Appendix

(**a**) (**b**) (**c**)

Figure S1. Substrates that were used in the study: (**a**) algae substrate "Wakame", *Undaria pinnatifida*; (**b**) OFMSW that was prepared in accordance with the recipe presented in the reference [1]; (**c**) GTS from the meat processing plant, Silesian region, Poland.

(**a**) (**b**)

Figure S2. Arrangement in incubators: (**a**) BMP assay; (**b**) physicochemical analysis.

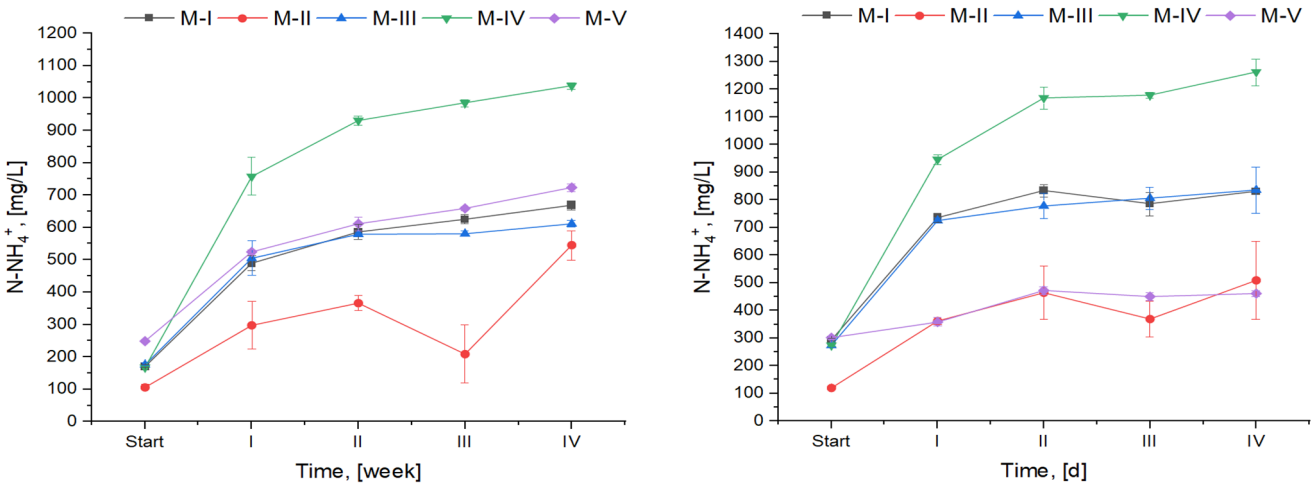

Figure S3. Change of N-NH_4^+ during four-week digestion period: (**a**) mesophilic temperature; (**b**) thermophilic temperature.

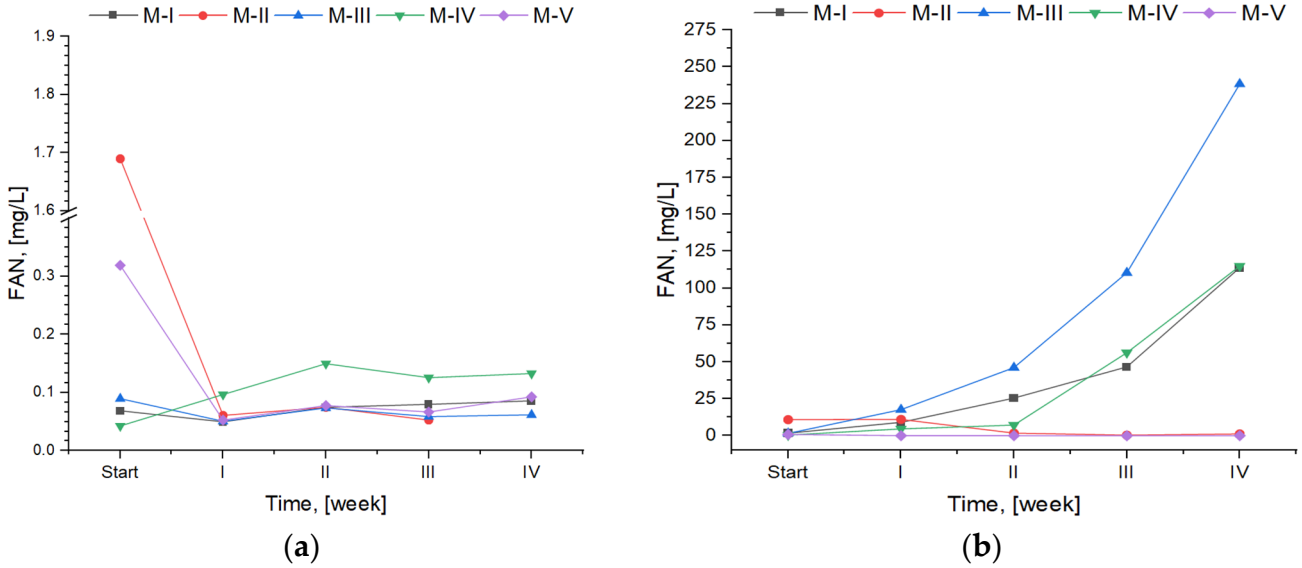

Figure S4. Change of FAN during four-week digestion period: (**a**) mesophilic temperature; (**b**) thermophilic temperature.

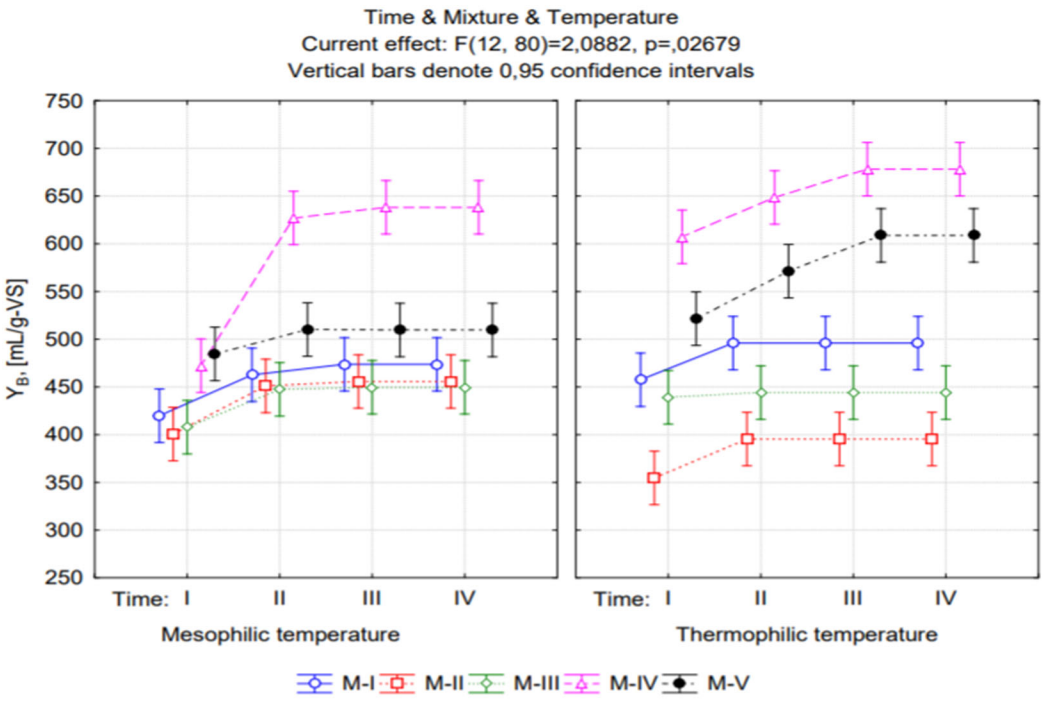

Figure S5. Factorial ANOVA results in relation to the Y_B.

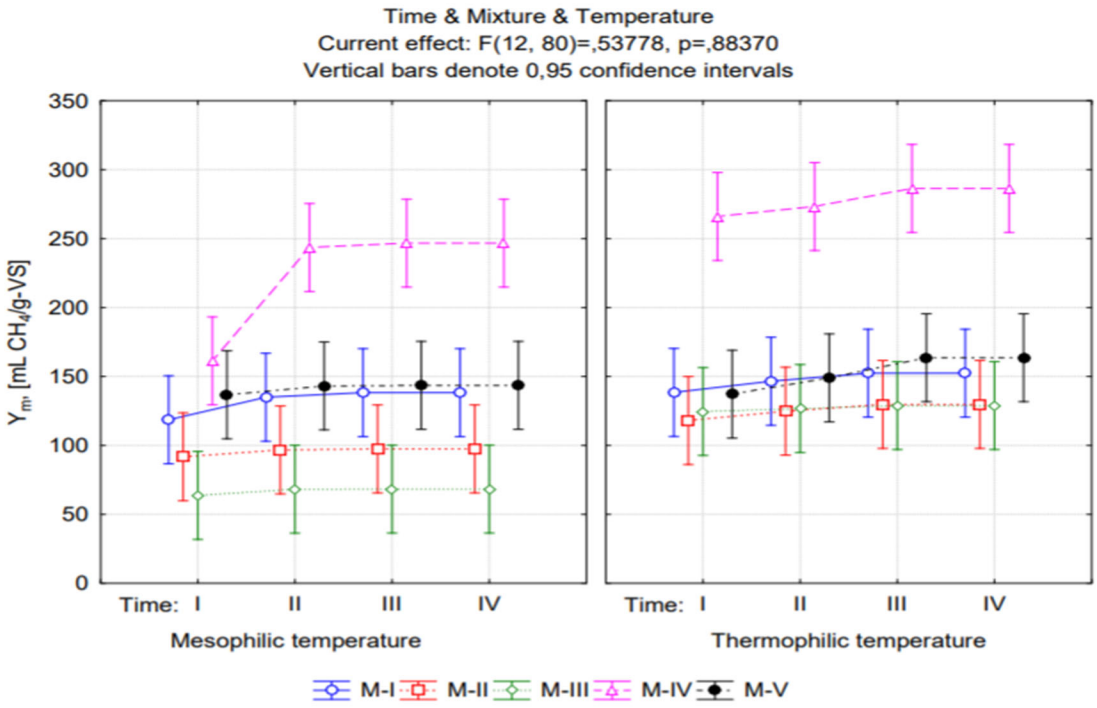

Figure S6. Factorial ANOVA results in relation to the Y_m.

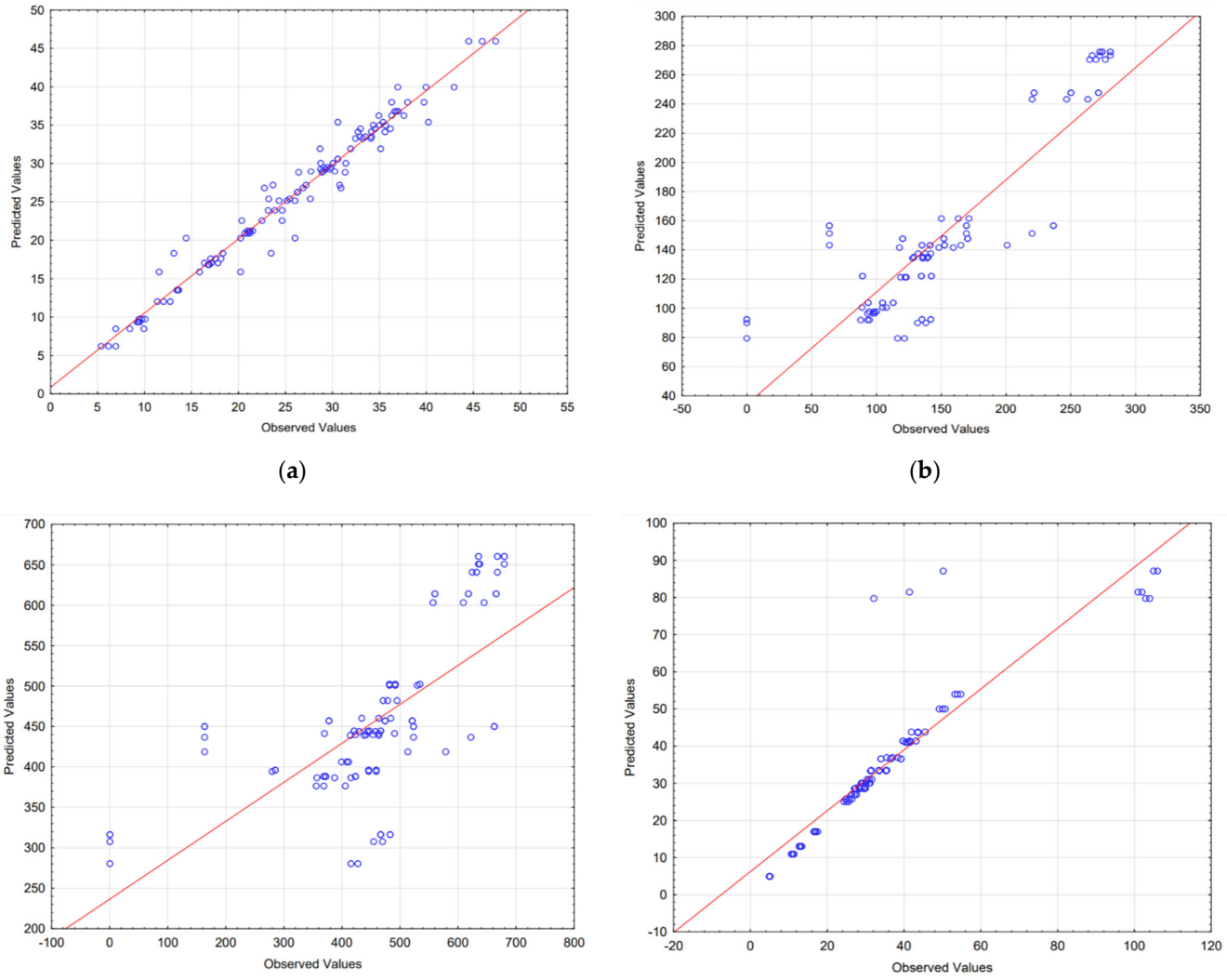

Figure S7. Observed versus predicted values: (**a**) VS removal; (**b**) Y_m; (**c**) Y_B; (**d**) variation of methane in biogas.

Table S1. Summarizing information regarding to the section and page in [2] for the parameters measured.

SMEWW			PN-ISO 10694:2002		FCBWiŚ (Physicochemical examination of water and wastewater)	
Parameter	**Section**	**Method**	**Parameter**	**Method**	**Parameter**	**Method**
VFA	2310, B and 2320, B	Titration method	TC	Total carbon content and high-temperature combustion method	$N\text{-}NH_4^+$	Determination of ammoniacal nitrogen after preliminary distillation
TS	2540, B	Total solids dried at 103 – 105 °C				
VS and FS	2540, E	Fixed and volatile solids ignited at 550 °C	NPOC			
KN	4500-N_{org}, B	Macro-Kjeldahl method				

Table S2. Measured physicochemical parameters of the studied mixtures.

Mixture	Week	VFA/alkalinity		$N\text{-}NH_4^+$ (mg/L)				FAN (mg/L)		pH (–)				NPOC (g/L)				TC (mg/g-TS)			
		M	T	M	SD	T	SD	M	T	M	SD	T	SD	M	SD	T	SD	M	SD	T	SD
M-I	Start[1)]	3.12	2.27	170.8	3.96	294	3.96	0.069	1.848	5.5	0.01	6.3	0.01	1.16	0.01	1.16	0.01	446,2	3.89	433,8	9.83
	I	6.82	2.26	490	23.54	736.4	16.80	0.050	9.177	4.9	0.01	6.6	0.08	3.96	0.13	3.09	0.08	Nm	Nm	Nm	Nm
	II	5.47	1.80	586.6	23.03	834.4	23.31	0.075	25.635	5	0.02	7	0.51	4.22	0.00	3.03	0.43	Nm	Nm	Nm	Nm
	III	5.41	1.36	625.8	14.73	786.8	42.28	0.080	46.800	5	0.01	7.3	0.01	4.38	0.03	3	0.03	Nm	Nm	Nm	Nm
	IV	5.29	1.08	669.2	14.82	831.6	10.72	0.086	113.997	5	0.01	7.7	0.10	4.52	0.01	2.85	0.01	Nm	Nm	Nm	Nm
M-II	Start[1)]	0.52	0.38	106.4	7.92	120.4	3.96	1.690	10.969	7.1	0.00	7.5	0.01	0.55	0.03	0.76	0.01	339,3	7.57	336,7	6.01
	I	4.05	1.06	298.2	73.35	362.6	12.42	0.061	11.140	5.2	0.11	7	0.01	4.55	0.13	3.11	0.18	Nm	Nm	Nm	Nm
	II	3.92	2.51	366.8	23.09	464.8	97.42	0.075	1.847	5.2	0.01	6.1	0.85	4.91	0.19	5.32	0.58	Nm	Nm	Nm	Nm
	III	3.24	2.91	209.06	91.05	369.6	64.66	0.053	0.466	5.3	0.06	5.6	0.25	4.81	0.33	5.66	0.07	Nm	Nm	Nm	Nm
	IV	2.95	2.56	546	46.21	509.6	142.41	0.880	1.280	6.1	1.28	5.9	0.53	4.36	0.30	5.51	0.02	Nm	Nm	Nm	Nm
M-III	Start[1)]	3.24	2.14	176.4	3.96	274.4	7.92	0.090	1.724	5.6	0.00	6.3	0.01	1.22	0.01	1.43	0.01	432,4	6.43	413,5	2.47
	I	6.21	1.87	505.4	54.17	725.9	10.06	0.051	17.827	4.9	0.05	6.9	0.02	4.24	0.04	3.18	0.01	Nm	Nm	Nm	Nm
	II	5.08	1.25	579.6	3.96	778.4	46.18	0.074	46.300	5	0.00	7.3	0.07	4.53	0.00	3.22	0.26	Nm	Nm	Nm	Nm
	III	6.25	1.00	581	8.40	806.4	39.86	0.059	110.543	4.9	0.02	7.7	0.03	4.85	0.01	2.79	0.42	Nm	Nm	Nm	Nm
	IV	6.25	0.54	611.8	9.56	836.2	84.06	0.062	238.502	4.9	0.04	8.1	0.14	5.08	0.10	1.68	0.03	Nm	Nm	Nm	Nm
M-IV	Start[1)]	4.37	2.44	168	0.00	274.4	7.92	0.043	0.548	5.3	0.00	5.8	0.01	1.4	0.01	1.37	0.01	451,7	1.13	463,7	2.40
	I	4.99	2.32	757.8	59.35	946.4	18.00	0.097	4.731	5	0.03	6.2	0.09	5.22	0.09	5.04	0.12	Nm	Nm	Nm	Nm
	II	4.43	2.42	931	14.73	1169	39.17	0.150	7.347	5.1	0.02	6.3	0.08	5.81	0.01	5.31	0.06	Nm	Nm	Nm	Nm
	III	5.48	1.72	985.6	11.20	1178.8	10.72	0.126	56.385	5	0.01	7.2	0.16	6.54	0.21	5.22	0.03	Nm	Nm	Nm	Nm
	IV	5.42	1.51	1038.8	10.72	1262.8	48.71	0.133	115.043	5	0.02	7.5	0.01	6.97	0.10	5.26	0.03	Nm	Nm	Nm	Nm
M-V	Start[1)]	2.43	2.35	249.2	3.96	302.4	0.00	0.319	0.955	6	0.01	6	0.01	3.13	0.00	2.96	0.03	406	2.47	436,4	1.77
	I	7.87	4.13	525	7.05	358.4	15.84	0.053	0.180	4.9	0.01	5.2	0.03	5.89	0.00	5.57	0.07	Nm	Nm	Nm	Nm
	II	5.73	5.35	611.8	21.14	473.2	14.09	0.078	0.150	5	0.03	5	0.01	6.36	0.03	6.64	0.04	Nm	Nm	Nm	Nm
	III	6.05	6.35	659.4	5.36	450.8	14.09	0.067	0.113	4.9	0.03	4.9	0.02	6.69	0.01	7.25	0.27	Nm	Nm	Nm	Nm
	IV	5.34	5.23	723.8	12.42	462	10.72	0.093	0.146	5	0.06	5	0.09	7.02	0.06	6.58	0.04	Nm	Nm	Nm	Nm

Nm – not measured

[1)] – Before pH correction

Table S3. Comparison of methane yields of different co-digestion mixture after treated in wet AcD.

Anaerobic conditions	Feedstock	Mixture (% of VS content)	Ym (NmL CH_4/g VS)	Enhanced yield (%)	Reference
Sewage sludge + algae					
Batch, 37°C, 1.2 L bottles Duration: 27 days	*Chlorella sorokiniana* and *Scenedesmus sp*. (AB)	100	331 ± 76	-	[3]
	activated sludge (AS) after the aerobic phase	100	363 ± 68	-	
	activated sludge (AS) after the aerobic phase/AB	90/10	400 ± 22	10[1]/21[2]	
	activated sludge (AS) after the anaerobic phase	100	449 ± 17	-	
	activated sludge (AS) after the anaerobic phase/AB	90/10	560 ± 24	25[1]/69[2]	
Batch, 37°C, 1 L conical flasks (working volume: 0.7 L), loading rate: 3 g VS/L S/I ratio 1:2 based on VS; Duration: 35 days	Microalgae A—wet from lake (MA) - *Scenedesmus* and *Chlorella vulgaris*	100	367 ± 5	-	[4]
	Sewage sludge (mixed WAS + PS)	100	331 ± 35	-	
	Sewage sludge (mixed WAS + PS) /MA	88/12	344 ± 15	4[1]/−6[2]	
	Sewage sludge (mixed WAS + PS)/MA	75/25	458 ± 61	38[1]/25[2]	
	Sewage sludge (mixed WAS + PS)/MA	63/37	408 ± 17	23[1]/11[2]	
	Microalgae—dry cultivated in municipal wastewater (MB)—*Scenedesmus*	100	179 ± 38	-	
	Sewage sludge (mixed WAS + PS)/MB	88/12	387 ± 67	17[1]/116[2]	
	Sewage sludge (mixed WAS + PS)/MB	75/25	348 ± 65	5[1]/94[2]	
	Sewage sludge (mixed WAS + PS)/MB	63/37	325 ± 67	−2[1]/81.5[2]	
Batch, 55°C, 0.1 L conical bottles (working volume: 0.07 L), loading rate: 3 g VS/L S/I ratio 1:2 based on VS; Duration: 35 days	Microalgae A—wet from lake (MA)	100	317 ± 53	-	
	Sewage sludge (mixed WAS + PS)	100	363 ± 6	-	
	Sewage sludge (mixed WAS + PS) /MA	88/12	388 ± 75	7[1]/22[2]	
	Sewage sludge (mixed WAS + PS)/MA	75/25	338 ± 65	−7[1]/7[2]	
	Sewage sludge (mixed WAS + PS)/MA	63/37	321 ± 15	−12[1]/1[2]	
	Microalgae B—dry cultivated in municipal wastewater (MB)	100	150 ± 13	-	
	Sewage sludge (mixed WAS + PS)/MB	88/12	323 ± 8	−11[1]/115[2]	
	Sewage sludge (mixed WAS + PS)/MB	75/25	298 ± 55	−18[1]/99[2]	
	Sewage sludge (mixed WAS + PS)/MB	63/37	276 ± 10	−24[1]/84[2]	

Batch, 33°C, 0.12 mL bottles, substrate amount was 0.12 g volatile solids (VS), stirring rate of 130 rpm Duration: 35 days	*Isochrysis galbana*, marine species	100	338 ± 3	-	[5]
	mixed WAS + PS	100	347 ± 9	-	
	mixed WAS + PS / *Isochrysis galbana*	75/25	318 ± 5	$-8^1/-6^2$	
	mixed WAS + PS / *Isochrysis galbana*	50/50	356	$3^1/5^2$	
	mixed WAS + PS / *Isochrysis galbana*	25/75	343	$-1^1/1^2$	
	Selenastrum capricornutum, freshwater species	100	209 ± 5	-	
	mixed WAS + PS / *Selenastrum capricornutum*	75/25	303 ± 11	$-13^1/45^2$	
	mixed WAS + PS / *Selenastrum capricornutum*	50/50	302 ± 3	$-13^1/44^2$	
	mixed WAS + PS / *Selenastrum capricornutum*	25/75	254 ± 5	$-17^1/21.5^2$	
Batch, 50°C, 0.12 mL bottles, substrate amount was 0.12 g volatile solids (VS), stirring rate of 130 rpm Duration: 57 days	*Isochrysis galbana*, marine species	100	464 ± 4	-	
	mixed WAS + PS	100	219 ± 1	-	
	mixed WAS + PS / *Isochrysis galbana*	75/25	420	$92^1/-9.5^2$	
	mixed WAS + PS / *Isochrysis galbana*	50/50	340	$-55^1/-27^2$	
	mixed WAS + PS / *Isochrysis galbana*	25/75	259	$18^1/-44^2$	
	Selenastrum capricornutum, freshwater species	100	152 ± 6	-	
	mixed WAS + PS / *Selenastrum capricornutum*	75/25	370	$69^1/143^2$	
	mixed WAS + PS / *Selenastrum capricornutum*	50/50	286	$30.5^1/88^2$	
	mixed WAS + PS / *Selenastrum capricornutum*	25/75	201	$-8^1/32^2$	
Batch, 35°C, 0.13 mL bottles (working volume), inoculum to substrate ratio of 2 (VS basis); addition, 130 µL of a trace element solution Duration:27 days	*Chlorella sorokiniana*	100	362	-	[6]
	WAS	100	318	-	
	WAS/ *Chlorella sorokiniana*	75/25	442	$39^1/22^2$	
	WAS/ *Chlorella sorokiniana*	50/50	380	$19^1/5^2$	
	WAS/ *Chlorella sorokiniana*	25/75	354	$11^1/-2^2$	
Batch, 37°C, serum bottle with a working volume of 0.1 L, Duration: 20 days	*Micractinium* sp. Isolated from the wall of a primary clarifier at a local WWTP	100	230	-	[7]
	WAS	100	243	-	
	WAS/ *Micractinium* sp	79/21	253	$4^1/10^2$	
	Chlorella sp. Isolated from the wall of a primary clarifier at a local WWTP	100	209	-	
	WAS/ *Chlorella* sp	79/21	236	$-3^1/13^2$	
Batch, 35°C, 1 L fermentation glass bottles, Duration: 26 days	dehydrated *Ulva* macroalgae powder/sewage sludge	6% (wt/wt) algae concentration	149	-	[8]

Batch, 35°C, 0.5 L flask (0.3 working volume), inoculum to substrate ratio of 1 (VS basis); stirring rate of 100 rpm	Macroalgal residue (MAR) - *Gelidium sesquipedale*	100	253 ± 4	-	[9]
	thickened waste activated sludge (TWAS)	100	127 ± 1	-	
	TWAS/MAR	50:50	182 ± 2	43[1]/−28[2]	
	TWAS/MAR + pre-treatment of MAR (Alkaline KOH-5%)	50:50	281 ± 10	121[1]/11[2]	
	TWAS/MAR + pre-treatment of MAR (Acid H_3PO_4-5% and heating−70 °C)	50:50	252 ± 6	98[1]/−0.4[2]	
	TWAS/MAR + pre-treatment of MAR (Heating−70 °C)	50:50	263 ± 2	107[1]/4[2]	
Batch, 35°C, 0.16 L serrum bottles, inoculum to substrate ratio of 0.5 g CODVS/g VS	Microalgae (M)	100	82 ± 10	-	[10]
	WAS	100	139 ± 3	-	
	Pretreatment M (PM)	100	134 ± 6	-	
	Pretreatment WAS (PWAS)	100	204 ± 3	-	
	Pretreatment (WAS + M)	20/80	187 ± 9	34.5[1]/128[2]	
	Pretreatment (WAS + M)	50/50	162 ± 6	16.5[1]/97.5[2]	
	Pretreatment (WAS + M)	80/20	132 ± 2	−5[1]/61[2]	
Algae + other organic waste					
Batch, 50°C, 1 L (0.7 working volume), stirring rate of 600 rpm	Food waste	100	537 ± 19	-	[11]
	Algal biomass	100	300 ± 11	-	
	Food waste/ algal biomas	75/25	496 ± 36	−8[3]/65[2]	
	Food waste/ algal biomas	50/50	427 ± 28	−20.5[3]/42[2]	
	Food waste/ algal biomas	25/75	390 ± 30	−27[3]/30[2]	
Batch, 55°C Organic loads for organic peels (i.e., 2.5, 3, and 5 kgVS/m^3) and seweed (i.e., 3 and 4 kgVS/m^3); inoculum to substrate ratio of 2 (VS basis); Duration: 30 days	Seaweed	100	349 ± 10	-	[12]
	Orange peels	100	398 ± 94	-	
	Orange peels/ seaweed	30/70	355 ± 5	2[2]	
	Orange peels/ seaweed	50/50	323 ± 4	−7.5[2]	
	Orange peels/ seaweed	70/30	375 ± 15	7[2]	
Batch, 35°C, 0.1 L substrate to inoculum (S/I) ratio: 0.5 g COD/g VS Duration: 60 days	Microalgal biomass (MA)	100	140 ± 4	-	[13]
	Pretreated Microalgal biomass (PMA)	100	226 ± 1	-	
	thickened primary sludge (TPS)	100	299 ± 1	-	
	fat, oil and grease from WWTP (FOG)	100	563 ± 15	-	
	MA/TPS	50/50	207 ± 5	−31[1]/48[2]	

	PMA/TPS	50/50	237 ± 1	−21[1]/69[2]	
	MA/TPS	50/50 + 10%FOG	259 ± 13	−13[1]/85[2]	
	PMA/TPS	50/50 + 10%FOG	298 ± 12	−0. 3[1]/113[2]	
	MA/TPS	50/50 + 20%FOG	293 ± 8	−2[1]/109[2]	
	PMA/TPS	50/50 + 20%FOG	334 ± 10	12[1]/138[2]	
Batch, 35-38°C, 2 L substrate to inoculum (S/I) ratio: 1 w/v Duration: 46 days	*Spirulina subsalsa*	100	81.40[4]	-	[14]
	Paddy straw	100	231.5[4]	-	
	Paddy straw/ *Spirulina subsalsa*	80/20	246[4]	2032	
	Paddy straw/ *Spirulina subsalsa*	70/30	260[4]	221[2]	
	Paddy straw/ *Spirulina subsalsa*	50/50	250[4]	208[2]	
	Paddy straw/ *Spirulina subsalsa*	30/70	190[4]	134[2]	
Batch, 35°C, 0.15 L substrate to inoculum (S/I) ratio: 1, stirring rate of 150 rpm Duration: 30 days	Taihu blue algae	100	201		[15]
	Taihu blue algae/ corn straw	20/80	325	62[2]	
Batch, 53°C, 0.337 L (0.1 L working volume) organic load: 2gVS/L Duration: 25 days	piggery slurry	100	255 ± 65	-	[16]
	Nannochloropsis limnetica / piggery slurry	40/60	355 ± 27	39[5]	
Batch, 37°C, 0.305 L (0.25 L working volume) Inoculum: 10% v/v All samles load: 3% TS Duration: 90 days	oil-extracted microalgae biomass from *Chlorella vulgaris* powder (M)	-	-	-	[17]
	Glicerol (G)	100	113.2	-	
	Chicken Litter (CL)	-	-	-	
	M/G/CL	0/1.5/98.5	97.4	−14[6]	
	M/G/CL	0/3/97	116.7	3[6]	
	M/G/CL	5/0.5/95.5	115.5	2[6]	
	M/G/CL	10/1/89	188.3	66[6]	
	M/G/CL	15/0/85	177.8	-	
	M/G/CL	15/1.5/83.5	122.3	8[6]	
	M/G/CL	20/2/78	116.5	3[6]	
	M/G/CL	25/2.5/72.5	127.7	13[6]	
	M/G/CL	30/0/70	129.6	-	
	M/G/CL	30/3/67	131.1	16[6]	

[1]—compared to AD of sewage sludge alone; [2]—compared to AD of algal biomass alone; [3]—compared to AD of food waste alone; [4]—ultimate biogas yield; [5]—compared to AD of piggery slurry alone; [6]—compared to AD of glycerol alone; WAS—waste activated sludge; PS—primary sludge.

Table B4 Methane potential of different raw organic waste

Substrate	Methane yield (m^3/Mg VS_{add})	Reference
Sewage sludge	260–460	[18]
Sewage sludge	220	
Sewage sludge	186	
Sewage sludge	143	
Floating sludges (fat)	600–700	
Fat (separators)	700 (1000)	
Grease trap sludge	845–928	
Chlorella sorokiniana	220–280	[19]
Spirulina maxima	250340	
Spirulina dunaliella	120–140	
Scenedesmus obliquus	180	
Macrocystis pyrifera	227–310	
Ascophyllum nodosum	110	
Laminaria saccharina	230	
Laminaria hyperborea	280	
Saccharina latissima	127	
Saccharina latissimi after steam exploded at 130 °C for 10 min	155	
Dunaliella tertiolecta	24[1]	
Dunaliella salina	505[1]	
Nannochloropsis oculata	204[1]	
Sewage sludge	115–300[2]	[20]
Sewage sludge	20–190[3]	
Sewage sludge	93–121[4]	

[1]—mL/g VS; [2]—High-solid anaerobic digestion in continuous bioreactors; [3]—High-solid anaerobic digestion in batch bioreactors; [4]—biogas yield, m^3/Mg $VS_{add.}$

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Nomenclature

AB—algae biomass

AcD—anaerobic co-digestion,

AD—anaerobic digestion

BMP—biochemical methane potential

C/N—carbon to nitrogen ratio,

FAN—free ammonia nitrogen (mg/L),

FCBWiŚ—fizyczne chemiczne badanie wody i ścieków (Physicochemical examination of water and wastewater)

GTS—grease trap sludge,

HSD—honestly significant difference,

IN—inoculum,

LDS—liquid displacement system,

LF—logistic function,

M—mesophilic temperature,

MG—modified Gompertz model,

M-I—sewage sludge standalone,

M-II—algae biomass standalone,

M-III—algae biomass plus sewage sludge,

M-IV—algae biomass plus sewage sludge plus grease trap sludge,

M-V—algae biomass plus sewage sludge plus organic fraction of municipal sewage waste,

N-NH_4^+—ionized ammonium nitrogen (mg/L),

NPOC—non-purgeable organic carbon (g/L),

OFMSW—organic fraction of municipal sewage waste,

P—pressure (Pa),

P_m—potential methane yield (N mL-CH_4/g-VS_{add}),

R_m—maximum rate of methane yield (N mL-CH_4 * g-VS_{add}^{-1} * d^{-1}),

SMEWW—Standard methods for the examination of water and wastewater,

SS—sewage sludge,

STP—standard temperature and pressure, successfully

T—temperature (K),

T—thermophilic temperature,

TC—total carbon (mg/g-TS),

TF—transference function,

TS—total solids (%),

VFA—volatile fatty acids (mg/L),

VS—volatile solids (%),

WWTP—wastewater treatment plant,

Y_B—cumulative specific biogas yield (N mL/g-VS_{add}),

Y_m—cumulative specific methane yield (N mL-CH_4/g-VS_{add}),

λ– lag phase time (d).