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Effect of hydrodynamic disintegration on the methane potential of the organic fraction of municipal solid waste

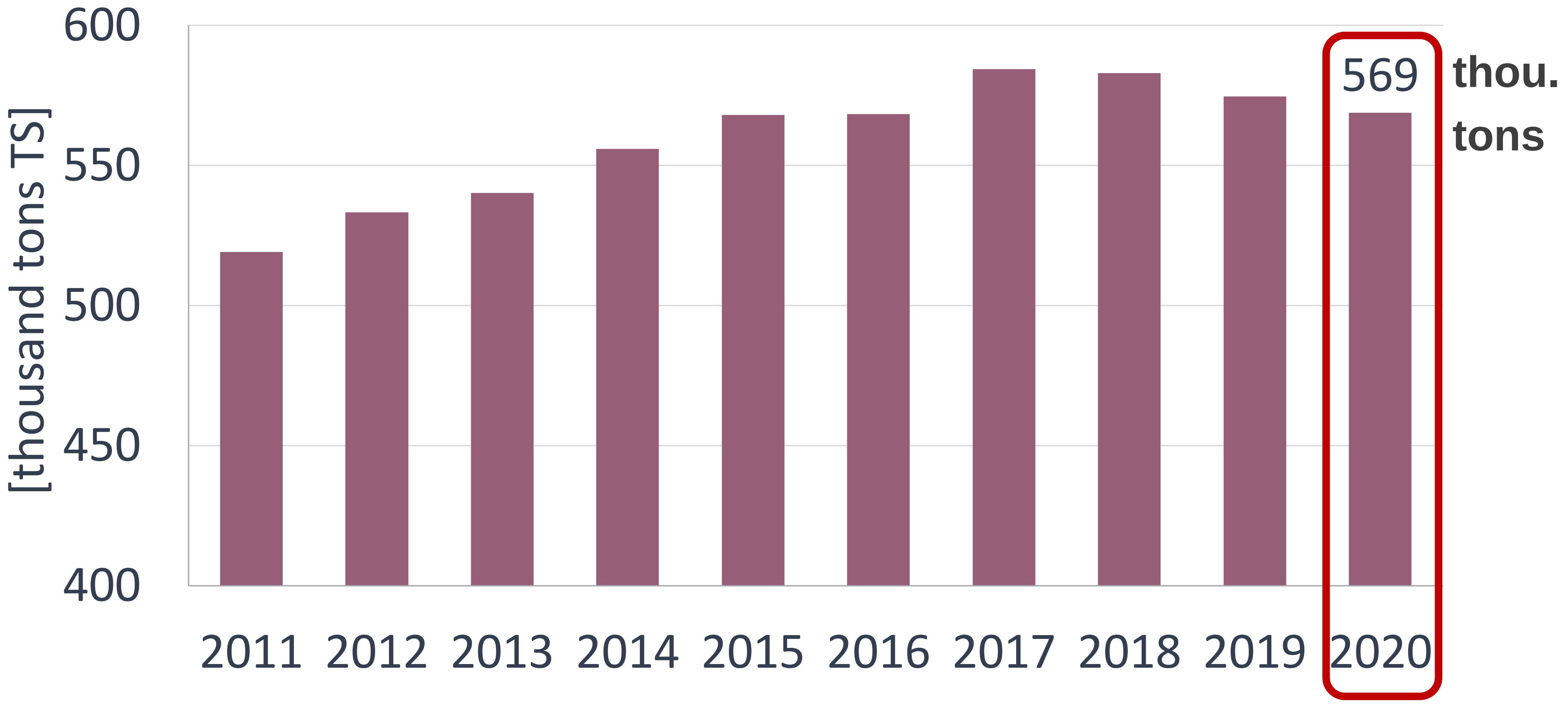
Justyna Walczak, Monika Zubrowska-Sudol

Research was funded by (POB Energy) of Warsaw University of Technology within the Excellence Initiative: Research University (IDUB) programme. Project **"Analysis of the possibility of increasing the renewable energy production in wastewater treatment plants via co-fermentation and substrates disintegration"**

WASTE

Mucicipal Sewage Sludge

Total solids of sewage sludge generated in Polish municipal WWTP*)



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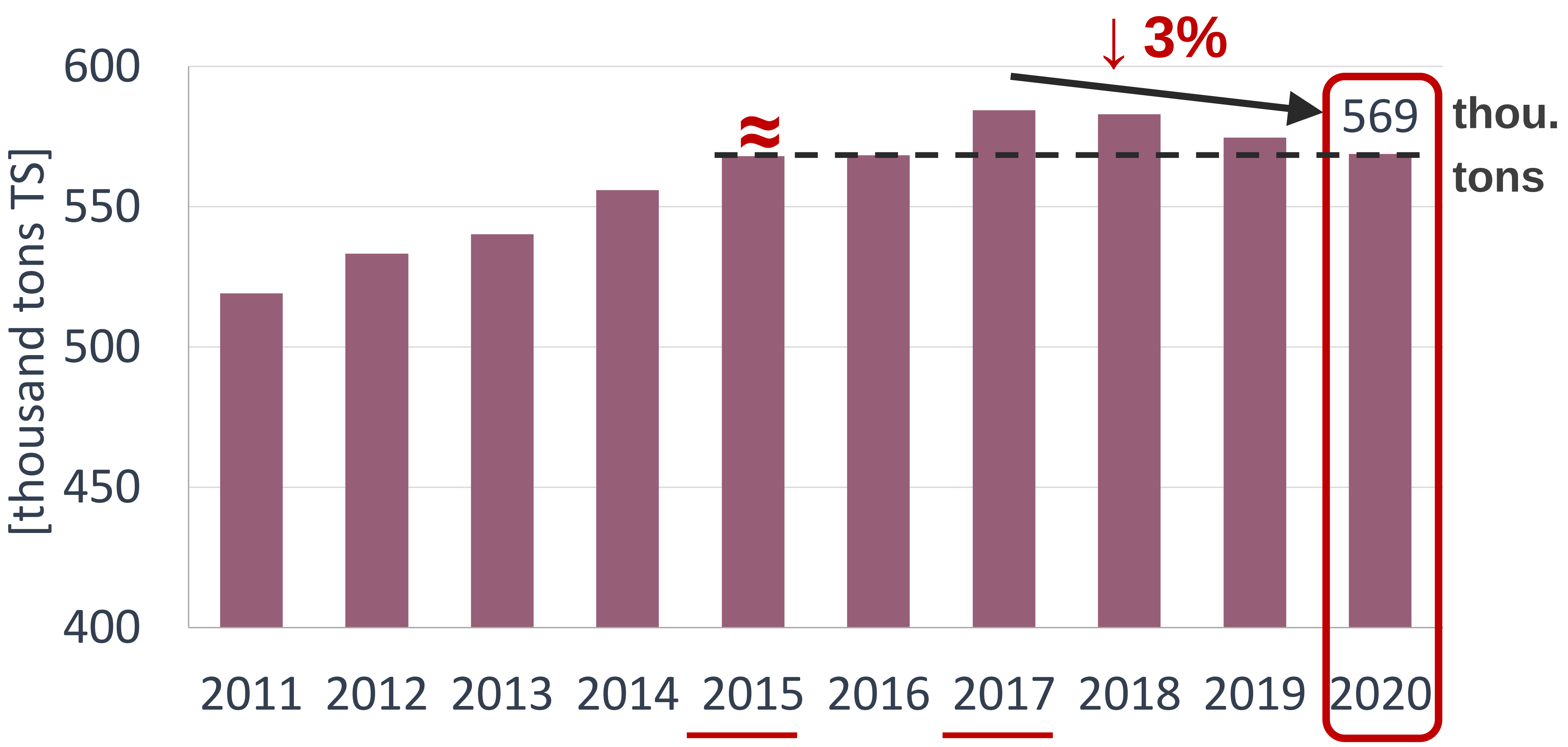

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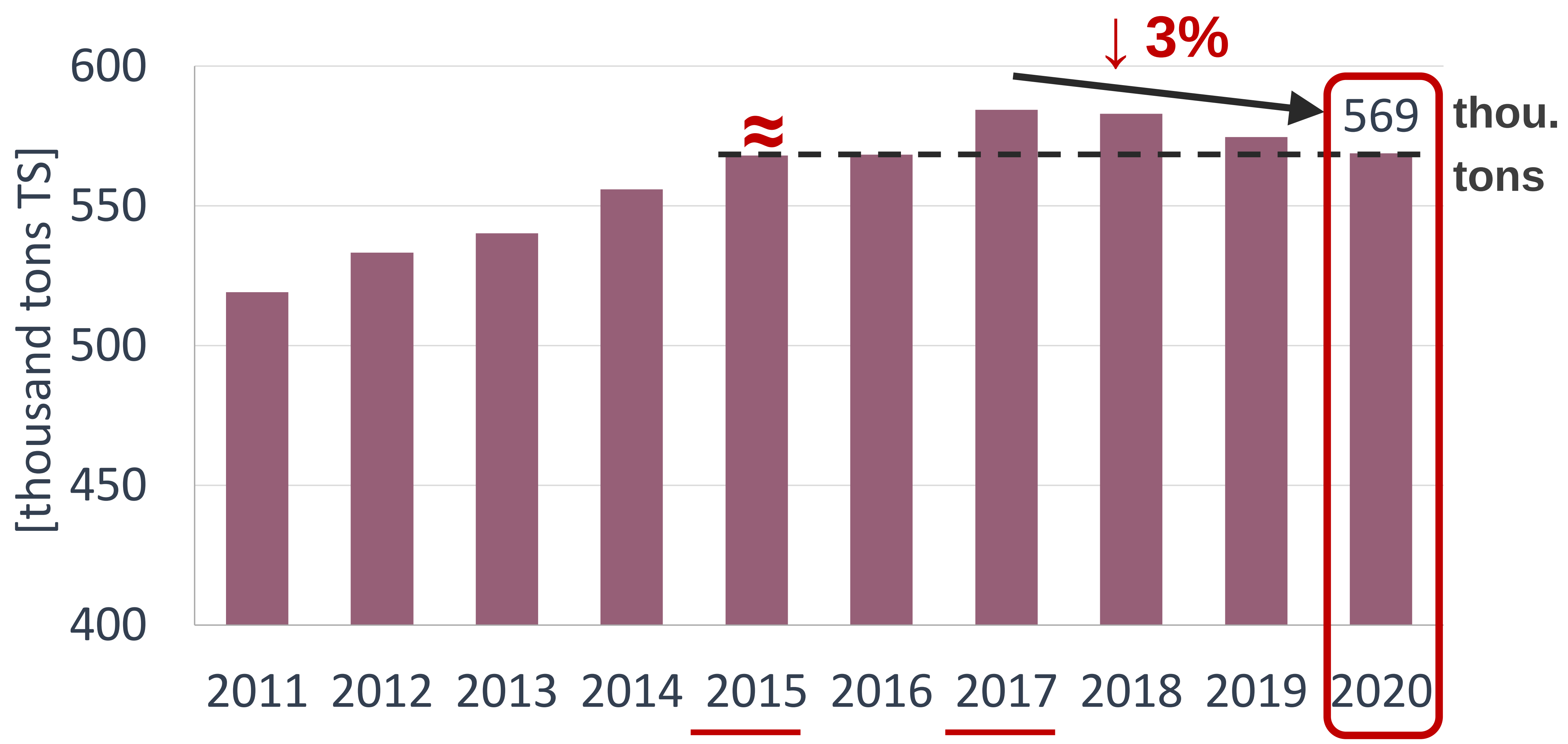

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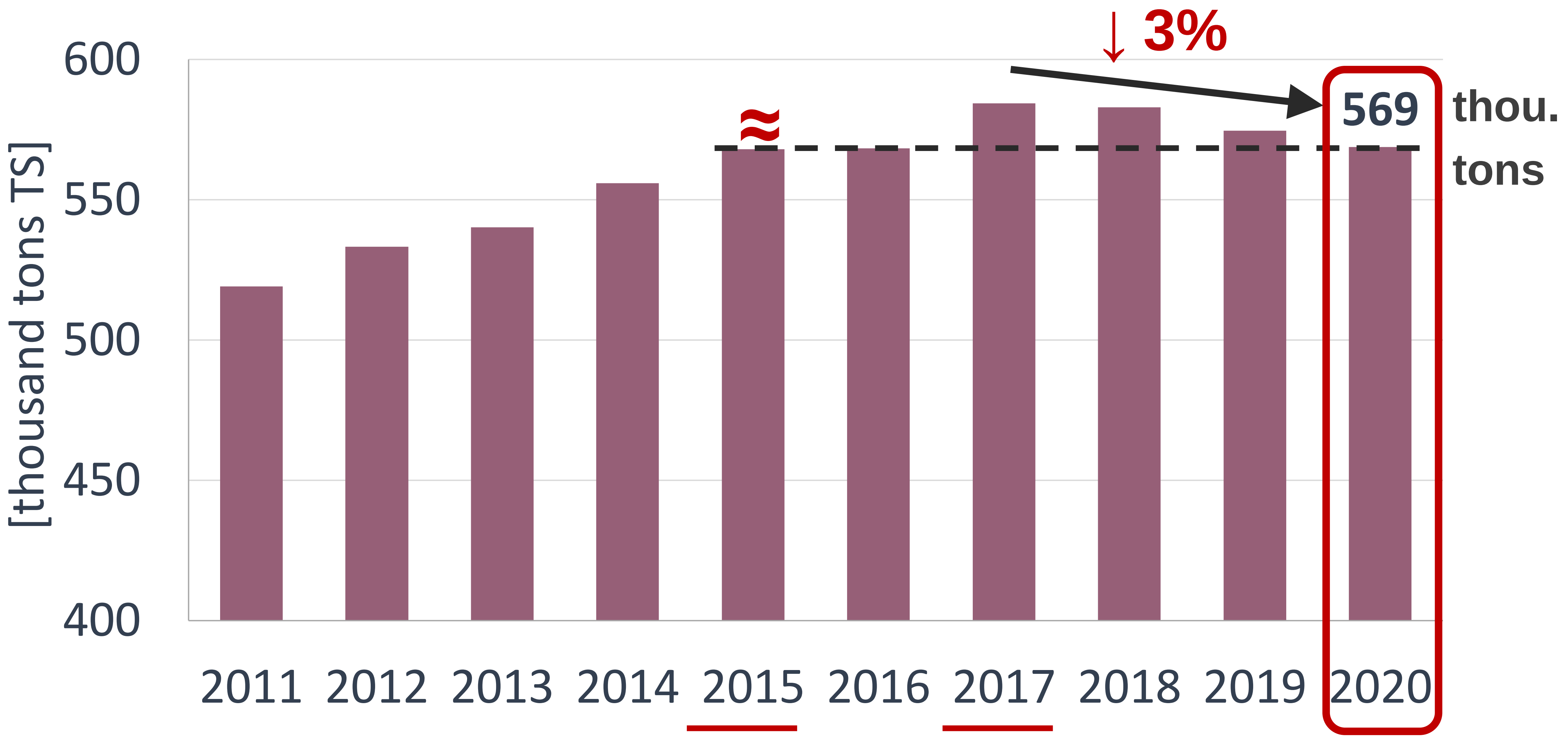
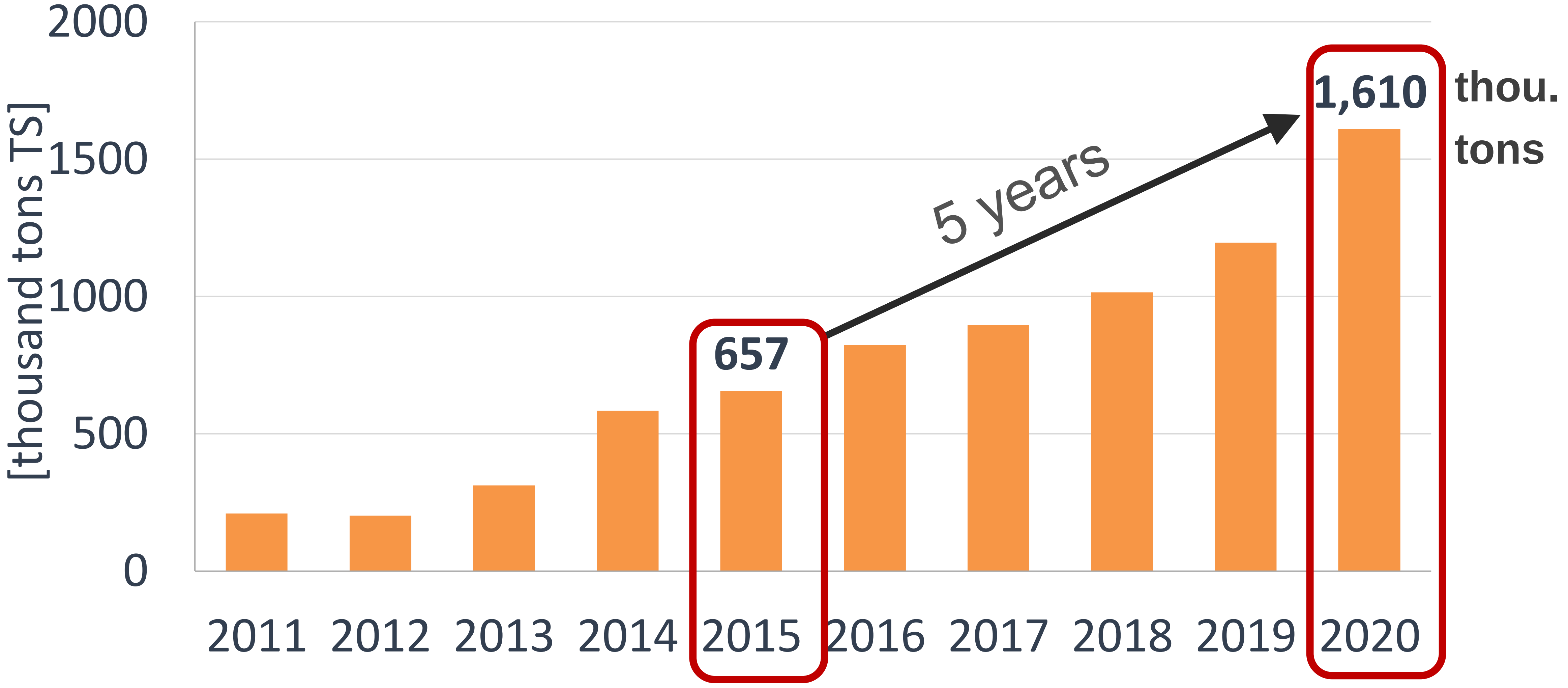


Municipal waste generated in Poland*) According to Polish Central Statistical Office



*) *Statistical information and elaborations, Environment 2021, Central Statistical Office of Poland*

Renewable Energy Sources (RES) i.a. BIOGAS

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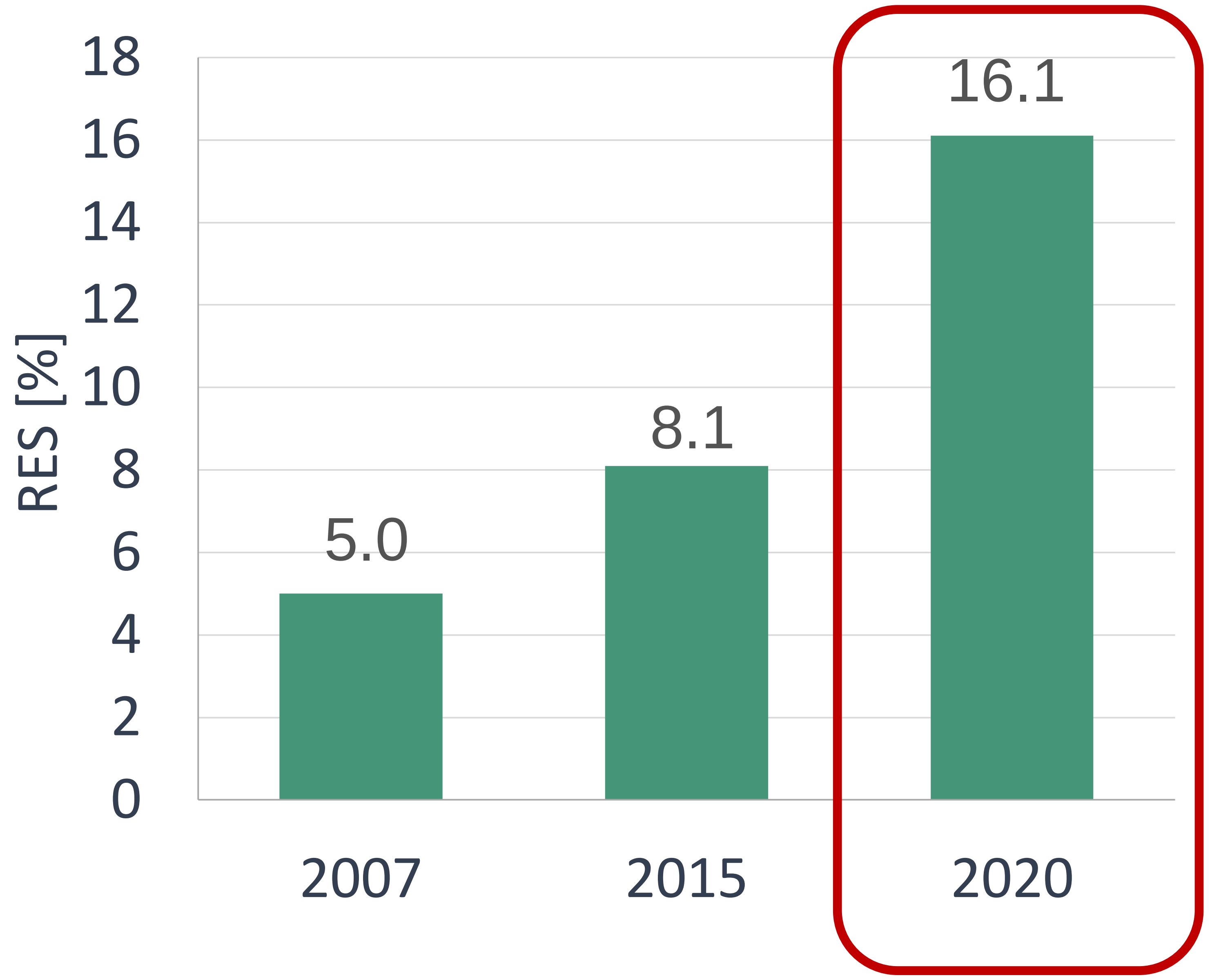
Renewable energy sources in total energy consumption*)



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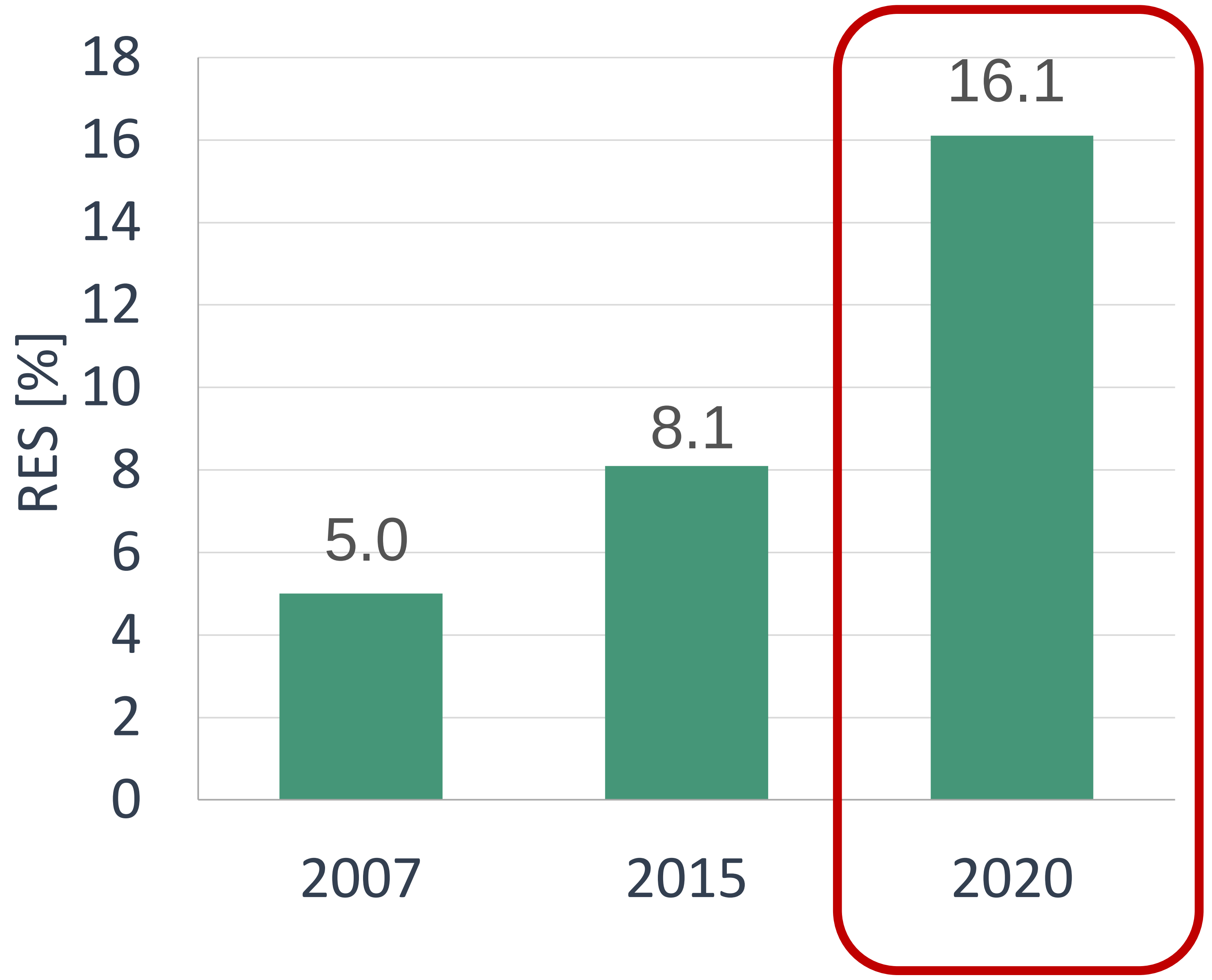
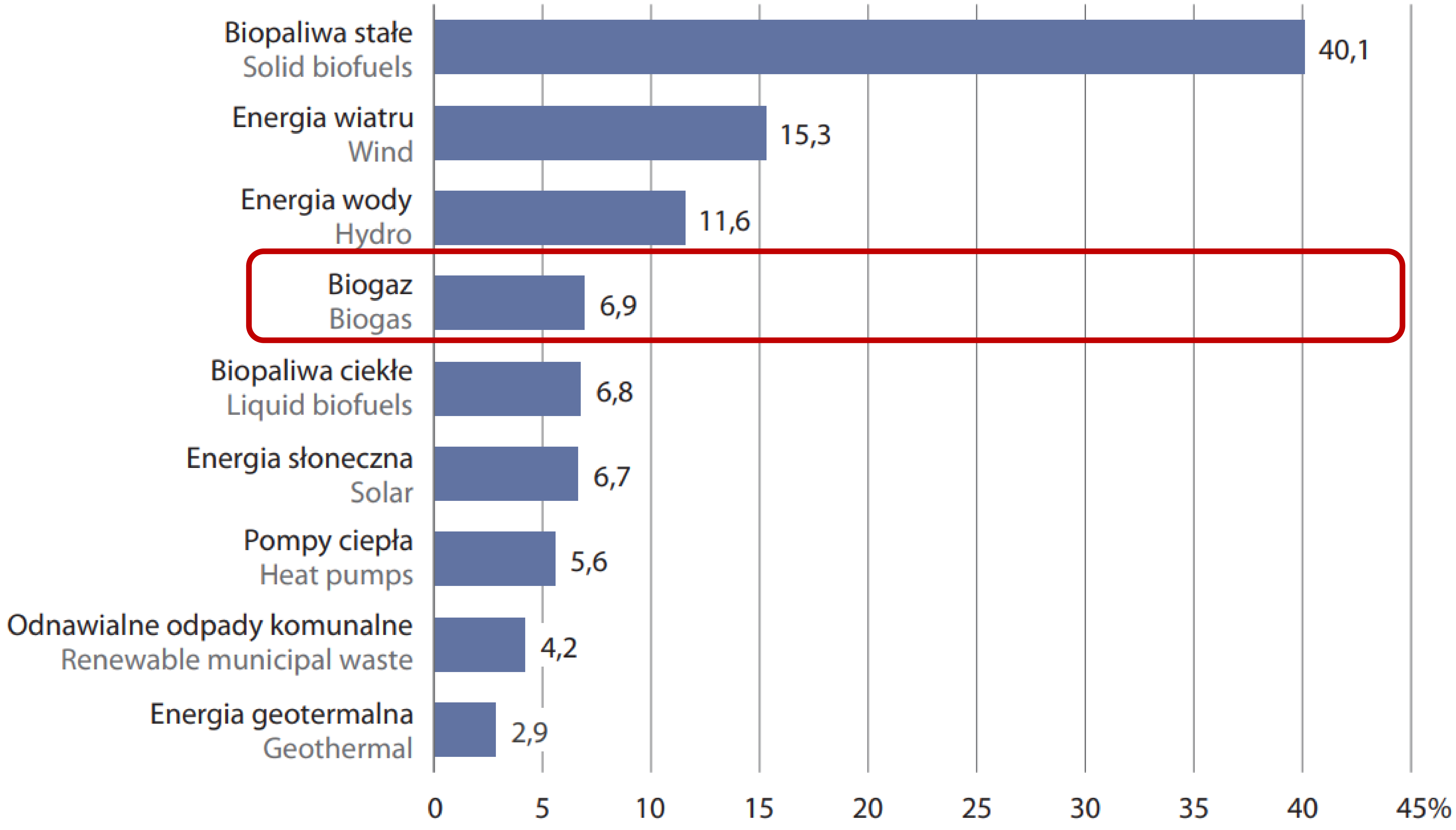


Production of energy from renewable sources by carriers in the EU-28 in 2019



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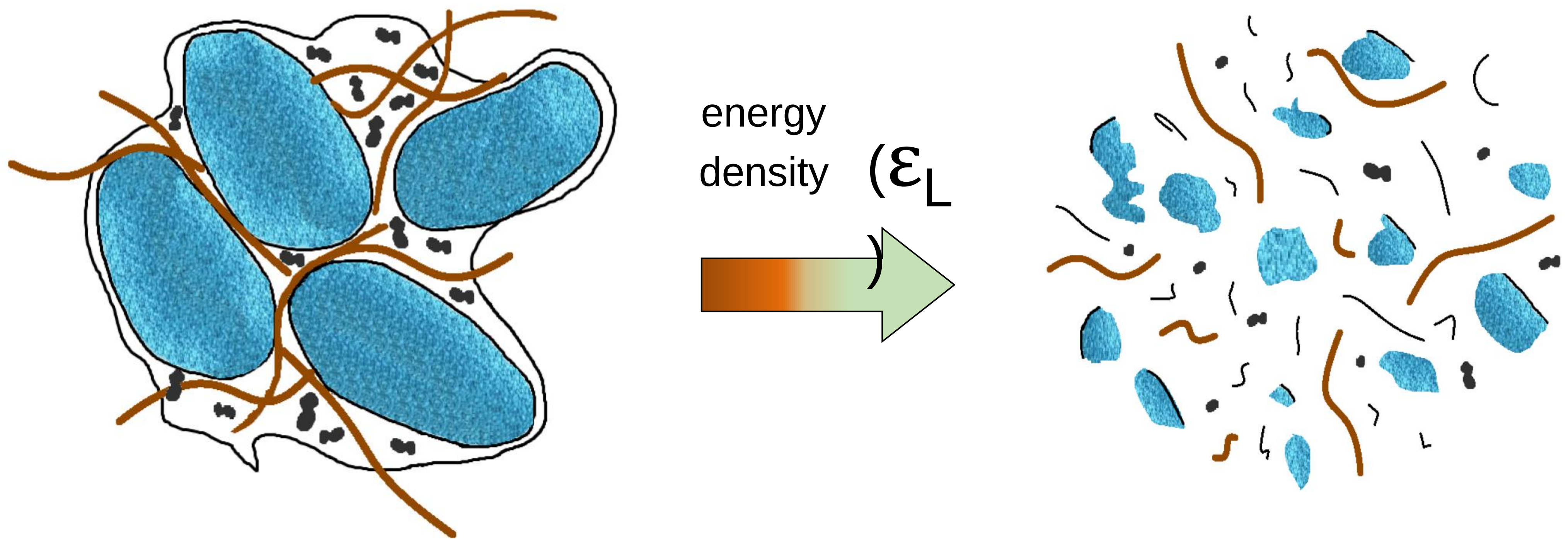
INCREASE OF BIOGAS PRODUCTION

sludge disintegration process

increase the availability of substrate in the sludge for bacteria carrying out acidogenesis and methanogenesis



co-digestion process

excess sludge + co-substrates

characterised by high biochemical methane potential

e.g. waste from the agricultural and food production sector

organic fraction of municipal solid waste (OFMSW)

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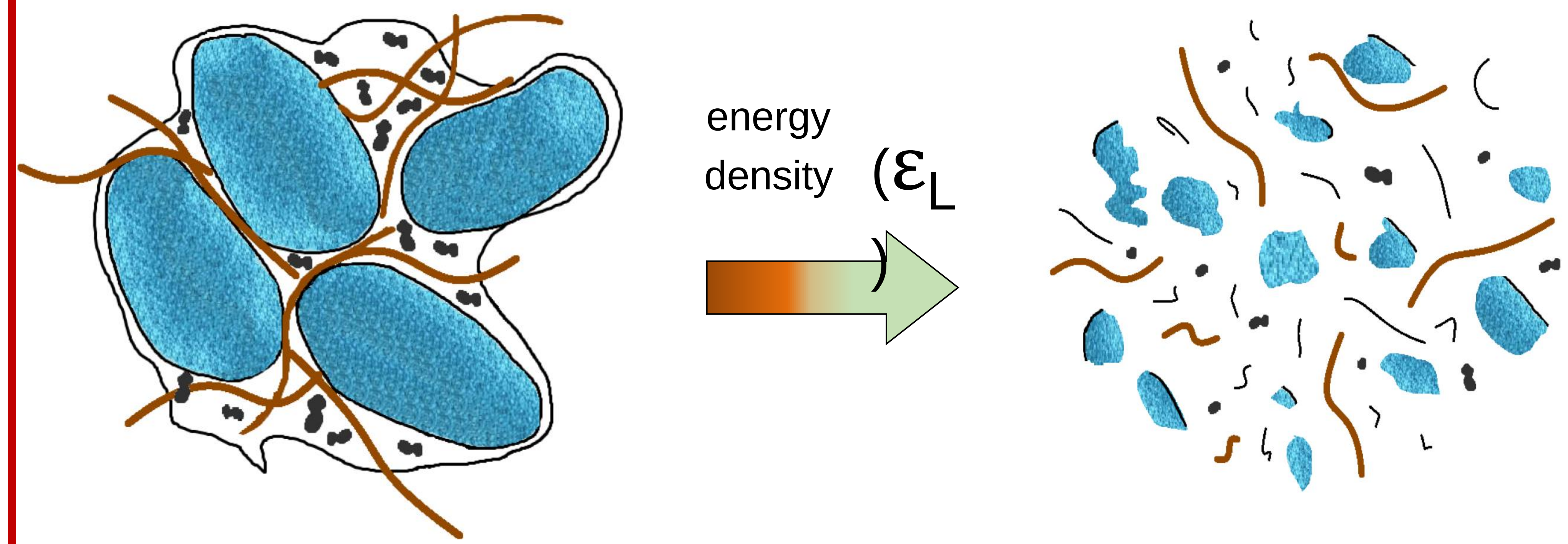

THIS STUDY

co-digestion process

excess sludge + co-substrates

characterised by high biochemical methane potential

e.g. waste from the agricultural and food production sector

organic fraction of municipal solid waste (OFMSW)

AIM

The main objective of the study was the determination of the effect of **hydrodynamic disintegration process (HD)** on the methane potential of organic fraction of municipal solid waste (OFMSW) and its comparison to the methane potential of sewage sludge (SS), with consideration of the variant with and without hydrodynamic disintegration.

AIM

The main objective of the study was the determination of the effect of **hydrodynamic disintegration process (HD)** on the methane potential of organic fraction of municipal solid waste (OFMSW) and its comparison to the methane potential of sewage sludge (SS), with consideration of the variant with and without hydrodynamic disintegration.

Partial objectives also included the analysis of the effect of the disintegration process on:

- ✓ chemical characteristics of the digestate sludge liquid, with particular consideration of nitrogen and phosphorus compounds;
- ✓ capillary suction time (CST).

METHODS substrates, preparation, origin

organic fraction of municipal solid waste (OFMSW)

selectively collected in the city of Warsaw , Poland

+ stood tap water

TS = 5.38 %

VTS = 4.93 %

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+ stood tap water

TS = 5.38 %

VTS = 4.93 %

sewage sludge (SS)

was obtained from a wastewater treatment plant with biological nutrient removal (PE = 2 100 000). Warsaw, Poland

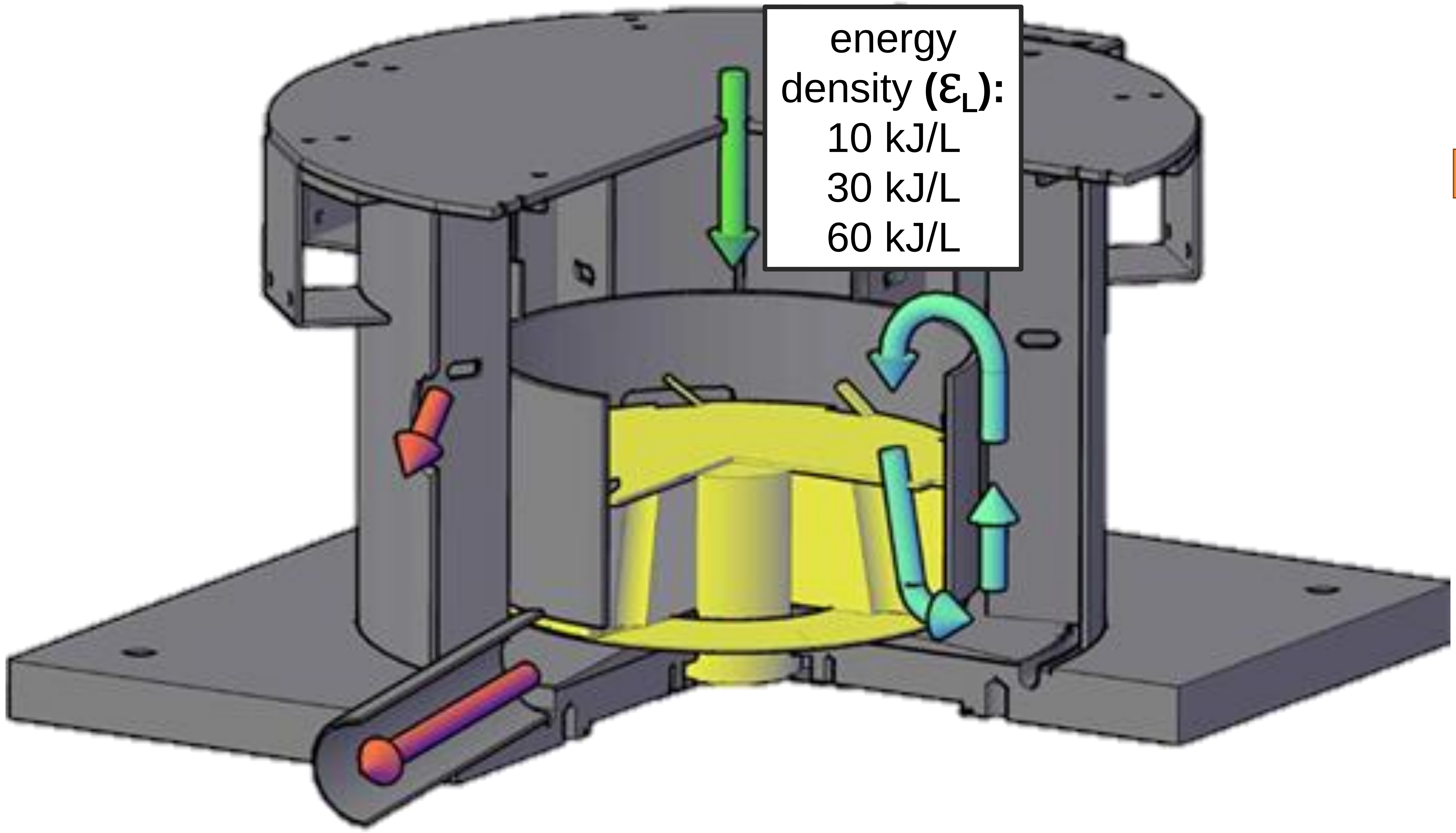
TS= 4.89 %

VTS = 3.64 %

METHODS disintegration apparatus

OFMW before disintegration

SS before disintegration



OFMW after disintegration

SS after disintegration

Hydrodynamic cavitation was conducted in a lab device: hydrodynamic disintegrator *(patent application WP-84/JW I3766I18)*

- Motor power: 5.5 kW
- Rotor revolution: 3000/min
- Volume of tank: 13 L

Legend

Structural elements:
- Rotor (yellow)
- Frame – support plate , chamber, cover (grey)

Medium motion:
- Outlet – cleaning hole, bleeder hole (red)
- Inlet (by cover) (green)
- Circulation (turquoise)

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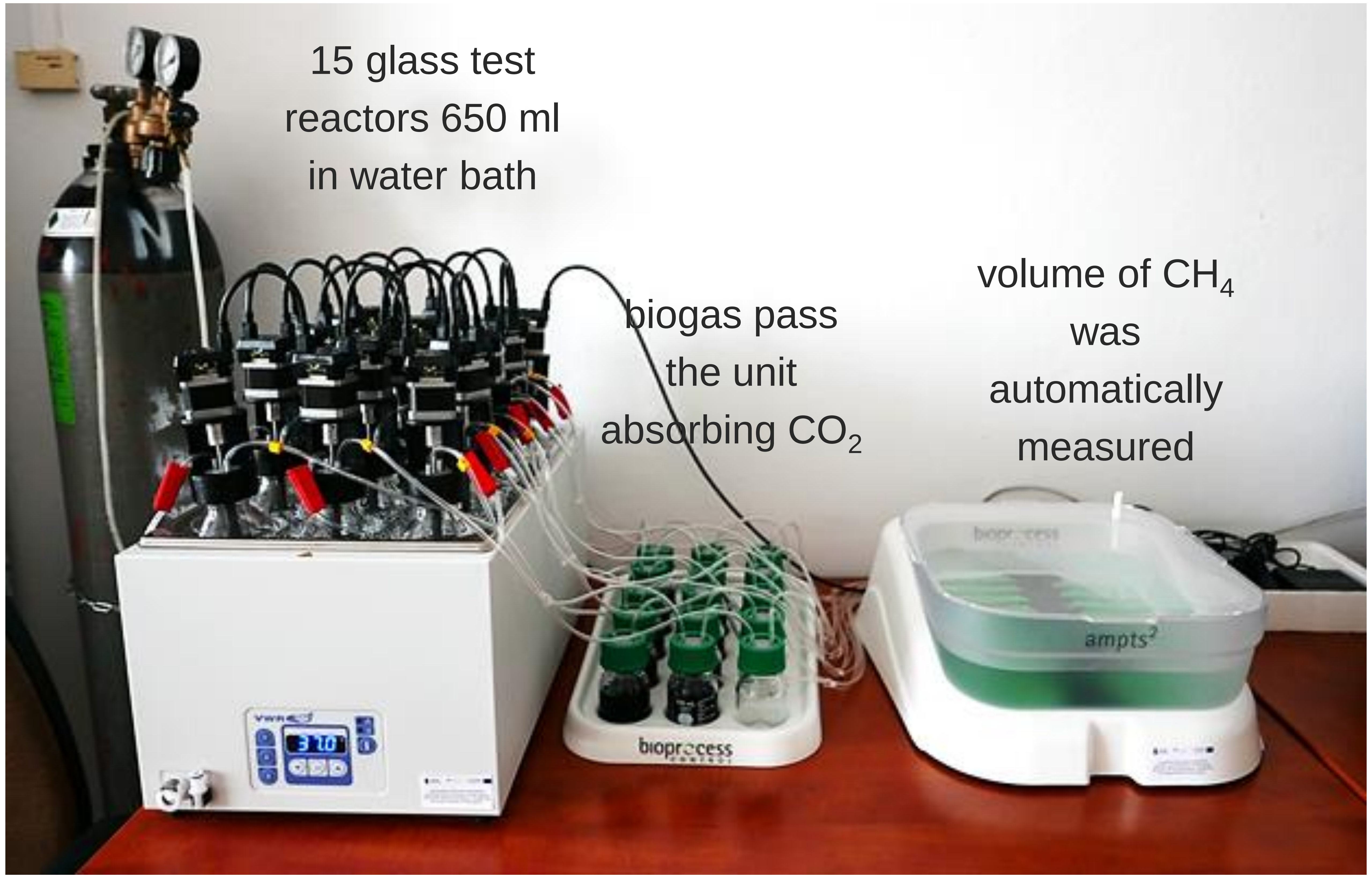
METHODS biochemical methane potential tests (BMP)*)



Automatic Methane Potential Test System
(*AMPTS II; Bioprocess Control Sweden*)

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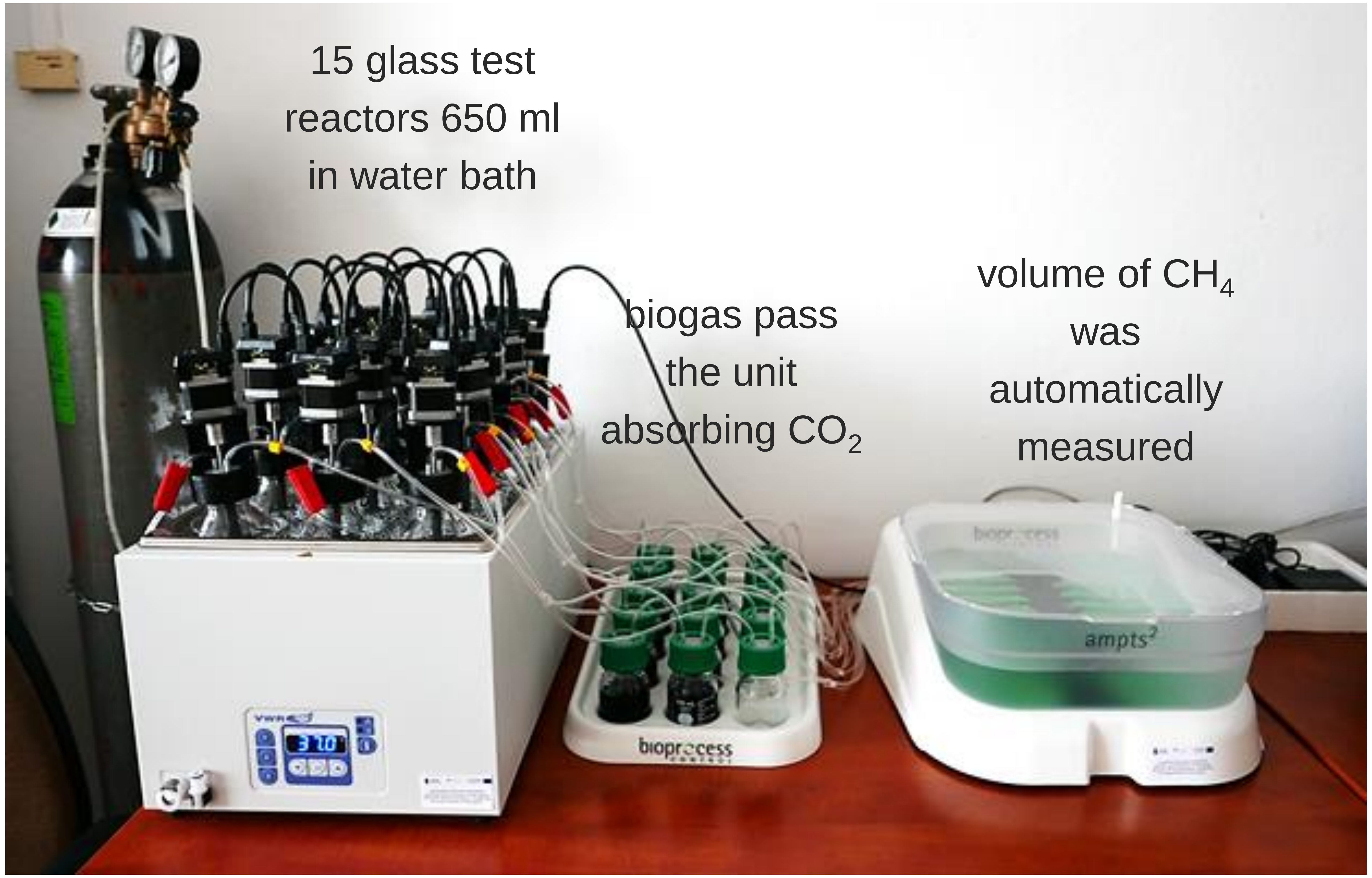

Automatic Methane Potential Test System
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- each assay was performed in **three** repetitions
- constant temperature of 3**7°C**
- amount of inoculum: **200 g**
- initial organic loading rate:
  5.0 gVTS$_{\text{of introduced substrate}}$/L **)

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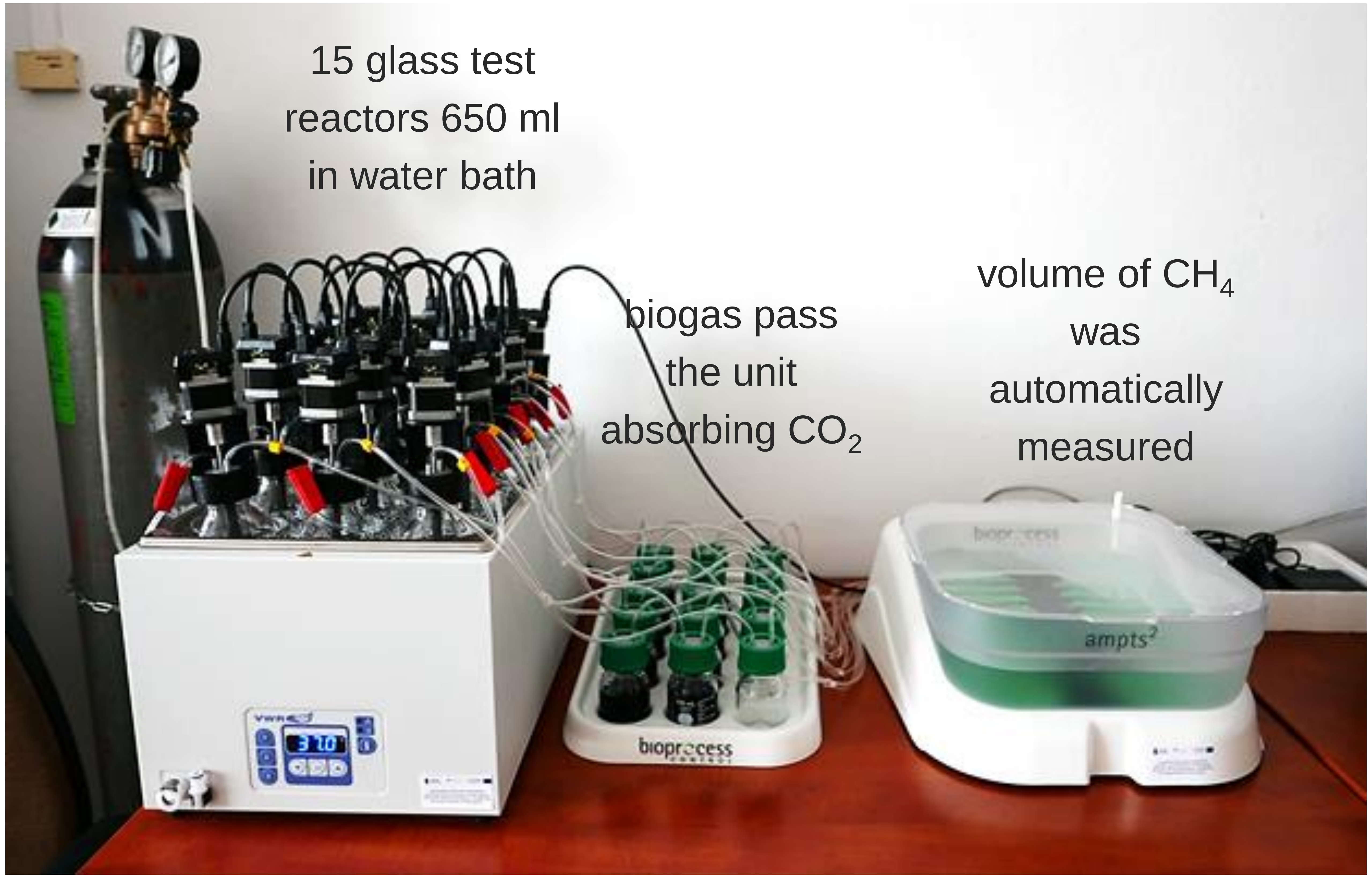

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↓

Specific Methane Production (SMP)

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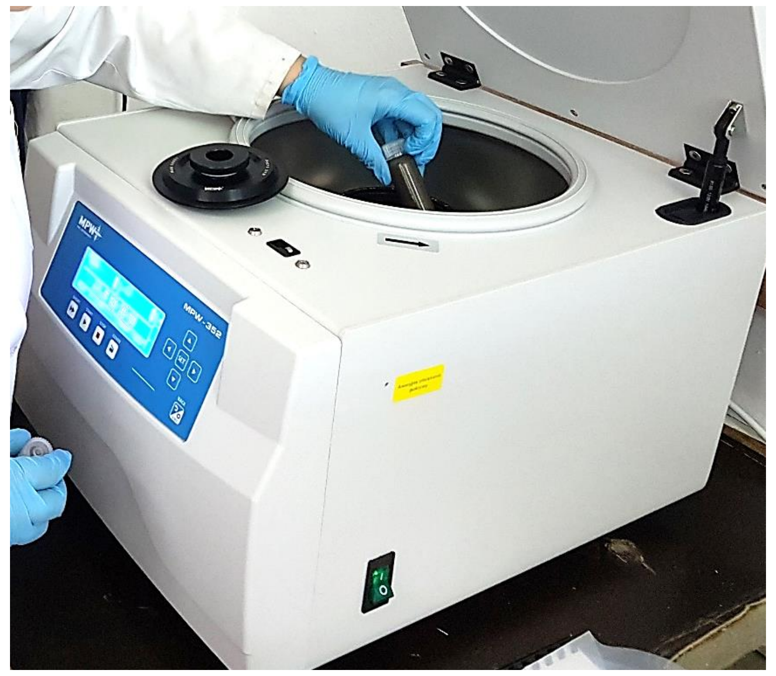
METHODS characteristics of the digestate liquid and capillary suction time (CST)

Digestate sludge liquid after BMP process

TN, NH_4-N, PO_4-P, TP in the filtrate
after anaerobic digestion



1) centrifuged for 30 min

2) filtered with 0.45 µm filters

3) analyzed according to standard analytical procedures (APHA)

Capillary suction time (CST)

The CST is defined as the time filtrate passing between circles of two different diameters (3.2 and 4.5 cm). The test allows for an assessment of the digestate dewatering.

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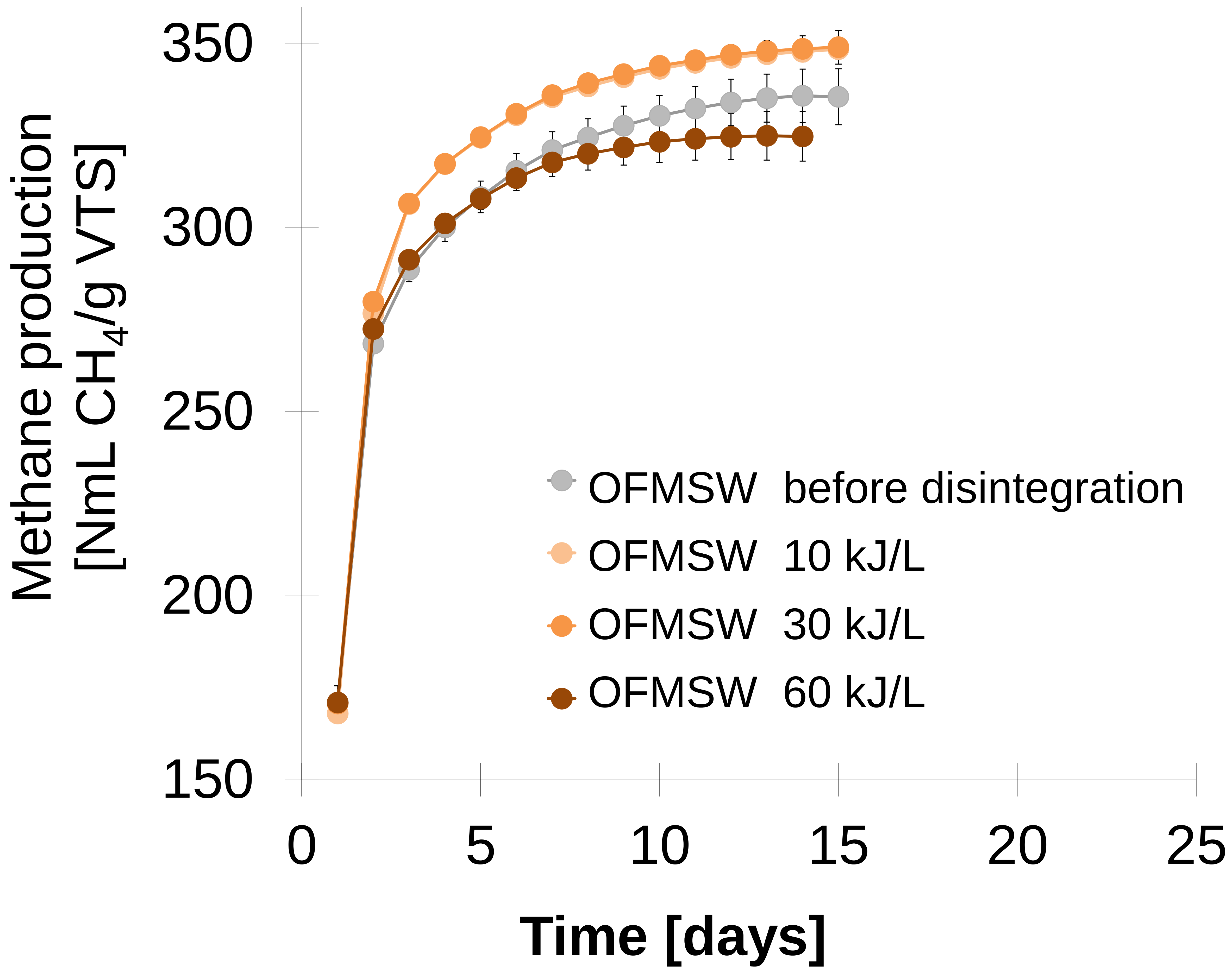
RESULTS

RESULTS determination of the specific methane production of **ORGANIC FRACTION OF MUNICIPAL SOLID WASTE (OFMSW)** with and without hydrodynamic disintegration



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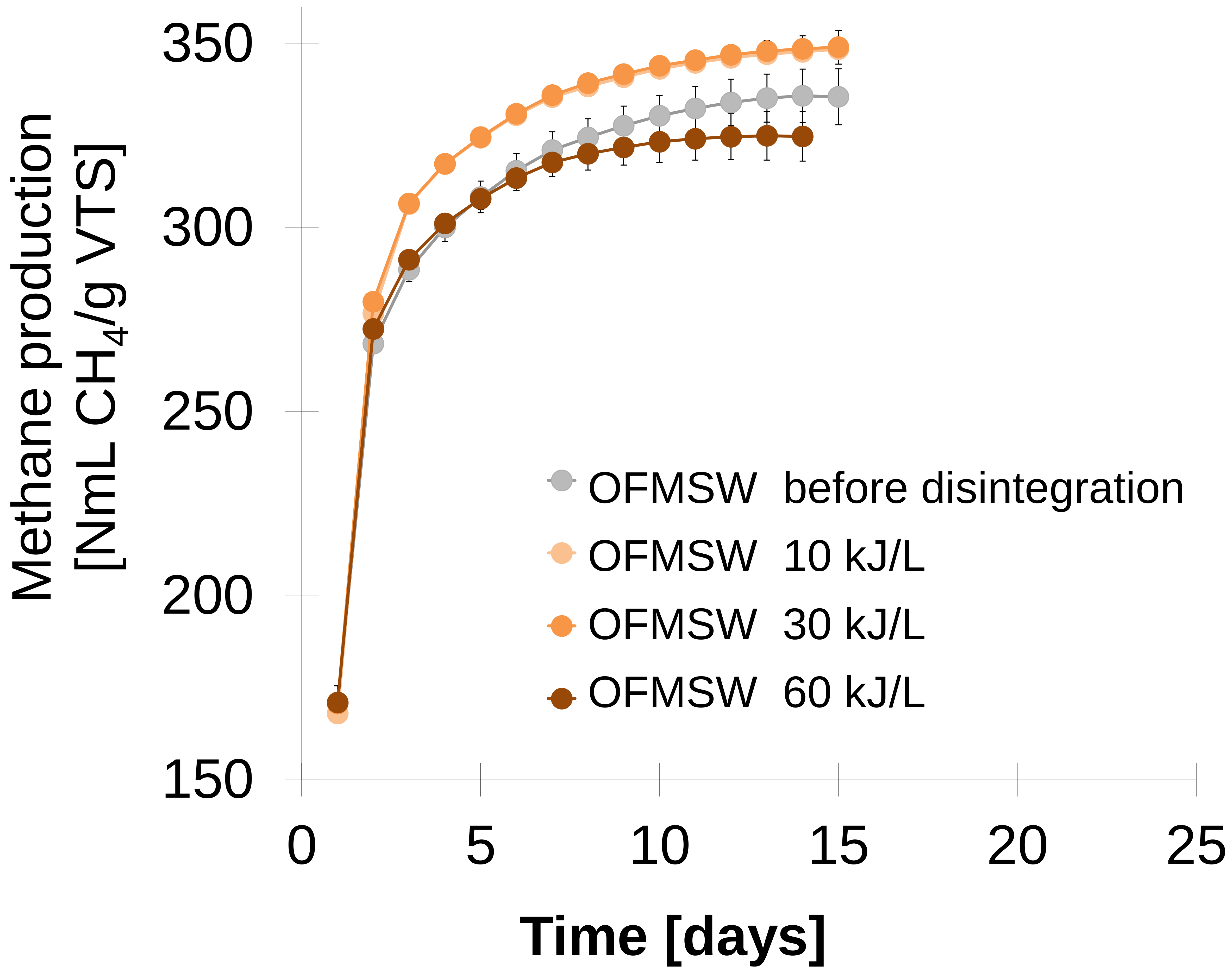

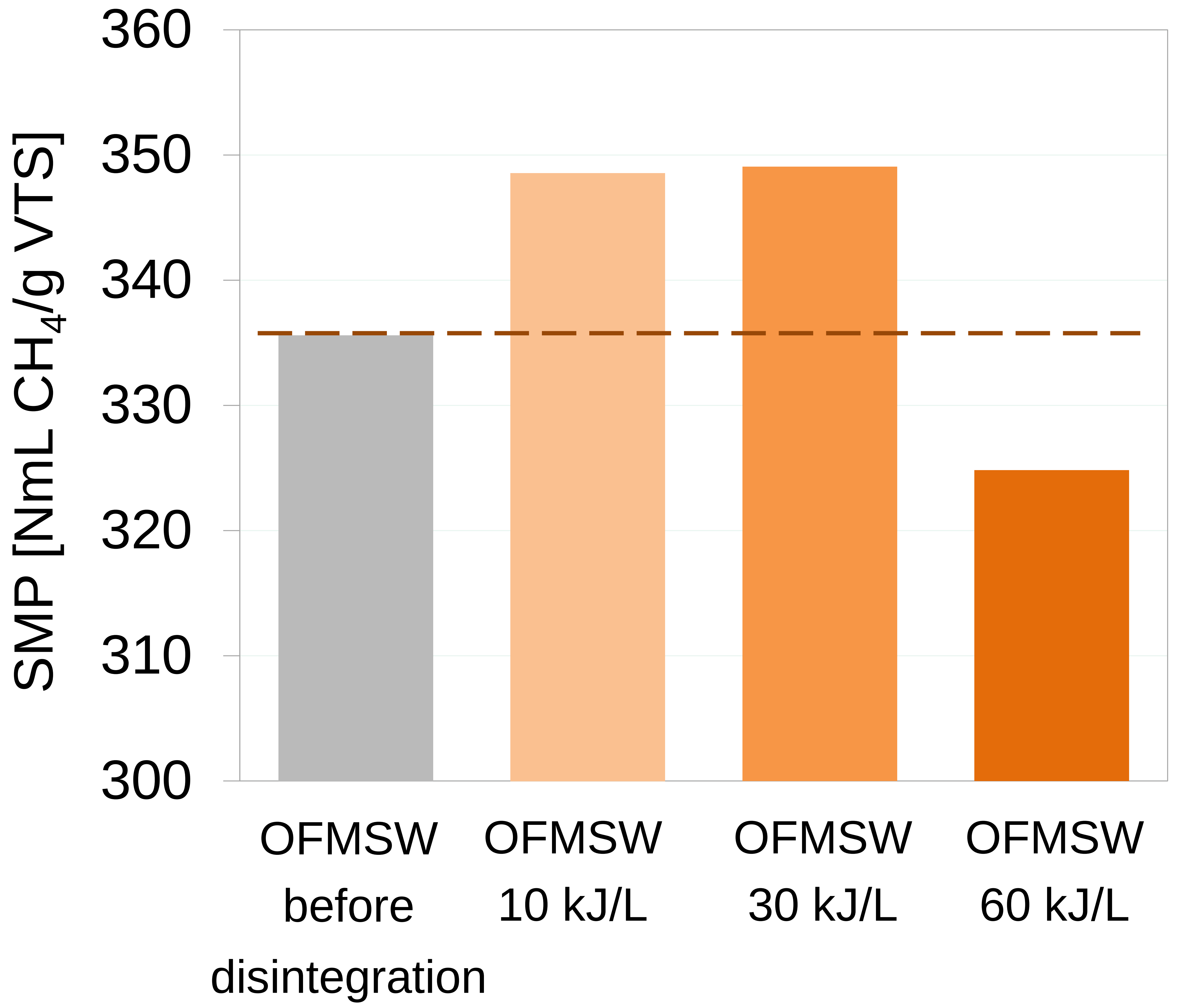

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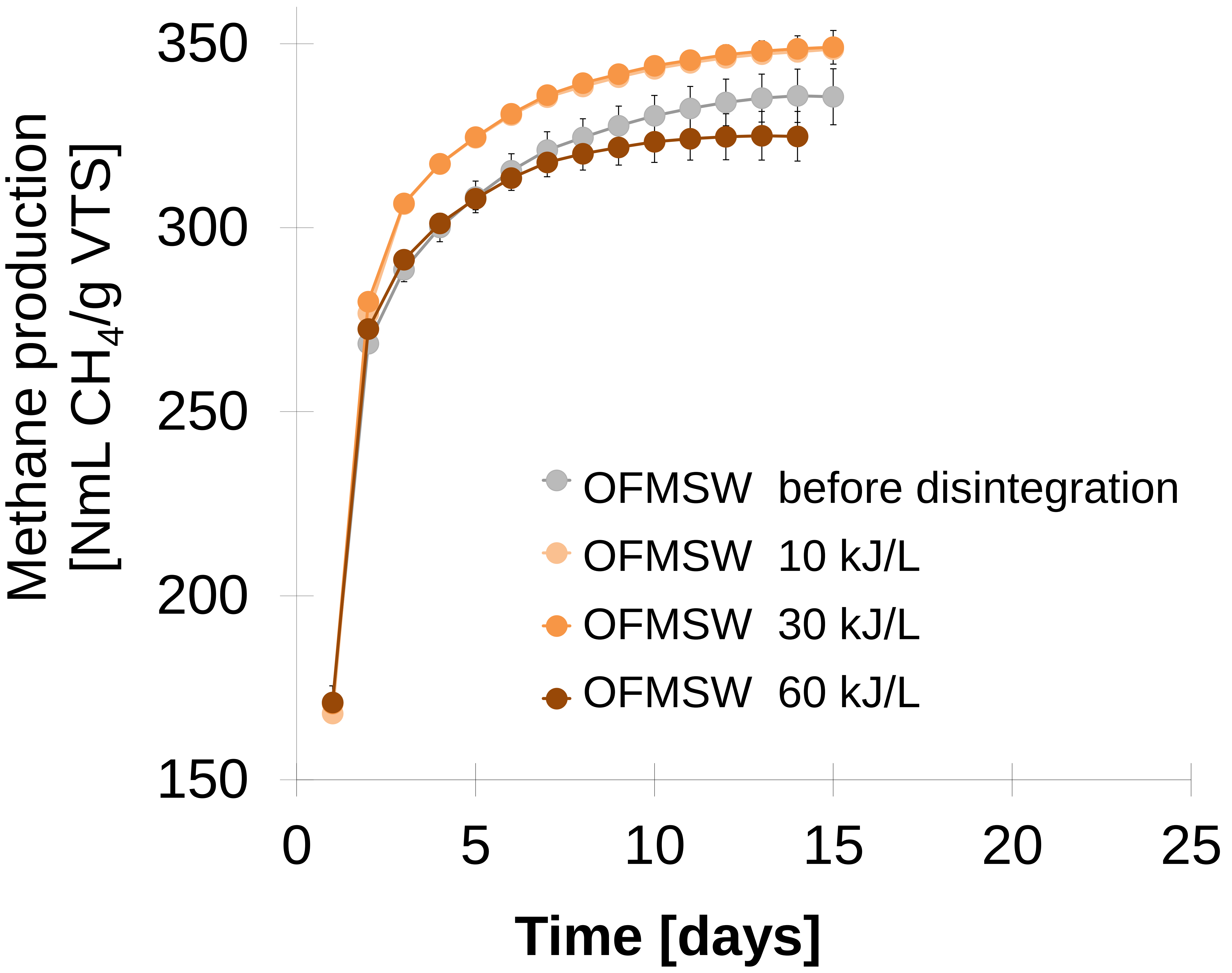

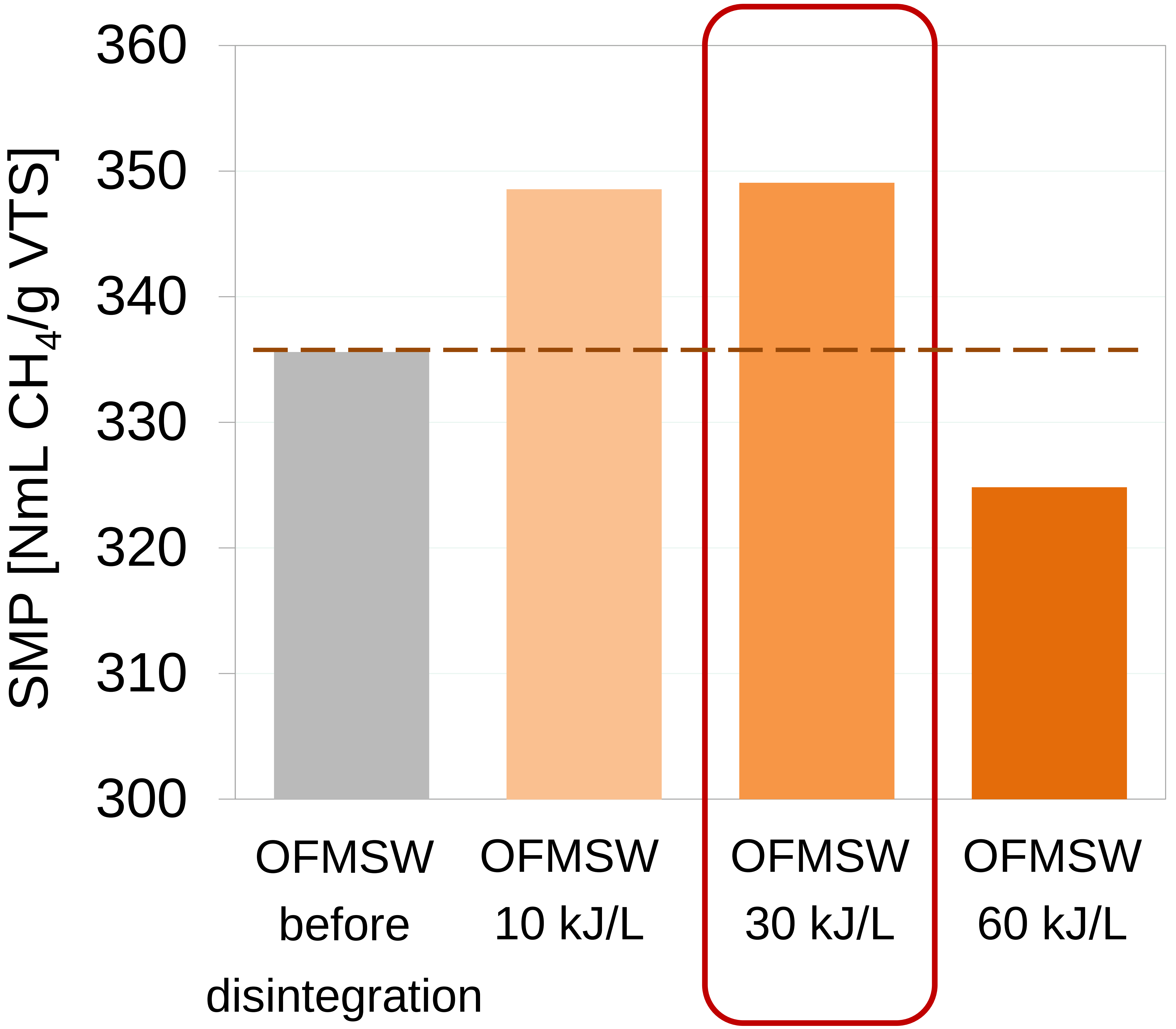

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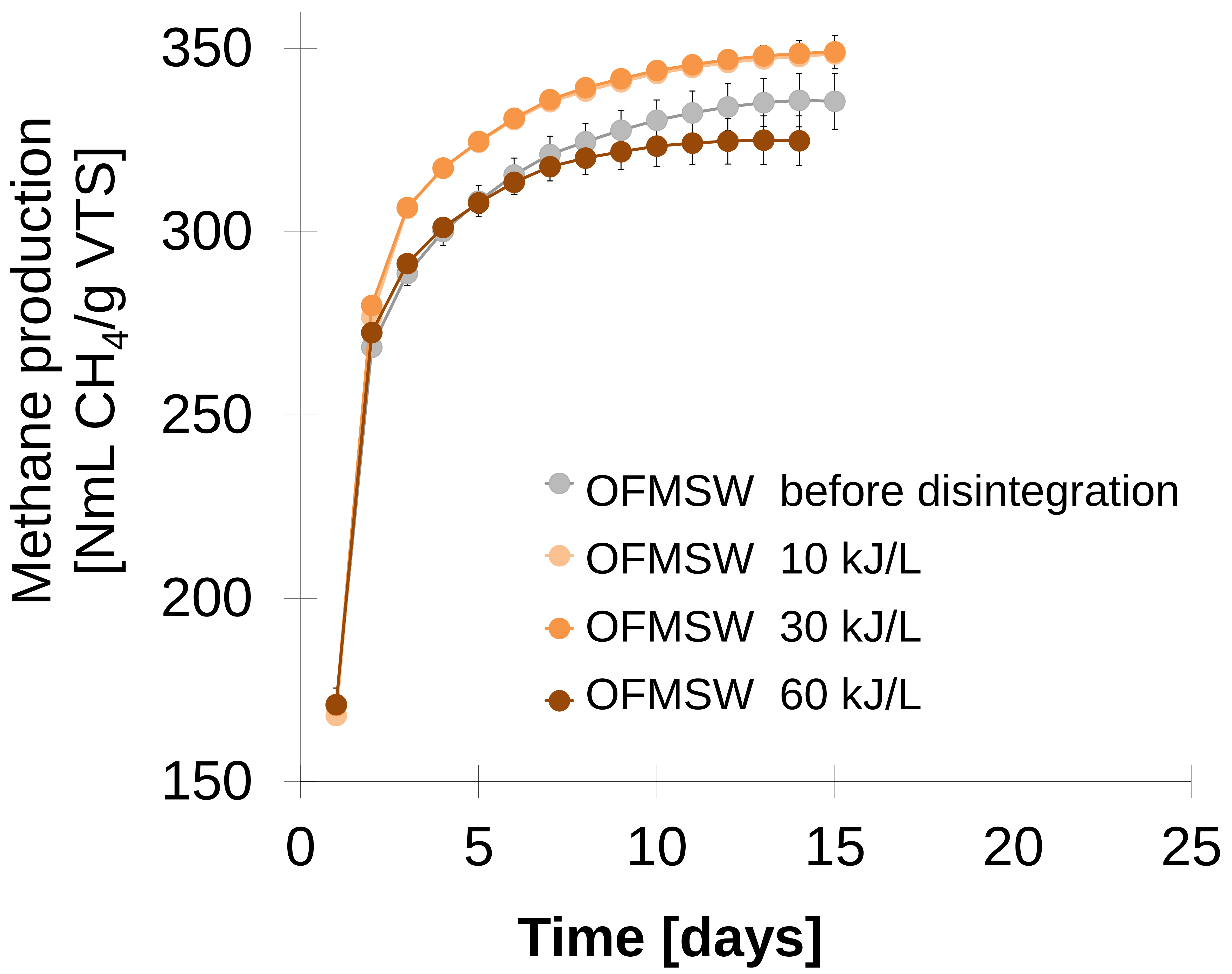

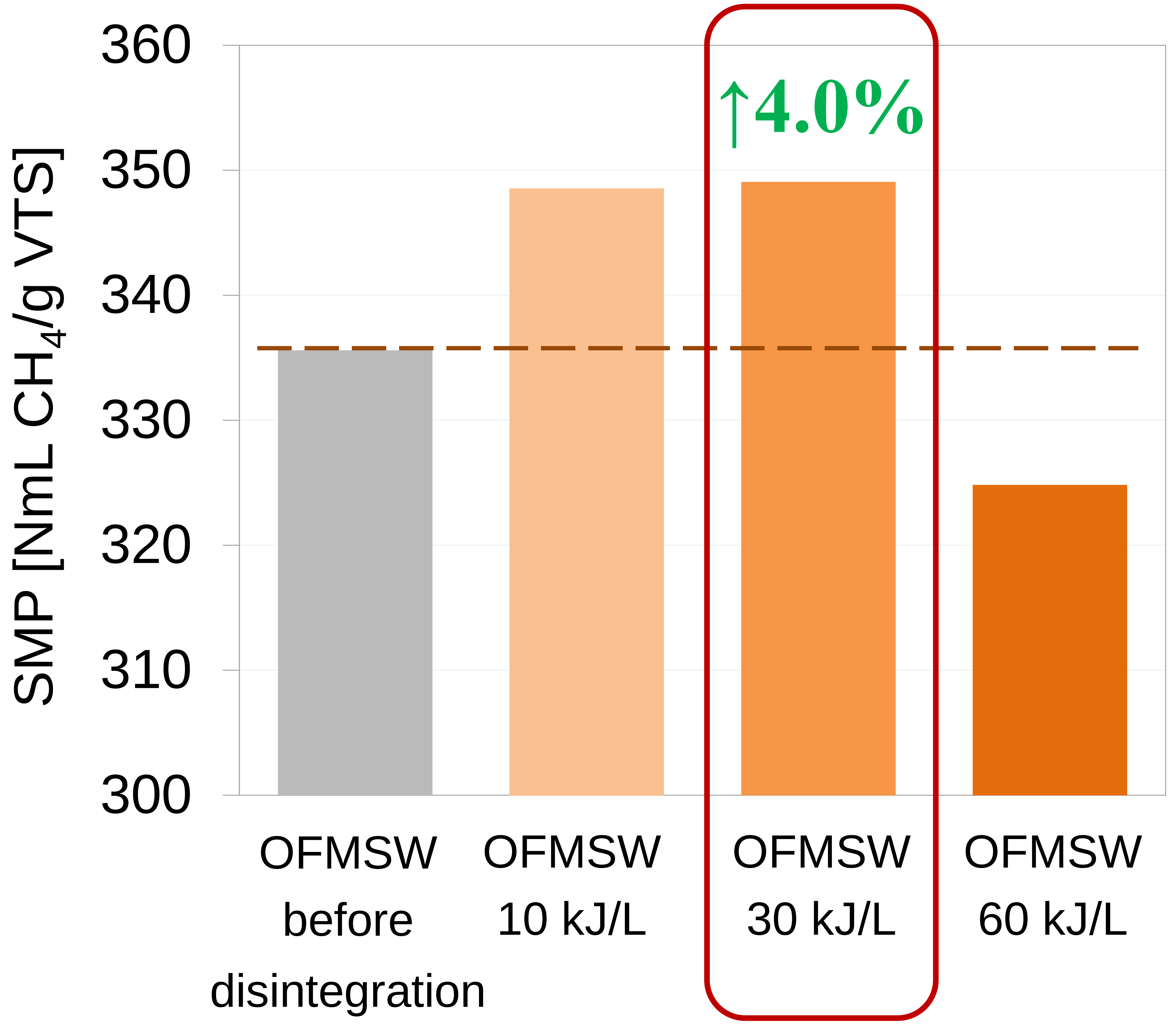

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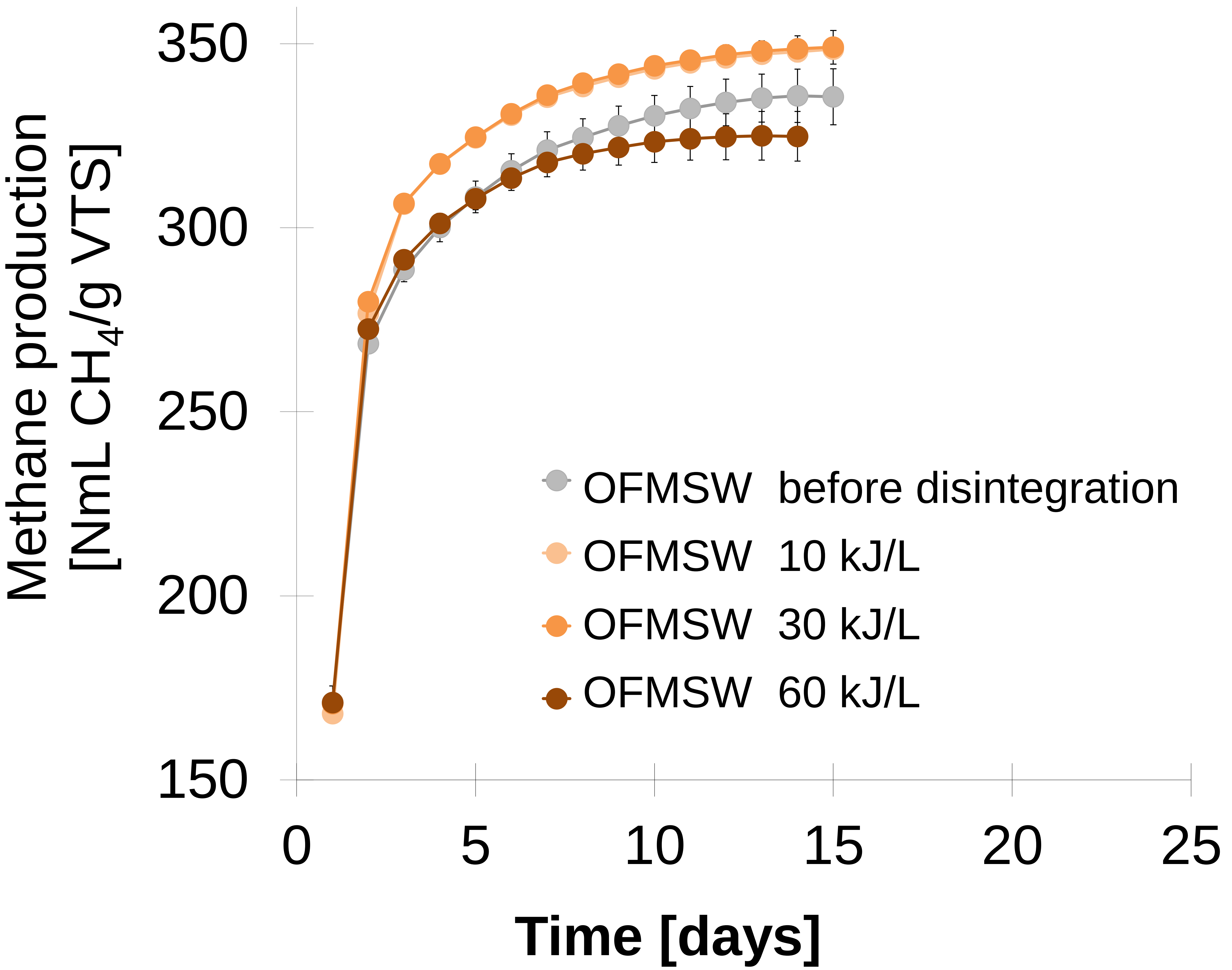

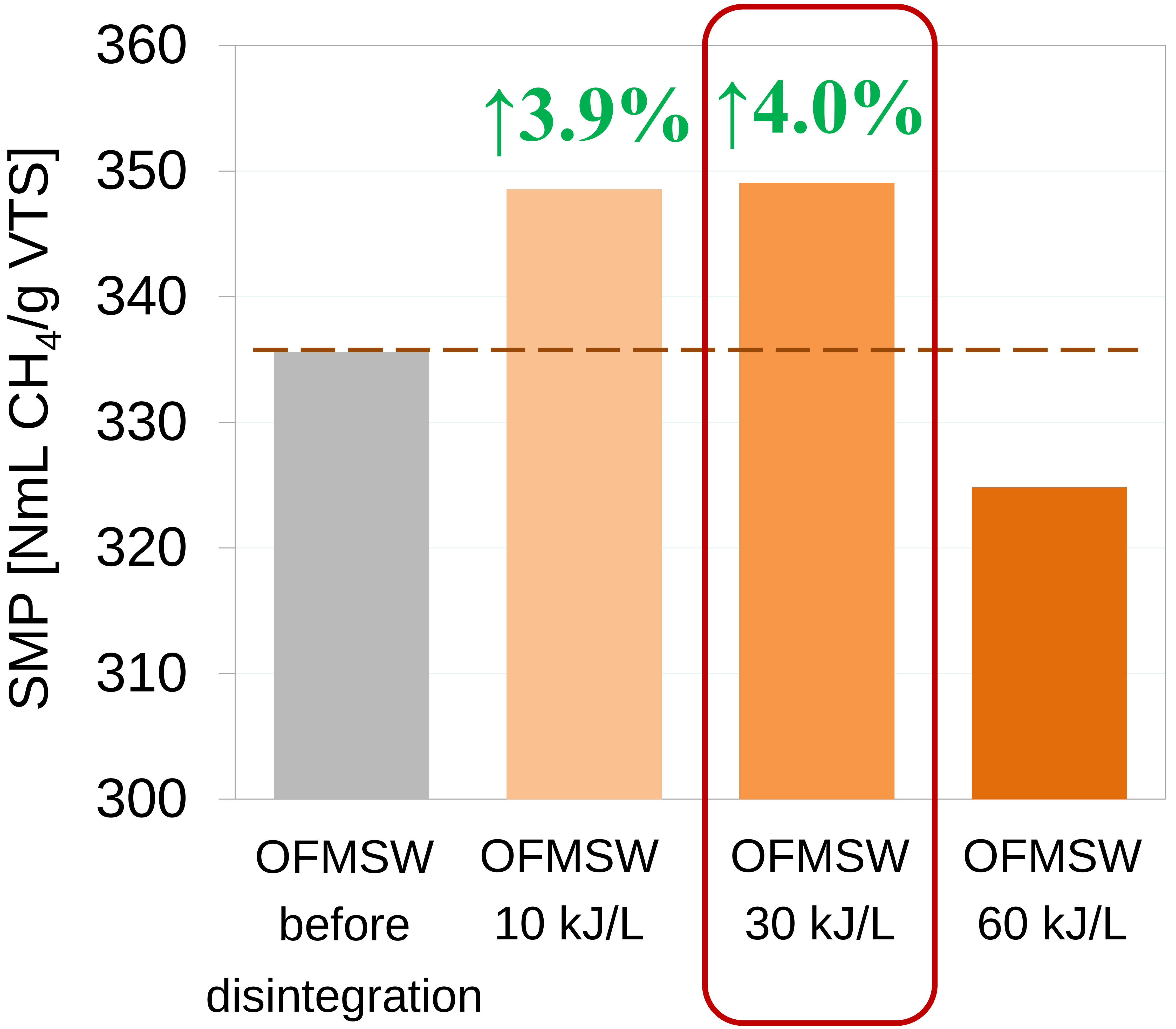

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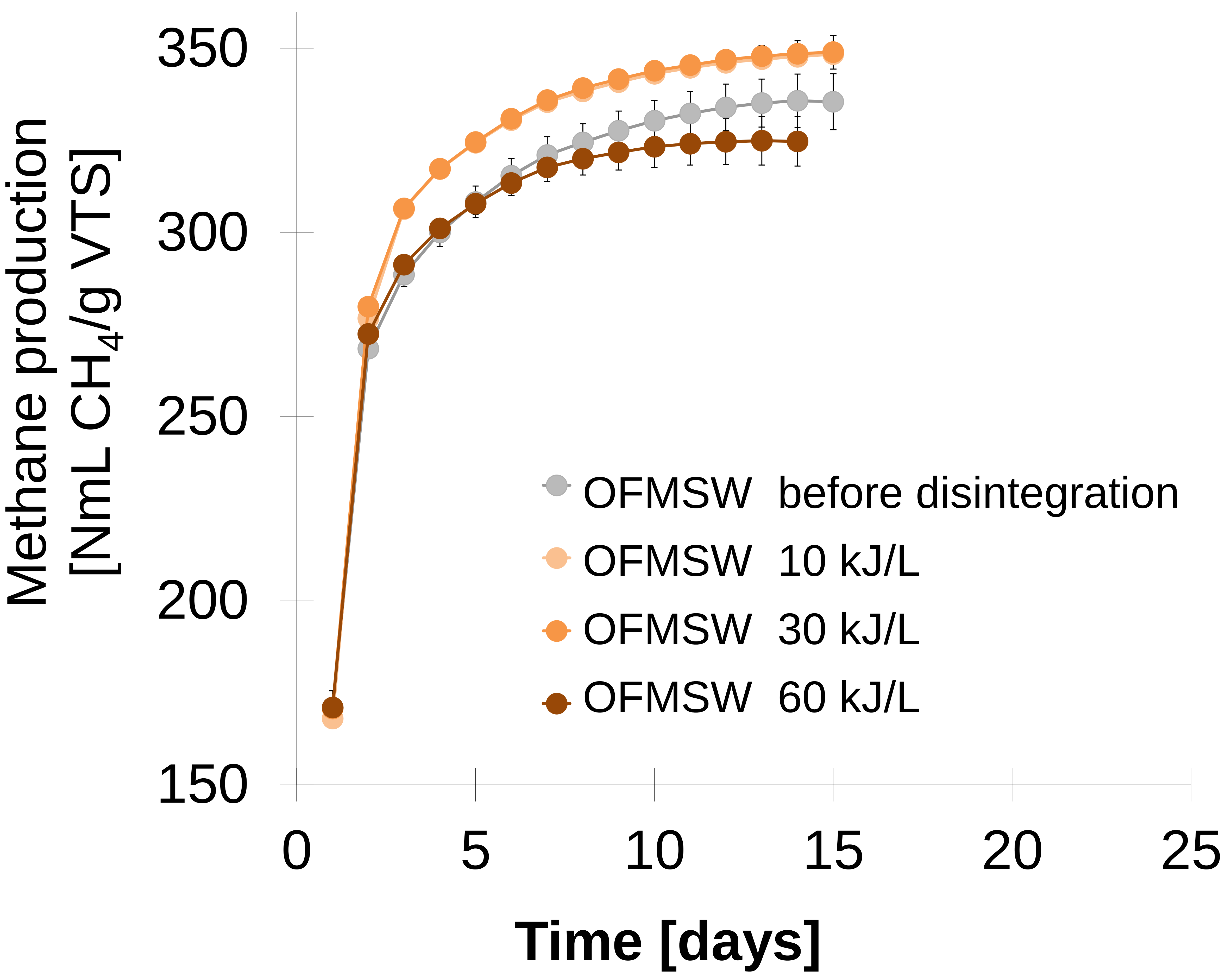
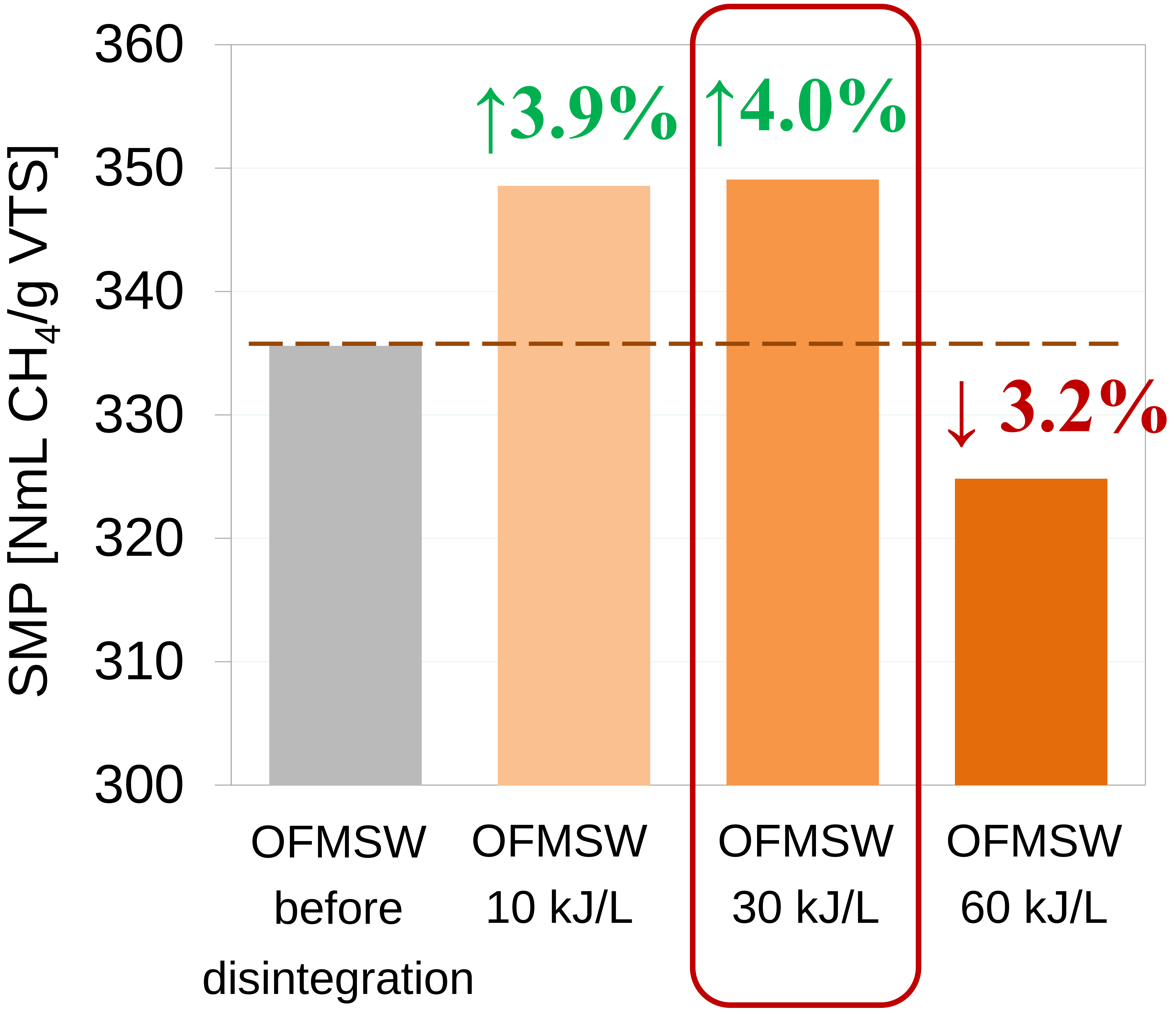
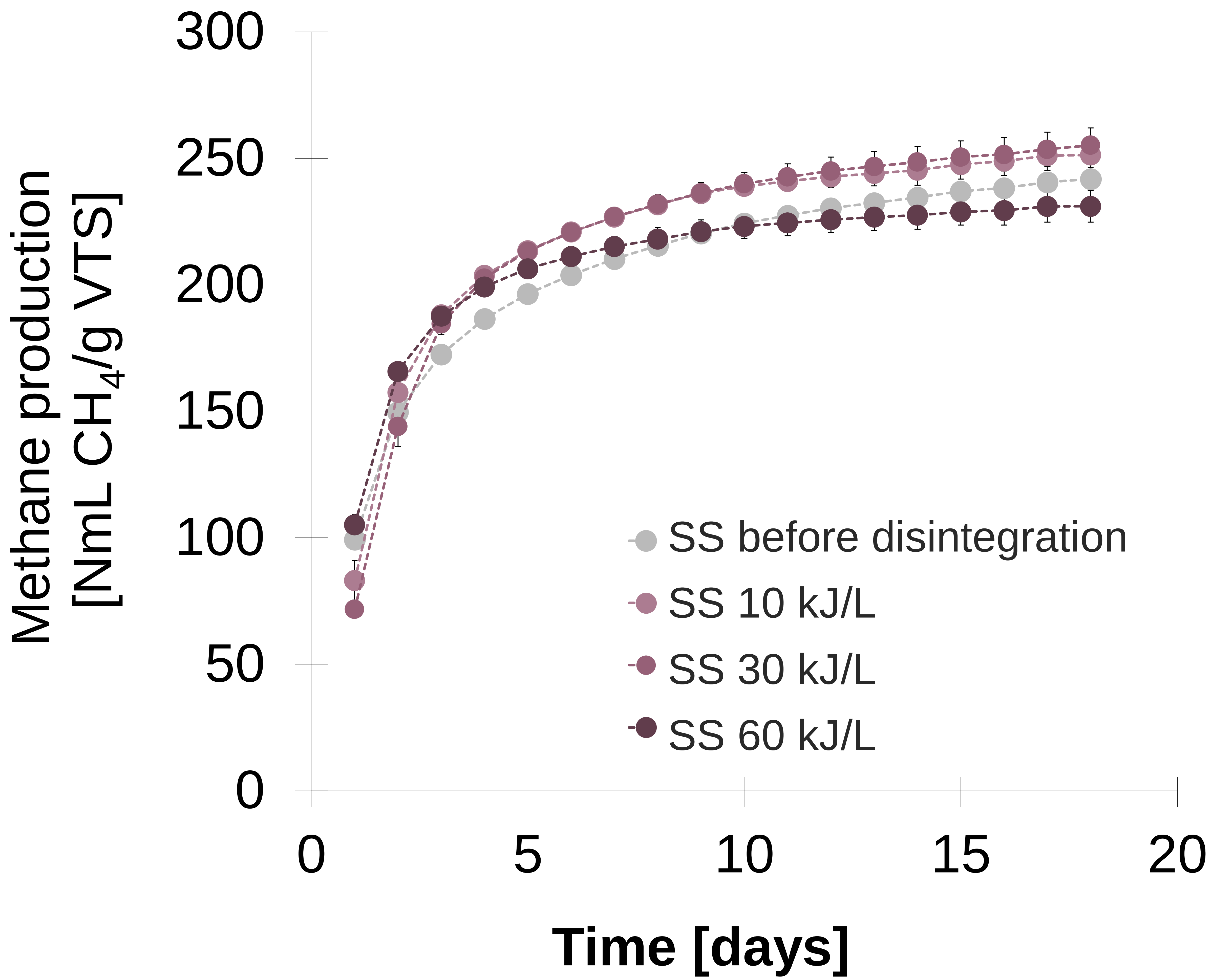




RESULTS determination of the specific methane production of **SEWAGE SLUDGE (SS)** with and without hydrodynamic disintegration



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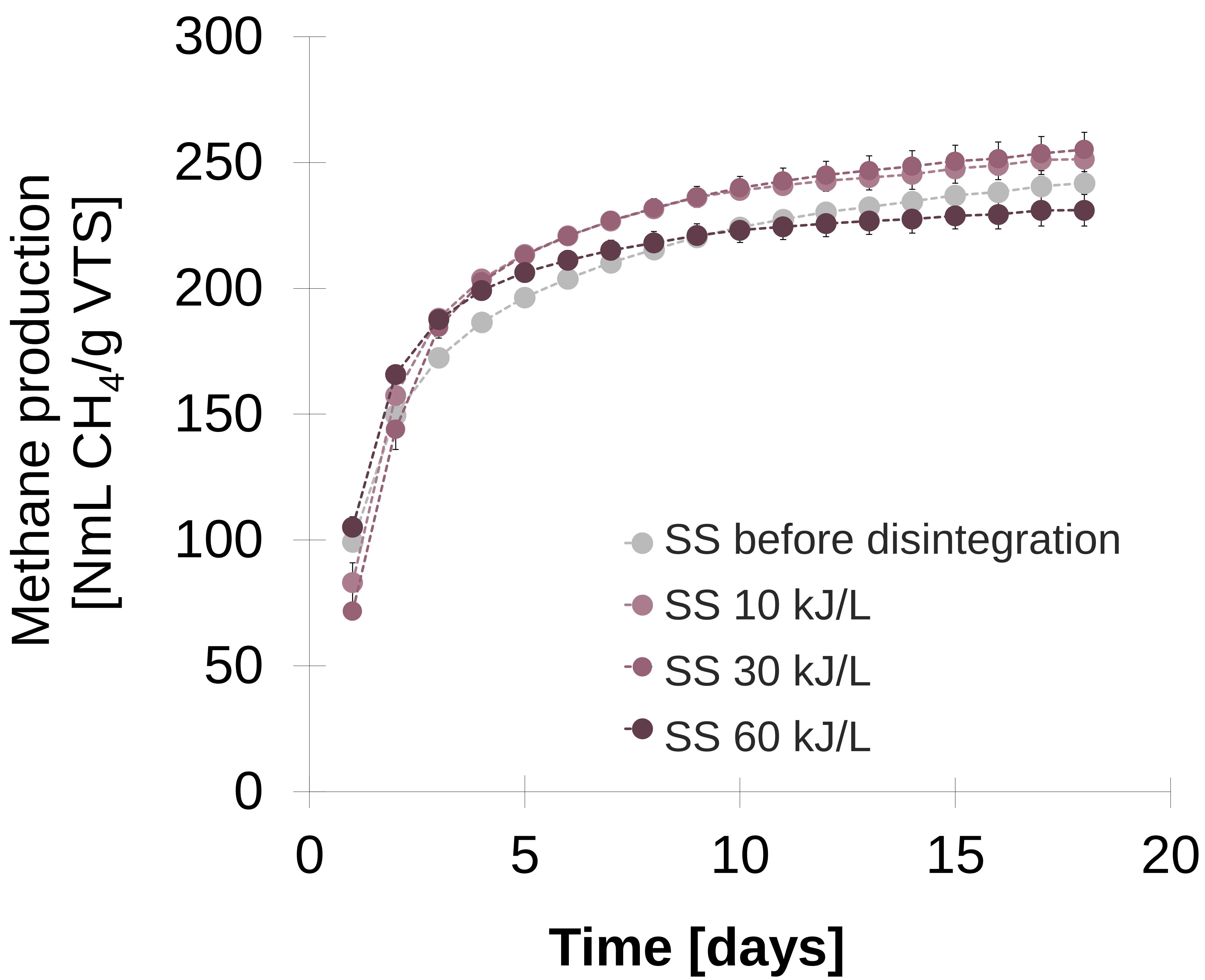

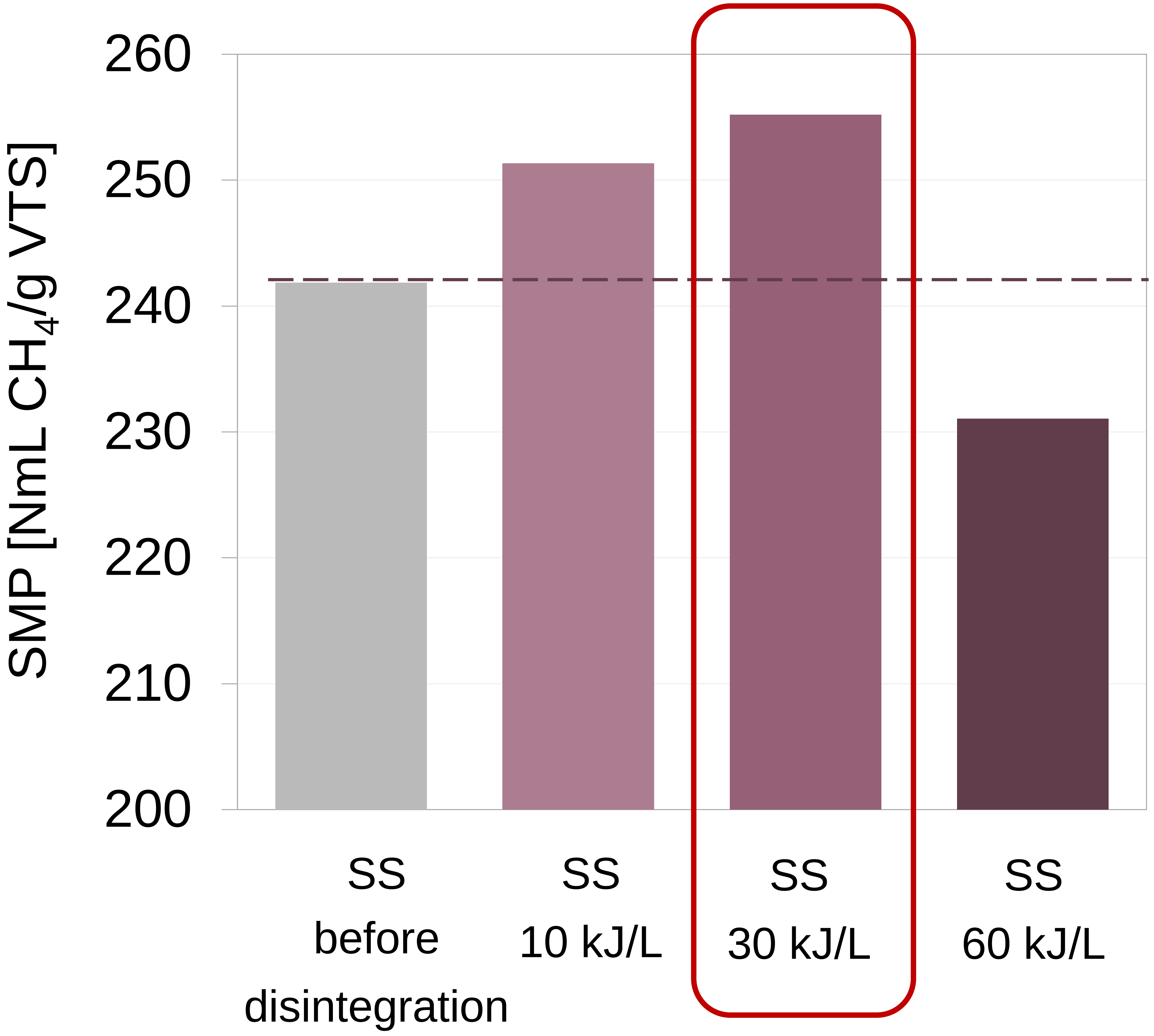

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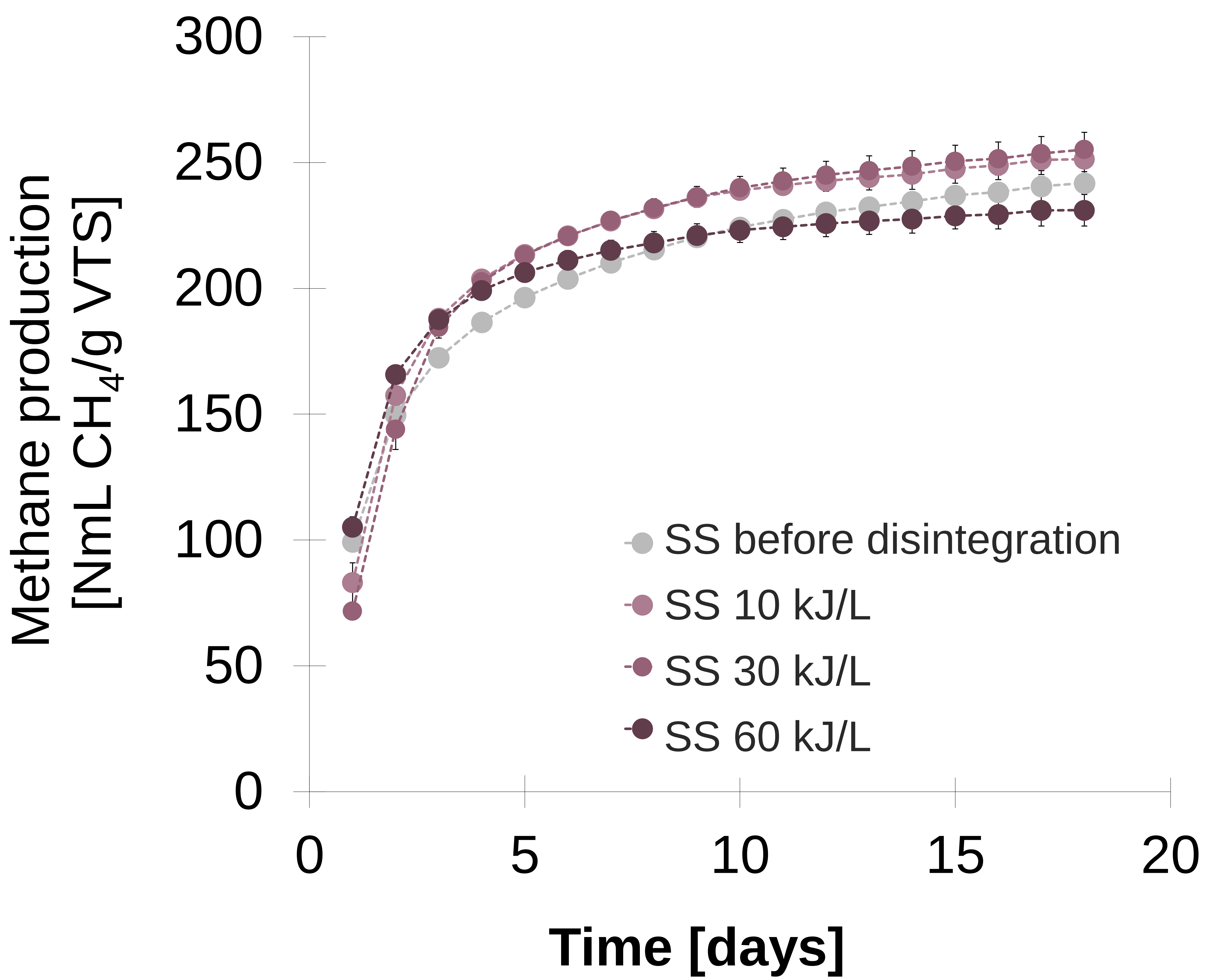

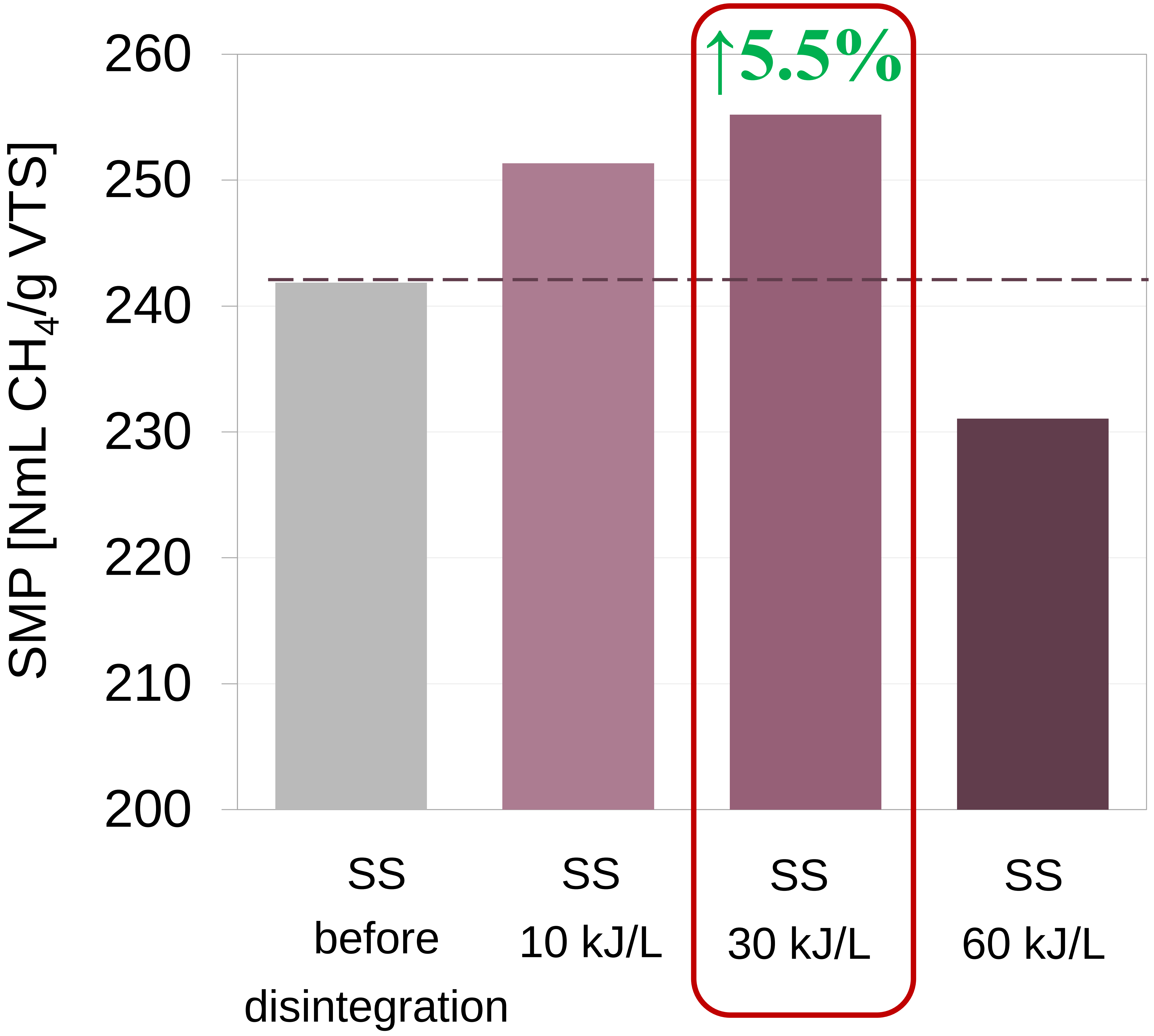

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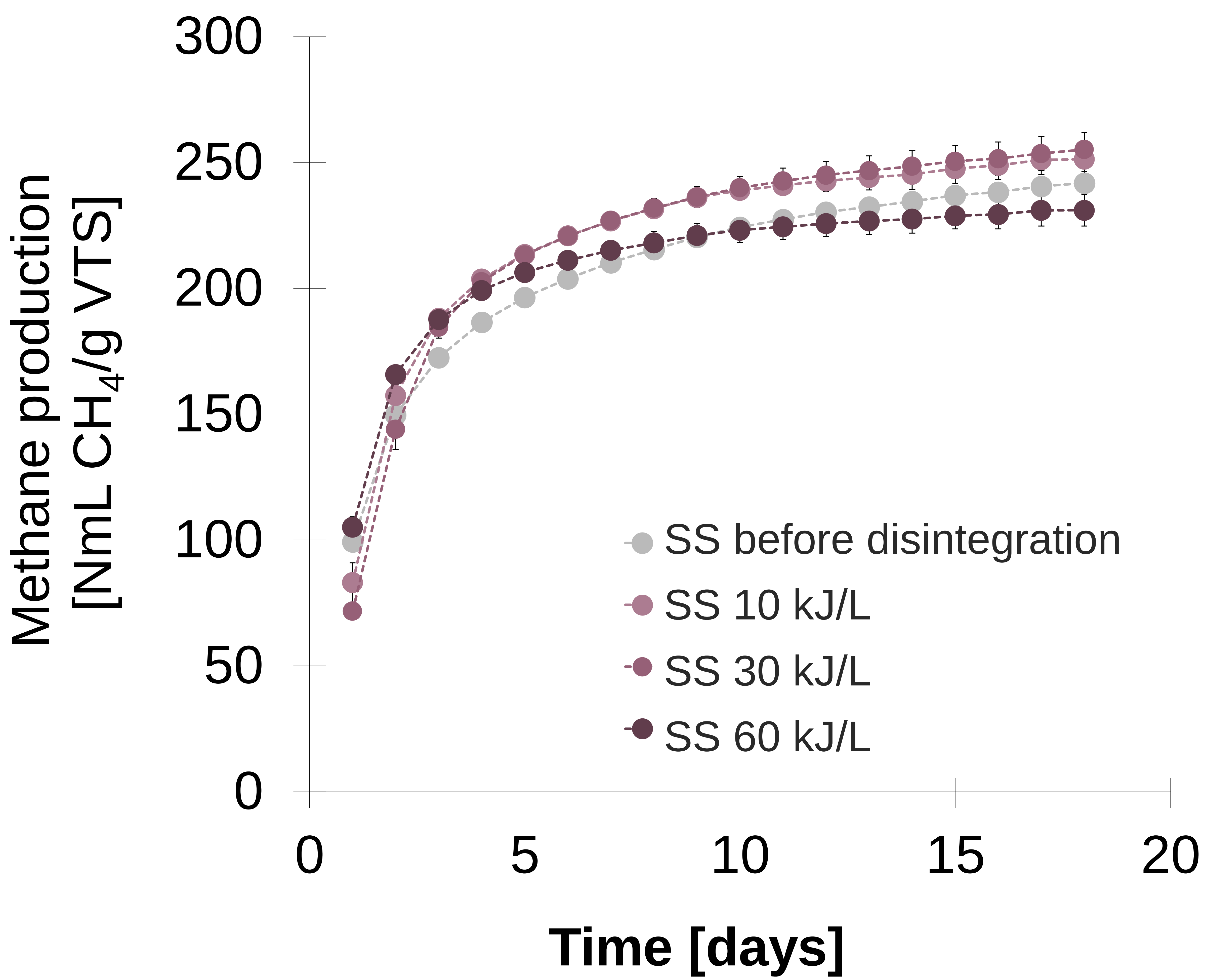

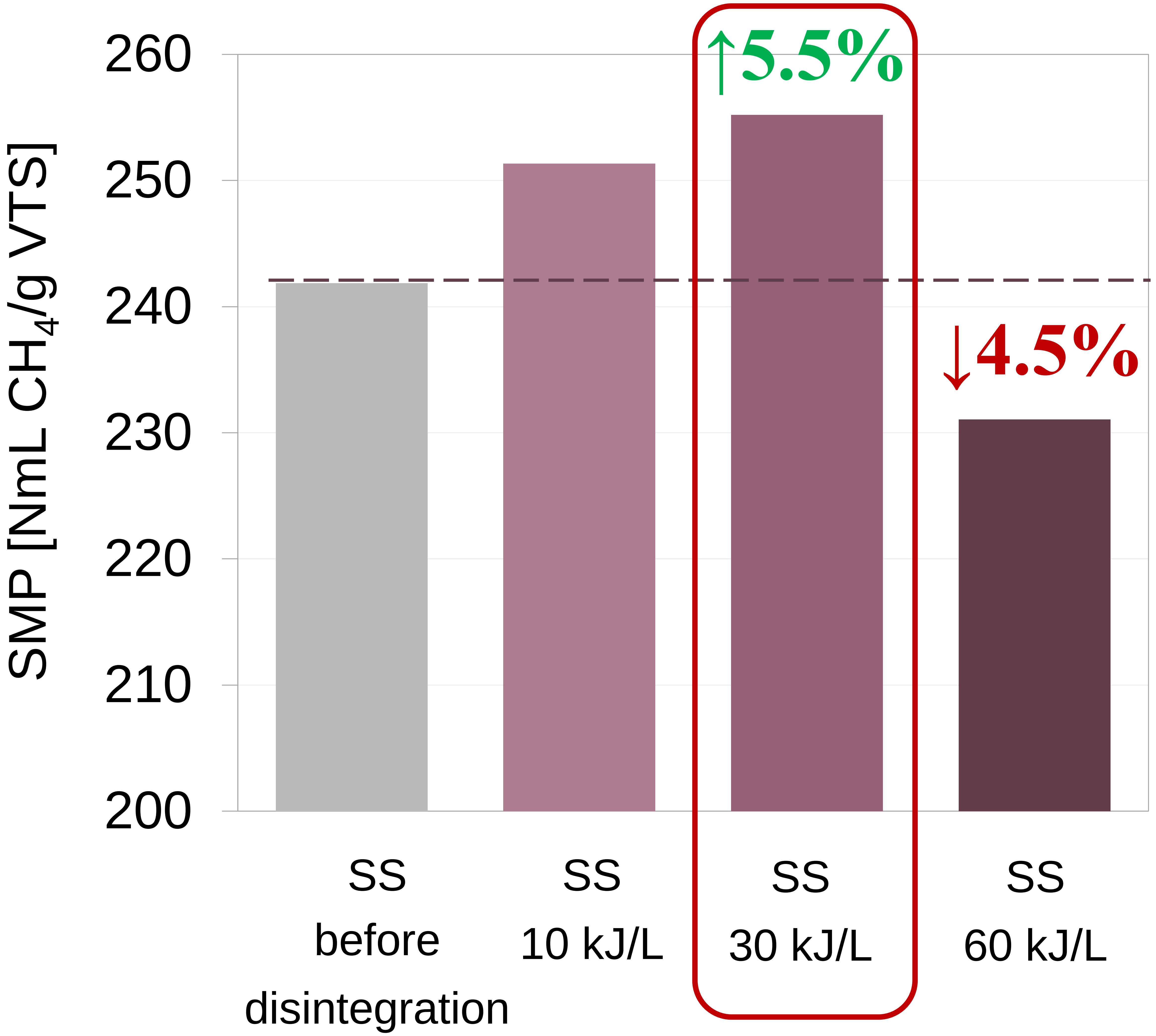

RESULTS digestate liquid

Indicator	OFMSW					SS				
	Inoculum	raw	10 kJ/L	30 kJ/L	60 kJ/L	Inoculum	raw	10 kJ/L	30 kJ/L	60 kJ/L
TN (mg/l)	1102	1122	1130	1128	1156	1028	1044	1054	1044	1080
NH_4-N (mg/l)	960	970	984	978	978	978	982	984	986	998
TP (mg/l)	19.1	18.1	17.9	17.2	17.1	16.3	17.5	17.5	16.8	16.9
PO_4-P (mg/l)	16.3	15.9	15.9	16.0	16.0	15.1	16.2	16.1	15.7	16.0

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TN (mg/l)	1102	1122	1130	1128	1156	1028	1044	1054	1044	1080
					↑ 0.5-3.0%					↑ 1.0-3.4%
NH_4-N (mg/l)	960	970	984	978	978	978	982	984	986	998
TP (mg/l)	19.1	18.1	17.9	17.2	17.1	16.3	17.5	17.5	16.8	16.9
PO_4-P (mg/l)	16.3	15.9	15.9	16.0	16.0	15.1	16.2	16.1	15.7	16.0

RESULTS digestate liquid

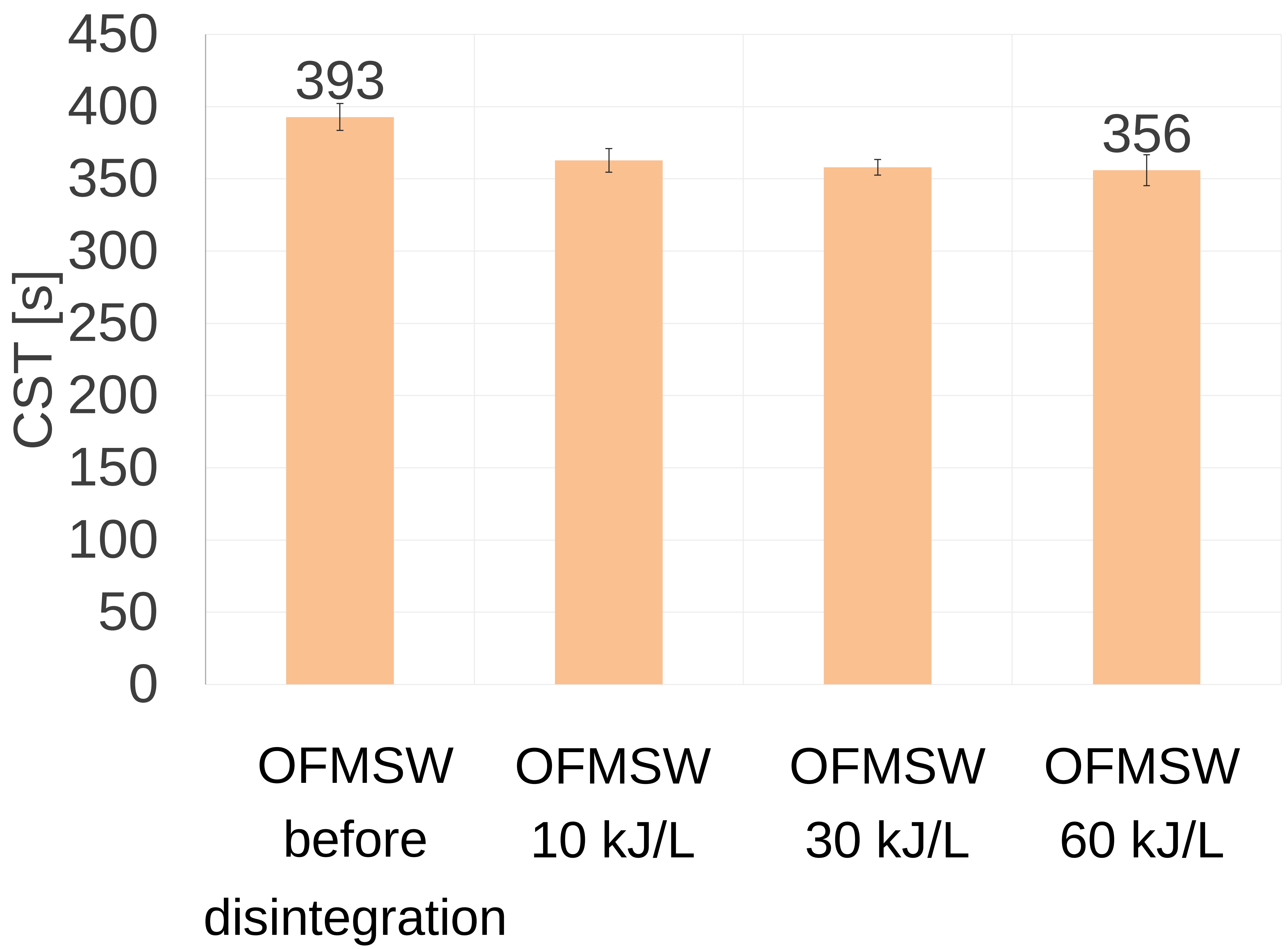
Indicator	OFMSW Inoculum	OFMSW raw	OFMSW 10 kJ/L	OFMSW 30 kJ/L	OFMSW 60 kJ/L	SS Inoculum	SS raw	SS 10 kJ/L	SS 30 kJ/L	SS 60 kJ/L
TN (mg/l)	1102	1122	1130	1128	1156	1028	1044	1054	1044	1080
NH_4-N (mg/l)	960	970	984	978	978	978	982	984	986	998
TP (mg/l)	19.1	18.1	17.9	17.2	17.1	16.3	17.5	17.5	16.8	16.9
PO_4-P (mg/l)	16.3	15.9	15.9	16.0	16.0	15.1	16.2	16.1	15.7	16.0

OFMSW: TN ↑ 0.5-3.0%; TP ↓ 1.1-5.5%

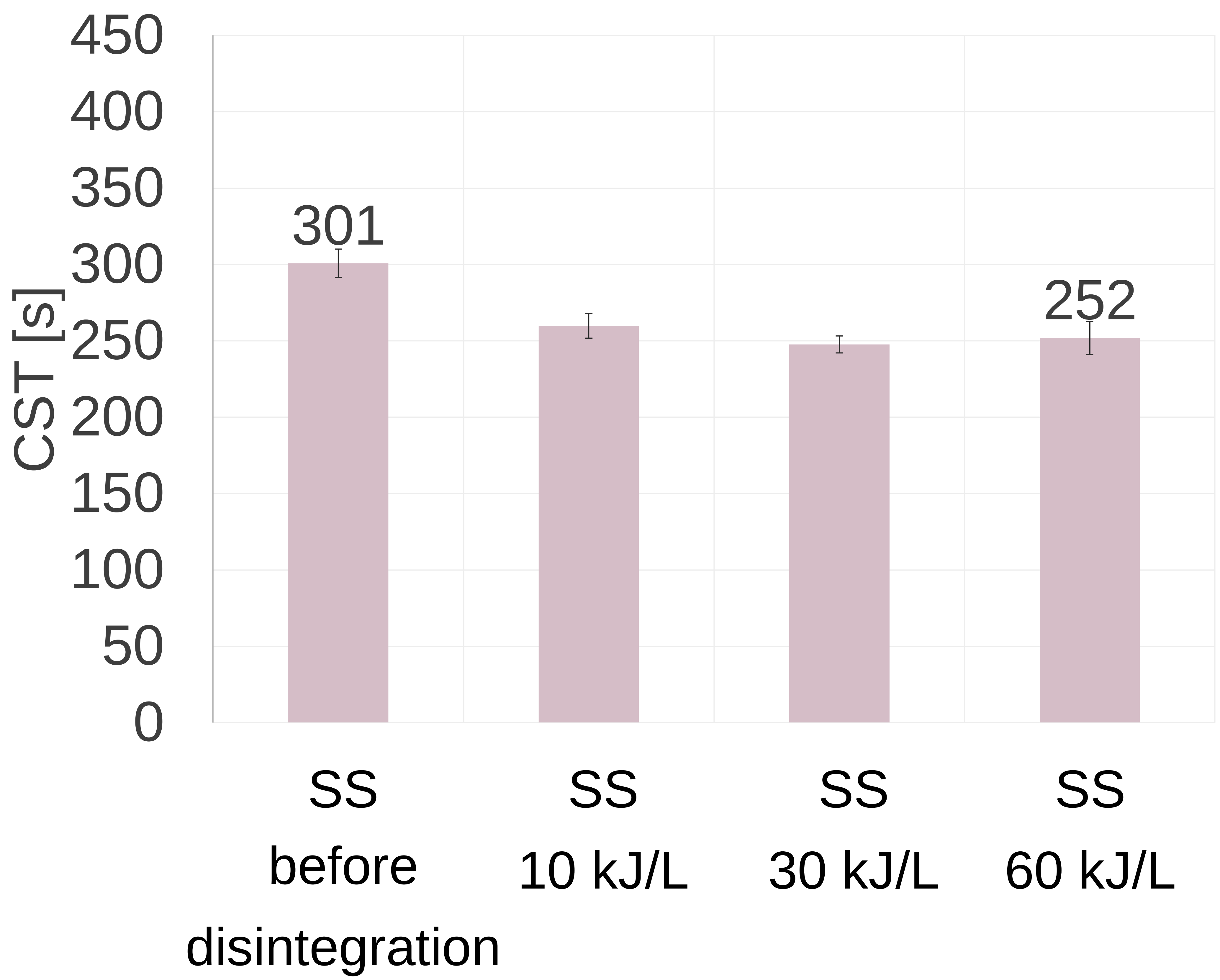
SS: TN ↑ 1.0-3.4%; TP ↓ 3.4-4.0%

RESULTS capillary suction time (CST)

digested OFMSW



digested SS



CONCLUSION

Hydrodynamic disintegration is
a **promising method** of pre-treatment
of organic fraction of municipal solid waste
and sewage sludge
before its use as substrates in the anaerobic digestion process.

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