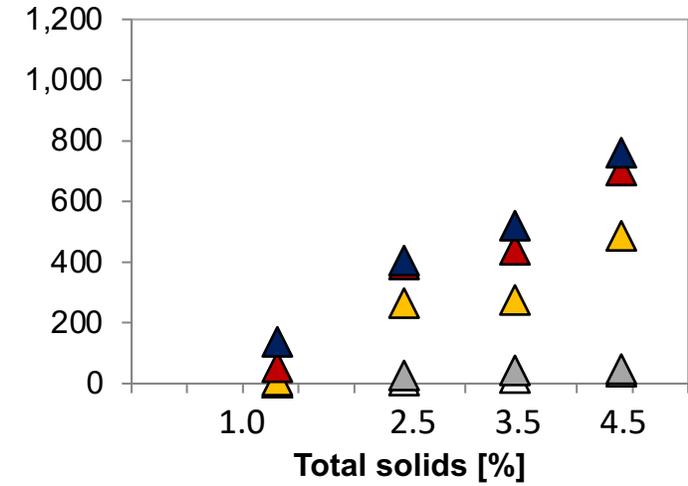
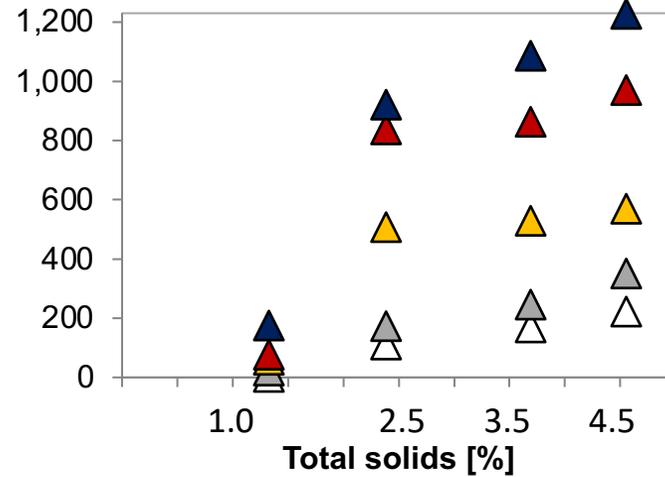
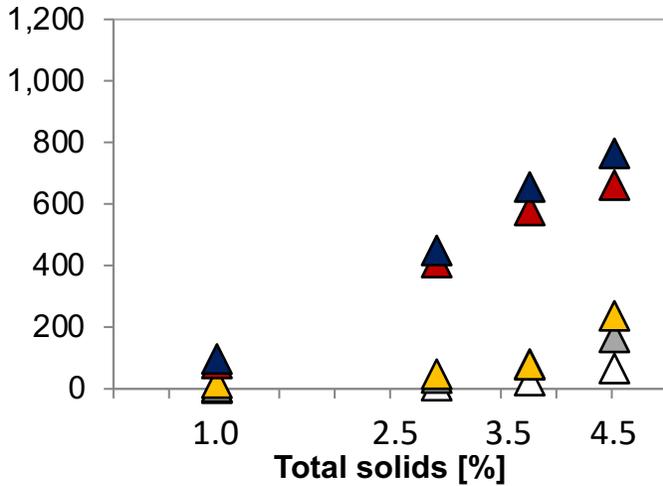


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SCOD [mg/L]

VFA [mg/L]

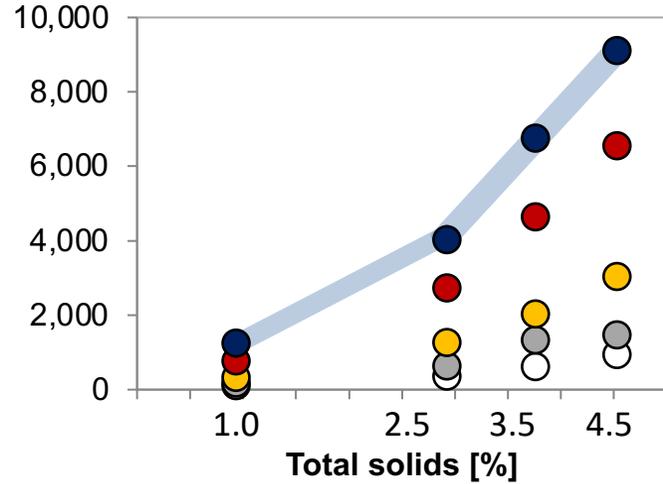


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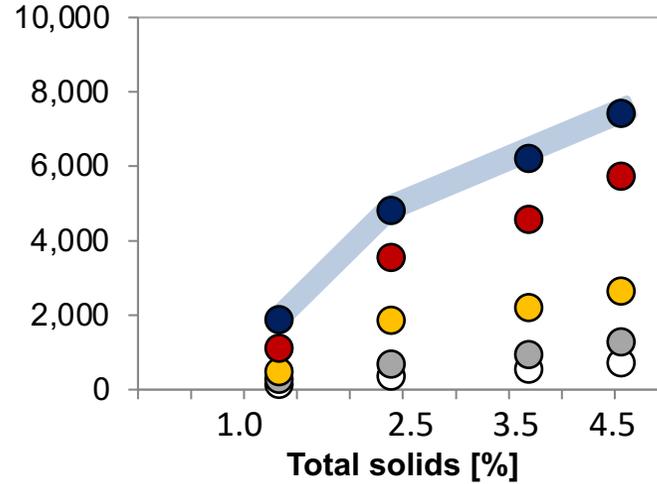
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RELEASE of SCOD and VFA

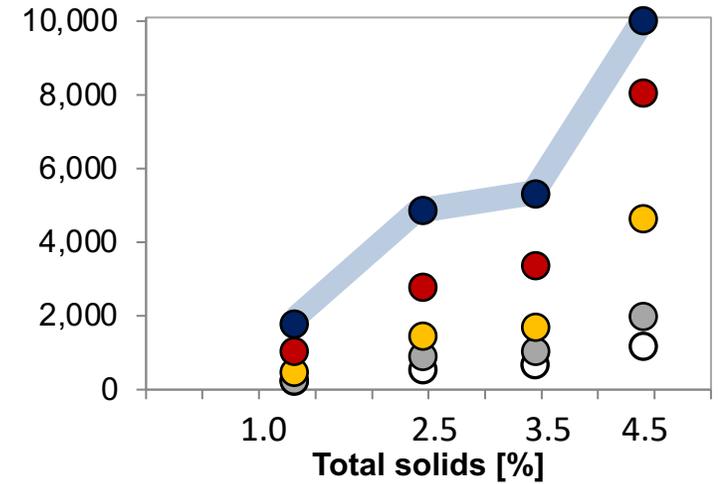
Serie A



Serie B



Serie C

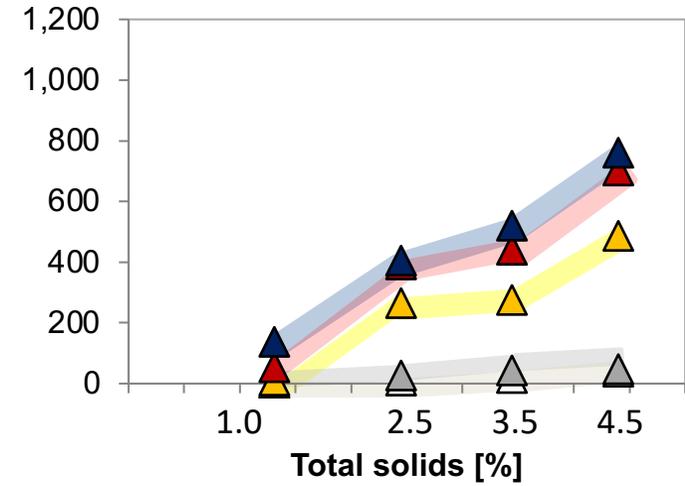
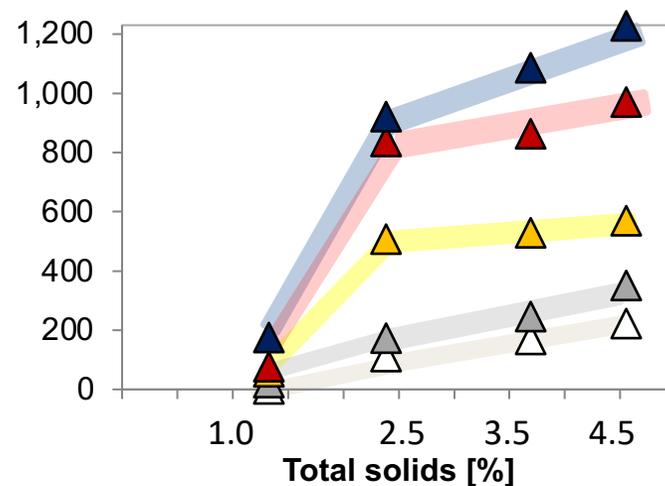
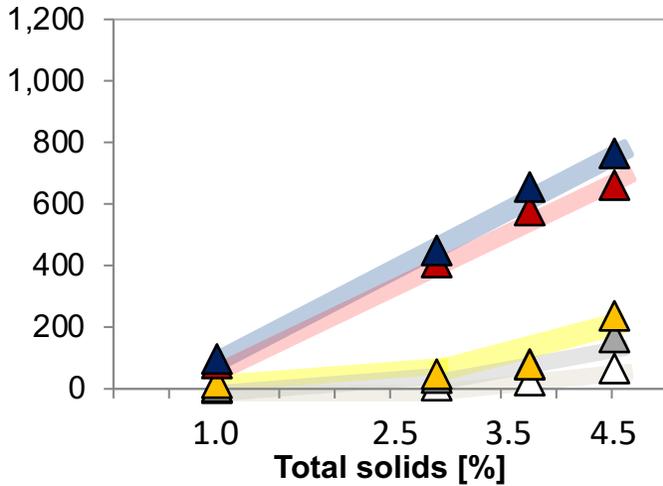


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SCOD [mg/L]

VFA [mg/L]



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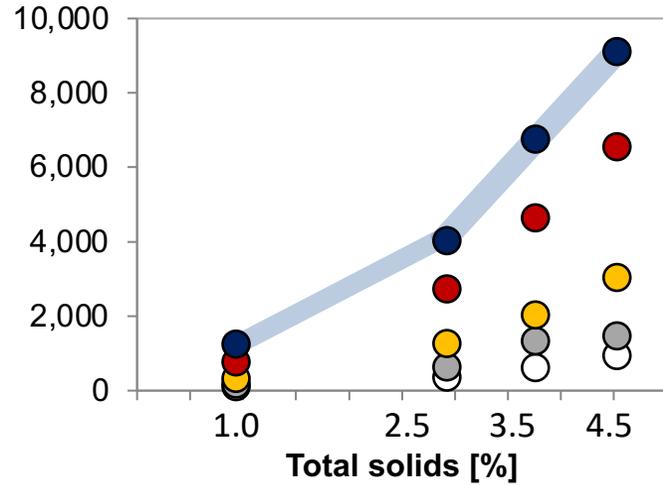
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RELEASE of SCOD and VFA

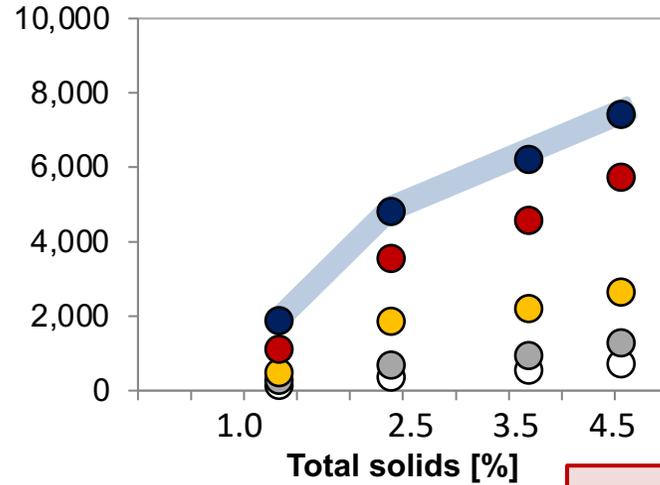
SCOD [mg/L]

VFA [mg/L]

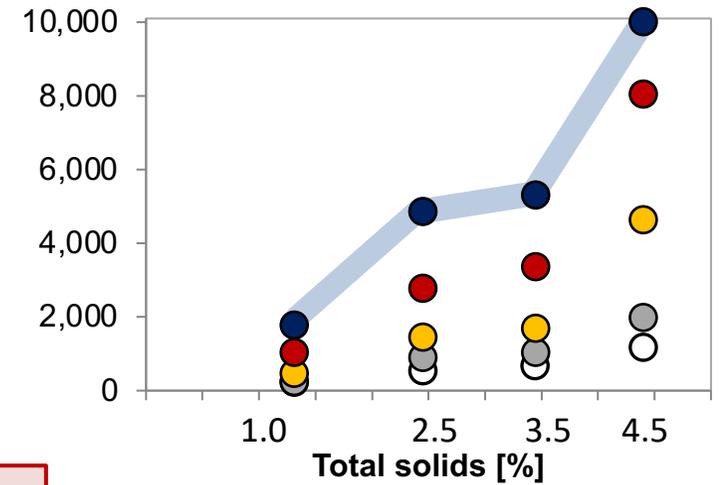
Serie A



Serie B



Serie C



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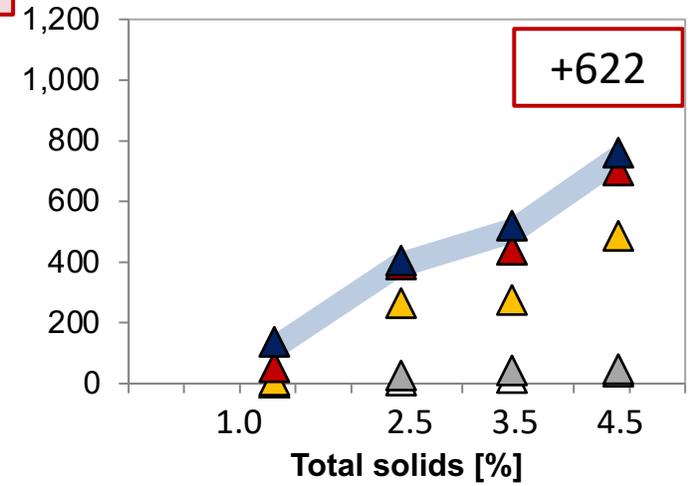
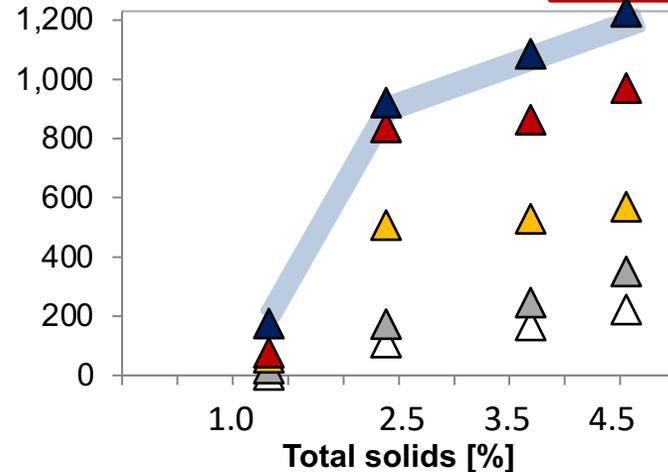
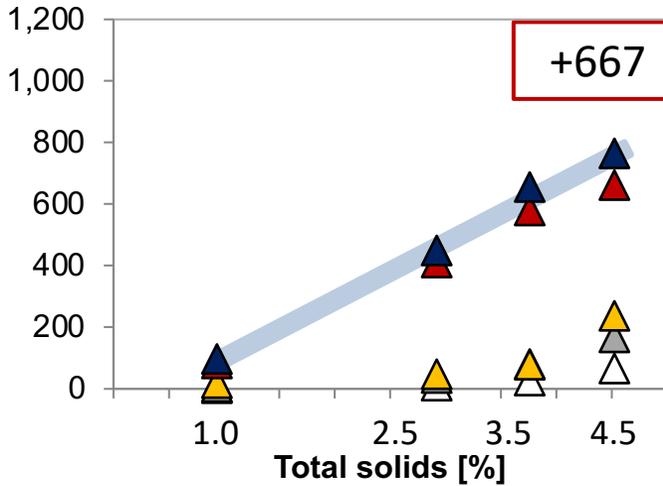
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+667

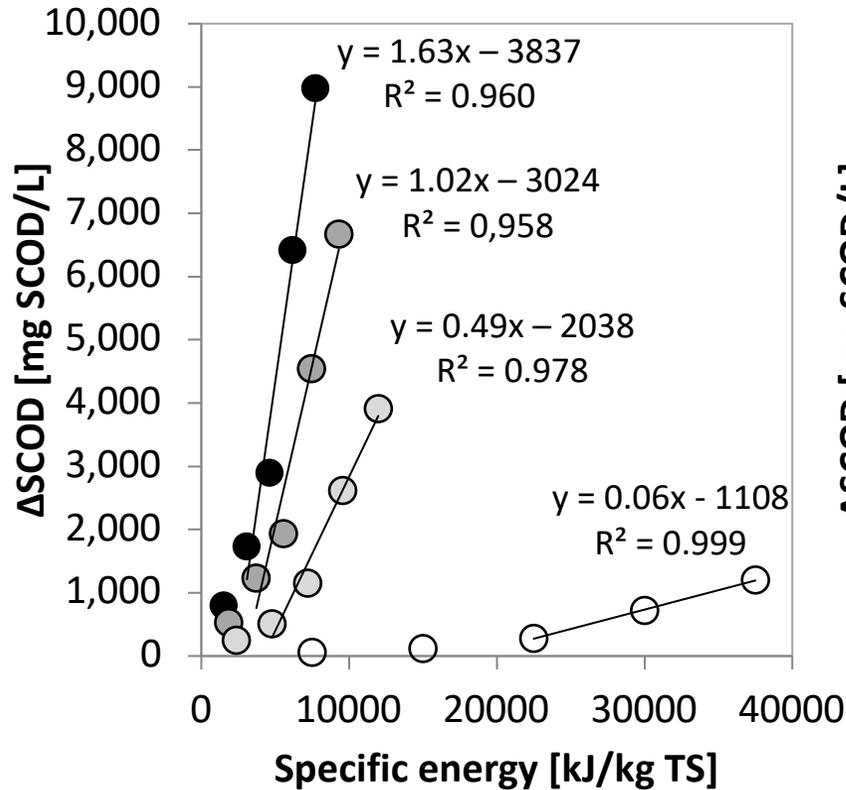
+1,051

+622

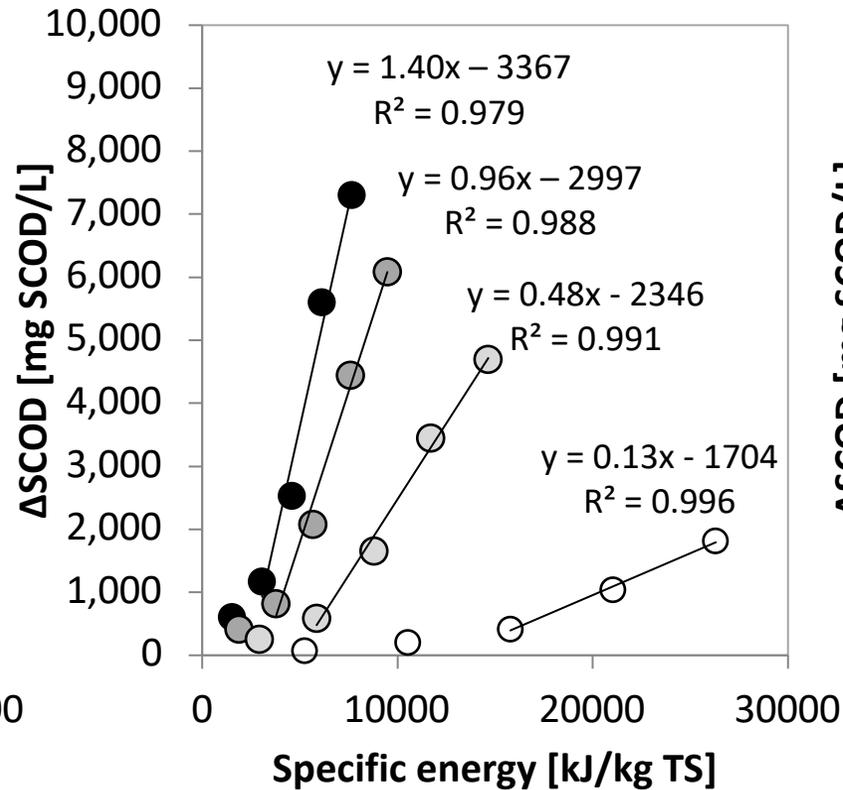


Δ SCOD

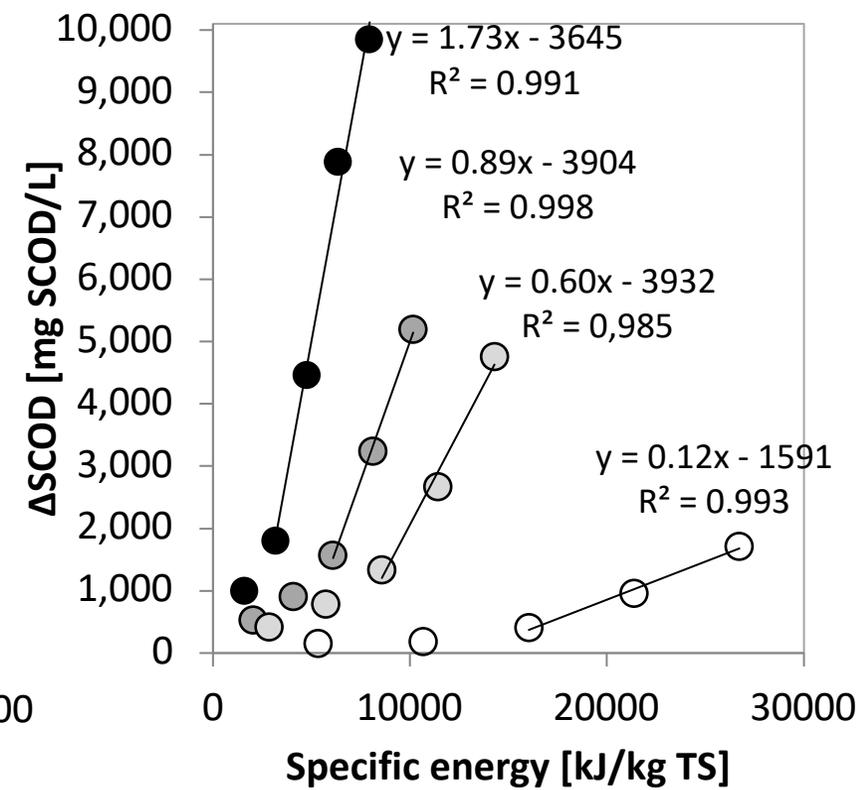
Serie A



Serie B



Serie C

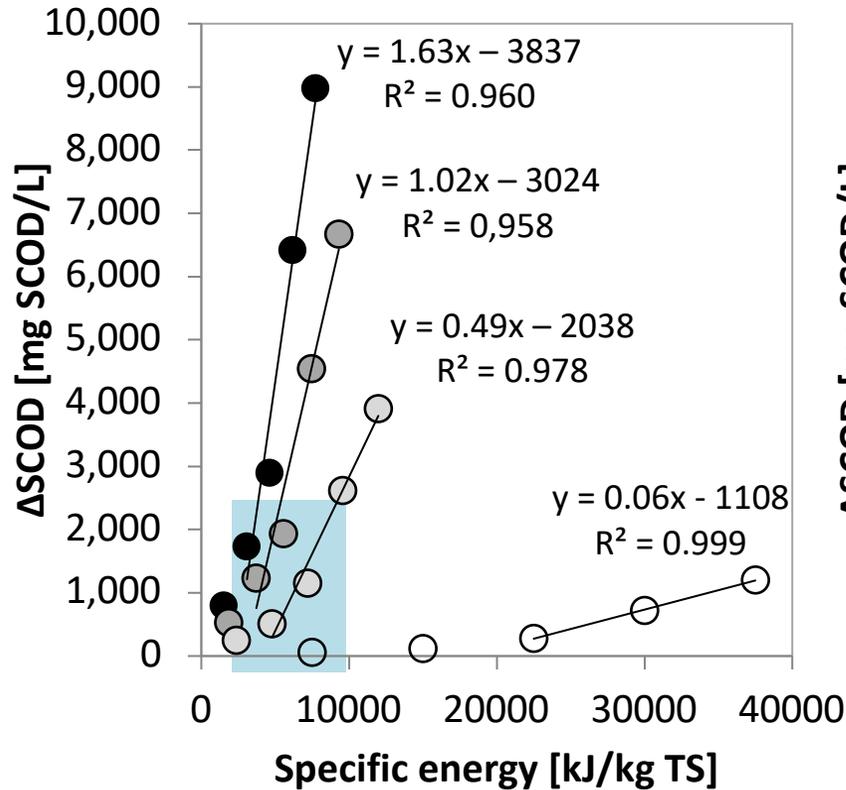


○ TS = approx. 1.0 % ○ TS = approx. 2.5 % ● TS = approx. 3.5 % ● TS approx. = 4.5 %

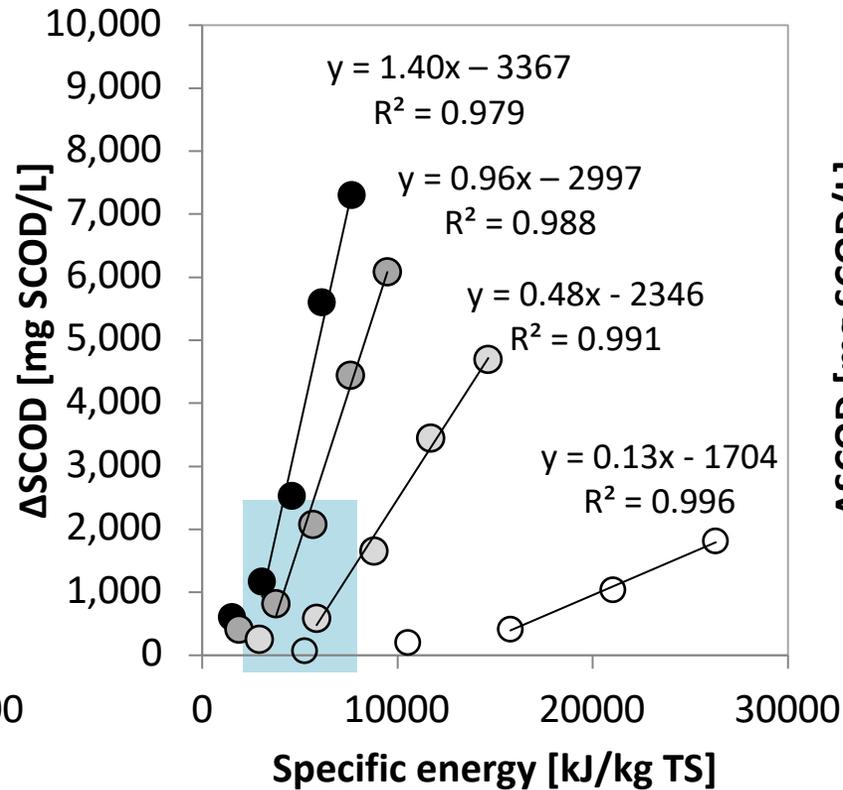
Fig. The efficiency of release of organic compounds (ΔSCOD) depending on Specific Energy (SE) and TS concentration

Δ SCOD

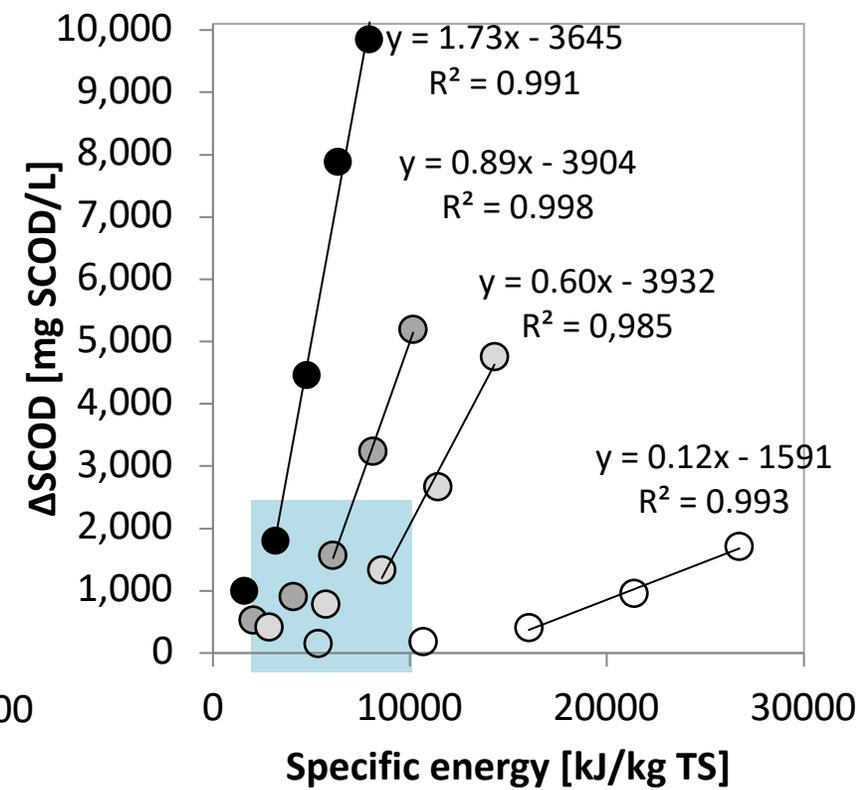
Serie A



Serie B



Serie C

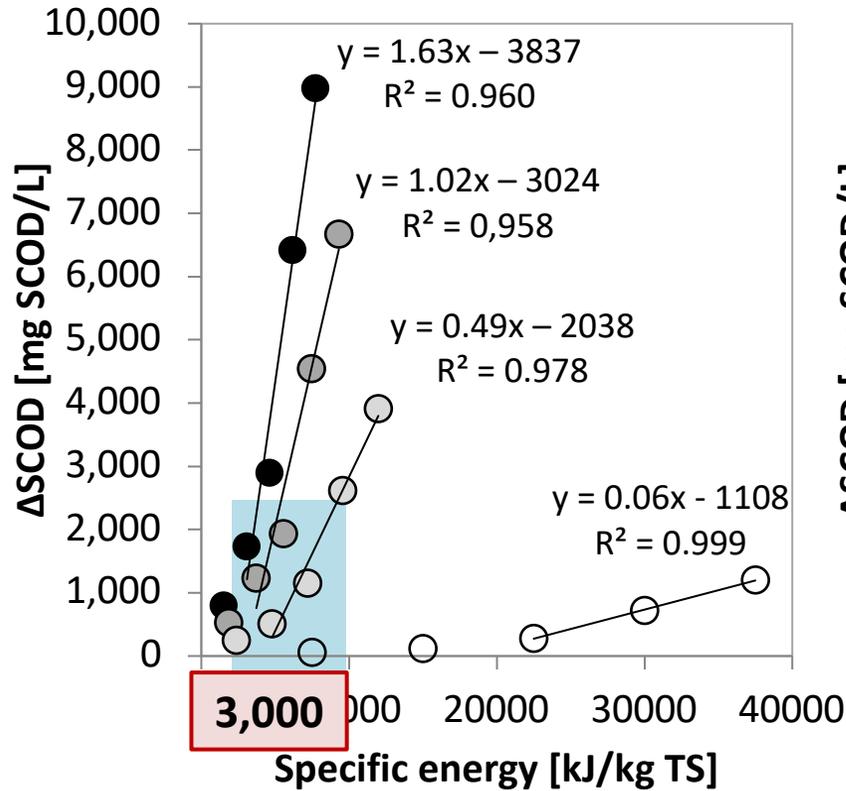


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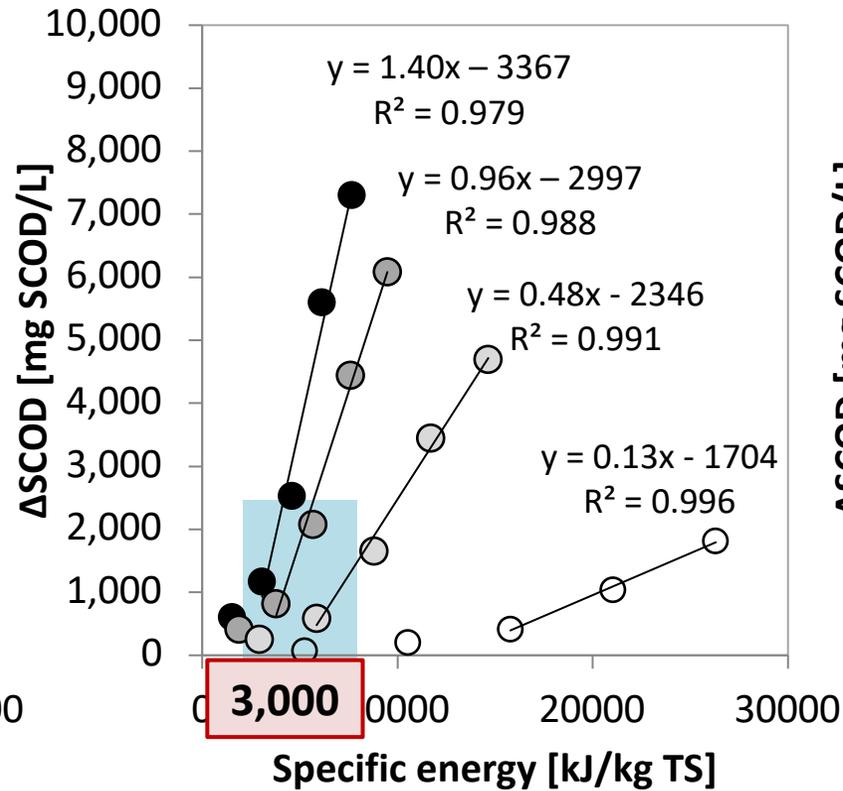
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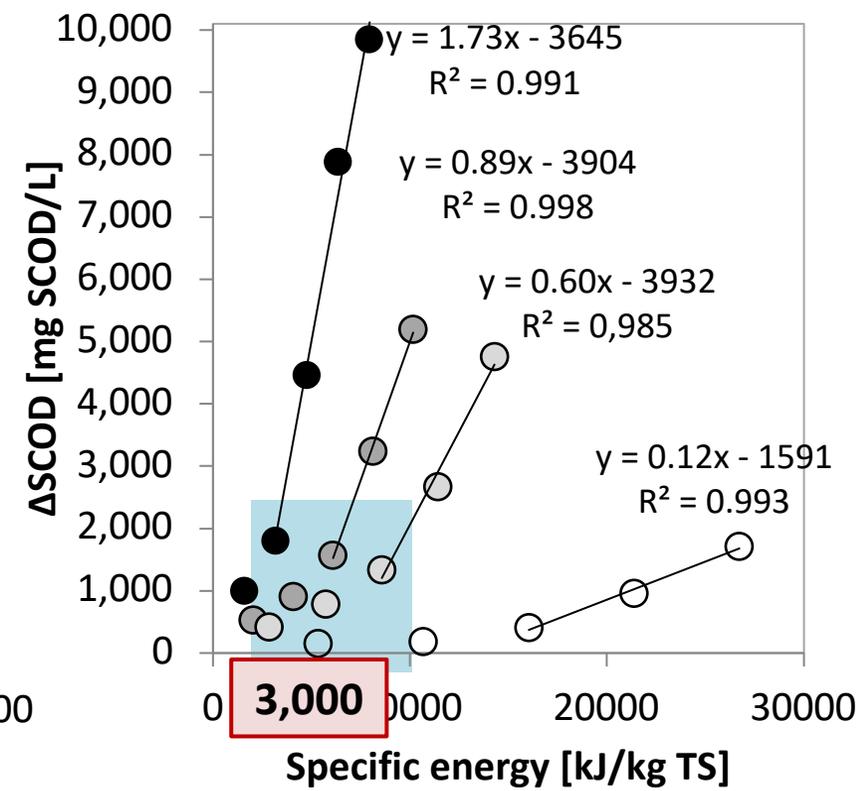
Serie A



Serie B



Serie C

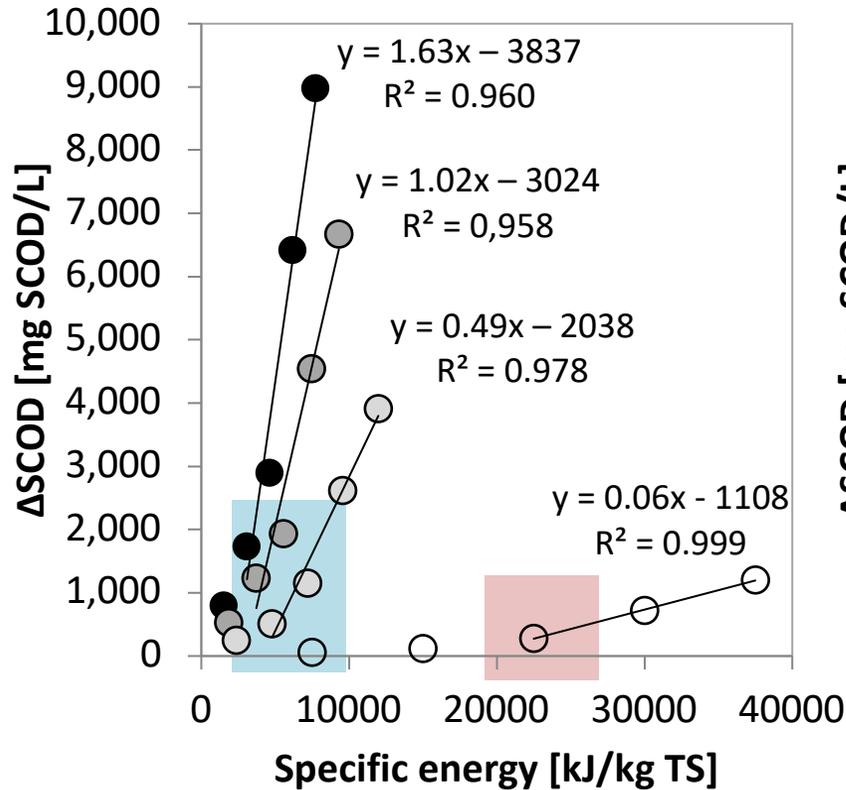


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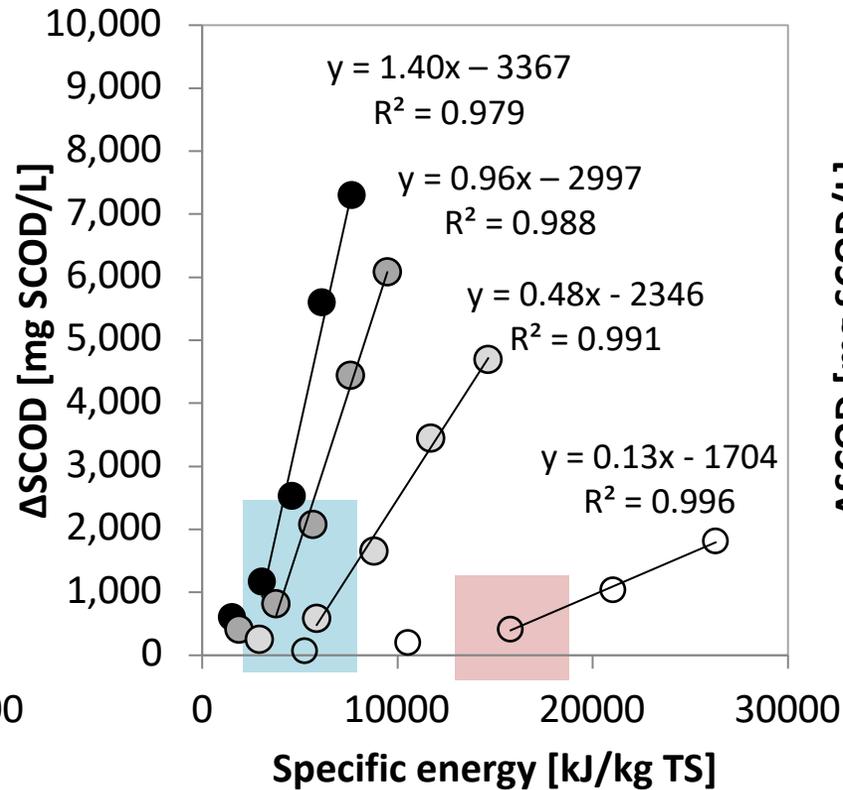
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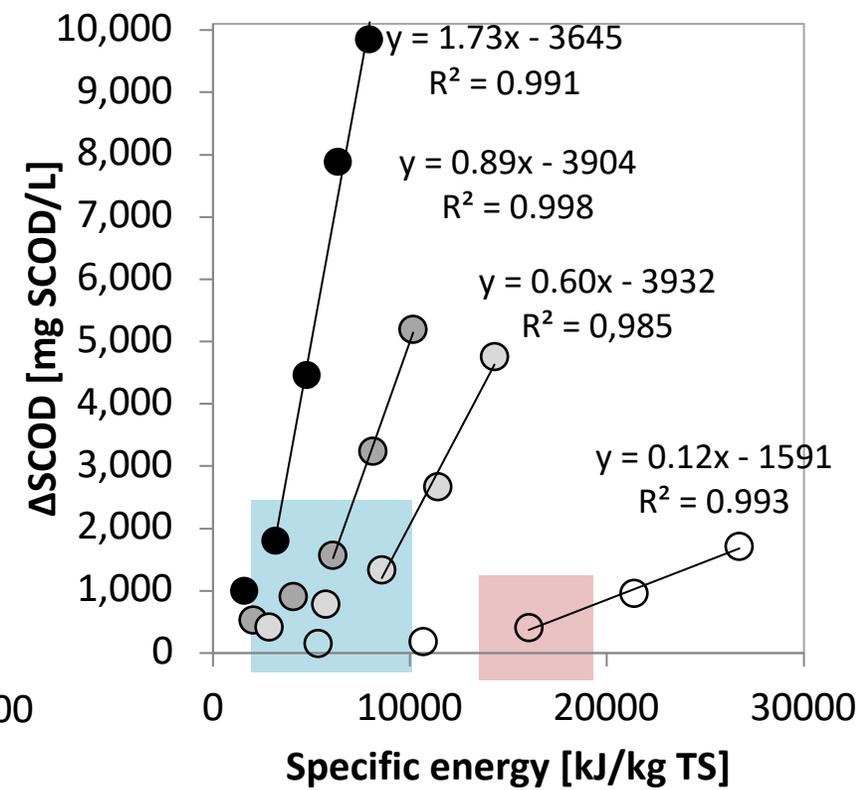
Serie A



Serie B



Serie C



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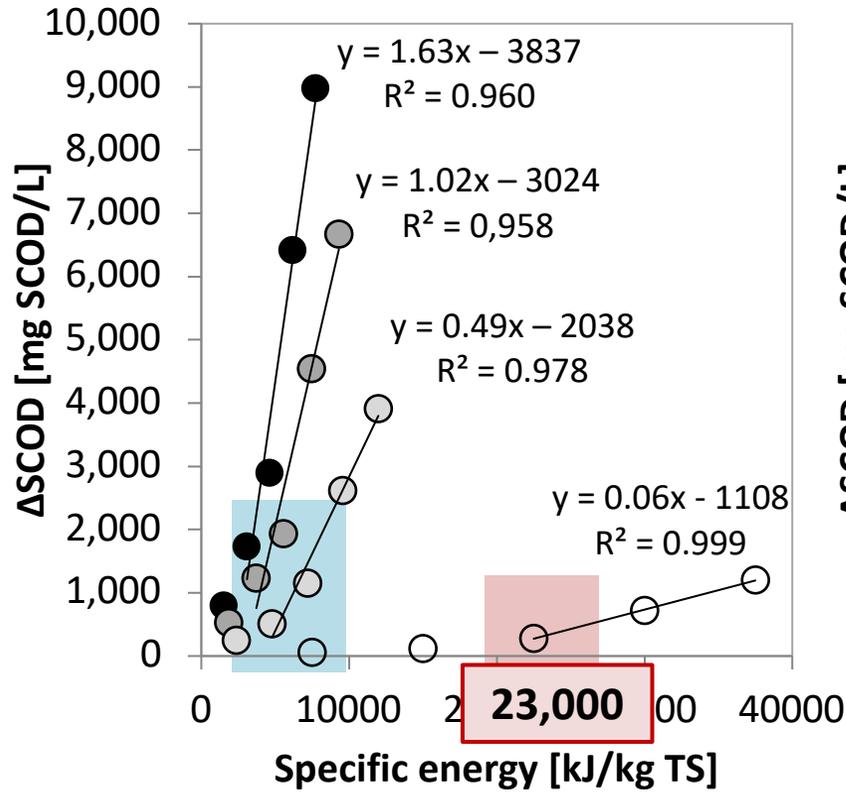
○ TS = approx. 3.5 %

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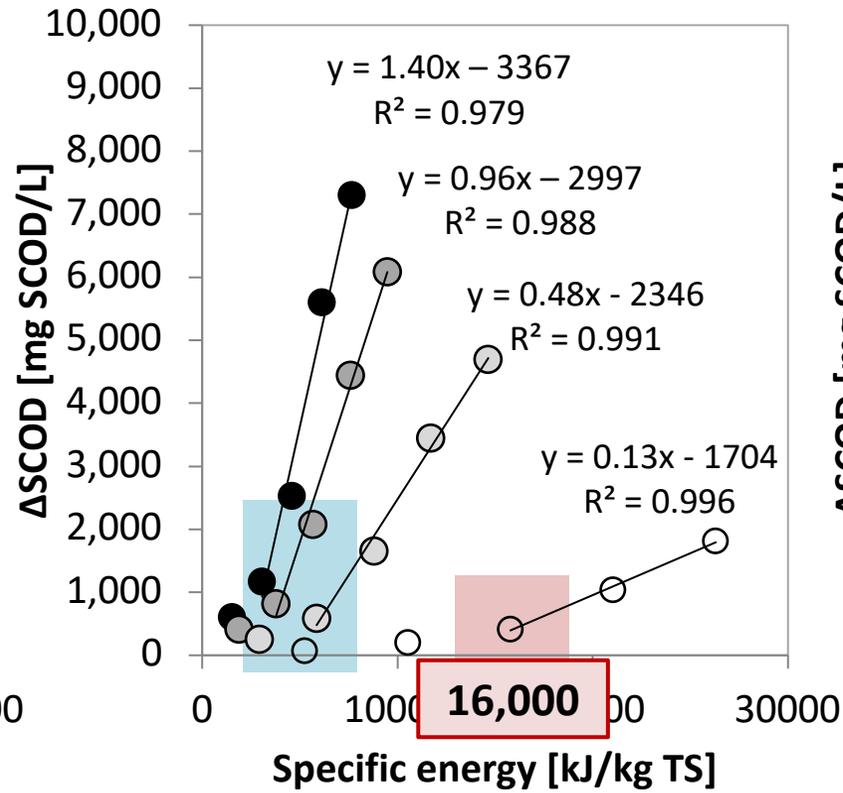
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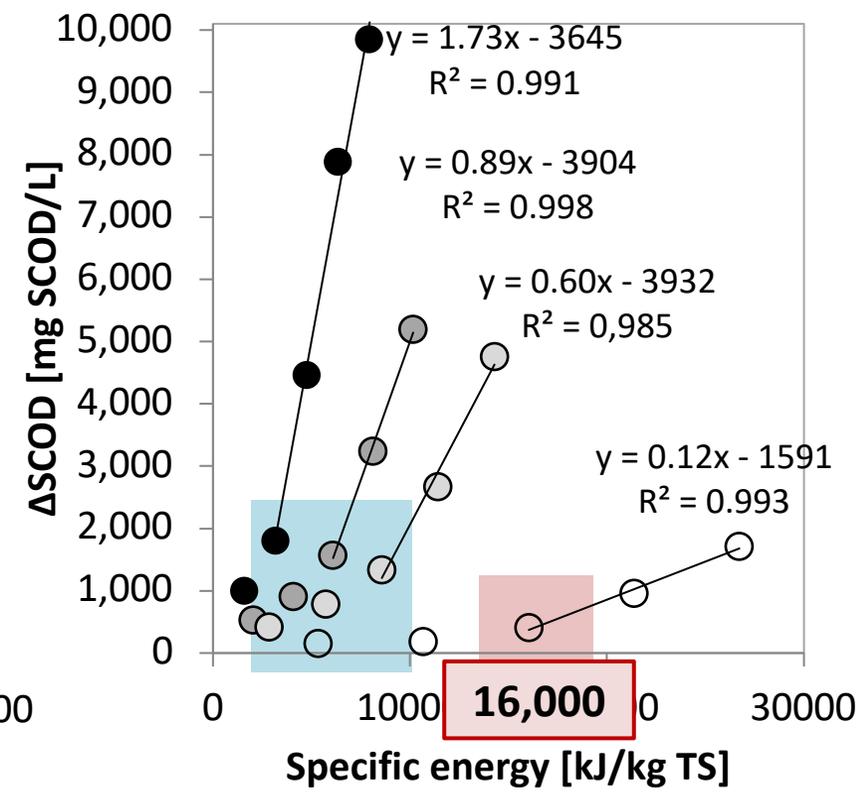
Serie A



Serie B



Serie C



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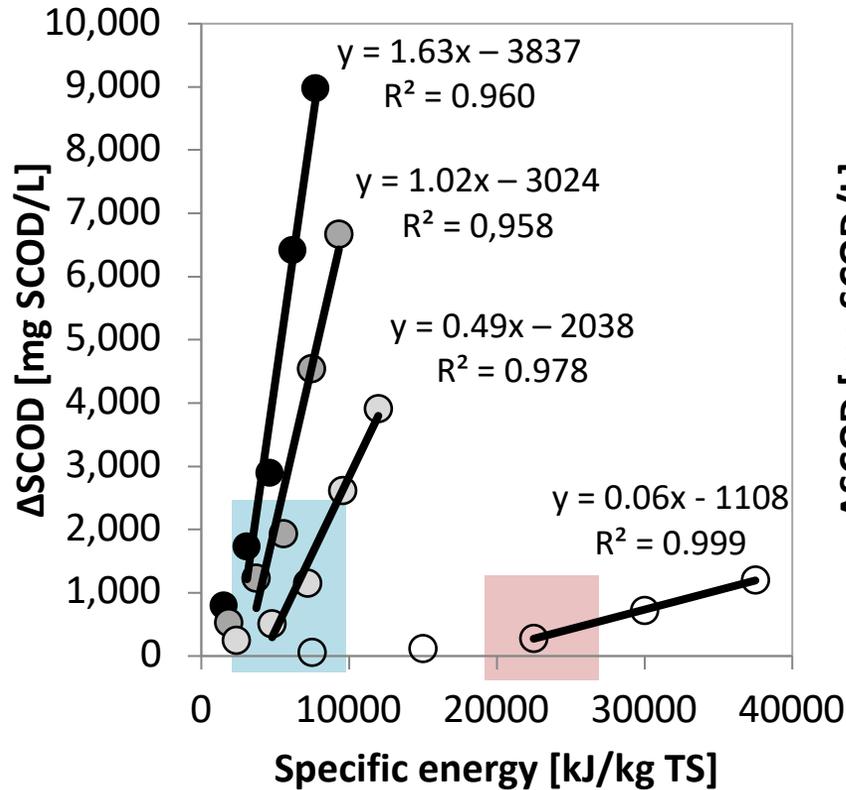
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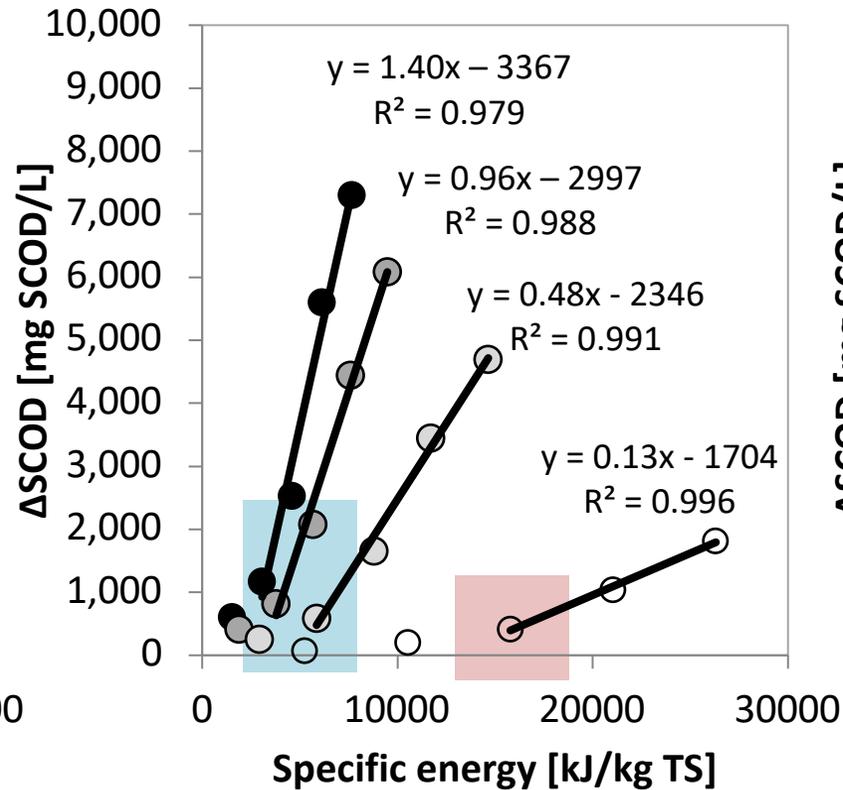
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Δ SCOD

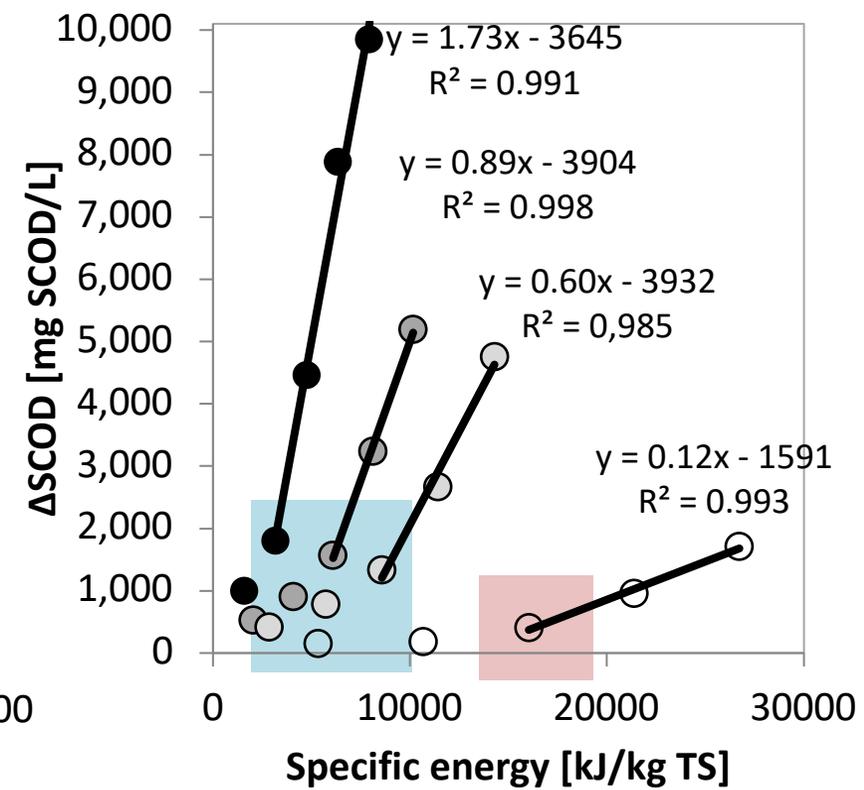
Serie A



Serie B



Serie C



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Fig. The efficiency of release of organic compounds (ΔSCOD) depending on Specific Energy (SE) and TS concentration

„Threshold” value of specific energy (SE)

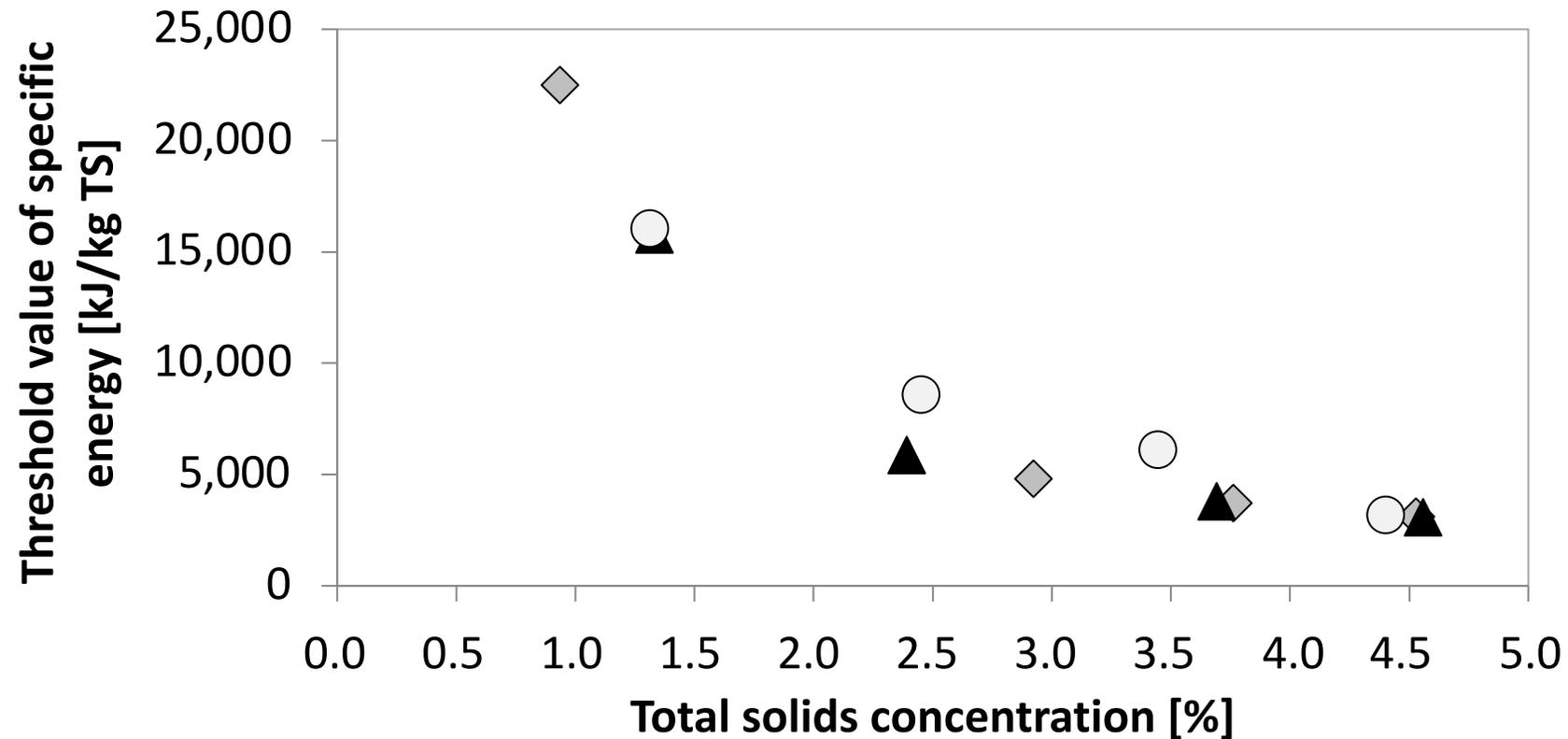


Fig. Threshold value of Specific Energy (SE) exceeding of which caused an increase in the intensity of release of organic compounds in the function of TS concentration of disintegration sludge

„Threshold” value of specific energy (SE)

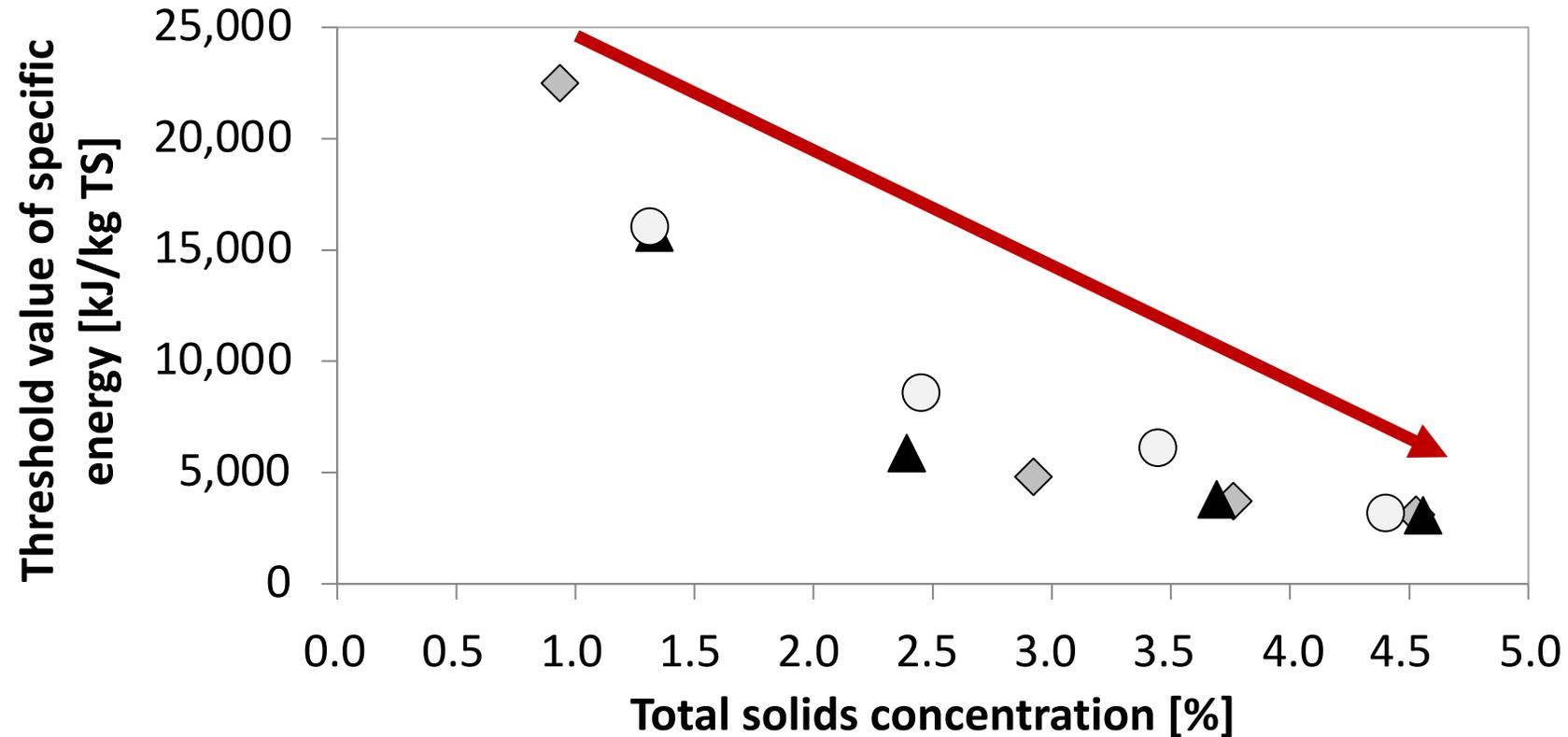


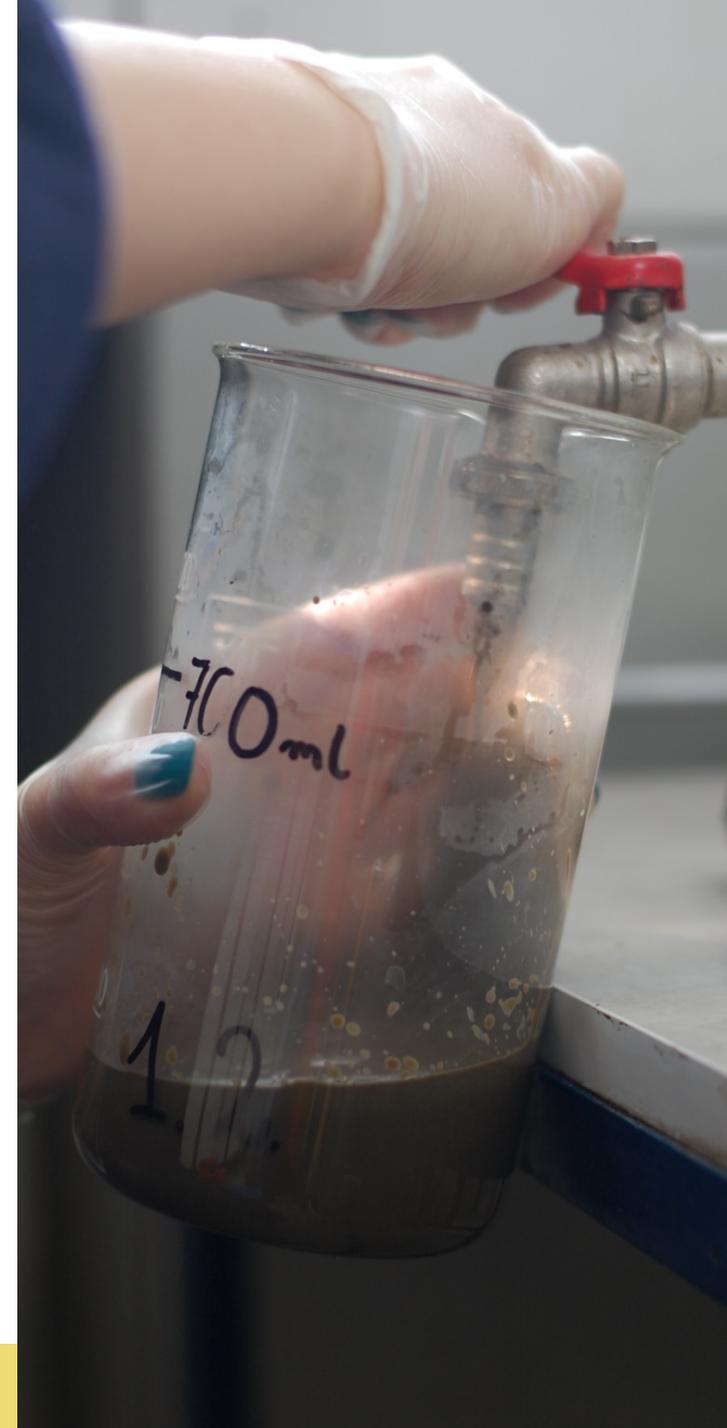
Fig. Threshold value of Specific Energy (SE) exceeding of which caused an increase in the intensity of release of organic compounds in the function of TS concentration of disintegration sludge

CONCLUSIONS

It was documented shown that **the total solids concentration** of disintegrated sludge is **one of the important factors** affecting the efficiency of the organic compounds release in the analyzed device

It was determined that **an increase in TS concentration caused a decrease in the threshold value of Specific Energy above which an increase in the intensity of release of organic compounds was observed**

In this study, the highest quantity of organic substrates was released from sludge with TS \approx 4.5%



THANK YOU
FOR **YOUR**
ATTENTION



Warsaw University of Technology, POLAND