Electronic Supplementary Material (ESI) for Environmental Science: Processes & Impacts.

SUPPLEMENTARY INFORMATION

Organic contaminants of emerging concern in Norwegian digestates from biogas production

Aasim M. Ali [,a], Astrid S. Nesse[b], Susanne Eich-Greatorex[b], Trine A. Sogn[b], Stine G. Aanrud[c], John A. Bunæs[c], Jan L. Lyche[c], Roland Kallenborn [a,c,d]*

[a] Faculty of Chemistry, Biotechnology and food Sciences (KBM); Norwegian University of Life Sciences (NMBU), NO-1432 Aas, Norway.

[b] Faculty of Environmental Sciences and Natural Resource Management (MiNa), Norwegian University of Life Sciences (NMBU), NO-1432 Aas, Norway.

[c] Faculty of Veterinary Medicine (VetFak), Norwegian University of Life Sciences (NMBU), NO-0454 Oslo, Norway

[d] University Centre in Svalbard, Arctic Technology, NO-9171 Longyearbyen, Svalbard, Norway

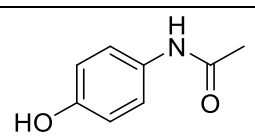
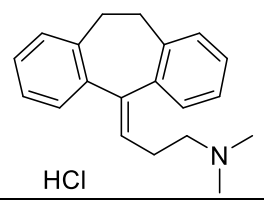
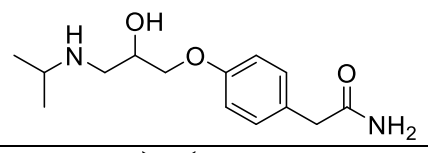
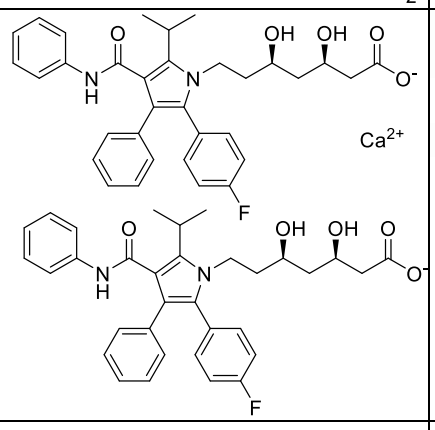
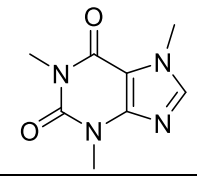
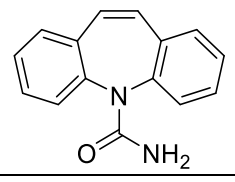
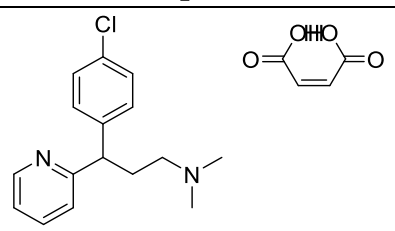
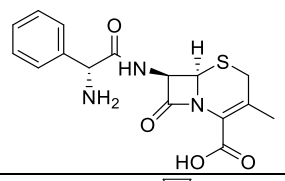
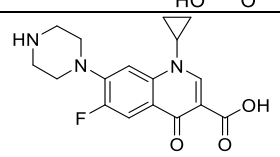
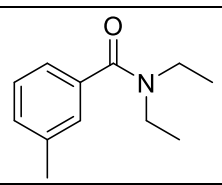
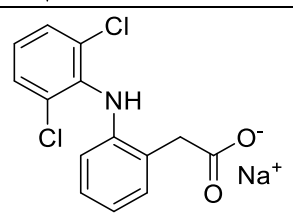
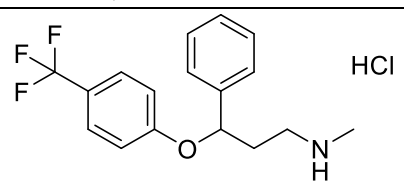
Method description

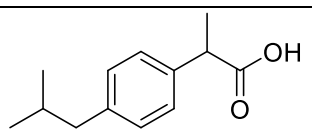
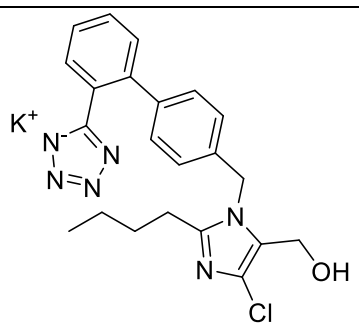
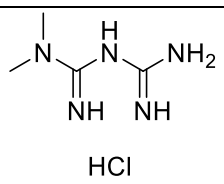
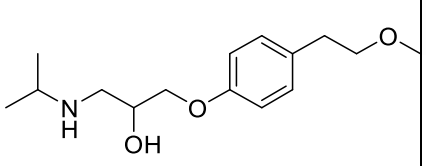
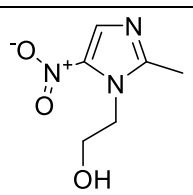
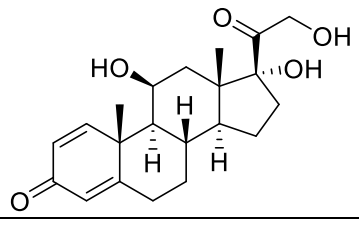
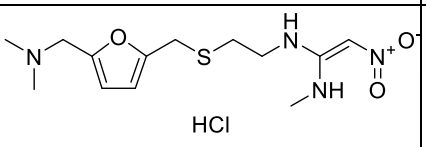
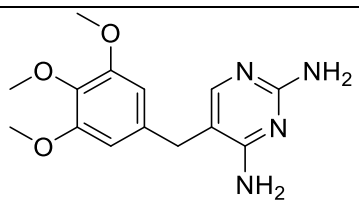
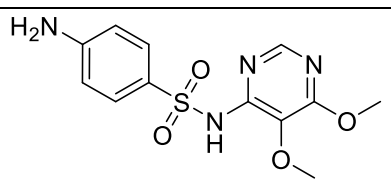
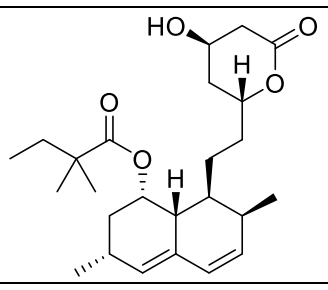
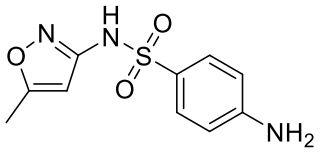
The methods applied for the quantification of targeted analytes for the here reported study was validated and optimised as follows**.**

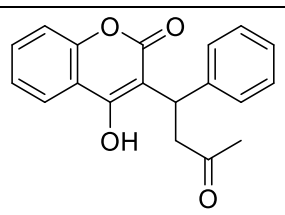
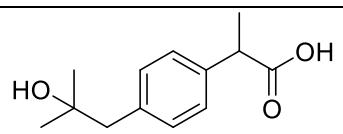
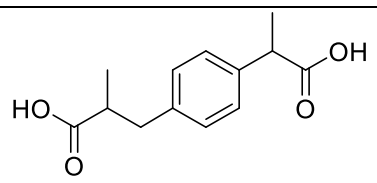
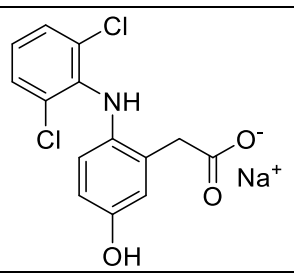
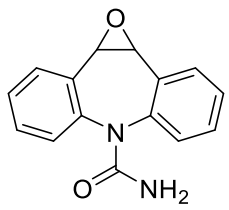
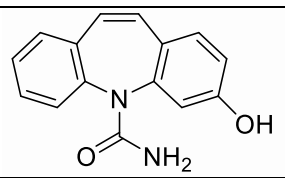
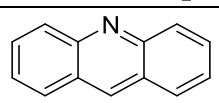
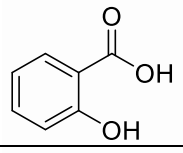
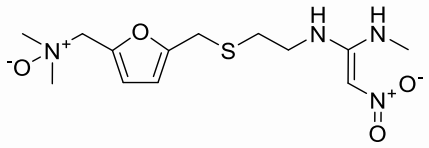
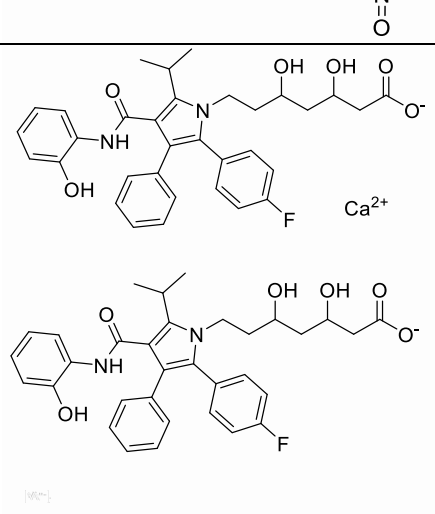
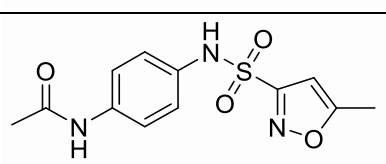
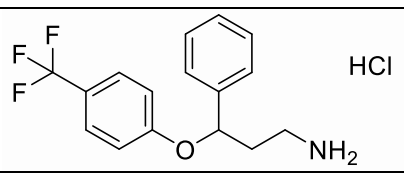
S1. Target substance characterisation

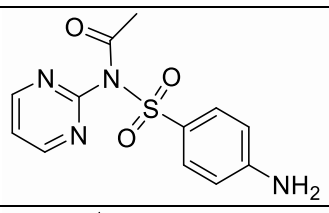
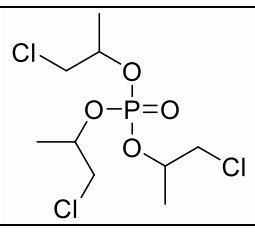
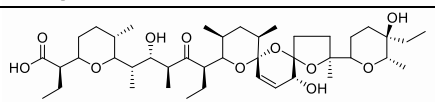
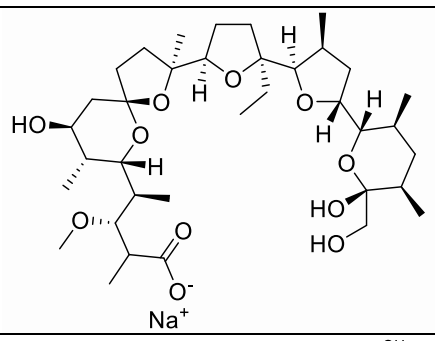
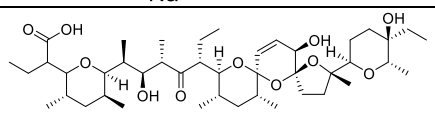
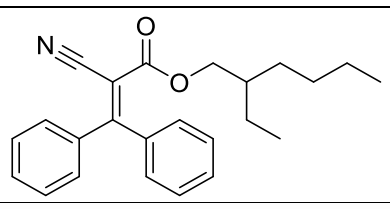
The selection of the compounds for the here performed study was based on their relatively high consumption rate and their previous detection in some environmental samples collected from Norway and the European environment. Table S1 lists the starting list of the selected CECs.

Table S1 : Target chemicals of emerging concern (CECs)

No.	Compound (Abbreviation)	Mol. formula	Structure	CAS Number	LogP*	LogD (pH 7.4)*	$LogK_{OC}$ (pH 7.4)*	Description	Supplier
1	Acetaminophen (ACE)	$C_8H_9NO_2$		103-90-2	0.34	0.40	1.59	nonsteroidal anti-inflammatory	Sigma Aldrich, Oslo, Norway
2	Amitriptyline hydrochloride (AMT)	$C_{20}H_{23}N \cdot HCl$		549-18-8	4.92	2.96	2.18	antidepressant	Sigma Aldrich, Oslo, Norway
3	Atenolol (ATN)	$C_{14}H_{22}N_2O_3$		29122-68-7	0.10	-1.85	0	beta-blocker	Sigma Aldrich, Oslo, Norway
4	Atorvastatin calcium salt trihydrate (ATO)	$C_{66}H_{68}CaF_2N_4O_{10}$		134523-03-8	4.13	1.25	0.64	antilipidemic	Toronto Research Chemicals, Toronto, Canada
5	Caffeine (CAF)	$C_8H_{10}N_4O_2$		58-08-2	-0.13	0.28	1.53	Psychostimulants	Sigma Aldrich, Oslo, Norway
6	Carbamazepine (CAR)	$C_{15}H_{12}N_2O$		298-46-4	2.67	2.28	2.61	anticonvulsant	Sigma Aldrich, Oslo, Norway
7	(±)-Chlorpheniramine maleate salt (CPA)	$C_{16}H_{19}ClN_2 \cdot C_4H_4O_4$		113-92-8	3.39	1.16	1.12	antihistaminic	Sigma Aldrich, Oslo, Norway
8	Cephalexin (CPX)	$C_{16}H_{17}N_3O_4S$		15686-71-2	0.65	-2.83	0	antibiotic	Sigma Aldrich, Oslo, Norway
9	Ciprofloxacin (CIP)	$C_{17}H_{18}FN_3O_3$		85721-33-1	0.65	-2.23	0	antibiotic	Sigma Aldrich, Oslo, Norway
10	*N*,*N*-Diethyl-3-methylbenzamide (DEET)	$C_{12}H_{17}NO$		134-62-3	1.96	2.24	2.59	insect repellent	Sigma Aldrich, Oslo, Norway
11	Diclofenac sodium salt (DCF)	$C_{14}H_{10}Cl_2NNaO_2$		15307-79-6	4.06	1.37	5.07	nonsteroidal anti-inflammatory	Sigma Aldrich, Oslo, Norway
12	Fluoxetine hydrochloride (FLX)	$C_{17}H_{18}F_3NO \cdot HCl$		56296-78-7	4.09	1.75	1.17	antidepressant	Sigma Aldrich, Oslo, Norway

No.	Compound (Abbreviation)	Mol. formula	Structure	CAS Number	LogP*	LogD (pH 7.4)*	$LogK_{OC}$ (pH 7.4)*	Description	Supplier
13	Ibuprofen (IBP)	$C_{13}H_{18}O_2$		15687-27-1	3.75	0.45	0.29	nonsteroidal anti-inflammatory	Sigma Aldrich, Oslo, Norway
14	Losartan potassium (LOS)	$C_{22}H_{22}ClKN_6O$		124750-99-8	3.56	1.29	1.17	Anti-hypertensive	Sigma Aldrich, Oslo, Norway
15	Metformin hydrochloride (MEF)	$NH_2C(=NH)NHC(=NH)N(CH_3)_2 \cdot HCl$		1115-70-4	-2.31	-3.36	0	Antidiabetic	Sigma Aldrich, Oslo, Norway
16	Metoprolol (MTP)	$C_{15}H_{25}NO_3$		37350-58-6	1.79	-0.25	0.28	β-blocker	Sigma Aldrich, Oslo, Norway
17	Metronidazole (MET)	$C_6H_9N_3O_3$		443-48-1	-0.01	0.05	1.40	antibiotic	Sigma Aldrich, Oslo, Norway
18	Prednisolone (PRE)	$C_{21}H_{28}O_5$		50-24-8	1.50	1.66	2.28	Corticosteroid	Sigma Aldrich, Oslo, Norway
19	Ranitidine hydrochloride (RAN)	$C_{13}H_{22}N_4O_3S \cdot HCl$		66357-59-3	1.23	-0.63	0.57	Histamine H_1 and H_2 receptor antagonist	Sigma Aldrich, Oslo, Norway
20	Trimethoprim (TRI)	$C_{14}H_{18}N_4O_3$		738-70-5	0.79	1	1.86	antibiotic	Sigma Aldrich, Oslo, Norway
21	Sulfadoxine (SUL)	$C_{12}H_{14}N_4O_4S$		2447-57-6	0.34	-1.04	0	antibiotic	Sigma Aldrich, Oslo, Norway
22	Simvastatin (SMV)	$C_{25}H_{38}O_5$		79902-63-9	4.41	4.60	3.88	antilipidemic	Chiron AS, Trondheim, Norway
23	Sulfamethoxazole (SMX)	$C_{10}H_{11}N_3O_3S$		723-46-6	0.89	-0.56	0.52	antibiotic	Sigma Aldrich, Oslo, Norway

No.	Compound (Abbreviation)	Mol. formula	Structure	CAS Number	LogP*	LogD (pH 7.4)*	$LogK_{OC}$ (pH 7.4)*	Description	Supplier
24	Warfarin (WAR)	$C_{19}H_{16}O_4$		81-81-2	3.42	0.30	0.26	Anticoagulant	Sigma Aldrich, Oslo, Norway
25	2-hydroxyibuprofen (IBP-OH)	$C_{13}H_{18}O_3$		51146-55-5	1.69	-0.51	0	transformation product of ibuprofen	Sigma Aldrich, Oslo, Norway
26	Carboxy ibuprofen (IBP-Car)	$C_{13}H_{16}O_4$		15935-54-3	1.82	-2.65	0	transformation product of ibuprofen	Sigma Aldrich, Oslo, Norway
27	5-Hydroxydiclofenac (5OH-DCF)	$C_{14}H_{11}Cl_2NO_3$		69002-84-2	3.91	0.96	0.45	transformation product of diclofenac	Sigma Aldrich, Oslo, Norway
28	Carbamazepine 10, 11-epoxide (CAR-1011)	$C_{15}H_{12}N_2O_2$		36507-30-9	1.26	1.31	2.09	transformation product of carbamazepine	Sigma Aldrich, Oslo, Norway
29	3-Hydroxycarbamazepine (CAR-3OH)	$C_{15}H_{12}N_2O_2$		68011-67-6	2.44	2.27	2.61	transformation product of carbamazepine	Sigma Aldrich, Oslo, Norway
30	Acridine (ACR)	$C_{13}H_9N$		260-94-6	3.40	3.34	3.18	transformation product of carbamazepine	Sigma Aldrich, Oslo, Norway
31	Salicylic acid (SA)	$C_7H_6O_3$		69-72-7	2.06	-0.77	0	anti-inflammatory	Sigma Aldrich, Oslo, Norway
32	Ranitidine N-oxide (RAN-O)	$C_{13}H_{22}N_4O_4S$		73857-20-2	-1.54	-0.76	0.96	transformation product of ranitidine	Sigma Aldrich, Oslo, Norway
33	2-Hydroxy Atorvastatin Calcium Salt (2OH-ATO)	$C_{66}H_{68}CaF_2N_4O_{12}$		265989-46-6	4.13	1.05	0.53	transformation product of atorvastatin	Toronto Research Chemicals, Toronto, Canada
34	N-Acetyl Sulfamethoxazole (ACY-SMX)	$C_{12}H_{13}N_3O_4S$		21312-10-7	1.48	-0.28	0.61	transformation product of sulfameth-oxazole	Toronto Research Chemicals, Toronto, Canada
35	Norfluoxetine hydrochloride (NOR)	$C_{16}H_{16}F_3NO \cdot HCl$		57226-68-3	4.36	2.23	1.84	antidepressant	Sigma Aldrich, Oslo, Norway

No.	Compound (Abbreviation)	Mol. formula	Structure	CAS Number	LogP*	LogD (pH 7.4)*	$LogK_{OC}$ (pH 7.4)*	Description	Supplier
36	N-Acetyl Sulfadiazine (ACY-SAD)	$C_{12}H_{12}N_4O_3S$		127-74-2	0.41	-0.86	0.38	transformation product of Sulfadiazine	Toronto Research Chemicals, Toronto, Canada
37	Tris (1-chloro-2-propyl) phosphate, mixture of isomers (TCPP)	$C_9H_{18}Cl_3O_4P$		13674-84-5	0.48	1.42	2.14	flame retardant	Sigma Aldrich, Oslo, Norway
38	Salinomycin (SLM)	$C_{42}H_{70}O_{11}$		53003-10-4	6.10	2.77	1.53	anticoccidial drug	Sigma Aldrich, Oslo, Norway
39	Monensin sodium salt (MON)	$C_{36}H_{61}NaO_{11}$		22373-78-0	3.72	0.45	0.23	anticoccidial drug	Sigma Aldrich, Oslo, Norway
40	Narasin (NAR)	$C_{43}H_{72}O_{11}$		55134-13-9	6.59	3.20	1.76	anticoccidial drug	Sigma Aldrich, Oslo, Norway
41	Octocrylene (OCR)	$C_{24}H_{27}NO_2$		6197-30-4	7.53	6.34	4.82	Sunscreen agents	Sigma Aldrich, Oslo, Norway

All structures were prepared with ChemDraw Professional (version 15.0.0.106), PerkinElmer Informatics, Inc. (Boston, Massachusetts, USA)

* Predicted data is calculated with ACD/Labs Percepta Platform − PhysChem Module, Toronto, CA. (http://www.chemspider.com/Chemical Structure.18219.html).

S.2. Chemicals

Acetonitrile (CH_3CN, HPLC grade) and methanol (MeOH, HPLC grade) were purchased from Sigma-Aldrich and VWR (West Chester, PA, USA). Reagent grade formic acid (CH_2O_2), hydrochloric acid (HCl), disodium ethylene diamine tetra acetate (Na_2EDTA), and ammonium hydroxide (NH_4OH) were purchased from Sigma-Aldrich. The water used was grade 1 purified with a Milli-Q water purification system (Millipore, Bedford, MA, USA).

S.3. Extraction and sample preparation

S.3.1. Extraction of the target compounds from solid digestate: An aliquot of 1.0 g (wet weight, ww) sample of a solid digestate was weighed into 15 mL polypropylene centrifuge tube. Subsequently, 6.0 mL of extraction solution A (MeOH: CH_3CN: Water with 0.1% Na_2EDTA and 0.2% formic acid; 70:20:10) was added into the sample and the mixture was vortexed for 20 s and then the tube was mechanically shaken for 10 min at 1400 rpm using IKA Vibrax VXR vibrator (Janke & Kunkel, Staufen, Germany). The mixture was further ultrasonically extracted for 10 min and then centrifuged for 5 min at 3000 rpm. Subsequently, the supernatant was transferred to another 15 mL polypropylene centrifuge tube. The sample was further extracted with 6.0 mL of extraction solution B (MeOH: CH_3CN: Water 0.1%NaEDTA, 0.2% NH_4OH; 70:20:10). The supernatants were combined and directly passed through an SPE cartridge PRiME HLB (60 mg, 3 mL) and collected. The collected solution was evaporated to dryness under air stream at 40 °C using a Reacti-Therm III evaporating unit (Thermo Fisher Scientific Inc., Rockford, USA). After addition of recovery standard (10 µg/mL, 2.5 µL), the residue was dissolved with 20 % CH_3CN in water until the final volume reached 0.5 mL, and the sample was then vortexed and subsequently filtered through a 0.2 µm microcentrifuge filter (Spin-X, Costar, Corning Inc., Corning, NY, USA). The resulting sample was finally transferred to polypropylene vials for quantitative LC–MS/MS analysis.

S.3.2. Extraction of the target compounds from liquid digestate: Aliquots*:* An aliquot of 2.0 mL of a liquid digestate sample was pipetted into 15 mL polypropylene centrifuge tube. Subsequently, 4.0 mL of extraction solution A was added, and the mixture was vortexed for 20 s. Subsequently, the tube was mechanically shaken for 10 min at 1400 rpm using an Vibrax VXR vibrator (IKA, Janke & Kunkel, Staufen, Germany). The mixture was further ultrasonically extracted for 10 min and then centrifuged for 5 min at 3000 rpm. Subsequently, the supernatant was transferred to a clean 15 mL polypropylene centrifuge tube. The extraction was repeated again using 4.0 mL of extraction solution B. The supernatants were combined, evaporated until the volume reached approximately 3 mL, 6.0 mL of Milli Q water was added, and the resulting solution was then directly loaded onto a SPE cartridge with PRiME HLB (60 mg, 3 mL) as adsorbnet. SPE was conducted by applying a low vacuum to the manifold (water jet), assuring a flow rate of 1- 3 drops per second. The cartridges were then washed with 2 mL of 5% MeOH in water and dried under low vacuum for 10 min. Elution was performed with 3.0 mL of (CH_3CN:MeOH; 9:1). The resulting eluates were evaporated to dryness under a gentle air stream (O_2, 5.0 quality, AGA, Oslo, Norway) at 40 °C using a Reacti-Therm III evaporating unit (Thermo Fisher Scientific Inc., Rockford, USA). After addition of the recovery standard (10 µg/mL, 2.5 µL), the residue was dissolved with 20 % CH_3CN in water until the final volume reached 0.5 mL, and the sample was then vortexed and subsequently filtered through a 0.2 µm microcentrifuge filter (Spin-X, Costar, Corning Inc., Corning, NY, USA) prior to quantification. The resulting sample was finally transferred to a polypropylene vial for immediate quantitative LC–MS/MS analysis.

S.4. High Performance Liquid chromatography (HPLC)

The quantitative determination all targeted analytes was performed on an Agilent 1200 series HPLC (Agilent Technologies, Waldbronn, Germany). The analytical column used for chromatographic separations was a Zorbax Eclipse plus C_{18} RRHD (2.1 x 100 mm, 1.8 µm) (Agilent, Palo Alto, USA) with a respective Guard Cartridge (4 µm x 3.0 mm ID) (Zorbax, Agilent, Palo Alto, USA). The column temperature was held isothermal at 25 ˚C. The injection volume was 10 µL. Separations were performed using a binary gradient with mobile phase consisting of water with 0.1% formic acid (A) pure CH_3CN (B) with a mobile phase flow rate of 0.35 mL/min (v:v). The initial mobile phase proportion was 100 % (A). B was then linearly increased to 100 % over 8 min and held for 7 min. Initial mobile phase conditions were restored over 1.0 min and the column was allowed to equilibrate for 4 min resulting in a total run time of 20 min. Combined chromatograms of the MRM transition for the product ions for each analyte are shown in Figure S1.

S.5. Electrospray ionization Mass spectrometry

An Agilent 6460 (Agilent Technologies, Santa Clara, CA, USA) triple quadrupole mass spectrometer with an Agilent Jet Stream electrospray ion source was used for the detection and quantitative analysis. The ions were monitored in positive and negative dynamic multiple reaction monitoring (dMRM). The ion source parameters are shown in Table S2. Table S3 contains information on the ion transitions monitored and their individual settings. Agilent MassHunter software (Version B.07.00 /Build 7.0.457.0, 2008) was used for instrument control, method validation and quantification.

Table S2: Ion source Parameters

Table 2 Ion source Parameters

Parameter	Value (+)	Value (-)
Gas Temp (°C)	320	320
Gas Flow (l/min)	10	10
Nebulizer (psi)	35	35
Sheath Gas Heater	390	390
Sheath Gas Flow	12	12
Capillary (V)	4000	3500

Table 3 Monitored ion transitions and their individual instrument settings; Precursor ion (Prec Ion), product ion (PI), Fragmentor voltage (FV), Collision Energy (CE), Retention time (RT), Retention time Window (RTW), and Polarity. For abbreviations and structure information on the target compounds, see table S1.

For abbreviations of CECs please consult table S1. <MLOQ: below method quantification limit, n.d. = not detected, <MLOD = below method detection limit.

Peak No	Compound Name	Prec Ion	PI	RT (min)	ΔRT	Frag (V)	CE	Polarity
1	MEF	130	71	0.76	2	60	20	+
1	MEF	130	60	0.76	2	60	20	+
2	ATN	267.2	190	1.4	2	80	20	+
2	ATN	267.2	145	1.4	2	80	30	+
3	RAN	315.1	170	1.6	2	60	10	+
3	RAN	315.1	130	1.6	2	60	20	+
4	RAN-O	331.1	176	1.8	2	90	20	+
4	RAN-O	331.1	130	1.8	2	90	30	+
5	ACE	152	110	2	3	60	15	+
5	ACE	152	65.1	2	3	60	35	+
6	MET	172	128	2	2	60	10	+
6	MET	172	82	2	2	60	25	+
7	CAF	195	138	4	2	110	20	+
7	CAF	195	110	4	2	110	30	+
8	$^{13}C_3$-CAF	198.2	140.2	4	2	110	20	+
8	$^{13}C_3$-CAF	198.2	112	4	2	110	20	+
9	CPX	348.1	174	4.3	2	70	15	+
9	CPX	348.1	158	4.3	2	70	5	+
9	CPX	348.1	106	4.3	2	70	20	+
10	$^{2}H_9$-TMP	300.3	264	4.3	2	80	30	+
10	$^{2}H_9$-TMP	300.3	243.1	4.3	2	80	30	+
10	$^{2}H_9$-TMP	300.3	122.9	4.3	2	80	30	+
11	TMP	291.5	261.1	4.3	2	100	25	+
11	TMP	291.5	123.2	4.3	2	100	25	+
12	ACY-SAD	293.1	198	4.4	2	100	20	+
12	ACY-SAD	293.1	134.2	4.4	2	100	30	+
12	ACY-SAD	293.1	65.2	4.4	2	100	35	+
13	ACR	180.1	152	4.5	2	70	60	+
14	CIP	332	288	4.6	2	80	20	+
14	CIP	332	245	4.6	2	80	30	+
15	MEP	268.3	116.2	5	2	70	20	+
15	MEP	268.3	98.1	5	2	70	20	+
15	MEP	268.3	74.1	5	2	70	20	+
16	$^{2}H_7$-MEP	275.3	191	5	2	100	20	+
16	$^{2}H_7$-MEP	275.3	121	5	2	100	20	+
16	$^{2}H_7$-MEP	275.3	105.2	5	2	100	20	+
17	CPA	275	230	5.3	2	60	10	+
17	CPA	275	167	5.3	2	60	30	+
18	$^{2}H_5$-Enrofloxacin	365	347	5.5	2	250	20	+

Table S3 continue

Peak No	Compound Name	Prec Ion	PI	RT (min)	ΔRT	Frag (V)	CE	Polarity
18	$^{2}H_5$-Enrofloxacin	365	321	5.5	2	250	20	+
18	$^{2}H_5$-Enrofloxacin	365	245	5.5	2	250	30	+
19	SUL	311	156.1	5.8	2	90	20	+
19	SUL	311	108	5.8	2	90	30	+
19	SUL	311	92.1	5.8	2	90	30	+
20	$^{2}H_3$- SUL	314.1	156	5.8	2	60	20	+
20	$^{2}H_3$- SUL	314.1	108	5.8	2	60	30	+
20	$^{2}H_3$- SUL	314.1	92.1	5.8	2	60	30	+
21	SMX	254	156	6	2	90	10	+
21	SMX	254	108	6	2	90	20	+
21	SMX	254	92	6	2	90	30	+
22	$^{13}C_6$-SMX	260	162	6	2	40	10	+
22	$^{13}C_6$-SMX	260	114	6	2	40	20	+
22	$^{13}C_6$-SMX	260	98	6	2	40	30	+
23	ACY-SMX	296.1	198	6.1	2	100	20	+
23	ACY-SMX	296.1	134	6.1	2	100	30	+
23	ACY-SMX	296.1	65	6.1	2	100	30	+
24	$^{2}H_4$-N-acetyl SMX	300.1	201.8	6.1	2	100	20	+
24	$^{2}H_4$-N-acetyl SMX	300.1	138	6.1	2	100	30	+
24	$^{2}H_4$-N-acetyl SMX	300.1	69	6.1	2	100	50	+
25	CAR-10,11	253.1	236.1	6.19	2	90	10	+
25	CAR-10,11	253.1	180.1	6.19	2	90	30	+
26	SA	137	93	6.19	2	90	20	-
26	SA	137	65	6.19	2	90	35	-
27	CAR-3OH	253.1	210.1	6.2	2	100	20	+
27	CAR-3OH	253.1	167.1	6.2	2	100	30	+
28	PRE	361.1	325.1	6.4	2	80	10	+
28	PRE	361.1	146.7	6.4	2	80	30	+
29	IBP-OH	221.2	177.1	6.48	2	100	10	-
29	IBP-Car	235.1	191	6.5	2	100	0	-
29	IBP-Car	235.1	73	6.5	2	100	30	-
30	AMT	278.2	105	6.7	3	40	20	+
30	AMT	278.2	91	6.7	3	40	30	+
31	NOR	296.2	134.2	6.7	2	100	10	+
31	NOR	296.2	105	6.7	2	100	10	+
32	CBZ	237	194	6.8	2	70	15	+
32	CBZ	237	179	6.8	2	70	35	+
33	$^{2}H_{10}$-Car	247.1	204.1	6.84	2	125	20	+
33	$^{2}H_{10}$-Car	247.1	187.1	6.84	2	125	40	+
33	$^{2}H_{10}$-Car	247.1	174.1	6.84	2	125	50	+
34	ATO	559.2	440.1	7	2	135	20	+
34	ATO	559.2	292.1	7	2	135	40	+
34	ATO	559.2	250	7	2	135	50	+
35	LOS	423.2	404.9	7.2	2	100	10	+
35	LOS	423.2	377	7.2	2	100	10	+
35	LOS	423.2	207	7.2	2	100	30	+
36	$^{2}H_{10}$-DEET	202.2	119	7.4	2	80	20	+
36	$^{2}H_{10}$-DEET	202.2	91.1	7.4	2	80	30	+
37	DEET	192	119	7.5	2	120	20	+
37	DEET	192	91	7.5	2	120	30	+
38	5OH-DCF	312	294	7.7	3	125	10	+
38	5OH-DCF	312	230.1	7.7	3	125	30	+
39	FLX	310	148	8	2	100	10	+
39	FLX	310	117	8	2	100	20	+
40	WAR	307.2	161	8.4	2	80	15	-
40	WAR	307.2	117.1	8.4	2	80	30	-
41	2OH-ATO	575.2	466.1	8.5	2	125	10	+
41	2OH-ATO	575.2	440	8.5	2	125	30	+

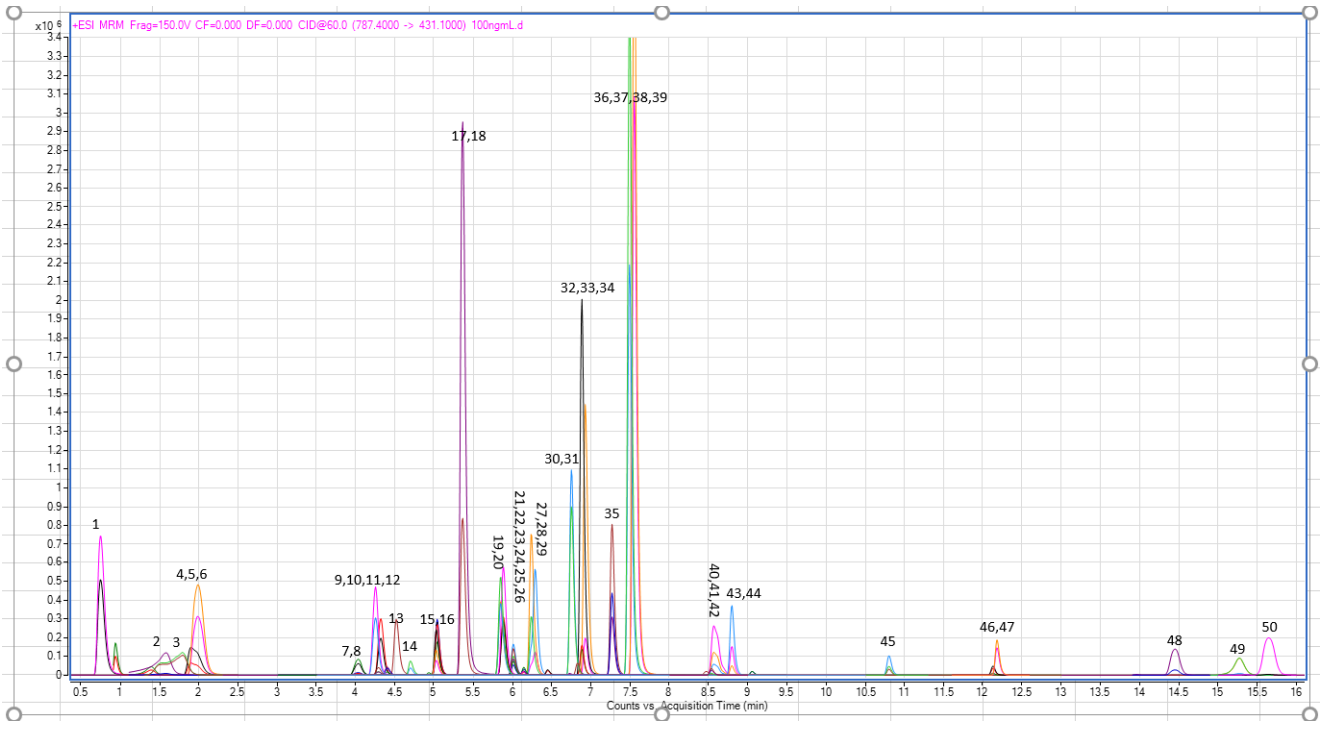


Figure S1.Typical combined MRM chromatograms of the target analytes with their respective internal standards. Individual peak assignments are listed in Table S3.

S.6. Quality control and calibration

S.6.1. Calibration: Matrix match and solvent matched calibration curves for targeted analytes and their calibration criteria of the method are shown in Table S4 in comparison. Calibration curves of five concentration levels (10, 20, 50, 80, and 100 ng/mL) were prepared for all isotope-labeled internal standards;$^{13}C_3$-CAF, $^{2}H_9$-Trimethoprin, $^{2}H_7$-Metoprolol, $^{2}H_3$-Sulfadoxine-d3, $^{13}C_6$-SMX, $^{2}H_4$-N-acetyl SMX, $^{2}H_{10}$-CBZ, $^{2}H_{10}$-DEET, $^{2}H_{15}$-Octocrylene and applying $^{2}H_5$-Enrofloxacin at concentration of 50 ng/mL as a recovery standard. The percentage recovery of internal standards was calculated based on these calibration curves.

S.6.2. Detection limits: The method detection limit (MDL) is defined as the minimum analyte concentration that can be detected and identified with a 99% confidence that its concentration is greater than zero [1]. MDL was calculated by multiplying the standard deviation of 5 spiked digestate samples at concentration of 5 and 10 ng/mL by student-t-test at the appropriate degree of freedom, the spiked samples were prepared and analysed according to the above described methods. The instrumental limit of detection (LOD) and limit of quantification (LOQ) were determined as LOD = 3*S/M and LOQ = 10*S/M, where S is signal standard deviation obtained by injecting solutions with a concentration of 5 ng/mL seven times, and M is the slope of the calibration curve[2].

S.6.3. Matrix effect: Matrix effect (ME %) was estimated using the following equation, where Sm and Ss are the slope of the matrix matched and solvent matched calibration curves respectively.

$$ME\% = \left[\left(\frac{Sm}{Ss}\right) - 1\right] \times 100$$

Positive ME% values indicate signal enhancement and negative values indicate ion suppression by the matrix. In general, ME% values ranging from −20% to +20% indicate acceptable matrix effect, while ME values <−20% or >+20% indicate significant matrix effects. Thus, in liquid digestate all compounds except ranitidine, narasin, and monesin experienced a significant matrix affect as shown in Table S6. Similarly, in solid digestate samples, all compounds experienced a significant matrix affect as shown except warfarin, fluoxetine and cephalexin (see table S5).

Table 4 Matrix match and solvent matched calibration curves. For abbreviations and structure information on the target compounds, see table S1

Compound	ISTD	Retention Time (min)	Conc. range (ng/mL) Solvent	R^{2**}	Conc. range (ng/mL) Solid digestate	R^2	Conc. range (ng/mL) Liquid digestate	R^2
2OH-ATO	$^{2}H_{10}$-DEET	8.5	0.2-500 (10)	0.993	0.2-500 (8)	0.991	0.5-300(7)	0.993
CAR-3OH	$^{2}H_{10}$-CBZ	6.2	0.2-200 (7)	0.997	0.5-500 (10)	0.990	0.2-300 (7)	0.994
5OH-DCF	$^{2}H_{10}$-DEET	7.7	5-600 (8)	0.994	1-500 (6)	0.992	10-500(5)	0.990
ACE	$^{2}H_{10}$-CBZ	2.0	0.2-200 (9)	0.995	25-100 (5)	0.979	0.5-500 (10)	0.975
ACR	$^{2}H_{9}$-TMP	4.5	0.2-500 (9)	0.994	0.2-500 (9)	0.996	0.2-500 (8)	0.982
AMT	$^{2}H_{10}$-DEET	6.7	0.2-500 (7)	0.995	0.2-200 (7)	0.994	0.2-500(6)	0.999
ATN	$^{13}C_{3}$-CAF	1.4	0.2-500 (10)	0.996	1-300 (7)	0.989	0.2-300 (8)*	0.991
CAF	$^{13}C_{3}$-CAF	4.0	0.2-500 (9)	0.994	0.2-500 (9)	0.992	0.2-500 (7)	0.986
IBP-Car	$^{2}H_{10}$-CBZ	6.5	5-600 (9)*	0.992	0.2-300 (5)	0.998	25-500(5)	0.986
CAR	$^{2}H_{10}$-CBZ	6.8	0.2-500 (11)	0.994	0.2-300 (7)	0.992	0.2-500 (10)	0.995
CAR-10,11	$^{2}H_{10}$-CBZ	6.1	0.2-200 (9)	0.990	0.2-500 (9)	0.994	0.2-300 (7)	0.997
CPX	$^{2}H_{9}$-TMP	4.3	1-600 (9)	0.994	1-500 (8)	0.993	5-500 (7)	0.984
CPA	$^{2}H_{3}$- SUL	5.3	0.2-300 (8)	0.997	25-600 (6)	0.980	0.5- 500 (7)	0.990
CIP	$^{2}H_{9}$-TMP	4.6	0.2-500 (11)	0.980	5-500 (6)	0.992	25-500 (5)	0.996
DCF	$^{2}H_{10}$-DEET	9.0	1-600 (8)	0.993	25-600 (5)	0.983	25-500 (4)*	0.999
DEET	$^{2}H_{10}$-DEET	7.5	0.2-100 (7)	0.990	0.2-600 (10)	0.995	0.2-500 (8)	0.995
FLX	$^{2}H_{10}$-DEET	8.0	0.2-500 (10)	0.994	5-500 (8)	0.99	5-500 (5)	0.990
IBP	$^{2}H_{10}$-DEET	5.0	50-600 (6)	0.992	-	-	25-500 (3)	0.985
LOS	$^{2}H_{10}$-DEET	7.2	0.2-200 (9)	0.991	0.2-600 (8)	0.993	25-500 (5)	0.993
MEF	$^{13}C_{3}$-CAF	0.76	0.2-100 (8)	0.996	0.5-200 (6)	0.995	0.2-300 (7)	0.980
MTP	$^{2}H_{7}$-MEP	5.0	0.2-500 (11)	0.994	0.2-500 (7)	0.994	5-300 (5)	0.978
MET	$^{13}C_{3}$-CAF	2.0	0.2-100 (7)	0.993	1-200 (5)	0.999	0.2-300(6)	0.997
MON	$^{2}H_{10}$-DEET	15.2	0.2-600 (6)	0.995	10-600 (5)*	0.987	0.2-500 (8)	0.999
ACY-SMX	$^{2}H_{4}$-N-acetyl SMX	6.1	0.5-500 (9)	0.993	25-500 (5)	0.989	25-500 (4)	0.996
ACY-SAD	$^{2}H_{7}$-MEP	4.4	0.2-300 (8)	0.990	5-600 (7)	0.992	5-500 (5)	0.996
NAR	$^{2}H_{10}$-DEET	15.5	0.2-100 (6)*	0.994	0.2-200 (5)*	0.986	1-500 (6)	0.975
NOR	$^{2}H_{10}$-DEET	6.7	1-500 (9)	0.997	5-300 (6)	0.991	5-500 (6)*	0.991
OCR	$^{2}H_{10}$-DEET	12.1	0.5-500 (6)	0.995	0.2-600 (6)	0.989	0.2 -500 (8)	0.997
PRE	$^{2}H_{10}$-DEET	6.4	0.5-100 (7)	0.987	25-500 (5)	0.996	5-500(6)	0.985
RAN	$^{2}H_{7}$-MEP	1.6	0.2-500 (11)	0.994	0.2-500(9)	0.997	0.2-500 (8)	0.993
RAN_O	$^{13}C_{3}$-CAF	1.9	0.2-200 (9)	0.992	0.5-600 (9)	0.990	0.2-500 (9)	0.990
SUL	$^{2}H_{7}$-MEP	5.8	0.2-200 (9)	0.993	5-500 (6)	0.996	5-500 (6)	0.986
SA	$^{2}H_{10}$-DEET	6.19	5-300 (6)	0.995	10-600 (4)	0.986	0.5-500 (8)*	0.990
SLM	$^{2}H_{10}$-DEET	14.4	0.2-500(5)	0.991	25-600 (6)	0.980	0.2-500 (8)	0.989
SMV	$^{2}H_{10}$-DEET	10.8	0.2-200 (6)	0.988	1-200 (5)*	0.993	10-500 (4)	0.978
SMX	$^{2}H_{4}$-N-acetyl SMX	6.0	0.2-500 (11)	0.994	5-500 (6)	0.995	5-500 (6)	0.980
TCPP	$^{2}H_{10}$-DEET	8.5	0.2-500 (11)	0.990	0.5-500 (7)	0.995	0.2-500(6)	0.992
TMP	$^{2}H_{9}$-TMP	4.3	0.2-500 (10)	0.991	1-500 (10)	0.991	5-500 (7)	0.987
WAR	$^{2}H_{10}$-DEET	8.4	0.5-500 (10)	0.982	5-500 (6)	0.991	1-500(6)	0.990

*Quadratic

**R^2 = Regression coefficient

Table 5 Matrix effect (ME %) values are color-coded (red: ion suppression, blue: signal enhancement, blank: no matrix effect). For abbreviations and structure information on the target compounds, see table S1.

Compound	ME % in liquid Digestate	ME% in solid Digestate
MEF	-68	-59
ATN	-55	-88
RAN	0	-59
RAN-O	-33	-76
ACE	-93	-94
MET	29	-72
CAF	-61	-81
CPX	98	224
ACY-SAD	-62	-52
TMP	-78	-87
ACR	-74	-70
CIP	-95	-79
MEP	-66	-69
SUL	-93	-88
SMX	-87	-79
CPA	-60	-80
ACY-SMX	-94	-77
NOR	-94	-80
SA	-71	-28
CAR-10,11	-81	-74
CAR-3OH	-85	-68
PRE	-98	-87
IBP-Car	-80	-55
IBP	-100	-100
CAR	-68	-64
IBP-OH	-85	-60
AMT	-94	-33
FLX	-98	0.6
LOS	-86	-75
DEET	-70	-60
5OH-DCF	-85	-56
ATO	-100	-100
WAR	-23	4
2OH-ATO	-67	-25
TCPP	-79	-85
DCF	-26	-45
SMV	-91	-78
OCR	-99	-98
SLM	79	-75
MON	7	-40
NAR	2	-57

The apparent recoveries for all analytes were also calculated using the following equation:

$$\text{Apparent Recovery}\% = 100 * \frac{\text{Calculated concentration of spiked sample} - \text{Calculated concentration of matrix blank}}{\text{Spiked concentration}}$$

A spiked sample is prepared by addition of a known concentration of native and internal standards before extraction to the matrix blank material before extraction and then the spiked sample was treated as real sample, and the concentration of the analytes in the spiked samples and blank was using matrix matched calibration graphs.

S.7. Method validation and quality control

The complete method for sample preparation procedure and quantitative analysis was subjected for comprehensive validation before the method was applied for quantitative analysis. The linear quantification range of the analytical instrument was confirmed with matrix-matched calibration.

Method validation: Extraction and clean-up

For complex matrices, such as biogas digestates, matrix matched calibration is mandatory in addition to efficient clean-up procedures as basis for high quality quantification of organic contaminants. In our studies a Hydrophilic – Lipophilic Balanced (HLB) solid phase extraction method was applied since this material proved to be well-suitable for sample preparation for multi-compound quantification in such complex matrices [3]. Sodium ethylene diamine tetra acetate-acetic (Na_2EDTA) was added during extraction in order to bind metals that may be present in the sample extract or adsorbed onto the surface of the sorbent [4]. Confirmed by earlier studies, free metal traces may covalently bind to target organic contaminants and, thus, significantly reduce their recoveries for quantitative analysis[5, 6].

As a part of the extraction method optimization, Oasis PRiME HLB was tested in two different modes, namely two- step clean-up (*pass-through*) and conventional three- step clean-up (*Catch and Release*) for solid and liquid digestate respectively. Furthermore, the effect of

sample size and acidification on matrix effect and recovery of target compounds were investigated for the optimum extraction of the target compounds. Based on the low matrix effect and good recovery of the target compounds, the two extraction methods (figure S2) were selected as optimal for the extraction of target compounds from solid and liquid digestate samples. The finally chosen method was based on 1g solid wet weight (ww) and 2 mL liquid samples, respectively, prepared for SPE with OASIS PRiME HLB as stationary phase. Please refer to the detailed description of extraction methods in section S3. The finally applied sample extraction and preparation methods for quantitative analysis are summarised in the flow chart in Figure S2.

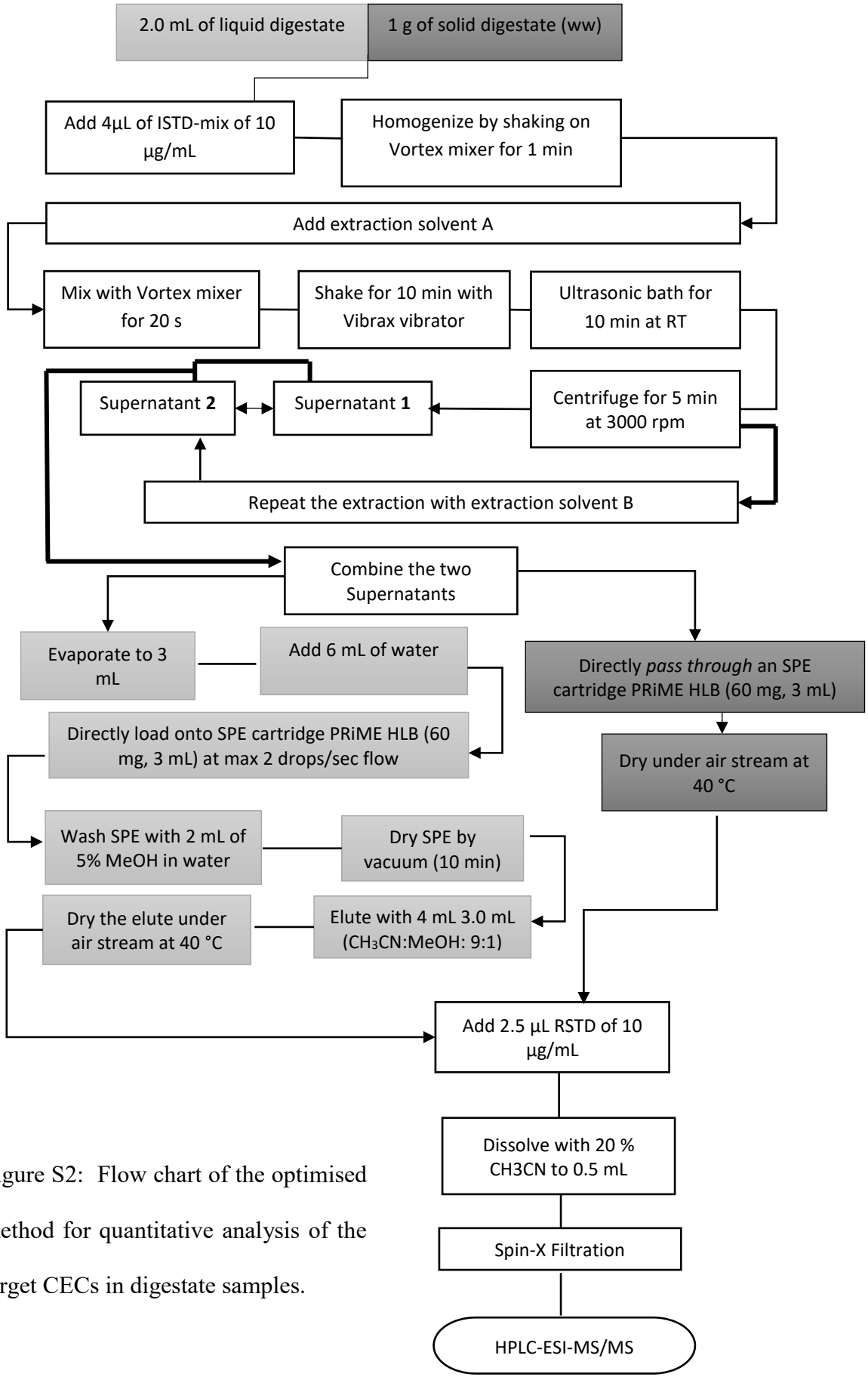


Figure S2: Flow chart of the optimised method for quantitative analysis of the target CECs in digestate samples.

Analytical method validation and quality control

The ultra-trace quantification method is based on high-performance liquid chromatography coupled to a triple-quadrupole mass selective detector with electrospray ionization (HPLC–ESI-MS/MS). This analytical technology is a well-established, validated and considered as a versatile scientific tool for the quantitative trace level detection of polar environmental contaminants. However, for the HPLC-ESI-MS/MS quantification method, non-linear matrix effects (ME) are often reported. MEs are usually attributed to co-eluting residual matrix components that affect the ionization efficiency of the target compounds. Typically, this results in either non-linear suppression or enhancement of target compound signal[7]. MEs are generally not reproducible or repeatable between various sample batches or even replicates of the same sample and, thus, compromise the quantitative analysis if not appropriately assessed [8, 9]. Therefore, the evaluation of MEs was also integrated in the quality control protocol of this study. In fact, for the present applied methods, considerable MEs were found for the quantification of the majority of the CECs. Thus, matrix-matched calibration was conducted using an experimental digestate prepared from a representative mixture of substrates in order to confirm the linear range of the method for reliable quantification (Table S4). For details on the evaluation, please refer to the detailed description in section S6.

All target analytes were separated in single chromatographic runs within a total analysis time of 20 min as depicted in Figure S1 (HPLC/MSxMS quantification). Method detection limit (MDL) in liquid and solid digestate, instrumental limit of detection (LOD), and instrumental lower limit of quantification (LOQ) values are summarised in Table S6. Instrument limits of quantification ranged from 0.2 pg/ mL^{-1} to 3.0 ng/mL^{-1}. For liquid digestate, MDL values for most compounds ranged from 0.25 to 20.55 ng/g while for solid digestate MDL values for most compounds are in the range 0.09 to 49.05 ng/g. The procedure for recovery calculation is summarised in Section S6 in the supplementary information. All individual target CEC recoveries are listed in Table S7. In total, 28 compounds in liquid digestates and 24 compounds in solid digestates showed satisfying recoveries (42 – 120%) in the initial method

validation. In the following spiking experiments, Atorvastatin, Ciprofloxacin (CIP), Sulfamethoxazole, N-acetyl sulfamethoxazole, Salicylic acid, Fluoxetine, Simvastatin, and Narasin were, however, not recovered in liquid samples and were therefore excluded from further quantitative analysis. For solid samples, CIP and Ranitidine *N*-oxide were not recovered from spiked solid samples and were, thus, also excluded from further quantitative analysis. All compounds which met the quality control criteria for final quantification in both liquid and solid digestate samples are marked orange in Table S7. Sample specific recovery rates for all internal standards (ISTD) from liquid and solid digestate samples were calculated applying known concentrations of $^{2}H_5$-enrofloxacin as a recovery standard. The recovery results are summarised in Table S7. The isotope labelled standards $^{2}H_3$-Sulfadoxine, $^{13}C_6$-Sulfamethoxazole and $^{2}H_{10}$-Octocrylene were excluded as internal standards for quantification since they were lost or showed low recovery rates during sample preparation and extraction (table S8). Therefore, Sulfadoxine, Sulfamethoxazole and Octocrylene were quantified in all digestate samples using the alternative internal standards as $^{2}H_7$-Metoprolol, 2H4-N-acetyl SMX and $^{2}H_{10}$-DEET, respectively.

Table 6: Method detection limit (MDL), instrumental limit of detection (LOD), and limit of quantification (LOQ). For abbreviations and structure information on the target compounds, see table S1

Compound	MDL (ng/g) in Solid Digestate	MDL (ng/mL) in Liquid Digestate	LOD (pg/µL)	LOQ (pg/µL)
MEF	4.95	0.45	0.01	0.04
ATN	2.5	2.8	0.01	0.04
RAN	1.35	1.1	0.01	0.03
RAN-O	0.04	0.15	0.02	0.08
ACE	44.75	1.3	0.007	0.02
MET	1.1	1.05	0.05	0.17
CAF	1.2	0.7	0.005	0.02
CPX	0.90	0.20	0.009	0.03
ACY-SAD	0.95	1.25	0.01	0.05
TRM	1.80	0.40	0.92	3.00
ACR	2.15	0.65	0.005	0.01
CIP	0.80	0.70	0.03	0.12
MEP	7.05	1.20	0.01	0.06
SUL	2.2	2.10	0.003	0.01
SMX	1.45	8.15	0.01	0.02
CPA	0.09	7,00	0.01	0.05
ACY-SMX	9.10	2.60	0.01	0.05
NOR	11.3	13.35	0.01	0.05
SAA	70.3	8.55	0.03	0.09
CAR-10,11	1.20	0.32	0.01	0.02
CAR-3OH	1.25	0.70	0.02	0.08
PRE	16.90	20.55	0.01	0.04
IBP-Car	18.75	3.45	0.03	0.12
IBP	66.40	66.40	17.5	58.6
CAR	3,00	0.745	0.03	0.11
IBP-OH	128.55	118.25	0.07	0.24
AMT	5.90	0.62	0.01	0.04
FLX	2.30	5.80	0.04	0.16
LOS	20.45	1.15	0.003	0.01
DEET	1.10	0.25	0.01	0.05
5OH-DCF	49.05	2,00	0.01	0.05
ATO	12.15	221.95	0.005	0.02
WAR	3.60	0.45	0.06	0.21
OH-ATO	57.4	0.60	0.01	0.03
TCPP	97.5	7.45	0.01	0.03
DCF	24.7	3.60	0.07	0.23
SMV	4.90	0.60	0.004	0.01
OCR	62.25	10.10	0.004	0.013
SLM	0.12	0.85	0.01	0.03
MON	0.35	3.40	0.02	0.06
NAR	0.13	7.95	0.25	0.85

Table 7. Recovery rates for all target compounds determined by repeated spiking of liquid and solid digestate sample. RSD = Relative standard deviation. For abbreviations and structure information on the target compounds, see table S1.

Compound/ concentration	**Recovery from liquid ± RSD (%, n = 6)**		**Recovery from solid ± RSD (%, n = 6)**
	25 ng/g	**100 ng/g**	**100 ng/g**
Metformin	5.7±22.0	6.6±19.1	83.6±13.9
Atenolol	83.8±11.8	84.7±15.0	82.4±15.0
Ranitidine	48.3±9.9	77.6±14.5	75.5±9.4
Ranitidine-*N*-oxide	2.7±13.8	5.10±10.0	0.2±109.9
Acetaminophen	66.2±8.8	25.1±21.8	136.8±7.8
Metronidazole	88.2±14.4	96.7±15.0	78.6±14.8
Caffeine	76.5±9.8	97.8±3.7	119.8±13.7
Cephalexin	2.0±33.5	1.7±8.5	42.5±3.6
N-acetyl sulfadiazine	2.5±138	11.7±29.8	96.1±14.8
Trimethoprim	75.6±14.5	88.8±11.4	68.9±10.5
Acridine	68.5±16.5	79.4±22.4	59.9±14.2
Metoprolol	80.5±7.7	98.1±12.9	99.6±13.1
Sulfadoxine	83.0±11.2	89.5±12.5	114.0±13.2
Chlorphenamine	5.9±42.2	14.1±47.6	2.6±110.2
Norfluoxetine HCL	54.2±18.9	3.23±31.1	108.4±15.0
CBZ-*10,11*-epoxide	85.2±7.2	89.3±13.3	96.8±14.0
3-hydroxy carbamazepine	83.2±9.5	87.4±14.1	86.8±14.0
Prednisolone	194.9±7.2	93.2±12.2	65.1±15.6
Carboxy-ibuprofen	42.2±1.3	7.3±55.5	138.4±14.5
carbamazepine	86.8±5.7	93.5±12.7	94.6±12.3
Ibuprofen	116.6±17.3	102.0±29	-

Compound	Recovery from liquid ± RSD (%, n = 6)		Recovery from solid ± RSD (%, n = 6)
	25 ng/g	100 ng/g	100 ng/g
2-hydroxy ibuprofen	156.7±96.2	91.5±38.7	-
Amitriptyline	42.4±16.8	58.3±17.8	44.8±16.8
Losartan	58.3±9.9	89.4±15.0	121.6±14.7
DEET	74.0±14.1	90.3±11.11	82.2±11.9
5-hydroxy diclofenac	28.2±15.0	57.7±12.1	138.8±12.0
WAR	67.1±13.5	68.8±14.4	36.2±51.8
2-hydroxy Atorvastatin	31.3±15.6	47.8±9.5	109.4±17.1
TCPP	67.2±7.3	93.1±14.9	108.6±16.4
Diclofenac	74.5±11.1	87.4±8.7	24.6±33.7
Octocrylene	44.6±29.7	43.4±14.9	50.4±36.9
Salinomycin	39.4±23.4	118.8±17.1	19.2±10.8
Monesin	81.1±11.0	92.3±4.0	10.7±14.9
Narasin	51.7±4.7	83.1±10.9	18.4±13.3
Sulfamethoxazole	-	-	108.8±13.4
N-acetyl sulfamethoxazole	-	-	87.4±13.5
Salicylic acid	-	-	12.4±308
Fluoxetine	-	-	13.8±60.3

Table 8 Sample specific recovery rates of internal standards from liquid and solid digestate samples calculated with solvent matched calibration curves using $^{2}H_5$-Enrofloxacin as a recovery standard. For abbreviations and structure information on the target compounds, see table S1

Compounds	**Average total recovery ±RSTD (%)**	**Average total recovery ±RSTD (%)**
$^{13}C_3$-CAF	63.1±19.6	52.3±9.0
$^{2}H_9$-Trimethoprin	207.8±7.4	77.5±15.4
$^{2}H_7$-Metoprolol	78.0±18.8	61.6±5.8
$^{2}H_3$-Sulfadoxine	-	-
$^{13}C_6$-SMX	9.2±67.5	31.49±5.4
$^{2}H_4$-N-acetyl SMX	109.9±18.6	97.0±25.1
$^{2}H_{10}$-CBZ	60.2±42	15.9±17.7
$^{2}H_{10}$-DEET	108.13±30.4	55.5±16.6
$^{2}H_{15}$-Octocrylene	-	-

- : not detected

Table 9 CEC levels in Liquid digestate [µg/L]

Station	$L_{(L)}$ (avg±std)	I_{sub} (avg±std)	$F_{(L)}$ (avg±std)	$I_{(L)}$ (avg±std)	I_{dig} (avg±std)	$C_{(L)}$ (avg±std)	$E_{(L)}$ (avg±std)	$G_{(L)}$ (avg±std)	$A_{(L)}$ (avg±std)
Atenolol	ND	ND	ND	ND	ND	0.34±0.48	0.60±0.11	2.2±0.01	ND
Acetaminophen	6.4±1.1	27.4±4.8	58.6±6.2	2.5±0.7	5.5±1.2	5.1±0.6	4.1±0.7	ND	8.9±0.9
Caffeine	2.1±0.02	10.0±0.85	ND	0.6±0.85	ND	5.5±0.15	1.25±0.1	3.0±0.90	2.3±0.03
Acridine	0.06±0.0001	0.051±0.001	0.06±0.0003	0.35±0.10	0.03±0.001	0.05±0.01	0.14±0.02	0.25±0.03	0.05±0.01
Metoprolol	6.2±0.13	ND	4.9±0.15	10.05±1.0	2.4±0.22	5.6±0.22	10.3±0.2	10.7±0.1	13.3±1.3
Sulfadoxine	ND	ND	ND	ND	ND	1.5±0.4	ND	ND	ND
3-hydroxy carbamazepine	ND	ND	0.11±0.02	0.13±0.005	0.12±0.04	ND	ND	ND	0.14±0.05
Prednisolone	-<LOQ	ND	<LOQ	ND	ND	16.4±2.5	ND	ND	ND
Carboxy-ibuprofen	ND	4.11±0.14	<LOQ	ND	ND	ND	ND	ND	ND
ibuprofen	ND	ND	ND	ND	ND	ND	36±51	ND	26.7±30.5
Carbamazepine	3.5±0.10	0.07±0.03	1.85±0.01	4.3±0.45	0.16±0.05	1.55±0.05	1.5±0.1	3.2±0.3	5.0±0.06
Amytriptyline	ND	ND	0.60±0.05	5.0±4.5	ND	1.4±0.25	1.4±0.60	ND	1.0±0.0005
Losartan	5.3±0.06	ND	6.3±0.05	10.5±0.5	7.7±0.03	6.0±0.04	5.5±0.1	5.6±0.05	8.15±0.1
DEET	8.50±0.45	0.35±0.06	0.045±0.06	ND	0.60±0.15	10.2±0.5	19.1±0.5	5.2±0.15	2.2±0.15
5-hydroxy DCF	ND	ND	5.6±0.3	6.5±1.7	ND	ND	ND	ND	3.2±0.7
2-hydroxy Atorvastatin	ND	ND	0.65±0.07	3.6±1.6	ND	ND	ND	0.17±0.001	0.65±0.01
TCPP	12.5±0.55	2.0±0.08	3.0±0.15	<LOQ	2.9±1.05	1.25±0.20	40.6±0.15	16.3±0.4	16.4±0.96
Diclofenac	5.0±0.35	ND	4.35±0.04	3.5±0.4	2.2±0.17	5.3±0.3	9.2±0.1	5.7±3.8	3.2±0.05
Octocrylene	25.8±1.3	4.5±5.4	25.5±11	146.6±8.0	6.2±1.45	71.0±5.0	224±113	44.8±6.8	19.3±8.4
Salinomycin	ND	ND	ND	ND	<LOQ	ND	ND	ND	ND
Monesin	0.050±0.005	ND	ND	ND	ND	ND	ND	ND	ND
SUM CEC	**75.1**	**25.8**	**114.4**	**193.6**	**22.3**	**131.1**	**353.6**	**97.1**	**110.3**

Table 10 CEC levels in solid digestate samples [ng/g ww]

Station	$D_{(S)}$ (avg±std)	$K_{(S)}$ (avg±std)	$A_{(S)}$ (avg±std)	$E_{(S)}$ (avg±std)	$I_{(S)}$ (avg±std)	$B_{(S)}$ (avg±std)	$L_{(S)}$ (avg±std)	$F_{(S)}$ (avg±std)	$H_{(S)}$ (avg±std)	$J_{(S)}$ (avg±std)
Ranitidine	15.8±1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Caffeine	ND	ND	54.3±5.3	29.7±5.1	ND	ND	208.3±8.2	ND	ND	ND
Acridine	3.8±0.34	15.3±1.1	8.8±0.9	ND	ND	7.2±0.7	3.1±0.02	2.5±0.6	5.1±4.6	8-0±5.4
Metoprolol	36.1±0.5	100.1±2.6	74.8±12.2	48.4±2.1	44.5±8.7	32.2±4.9	21.6±2.0	14.0±0.8	17.2±9.1	58.4±0.5
Prednisolone	ND	ND	ND	<LOQ	ND	ND	ND	ND	ND	ND
Carboxy-IBP	ND	ND	ND	ND	ND	ND	ND	<LOQ	ND	ND
Carbamazepine	62.8±0.4	89.9±6.3	65.0±0.7	7.1±2.3	57.5±4.0	53.7±3.8	6.9±0.33	6.0±1.8	6.7±0.12	35.7±2.7
Amitriptyline	ND	ND	52.8±74.7	81.1±1.4	ND	131.7±15.3	ND	ND	ND	ND
Losartan	15.7±9.5	46.6±22.0	60.48±5.5	0.5±0.7	71.5±2.2	55.12±3.0	ND	8.3±1.2	76.5±65.8	50±33
DEET	<LOQ	<LOQ	11.8±1.7	<LOQ	<LOQ	1.07±0.05	<LOQ	<LOQ	<LOQ	1.6±0.12
5-hydroxy DCF	ND	ND	ND	ND	<LOQ	ND	ND	ND	ND	ND
Atorvastatin	ND	ND	ND	ND	>500	ND	ND	>500	ND	ND
2-hydroxy Atorvastatin	45.1±6.0	187.6±7.1	130±118	<LOQ	201±26	29.7±1.9	<LOQ	58.5±2.5	8.7±11.6	17.5±20.1
TCPP	238.5±88.9	304±102	475 ±135	>500	15.2±4.0	>500	463.2±36.5	105.7±12.5	33.6±4.3	15.3±21.7
Diclofenac	ND	ND	ND	ND	ND	ND	84.0±2.3	ND	ND	ND
Octocrylene	ND	ND	260±368	>600	<LOQ	>600	ND	ND	466±659	107±152
SUM CEC	**417.4**	**743.4**	**1202.9**	**1266.8**	**889.7**	**1410.7**	**849.3**	**691.3**	**613.8**	**614**

Table S11. Polymer used in biogas plants

Biogas plant	Polymer (Nature)	Amount	Added at which point
F	FLOPAM™ FO 4240, (cationic)	2-4 kg / 1000 kg digestate	Before centrifugation
E	long chained (cationic)	7-8 kg / 1000 kg digestate	Before centrifugation
D	Zetag 8185 (cationic)	3.35 kg Dry matter polymer / 1000 kg digestate	Before pressing in a filter press
A	Zetag 7563 (cationic)	17 tonnes / 40.000 tonnes digestate (annual amout)	Before centrifugation
B[1]	CC FLOC D 6144 K, (cationic)	At dewatering: Ca. 8 kg polymer / 1000 kg digestate At thickening: 4 kg polymer / 1000 kg digestate	At centrifugation
H	Zetag 7563 (cationic)	5-6 kg / 100 kg digestate	At centrifugation
K[2]	Zetag 8147 (cationic) – at "pre dewatering" Zetag 8180 (cationic) – at "end dewatering"	10 kg / tonnes of dry matter 10 kg / tonnes of dry matter	
J	Zetag 8125 (cationic)	6.5-7.2 kg / 1000 kg digestate	Before centrifugation
I	Zetag 7563 (cationic)	2-3 kg / 1000 kg digestate	Before centrifugation

[1] In addition, PRAESTOL K 144 L (cationic liquid polymer) is used as a lubricant in pipes to transport dewatered excreted digestate via pumps into digestate silos.

[2] K plant uses polymer at two steps.

Table 12. Literature comparison of concentration levels for selected CECs in related matrices.

Sample type (country of origin)	CAF (ng/g)	CAR (ng/g)	DCF (ng/g)	TCPP (ng/g)	OC (ng/g)	AMT (ng/g)	LOS (ng/g)	Ref.
Feather meal intended as fertilizer (USA)	<6.0 - 201							10
Feather meal intended as fertilizer (China)	59.6 - 153							10
Sewage sludge (Spain)	<MLOQ-74	12-42	<MLOQ-83					11
Fish fillet (USA)		<MDL–0.60						12
Sewage sludge (Spain)				429- 912				13
Sewage sludge (Catalonia, Spain)					1060-9170			14
US Herring gull eggs (*Larus argentatus*)				<MLOQ – 4.1				15
Whole Fish (Spain)	1.6 - 3.3				<MDL – 30.4			16
Soil, irrigated with reclaimed water (Spain)		0.10 - 8.2				<MLOQ – 9.8		17
Sewage sludge (Japan)		n.d. - 12	8.1 – 29				25 – 86	18
Soil (China)			n.d. - 1.16					19
Soil (UK)			0.14 -0.21					20
Sewage sludge (Spain)		73.6 – 89.7	n.d.–424.7					21
Sewage sludge (Ireland)		120						22
Sewage sludge (Switzerland)					32 0– 18740			23
Solid digestate (Norway)	**n.d .- 210**	**6 - 90**	**n.d . -84**	**14 - >500**	**100 - >600**	**n.d. – 132**	**n.d. - 76**	**This study**

For abbreviations of CECs please consult table S1. <MLOQ: below method quantification limit, n.d. = not detected, <MLOD = below method detection limit.

Table 13 List of the used instruments and software

Item	Specification	Producer	Supplier
MS	6460 series triple quadrupole LC/MS	Agilent Technologies, Santa Clara, CA, USA	Matriks AS, Oslo, Norway
HPLC	Agilent 1200 series with auto sampler, binary pump and column oven	Agilent Technologies, Santa Clara, CA, USA	Matriks AS, Oslo, Norway
Software	MassHunter, Quantitative analysis for QQQ, Versjon B.07.00/Build 7.0.457.0	Agilent Technologies, Santa Clara, CA, USA	Matriks AS, Oslo, Norway
Software	MassHunter, Qualititative analysis for QQQ, Versjon B.06.00/Build 6.0.633.10	Agilent Technologies, Santa Clara, CA, USA	Matriks AS, Oslo, Norway
Evaporator	Reacti-Vap III™ Evaporator	Thermo Scientific, Waltham, MA, USA	VWR International AS, Oslo, Norge
Shaker	VXR basic Vibrax	IKA® Werke GmbH & Co, KG. Staufen, Tyskland	Sigma Aldrich, Oslo, Norge
Centrifuge	Rotanta, 50 mL	Andreas Hettih GmbH & Co. KG, Tuttlingen, Tysklan	Dipl.ing. Houm AS, Oslo, Norge
Vortex	MS 3 basic	IKA-Werke GmbH & Co, KG. Wilmington, N.C, USA	

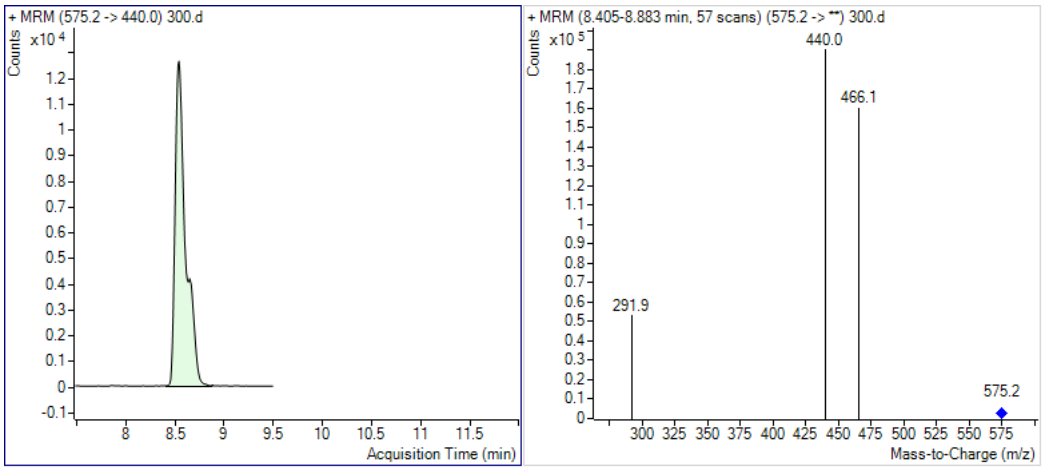


Figure S3a. MRM chromatogram and mass spectrum of 2-Hydroxy Atorvastatin standard

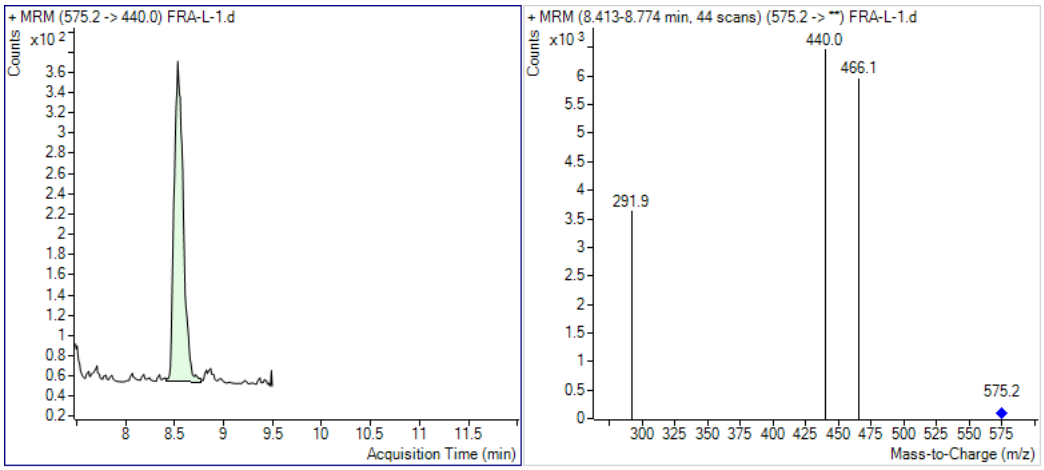


Figure S3b. MRM chromatogram and mass spectrum of 2-Hydroxy Atorvastatin detected in digestate sample ($F_{(S)}$)

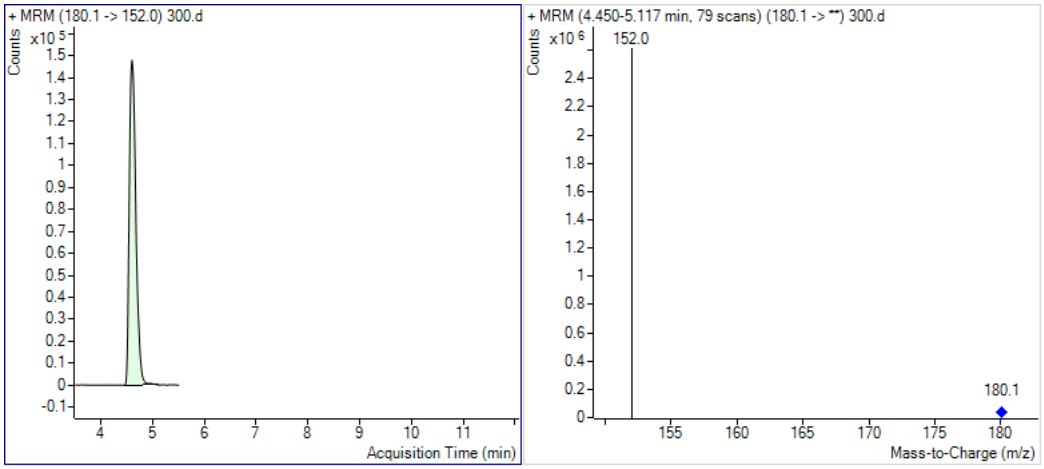


Figure S4a MRM chromatogram and mass spectrum of Acridine standard

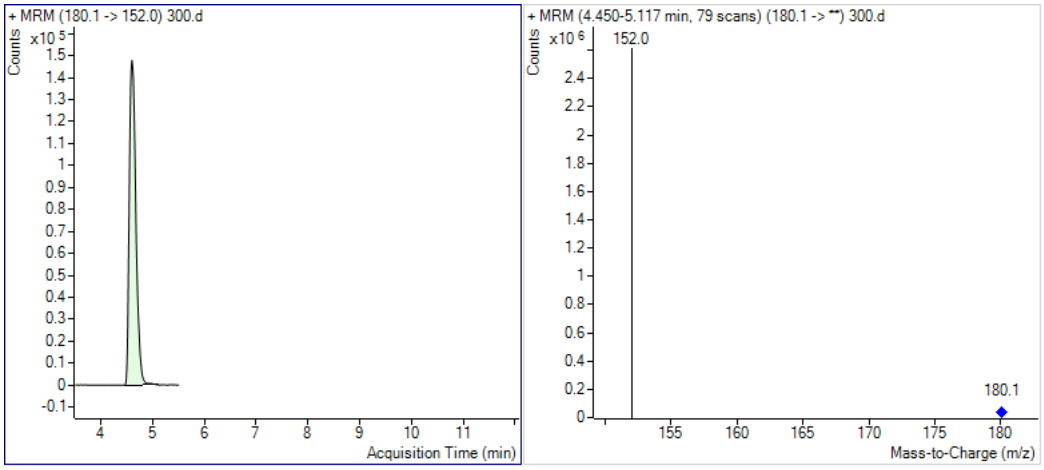


Figure S4b MRM chromatogram and mass spectrum of Acridine detected in digestate sample ($I_{(L)}$)

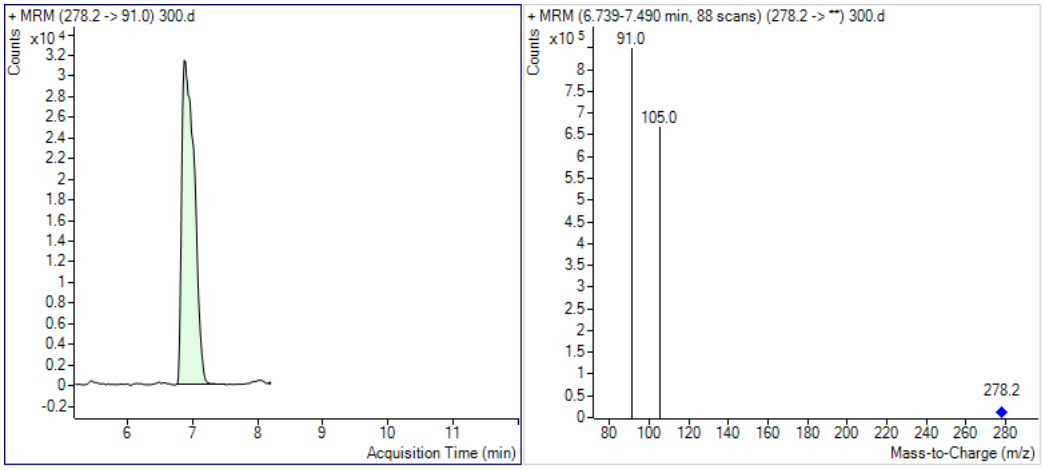


Figure S5aMRM chromatogram and mass spectrum of Amitriptyline standard

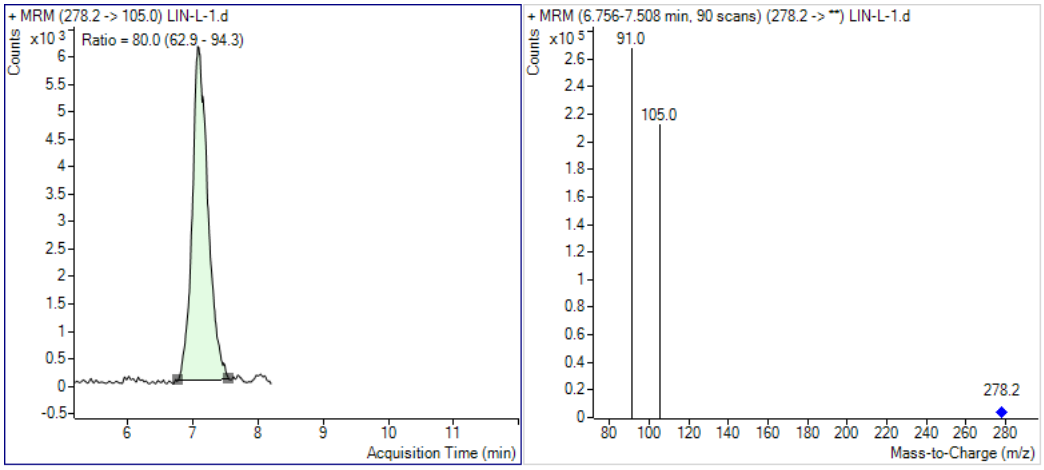


Figure S5b MRM chromatogram and mass spectrum of Amitriptyline detected in digestate sample ($I_{(L)}$)

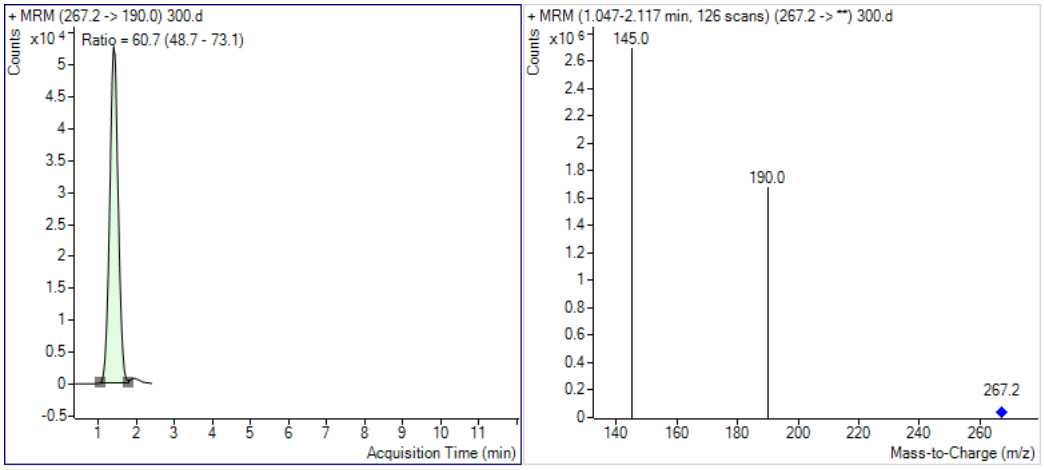


Figure S6a MRM chromatogram and mass spectrum of Atenolol standard

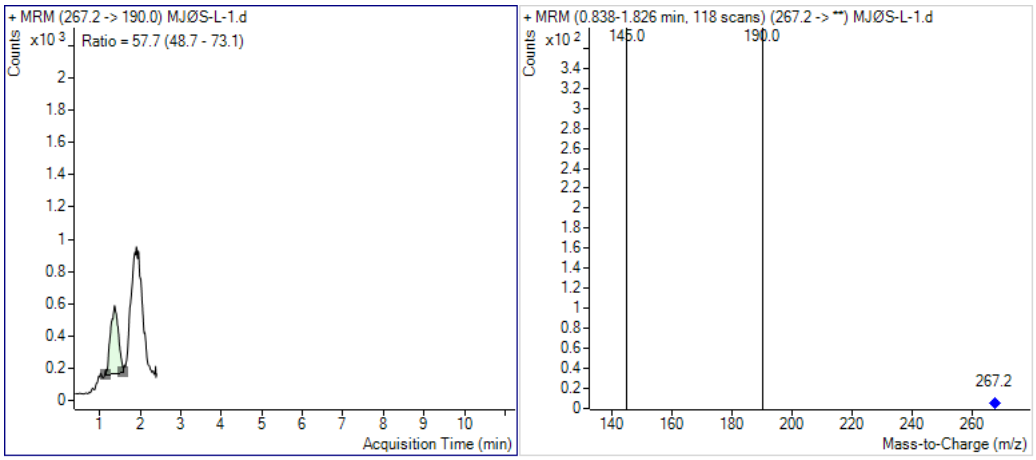


Figure S6b MRM chromatogram and mass spectrum of Atenolol detected in digestate sample ($C_{(L)}$)

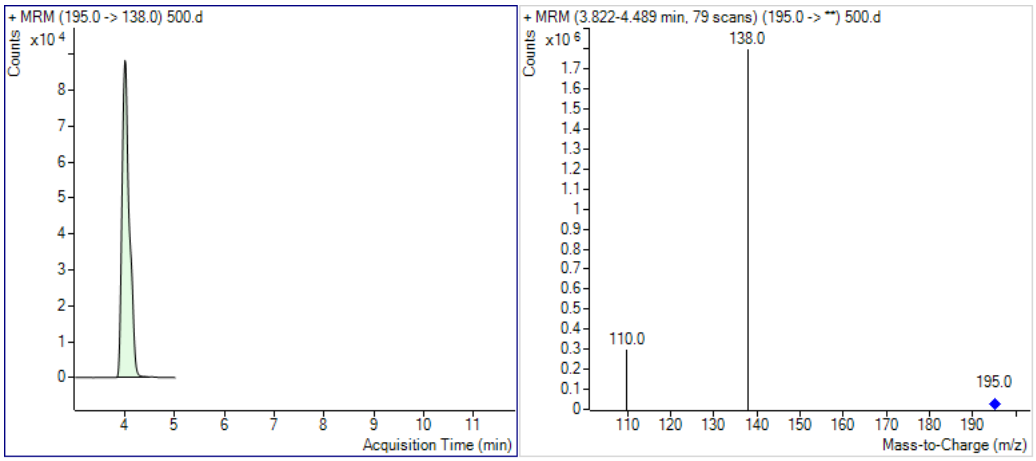


Figure S7a MRM chromatogram and mass spectrum of Caffeine standard

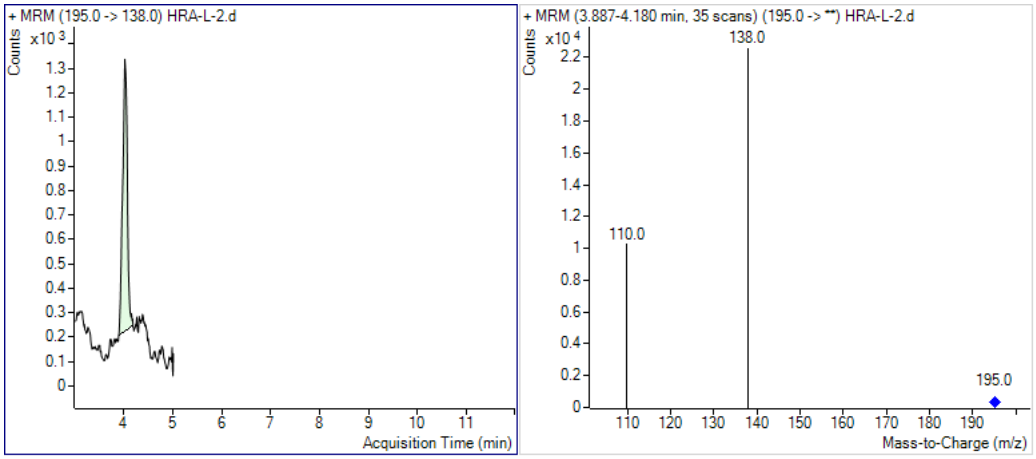


Figure S7b MRM chromatogram and mass spectrum of Caffeine detected in digestate sample ($L_{(S)}$)

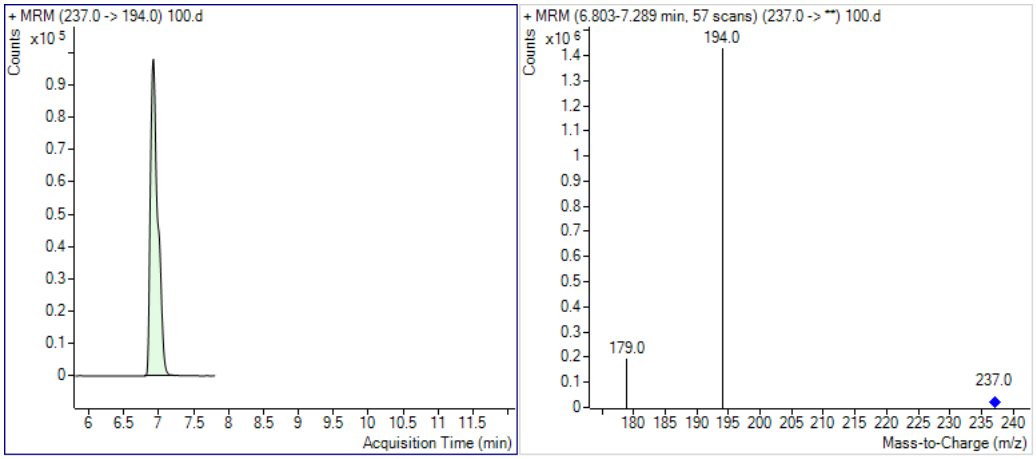


Figure S8a MRM chromatogram and mass spectrum of Carbamazepine standard

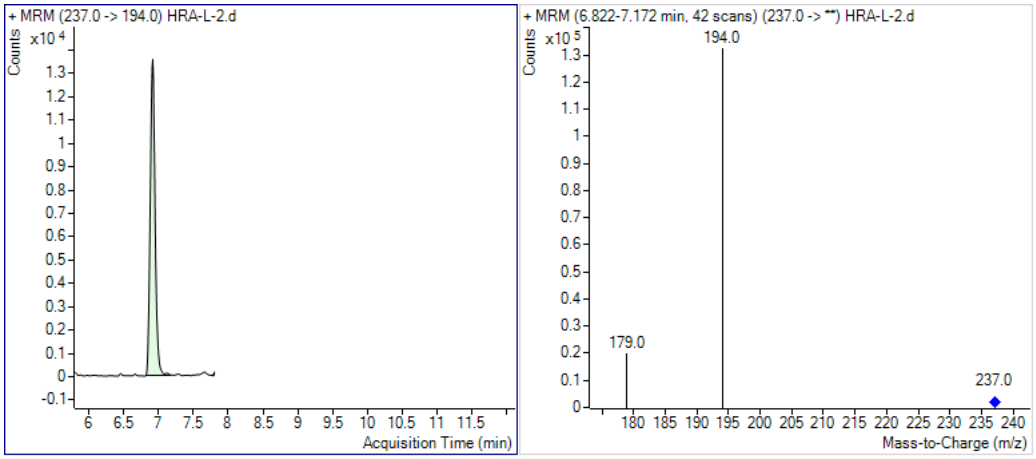


Figure S8b MRM chromatogram and mass spectrum of Carbamazepine detected in digestate sample ($L_{(S)}$)

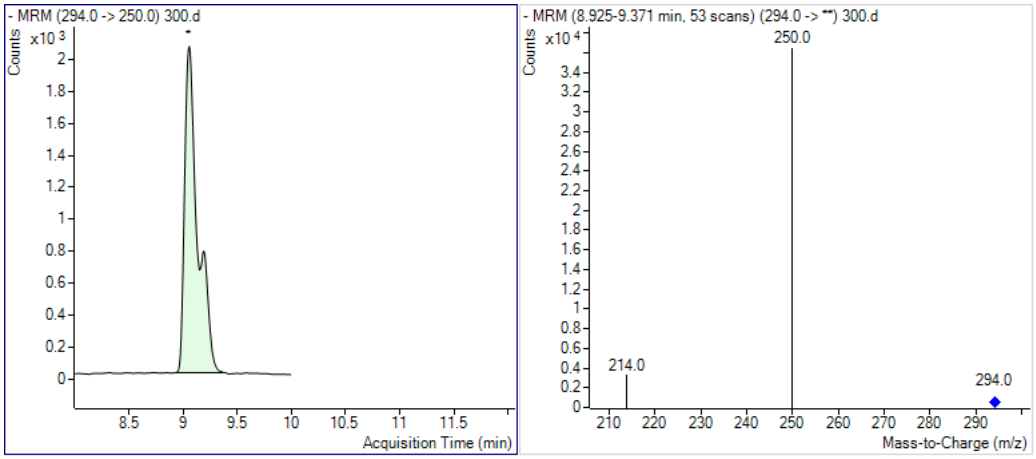


Figure S9a MRM chromatogram and mass spectrum of Diclofenac standard

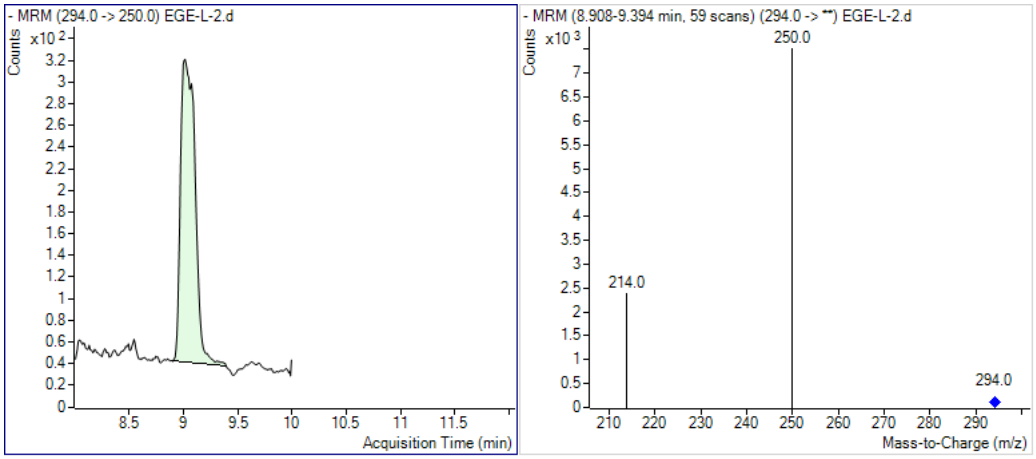


Figure S9b MRM chromatogram and mass spectrum of Diclofenac detected in digestate sample ($E_{(L)}$)

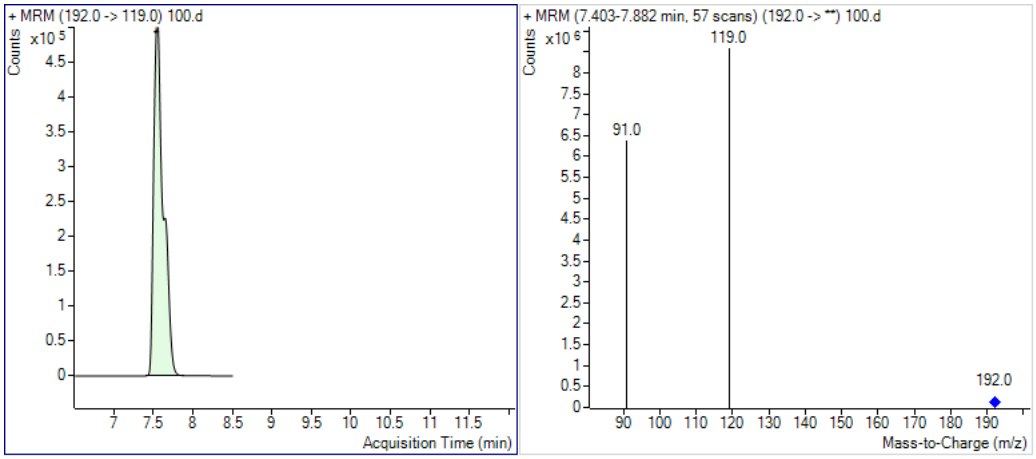


Figure S10a MRM chromatogram and mass spectrum of DEET standard

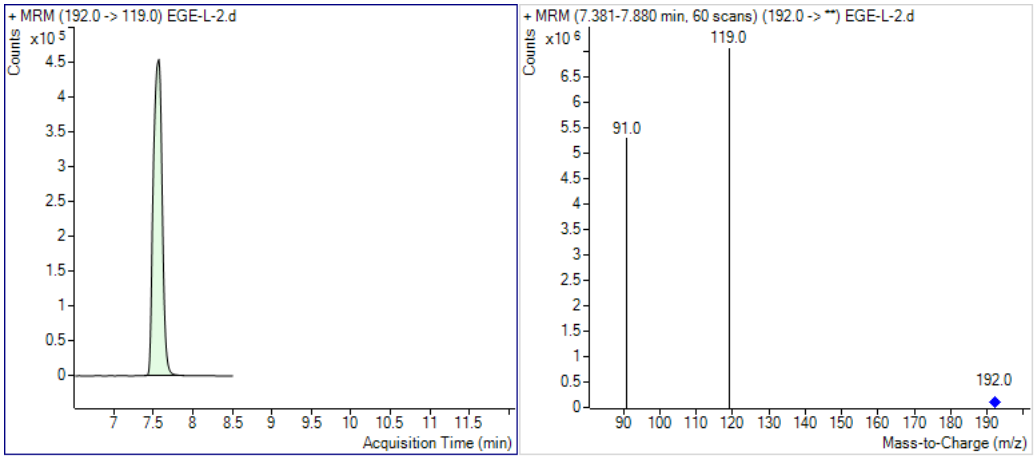


Figure S10b MRM chromatogram and mass spectrum of DEET detected in digestate sample ($E_{(L)}$)

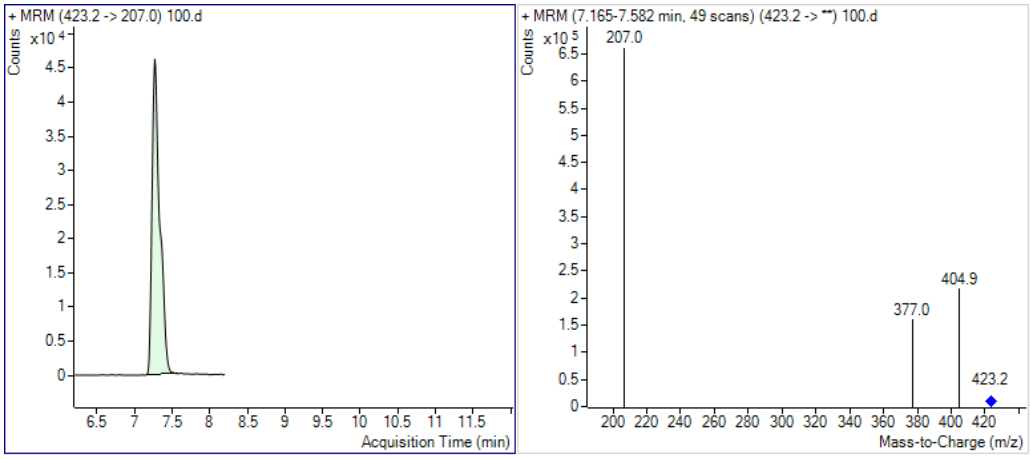


Figure S11a MRM chromatogram and mass spectrum of Losartan standard

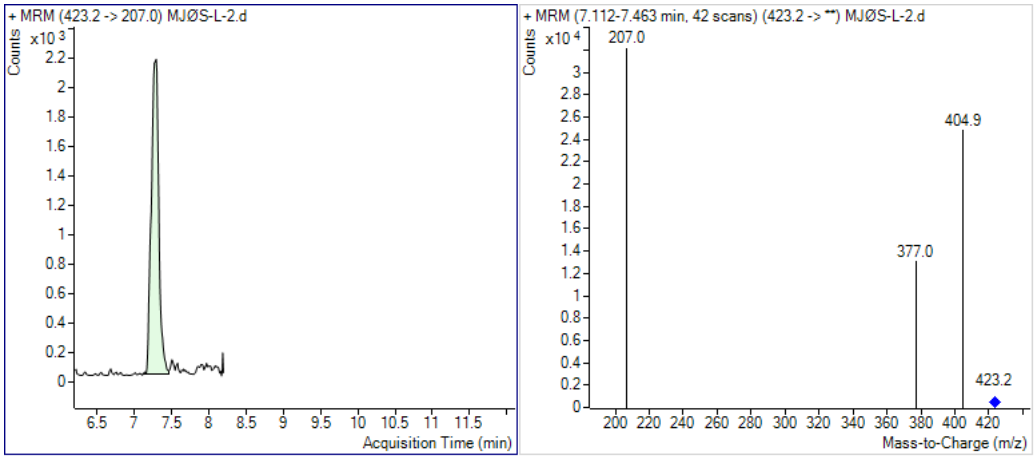


Figure S11b MRM chromatogram and mass spectrum of Losartan detected in digestate sample ($K_{(S)}$)

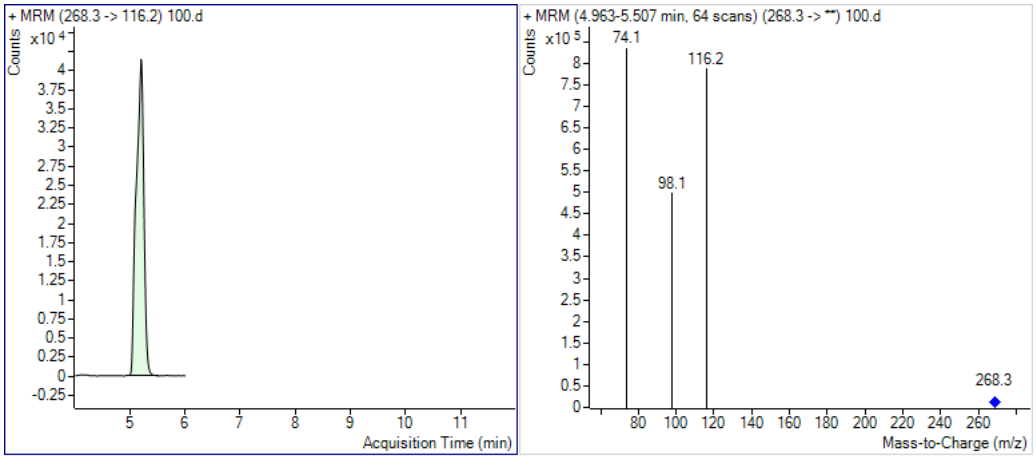


Figure S12a MRM chromatogram and mass spectrum of Metoprolol standard

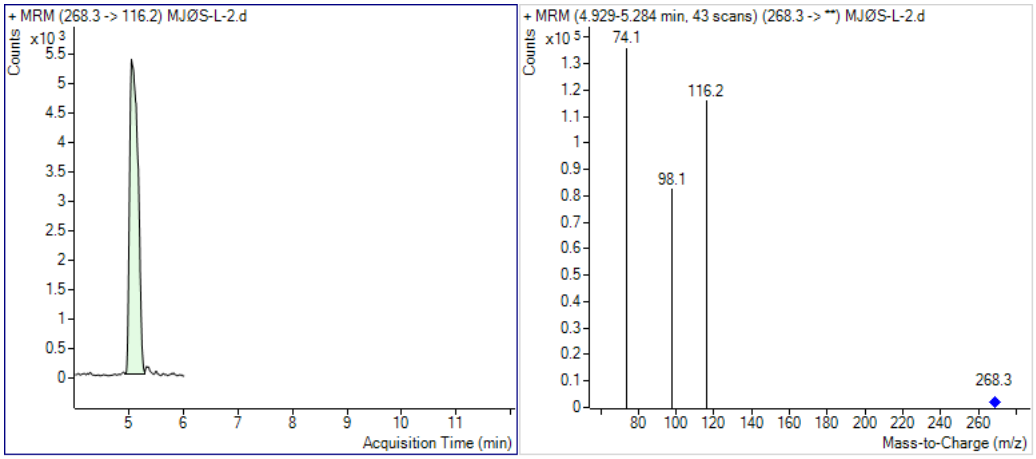


Figure S12b MRM chromatogram and mass spectrum of Metoprolol detected in digestate sample ($K_{(S)}$)

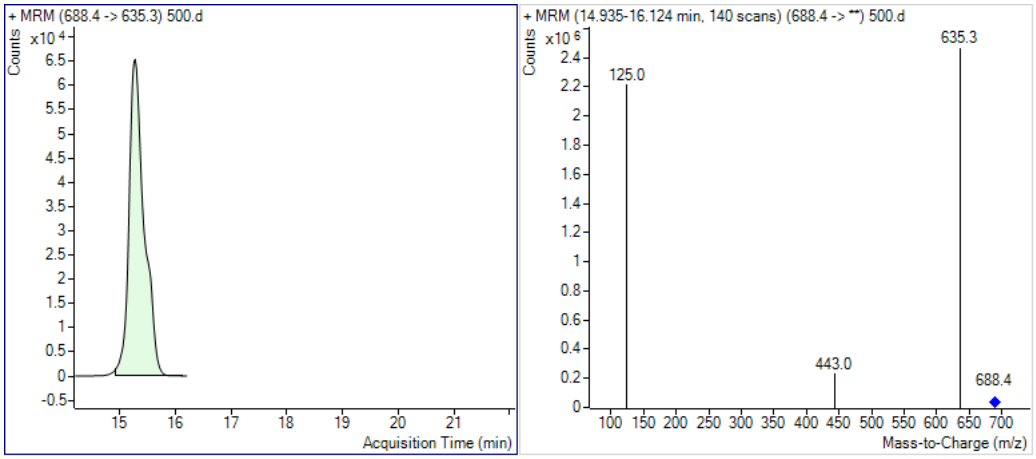


Figure S13a MRM chromatogram Monesin standard

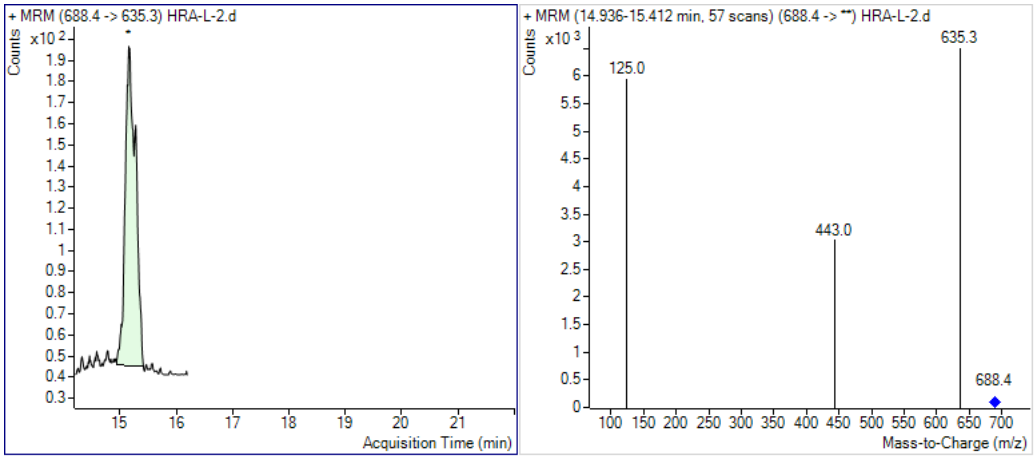


Figure S13b MRM chromatogram Monesin detected in digestate sample ($L_{(L)}$)

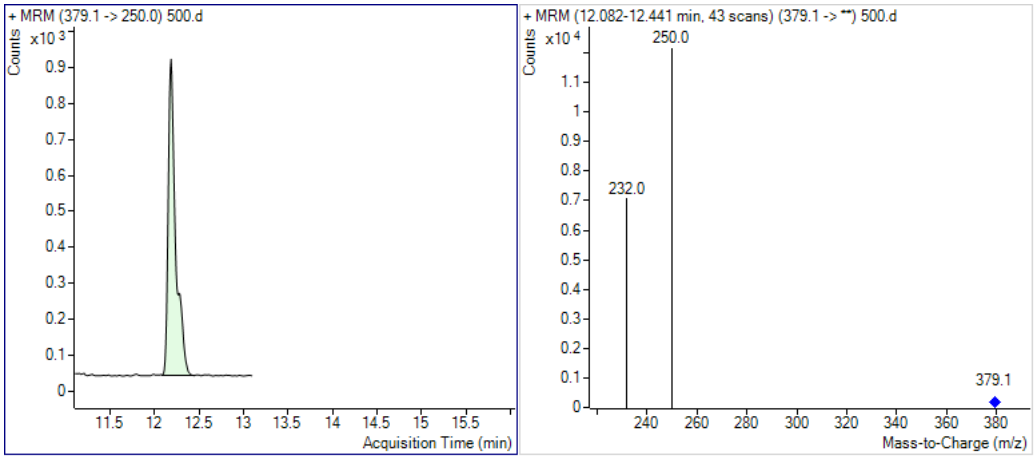


Figure S14a MRM chromatogram and mass spectrum of Octocrylene standard

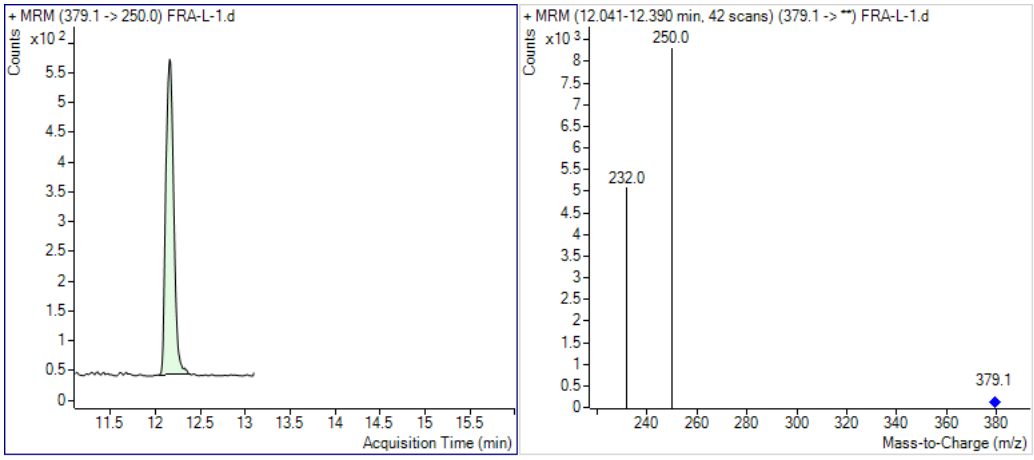


Figure S14b MRM chromatogram and mass spectrum of Octocrylene detected in digestate sample ($B_{(S)}$)

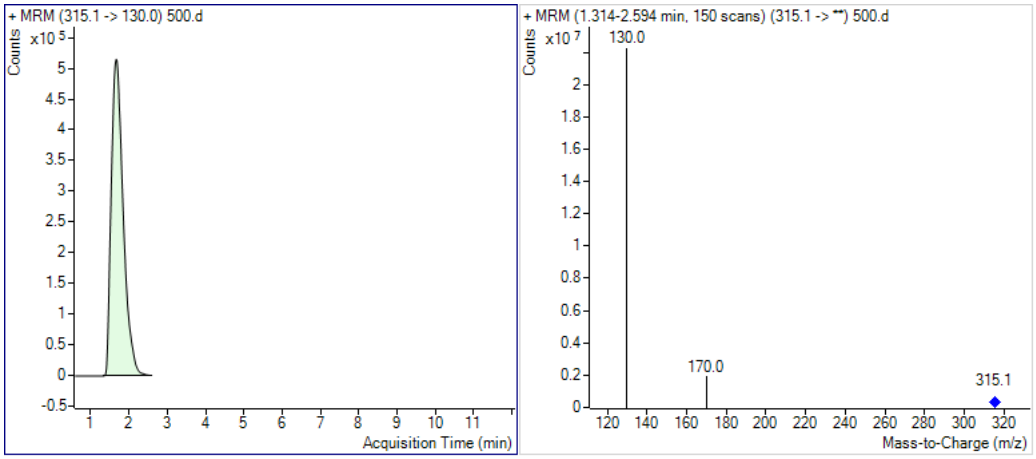


Figure S15a MRM chromatogram and mass spectrum of Ranitidine standard

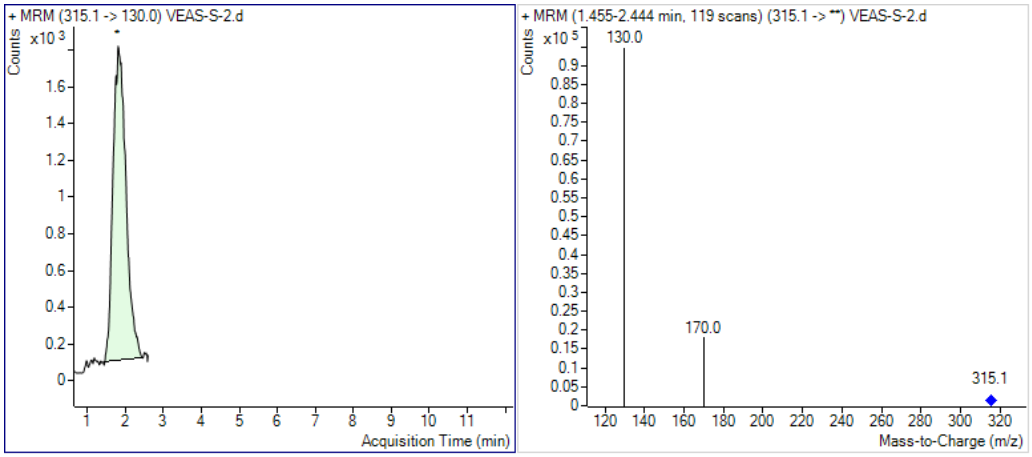


Figure S15b MRM chromatogram and mass spectrum of Ranitidine detected in digestate sample ($B_{(S)}$)

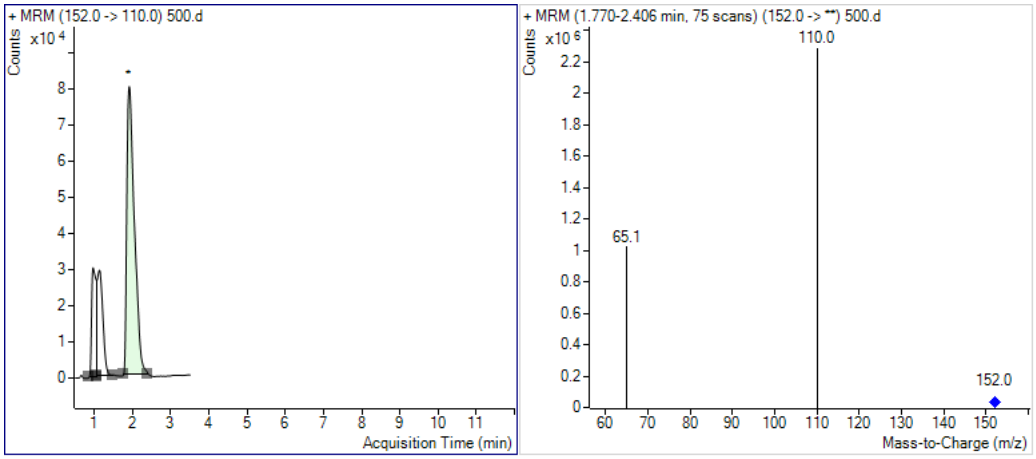


Figure S16a MRM chromatogram and mass spectrum of Acetaminophen standard

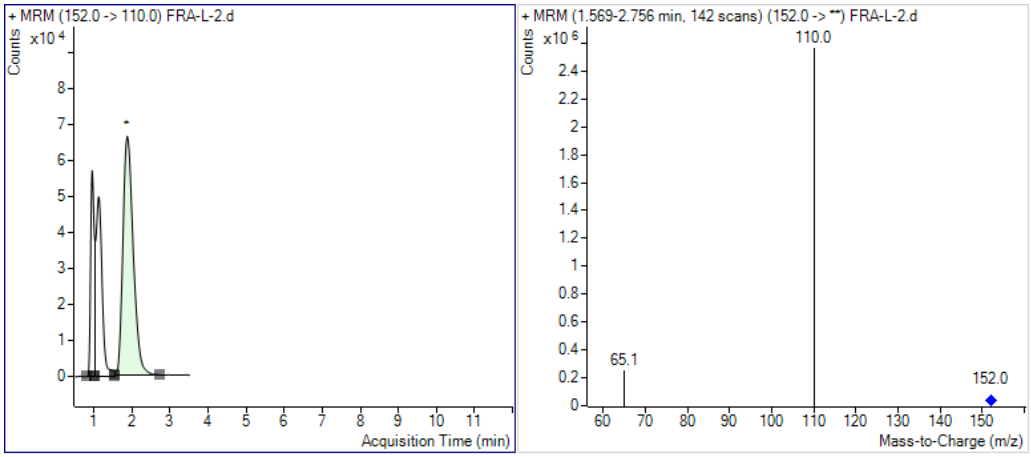


Figure S16b MRM chromatogram and mass spectrum of Acetaminophen detected in digestate sample ($F_{(L)}$)

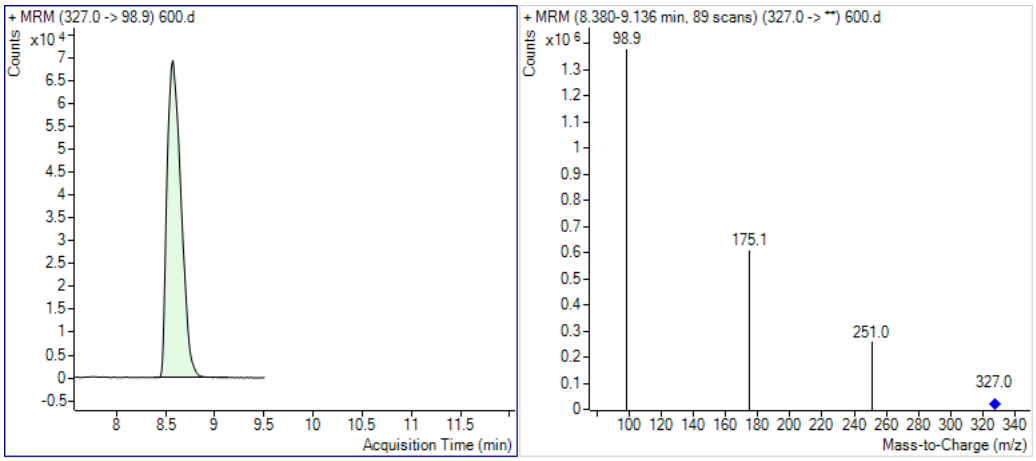


Figure S17a MRM chromatogram and mass spectrum of SUM TCPP standard

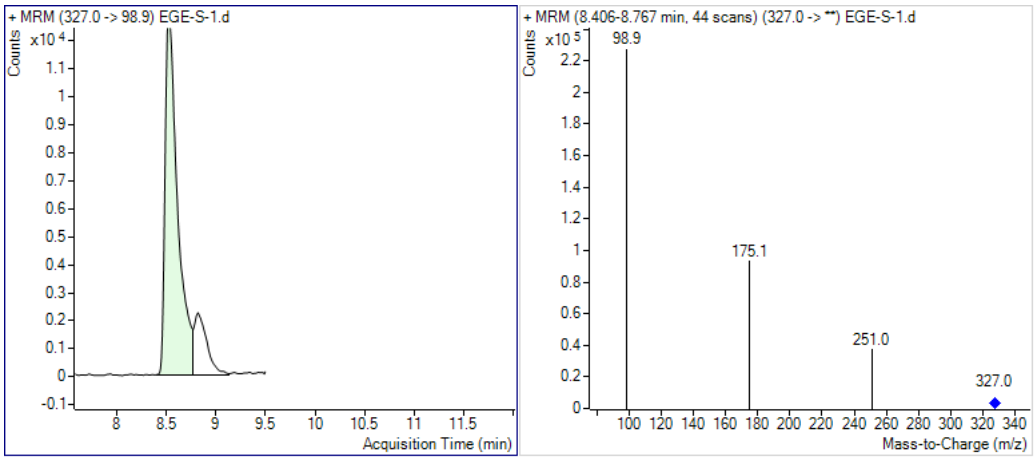


Figure S17b MRM chromatogram and mass spectrum of SUM TCPP detected in digestate sample ($E_{(S)}$)

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