Supporting Information

Use patterns, excretion masses and contamination profiles of antibiotics in a typical swine farm, in south China

Li-Jun Zhou, Guang-Guo Ying [*], *Rui-Quan Zhang, Shan Liu, Hua-Jie Lai, Zhi-Feng Chen, Bin Yang, Jian-Liang Zhao*

[a] State Key Laboratory of Organic Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

* Corresponding author. Phone/fax: +86 20 85290200. Email address: guangguo.ying@gmail.com; guang-guo.ying@gig.ac.cn.

Reagents and Materials. Target standards (sulfapyridine (SPD), sulfadiazine (SDZ), sulfamethazine (SMZ), sulfamethoxazole (SMX), sulfacetamide (SCT), sulfisoxazole (SX), sulfadimethoxine (SDM), sulfathiazole (STZ), sulfachlorpyridazine (SCP), sulfamonomethoxine (SMM), sulfameter (SM), sulfanilamide (SA), sulfaguanidine (SG), sulfadoxine (SDO), sulfaquinoxaline (SQX), trimethoprim (TMP), ormetoprim (OMP), oxytetracycline (OTC), tetracycline (TC), chlortetracycline (CTC), doxycycline (DC), methacycline (MT), norfloxacin (NFX), ciprofloxacin (CFX), ofloxacin (OFX), lomefloxacin (LFX), enrofloxacin (EFX), fleroxacin (FL), danofloxacin (DAN), pefloxacin (PEF), marbofloxacin (MAR), difloxacin (DIF), sarafloxacin (SAR), carbadox (CAR), oleandomycin (ODM), leucomycin (LCM), clarithromycin (CTM), florfenicol (FF), chloramphenicol (CAP), lincomycin (LIN), bacitracin (BACI), salinomycin (SAL), monensin (MON), ceftiofur (CEFT), cloxacillin (CLOX) and novobiocin (NOV)) were purchased from Dr. Ehrenstorfer GmbH (Germany). Three antibiotics roxithromycin (RTM), tylosin (TYL) and erythromycin (ETM) were obtained from Sigma-Aldrich (St. Louis, MO, USA) while Narasin (NAR) was purchased from US Pharmacopoeia (Rockville, Maryland). Erythromycin-H_2O (ETM-H_2O) was prepared in our laboratory by acidification according to the procedure described by Xu et al. [1]. Internal standard meclocycline (MC) was purchased from Sigma-Aldrich (St. Louis, MO, USA), while sulfamerazine (SMR) and chloramphenicol-D_5 (CAP-D_5) were obtained from Dr. Ehrenstorfer GmbH (Germany). Another seven isotope-labeled internal standards sulfamethoxazole-D_4 (SMX-D_4), erythromycin-^{13}C-D_3 (ETM-^{13}C-D_3), thiabendazole-D_4 (TBD-D_4), ciprofloxacin-D_8 (CFX-D_8), trimethoprim-D_3 (TMP-D_3) and lincomycin-D_3 (LIN-D_3) were obtained from Toronto Research Chemicals (North York, ON, Canada) while sulfamethazine-$^{13}C_6$ (SMZ-$^{13}C_6$) was purchased from Cambridge Isotope Laboratories (Andover, MA, USA). The physicochemical properties of the target compounds are summarized in Table S1.

Methanol and acetonitrile of HPLC grade were purchased from Merck (Darmstadt, Germany), formic acid from Tedia Company (Fairfield, OH, USA), and oxalic acid and ammonium acetate from Sigma-Aldrich (St. Louis, MO, USA). Other chemicals disodium ethylenediamine tetraacetate (Na_2EDTA), citric acid and sodium citrate were of analytical grade and obtained from Yaohua Chemical Reagent Factory (Tianjin, China). Strong anion exchange (SAX) cartridges (6 mL, 500 mg) were provided by Varian (Lake Forest, CA, USA) while Oasis HLB cartridges (6 mL, 200 mg or 6 mL, 500 mg) were supplied by Waters (Milford, MA, USA). Glass fiber filters (GF/F, pore size 0.7 μm) were purchased from Whatman (Maidstone, England) and pyrolyzed at 450 ^{o}C for 4 h prior to use.

About 10 mg of individual standard (corrected by purity and salt form) was accurately weighed. Fluoroquinolones (FQs) (including CAR) were first dissolved in 0.5 mL NaOH and then diluted to 100 mL with methanol. β-Lactam compounds were dissolved with 100 mL of deionized water and stored at 4 ^{o}C for one week. Other agents were dissolved in 100 mL of methanol and stock solutions were stored at −20 ^{o}C. From these stock solutions, working solutions were prepared by gradient dilution.

LC-MS/MS conditions. The target antibiotic compounds were analyzed by RRLC-MS/MS (Agilent Liquid Chromatography 1200 series RRLC system coupled to an Agilent 6460 triple quadrupole MS equipped with an electrospray ionization (ESI) source (Agilent, Palo Alto, CA, USA)) in multiple-reaction monitoring (MRM) mode. The analyses were performed in the negative mode for two target compounds (CAP and FF) and in the positive mode for the other compounds. All the target compounds were separated by Agilent 1200 series (Agilent, Palo Alto, USA) on an Agilent Eclipse Plus-C18 (100 mm × 2.1 mm, 1.8 μm) column with its corresponding pre-column. The column temperature was set at 40 °C. The injection volume for each sample was 5 μL. Mass spectrometric conditions were optimized using Optimizer (Agilent, Palo Alto, USA) for collision energy (CE), fragmentor voltage, and multiple

reaction monitoring mode (MRM) transitions for each compound (Table S2).

The mobile phases for the positive mode were MilliQ water with 0.2% formic acid and 2 mM ammonium acetate (A) and Acetonitrile (B). The mobile phase gradient for the positive mode was ramped at a flow rate of 0.3 mL/min from 10% to 15% B in 5 min, 15-20% B in 2 min, 20-40% B in 4 min, 40-60% B in 4 min and then ramped to 95% B in 1min and kept for 9 min. The MS operating conditions in the positive mode were set as follows: gas temperature, 325 ^{o}C; gas flow, 6 mL/min; nebulizer pressure, 45 psi; sheath gas flow, 11 L/min; sheath gas temperature, 350 ^{o}C; nozzle voltage, 0 V; and capillary voltage, 3500 V.

The mobile phases for the negative mode were MilliQ water (A) and Acetonitrile (B). The mobile phase gradient for the positive mode was ramped at a flow rate of 0.3 mL/min from 25% to 40% B in 4 min, and then ramped to 95% B in 0.5 min and kept for 1.5 min. The MS operating conditions in the positive mode were set as follows: gas temperature, 325 ^{o}C; gas flow, 6 mL/min; nebulizer pressure, 45 psi; sheath gas flow, 11 L/min; sheath gas temperature, 350 ^{o}C; nozzle voltage, -1500 V; and capillary voltage, 3500 V.

Method quality

Concentrations of the target compounds in the samples were performed using internal standard method. All data generated from the analysis were subject to strict quality control procedures. With each set of samples to be analyzed, a solvent blank, a procedure blank and an independent check standard were run in sequence to check for carryover, background contamination, and system performance. Appropriate field quality assurance and quality control (QA/QC) procedures were followed. Laboratory blanks and field blanks were analyzed along with the samples to assess potential sample contamination. The reported quantitative values of each target compound in the samples were required to have the same retention time as its calibration standard (within ± 5%) and the same ion ratios (within ± 20%).

Independent check standard was injected approximately every twenty injections, and the concentration computed was required to be within 20% of the expected value.

Recovery experiments were performed by spiking the standard solutions to surface water, lagoon wastewater, sediment, manure and sludge samples. Among the 50 target compounds, the recoveries in the range of 50-150% were obtained for 39, 40, 38, 33 and 36 antibiotics in the spiked samples of surface water, lagoon wastewater, sediment and manure with three concentrations, respectively (Table S3-5). Method detection limits (MDLs) and quantification limits (MQLs) were determined as the minimum detectable amount of an analyte from the seven environmental matrix spiked extract in MRM mode with a signal-to-noise of 3 and 10, respectively. The MDLs of the target antibiotics in the surface water, lagoon wastewater, sediment, manure and sludge were 0.16-1.76 ng/L, 0.71-19.7 ng/L, 0.19-2.00 ng/g (except bacitracin and cloxacillin), 0.36-5.22 ng/g (except salinomycin, narasin, monensin, cloxacillin and novobiocin), and 0.45-8.57 ng/g (except salinomycin, narasin, monensin and cloxacillin) , respectively (Table S3-5). Those target compounds without MQLs results were only used for qualitative analysis. Sample concentrations were not corrected for the method recoveries.

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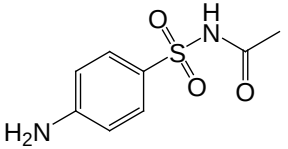
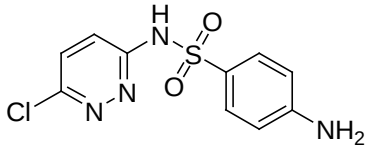
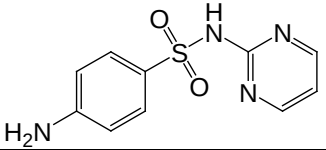
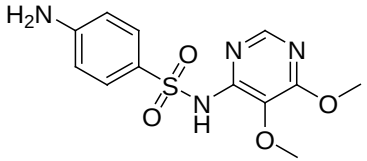
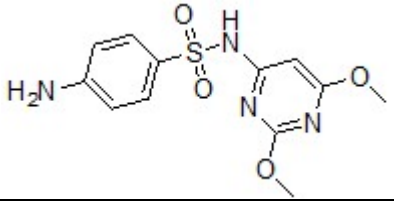
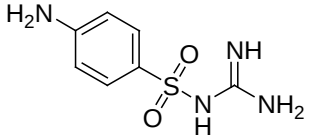
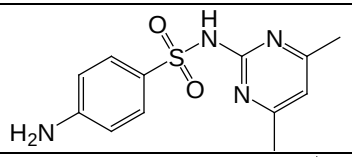
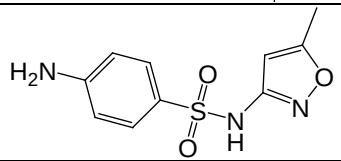
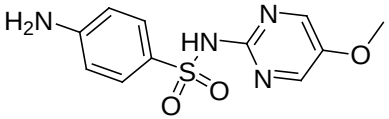
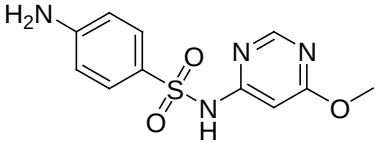
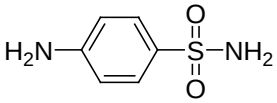
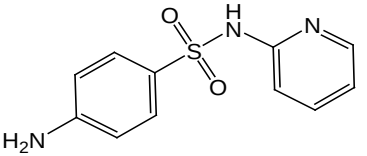
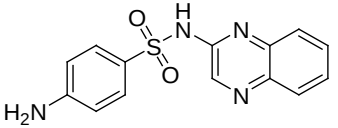
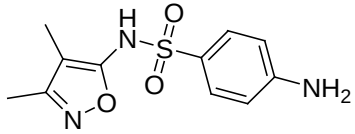
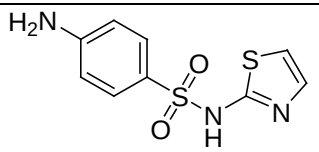
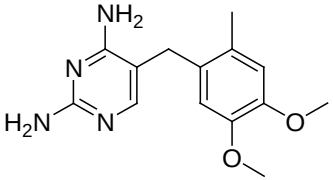
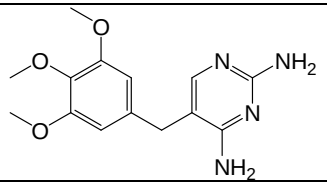
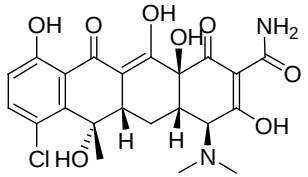
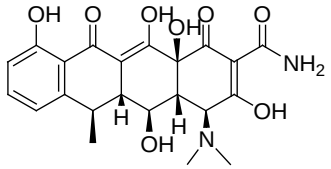
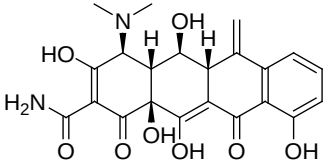
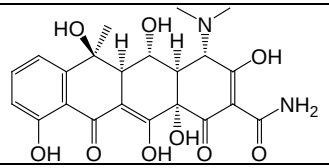
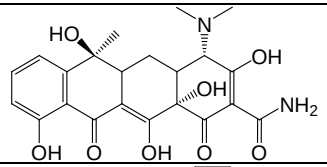
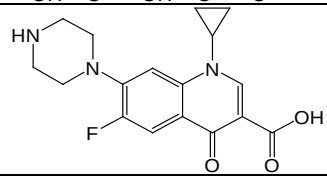
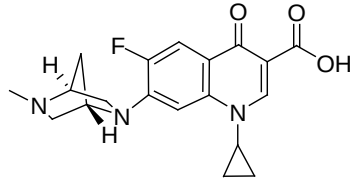
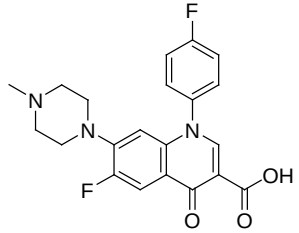
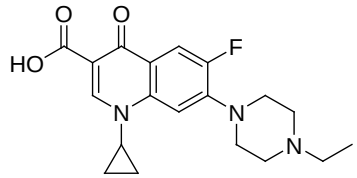
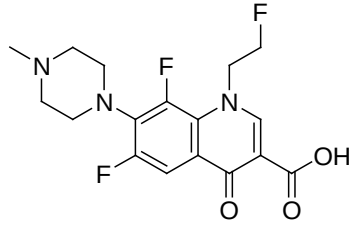
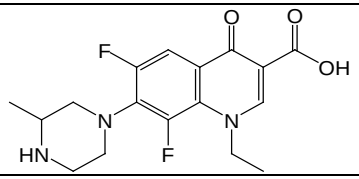
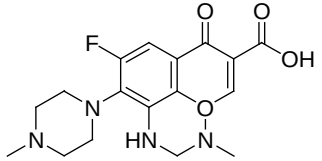
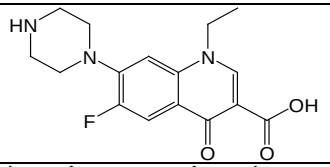
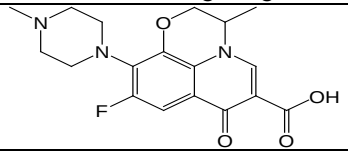
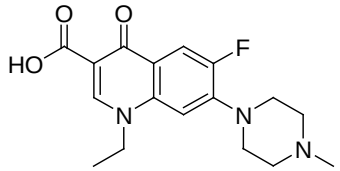
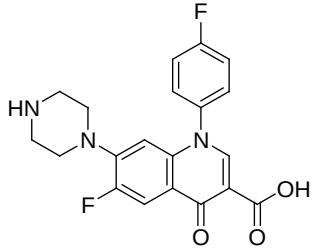
Table S1 Structures of the antibiotics used in the study

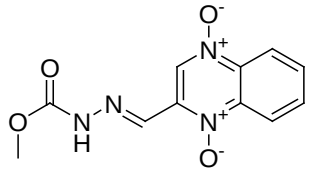
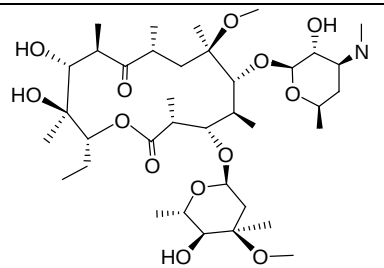
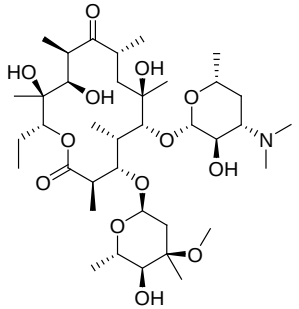
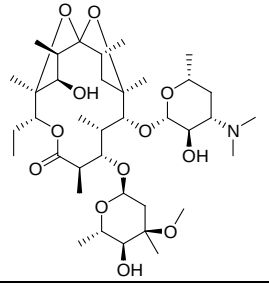
Class	Compound	CAS	MW	Formula	Solubility (in water, mg L^{-1})	$LogK_{ow}$ [a]	pK_a [b]	Structure
Sulfonamides	Sulfacetamide	144-80-9	214.2	$C_8H_{10}N_2O_3S$	12500 [c]	-0.96 [c]	5.4 [d]	
	Sulfachlorpyridazine	80-32-0	284.7	$C_{10}H_9ClN_4O_2S$			1.87, 5.45 [e]	
	Sulfadiazine	68-35-9	250.3	$C_{10}H_{10}N_4O_2S$	77 [f]	-0.09 [f]	1.6 6.4 [f]	
	Sulfadoxine	2447-57-6	310.3	$C_{12}H_{14}N_4O_4S$	2700 [c]	0.7 [c]	3.15 6.16 [g]	
	Sulfadimethoxine	122-11-2	310.3	$C_{12}H_{14}N_4O_4S$	343 [c]	1.63 [c] 1.4 [h]	6.3 [d] 2.13, 6.08 [e]	
	Sulfaguanidine	57-67-0	214.2	$C_7H_{10}N_4O_2S$	2200 [c]	-1.22 [c]	11.3 [d]	

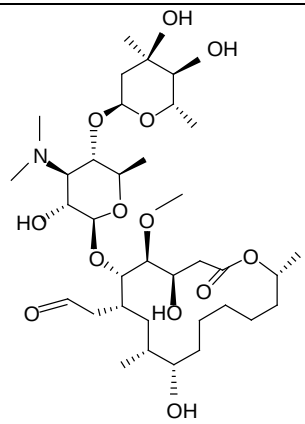
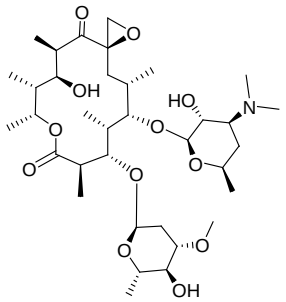
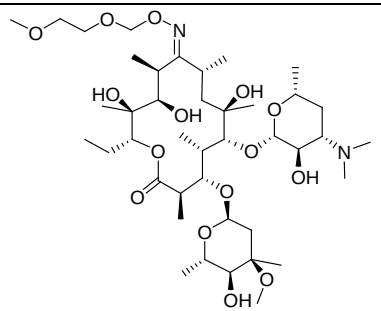
	Sulfamethazine	57-68-1	278.3	$C_{12}H_{14}N_4O_2S$	1500 [f]	0.80 [f]	2.07 7.49 [e] 2.65 [d]	
	Sulfamethoxazole	723-46-6	253.3	$C_{10}H_{11}N_3O_3S$	610 [c]	0.89 [c]	1.85 5.6 [c] 5.9 [d]	
	Sulfameter	651-06-9	280.3	$C_{11}H_{12}N_4O_3S$	730 [c]	0.41 [c]	1.48 6.49 [g]	
	Sulfamonomethoxine	1220-83-3	280.3	$C_{11}H_{12}N_4O_3S$	4030 [c]	0.7 [c]		
	Sulfanilamide	63-74-1	172.2	$C_6H_8N_2O_2S$	7500 [c]	-0.62 [c]	10.58 [c]	
	Sulfapyridine	144-83-2	249.3	$C_{11}H_{11}N_3O_2S$	270 [f]	0.35 [f]	2.58 8.43 [f] 8.4 [d]	
	Sulfaquinoxaline	59-40-5	300.4	$C_{14}H_{12}N_4O_2S$	7.5 [c]	1.68 [c]		
	Sulfisoxazole	127-69-5	267.3	$C_{11}H_{13}N_3O_3S$	300 [c]	1.01 [c]		

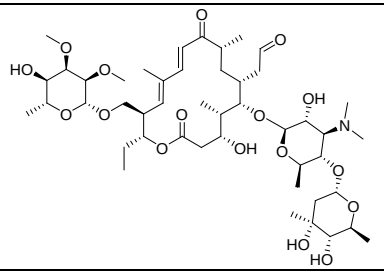
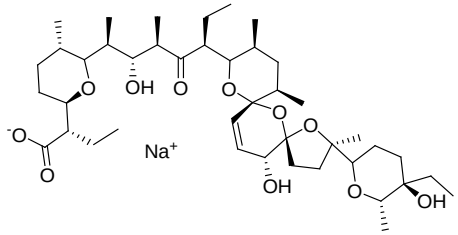
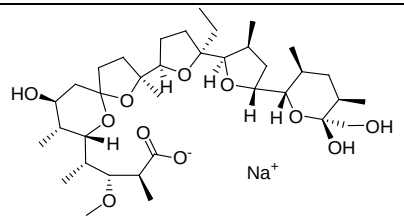
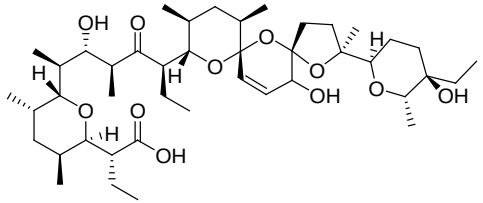
	Sulfathiazole	72-14-0	255.3	$C_9H_9N_3O_2S_2$	373 [c]	0.05 [c]	2.0 [d] 2.01, 7.11 [e]	
Diaminopyrimidines	Ormetoprim	6981-18-6	274.3	$C_{14}H_{18}N_4O_2$	1540 [c]	1.23 [c]		
	Trimethoprim	738-70-5	290.3	$C_{14}H_{18}N_4O_3$	400 [c]	0.91 [c]	3.23 6.76 [c]	
Tetracyclines	Chlortetracycline	57-62-5	478	$C_{22}H_{23}ClN_2O_8$	630 [c]	-0.62 [c]	3.33 7.55 9.33 [e]	
	Doxycycline	564-25-0	444.4	$C_{22}H_{24}N_2O_8$	630 [c]	-0.02 [c]	3.02 7.97 9.15 [e]	
	Methacycline	914-00-1	442.4	$C_{22}H_{22}N_2O_8$	7550 [c]	-1.37 [c]	4.05 6.87 9.59 [e]	
	Oxytetracycline	79-57-2	460.4	$C_{22}H_{24}N_2O_8$	1000 [i]	-1.22 [i]	3.22 7.46 8.94 [e]	

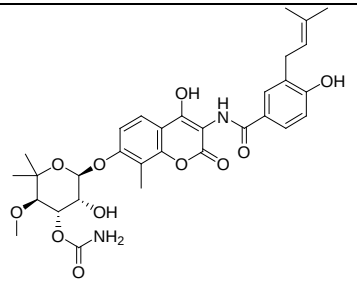
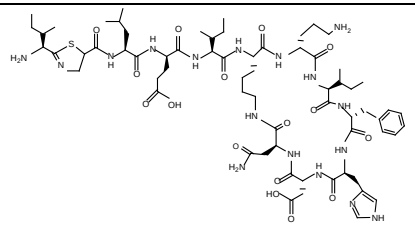
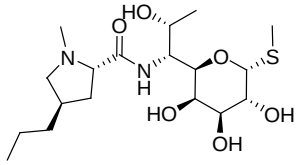
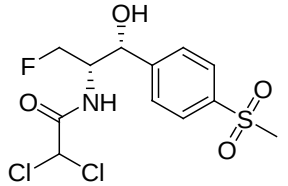
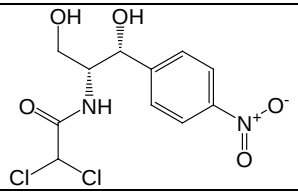
	Tetracycline	60-54-8	444.4	$C_{22}H_{24}N_2O_8$	1700 [i]	-1.19 [i]	3.32 7.78 9.58 [e]	
Fluoroquinolones	Ciprofloxacin	85721-33-1	331.3	$C_{17}H_{18}FN_3O_3$	30000 [i]	0.4 [i]	3.01 6.14 8.70 10.58 [e]	
	Danofloxacin	112398-08-0	357.4	$C_{19}H_{20}FN_3O_3$		1.85 [f]	2.73 9.13 [f]	
	Difloxacin	98106-17-3	399.4	$C_{21}H_{19}F_2N_3O_3$	1330 [c]	0.89 [c]		
	Enrofloxacin	93106-60-6	359.4	$C_{19}H_{22}FN_3O_3$	130000 [c]	1.1 [i]	3.85 6.19 7.59 9.86 [e]	
	Fleroxacin	79660-72-3	369.34	$C_{17}H_{18}F_3N_3O_3$	7320 [c]	0.24 [c]		

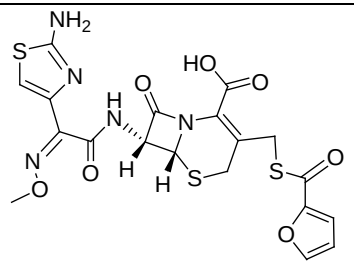
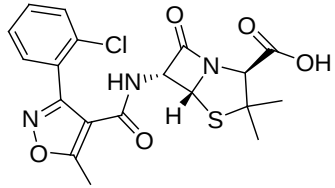
	Lomefloxacin	98079-51-7	351.3	$C_{17}H_{19}F_2N_3O_3$	27200 [c]	-0.3 [c]		
	Marbofloxacin	115550-35-1	362.4	$C_{17}H_{19}FN_4O_4$				
	Norfloxacin	70458-96-7	319.3	$C_{16}H_{18}FN_3O_3$	17800 [c]	-1.03 [c]	3.11 6.10 8.6 10.56 [e]	
	Ofloxacin	82419-36-1	361.3	$C_{18}H_{20}FN_3O_4$	2830 [c]	0.36 [j]	5.97 8.28 [k]	
	Pefloxacin	70458-92-3	333.4	$C_{17}H_{20}FN_3O_3$	1140 [c]	0.27 [c]		
	Sarafloxacin	98105-99-8	385.4	$C_{20}H_{17}F_2N_3O_3$	100 [l]	1.07 [c]	6.0 8.6 [i]	

	Carbadox	6804-7-5	262.2	$C_{11}H_{10}N_4O_4$	15000 [c]	-1.37 [c]		
Macrolides	Clarithromycin	81103-11-9	748.0	$C_{38}H_{69}NO_{13}$	0.342 [c]	3.16 [c]	8.99 [c]	
	Erythromycin	114-07-8	733.9	$C_{37}H_{67}NO_{13}$	2000 [l]	3.06 [c]	8.9 [e]	
	Erythromycin-H_2O	23893-13-2	715.9	$C_{37}H_{65}NO_{12}$				

	Leucomycin	1392-21-8	771	$C_{39}H_{65}NO_{14}$				
	Oleandomycin	3922-90-5	687.9	$C_{35}H_{61}NO_{12}$	15.5 [c]	1.69 [c]	3.31 7.50 [e] 8.84 [c]	
	Roxithromycin	80214-83-1	837.0	$C_{41}H_{76}N_2O_{15}$		2.75 [c]	9.17 [e]	

	Tylosin	1401-69-0	916.1	$C_{46}H_{77}NO_{17}$	5 [c]	1.63 [c]	7.73 [c]	
Ionophores	Salinomycin	53003-10-4	751	$C_{42}H_{70}O_{11}$	17-905 [m]	8.53 [c] 5.15 [m]	4.5,6.4 [m]	
	Monensin	17090-79-8	670.9	$C_{36}H_{62}O_{11}$	63 [n] 5-63 [m]	2.75 [n] 2.8-4.1 [m]	6.65 [n] 6.7 [m]	
	Narasin	55134-13-9	765.0	$C_{43}H_{72}O_{11}$	102-681 [m]	4.9-6.2 [m]	7.9 [m]	

Aminocoumarins	Novobiocin	303-81-1	612.6	$C_{31}H_{36}N_2O_{11}$		2.45 [c]	4.3 [c]	
Polypeptides	Bacitracin	1405-87-4	1422.7	$C_{66}H_{103}N_{17}O_{16}S$				
Lincosamides	Lincomycin	154-21-2	406.5	$C_{18}H_{34}N_2O_6S$	927 [c]	0.56 [c]		
Chloramphenicol derivatives	Florfenicol	73231-34-2	358.2	$C_{12}H_{14}Cl_2FNO_4S$		-0.04 [o]	-	
	Chloramphenicol	154-75-2	323.1	$C_{11}H_{12}Cl_2FN_2O_5$	2500 [c]	1.14 [c]		

β-Lactams	Ceftiofur	80370-57-6	523.6	$C_{19}H_{17}N_5O_7S_3$			
	Cloxacillin	61-72-3	435.9	$C_{19}H_{18}ClN_3O_5S$	2.48[c]	2.78[c]	

[a] K_{ow}: the octanol-water partition coefficient; [b] pK_a: acidity constant; [c] U.S. National Library of Medicine ChemIDPlus Advanced. (http://chem.sis.nlm.nih.gov/chemidplus/), accessed on 10 September, 2011; [d] [2]; [e] [3]; [f] [4]; [g] [5]; [h] [6]; [i] [7]; [j] [8]; [k] [9]; [l] [10]; [m] [11]; [n] [12]; [o] [13].
Note: Target compounds presented in the Table S1 were selected based on their usages in China, which are not regularly used together in the swine farm.

Table S2

RRLC-MS/MS parameters for the antibiotics.

Analyte	Abbr. [a]	R.T. [b] (min)	MRM-transitions [c]	Fragmentor (V)	CE [d] (eV)	Ion ratios [e]	Analyte	Abbr.	R.T. (min)	MRM-transitions	Fragmentor (V)	CE (eV)	Ion ratios
ESI+													
Sulfonamides	SAs												
Sulfacetamide	SCT	2.203	215.2→92.1 215.2→156.0	65	21 5	2.2	Sulfamethoxazole	SMX	8.903	254.3→156.0 254.3→108.1	90	13 21	1.1
Sulfachloryridazine	SCP	7.826	285.7→109.0 285.7→92.1	115	24 24	1.1	Sulfamethoxazole-D_4 (IS [f])	SMX- D_4	8.830	258.1→160.1 258.1→112	110	13 21	1.2
Sulfadiazine	SDZ	2.582	251.3→156 251.3→92.1	100	9 25	1.1	Sulfameter	SM	5.618	281.3→92.1 281.3→108.1	115	32 28	1.1
Sulfadoxine	SDO	9.006	311.3→156.0 311.3→108.1	115	16 28	3.5	Sulfamerazine (IS)	SMR	3.860	265.1→156.0 265.1→108.0	104	13 25	1.4
Sulfadimethoxine	SDM	11.325	311.3→156.0 311.3→92.1	130	20 36	4.9	Sulfamonomethoxine	SMM	7.457	281.3→92.1 281.3→108.1	120	36 28	1.1
Sulfamethazine	SMZ	5.272	279.3→124.1 279.3→156	124	21 12	2.0	Sulfapyridine	SPD	3.361	250.3→156.0 250.3→108.1	114	21 13	1.1
Sulfamethazine-$^{13}C_6$ (IS)	SMZ-$^{13}C_6$	5.275	285.3→124.1 285.3→162	105	24 12	2.0	Sulfaquinoxaline	SQX	11.420	301.3→92.1 301.3→108.1	115	36 28	1.1
Sulfathiazole	STZ	3.093	256.3→92.1 256.3→108.1	120	24 24	1.3	Sulfisoxazole	SX	9.903	268.3→156.0 268.3→113.1	100	9 13	1.3
Sulfanilamide	SA	1.283	173.2→93.1 173.2→75.1	115	16 28	7.8	Sulfaguanidine	SG	1.098	215.2→92.1 215.2→65.1	95	24 44	1.8
Tetracyclines	TCs						Meclocycline (IS)	MC	11.281	477.1→460.0	134	17	
Chlortetracycline	CTC	9.986	479.1→444 479.1→462	119	17 17	1.6	Thiabendazole-D_4 (IS)	TBD- D_4	3.058	206.1→135.1 206.1→179.1	130	35 25	1.1
Doxycycline	DC	10.360	445.2→428.1 445.2→154	134	17 25	18	Oxytetracycline	OTC	5.052	461.2→426.1 461.2→201.1	119	17 41	7.0
Methacycline	MT	10.017	443.4→426.1 443.4→201.1	125	16 36	6.9	Tetracycline	TC	6.054	445.0→410.0 445.0→427.0	110	15 5	2.4
Fluoroquinolones	FQs						Norfloxacin	NFX	5.252	320.3→302.1 320.3→276	129	17 17	6.9
Ciprofloxacin	CFX	5.738	332.2→314 332.2→288	124	17 17	5.5	Lomefloxacin	LFX	6.426	352.3→265.1 352.3→334.1	124	25 17	1.4
Ciprofloxacin-D_8 (IS)	CFX-D_8	5.633	340.2→322 340.2→296.2	110	17 17	8.8	Marbofloxacin	MAR	4.510	363.4→72.1 363.4→70.1	125	24 44	8.8
Danofloxacin	DAN	6.818	358.4→340.1 358.4→283.1	165	20 24	27	Ofloxacin	OFX	5.334	362.0→261.0 362.0→318.0	130	25 15	1.3
Difloxacin	DIF	8.718	400.4→299.1 400.4→356.2	165	28 20	1.0	Pefloxacin	PEF	5.573	334.4→290.2 334.4→316.2	145	20 16	4.1

Enrofloxacin	EFX	7.237	360.4→316.1 360.4→342.1	134	17 17	1.3	Sarafloxacin	SAR	8.514	386.4→368.2 386.4→342.2	155	24 16	2.6
Fleroxacin	FL	5.103	370.3→326.2 370.3→269.1	145	20 28	1.5	Carbadox	CAR	5.046	263.2→129.0 263.2→102.1	120	32 56	1.5
Macrolides	MLs						Roxithromycin	RTM	13.576	838.1→158.1 838.1→679	178	37 15	3.8
Clarithromycin	CTM	15.333	748.9→158.1 748.9→590	180	24 14	2.3	Oleandomycin	ODM	13.662	689→158.1 689→544	170	29 15	2.4
Erythromycin-H_2O	ETM-H_2O	12.944	716.5→158.2 716.2→558	160	25 25	8.4	Erythromycin-^{13}C-D_3 (IS)	ETM-^{13}C-D_3	12.976	720.6→162.2 720.6→562.2	162	25 20	2.4
Leucomycin	LCM	13.147	772.4→109.1 772.4→83.1	230	44 68	1.3	Tylosin	TYL	12.609	916.5→174.1 916.5→132.1	320	29 33	7.7
Ionophores	IPs						Narasin	NAR	19.130	787.5→431.2 787.5→531.3	300	56 32	8.6
Salinomycin	SAL	18.792	773.5→431.2 773.5→265.1	320	56 60	3.0	Monensin	MON	21.879	693.8→675.5 693.8→479.3	275	40 56	2.3
Others							Trimethoprim-D_3 (IS)	TMP- D_3	4.143	294.4→123.0 294.4→230.0	152	21 21	1.0
Trimethoprim	TMP	4.219	291.3→123.1 291.3→230.1	144	25 21	1.2	Ormetoprim	OMP	5.251	275.3→259.1 275.3→123.1	170	28 24	1.0
Ceftiofur	CEFT	11.127	524.5→241.1 524.5→125.0	165	16 76	1.1	Cloxacillin	CLOX	14.213	436.9→160.1 436.9→277.7	105	12 8	1.1
Novobiocin	NOV	17.382	613.6→189.1 613.6→133	145	24 72	1.3	Bacitracin	BACI	11.082	712.1→669.4 712.1→869.4	204	24 28	3.6
Lincomycin	LIN	2.964	407.5→126.1 407.5→70.1	155	32 72	23	Lincomycin-D_3	LIN-D_3	2.962	410.6→129.1 410.6→73.1	170	36 76	29
ESI-							Florfenicol	FF	2.630	357.2→337 357.2→185	90	4 12	1.3
Chloramphenicol	CAP	3.086	321.1→152.1 321.1→257	115	4 0	1.4	Chloramphenicol-D_5 (IS)	CAP-D_5	3.066	327.1→157.1 327.1→262.1	125	17 0	4.9

[a] Abbreviation. [b] Retention time. [c] All the coupounds were $[M+H]^+$, except ionophore compounds ($[M+Na]^+$), bacitracin ($[M+2H]^{2+}$), florfenicol and chlormphenicol ($[M-H]^-$). The underlined MRM transitions were used for quantification. [d] Collision energy. [e] Ion ratios of two selected transitions were calculated by dividing the more abundance MRM with the less abundance MRM. [f] Internal standard.

Table S3

Recoveries (n = 3), method detection limits (MDLs), and method quantitation limits (MQLs) of the antibiotics from surface water and lagoon wastewater.

Analyte	IS [a]	Surface water					Lagoon wastewater [b]					
		10 ng/L	100 ng/L	Matrix%[c]	MDLs (ng/L)	MQLs (ng/L)	200 ng/L	1000 ng/L	2000 ng/L	Matrix%	MDLs (ng/L)	MQLs (ng/L)
SCT	SMX-D_4	**32±2**[d,e]	**34±4**	83±3	1.57	5.23	**41±0.6**	**37±2**	**40±0.7**	50±2	4.52	15.1
SCP	SMX-D_4	74±3	81±2	81±1	0.70	2.33	88±9	65±3	68±2	91±3	8.32	27.7
SDZ	SMR	96±8	107±0.7	100±3	0.39	1.29	128±10	129±6	124±3	101±2	3.39	11.3
SDO	SMX-D_4	74±3	81±2	81±1	0.45	1.50	58±1	55±2	51±1	57±2	1.70	5.67
SDM	SMX-D_4	71±4	79±3	81±2	0.56	1.87	53±1	54±2	51±1	57±1	1.23	4.10
SMZ	SMZ-$^{13}C_6$	87±3	99±1	117±1	0.31	1.03	74±0.3	79±3	88±1	112±1	1.64	5.47
SMX	SMX-D_4	65±4	86±2	117±3	0.29	0.96	71±1	80±4	88±1	112±2	1.55	5.17
SM	SMZ-$^{13}C_6$	130±11	125±2	117±2	0.34	1.13	121±2	102±5	112±4	95±3	1.88	6.27
SMM	SMX-D_4	112±4	120±4	106±2	0.21	0.70	69±6	65±3	70±2	90±3	2.16	7.20
SPD	SMR	79±8	81±5	102±4	0.29	0.98	53±2	82±2	84±0.5	101±3	1.92	6.41
SQX	SMX-D_4	63±3	60±2	92±2	0.19	0.63	78±2	68±1	76±2	88±2	3.01	10.0
SX	SMX-D_4	136±1	78±2	114±1	0.30	1.00	66±4	65±1	70±2	90±3	2.77	9.23
STZ	SMR	121±13	132±4	111±0.7	0.26	0.88	87±3	109±2	110±3	113±3	2.55	8.50
CTC	MC	118±5	113±16	140±4	0.88	2.94	85±8	95±5	107±5	**154±8**	11.4	38.1
DC	MC	124±5	141±2	98±3	1.33	4.43	74±15	95±8	122±4	123±4	18.5	61.7
MT	MC	99±13	96±9	116±3	1.57	5.22	90±7	86±1	89±0.7	76±3	9.23	30.8
OTC	MC	140±5	**159±18**	**170±5**	0.63	2.08	**197±6**	**168±19**	**177±5**	134±5	3.84	12.8
TC	MC	109±9	112±12	139±3	0.90	3.00	88±19	78±5	83±2	107±6	2.02	6.73
CFX	CFX-D_8	140±7	138±2	103±1	1.09	3.63	100±1.4	103±5	110±2	107±3	1.23	4.10
DAN	CFX-D_8	108±30	97±19	93±3	0.34	1.13	142±7	**151±3**	**159±10**	107±4	2.32	7.74
DIF	CFX-D_8	**211±18**	**229±28**	76±2	1.09	3.64	75±2	56±2	58±0.9	53±0.7	1.78	5.92
EFX	CFX-D_8	**292±28**	**221±21**	110±1	0.39	1.29	**223±10**	**200±6**	**221±0.6**	106±2	2.37	7.89
FL	CFX-D_8	143±2	89±7	87±0.4	0.54	1.80	102±4	87±0.3	91±2	78±0.4	1.62	5.41
LFX	CFX-D_8	**279±41**	**175±38**	85±2	0.65	2.18	102±4	75±3	78±2	52±2	1.41	4.70
MAR	CFX-D_8	129±31	103±8	86±3	0.29	0.95	138±6	108±2	111±3	86±4	1.00	3.34
NFX	CFX-D_8	96±17	72±6	101±1	0.88	2.93	103±1	102±5	99±1	122±2	3.14	10.5
OFX	CFX-D_8	125±7	133±12	88±1	0.29	0.96	108±14	101±4	101±3	85±2	3.17	10.6
PEF	CFX-D_8	144±2	123±21	102±3	0.26	0.88	**151±7**	150±8	149±8	105±2	3.77	12.6
SAR	CFX-D_8	**184±19**	**192±28**	90±2	0.30	0.98	74±3	53±3	53±0.4	74±2	5.81	19.4
CAR	TBD-D_4	122±4	130±7	140±6	0.95	3.17	85±8	84±2	86±2	134±3	6.67	22.2
CTM	ETM-^{13}C-D_3	78±3	82±6	87±2	0.52	1.73	96±5	80±3	83±4	110±2	1.36	4.53

ETM-H_2O	ETM-^{13}C-D_3	134±16	98±16	123±14	0.31	1.02	137±11	119±13	149±13	124±8	3.01	10.0
LCM	ETM-^{13}C-D_3	119±3	94±4	136±2	0.16	0.52	131±8	137±3	132±3	72±0.2	2.21	7.36
ODM	ETM-^{13}C-D_3	95±4	148±3	142±2	0.47	1.57	**189±3**	**186±2**	**191±7**	98±0.9	0.71	2.36
RTM	ETM-^{13}C-D_3	94±3	109±2	106±2	0.21	0.70	143±8	136±6	138±4	149±1	0.93	3.10
TYL	ETM-^{13}C-D_3	119±4	97±3	134±2	0.51	1.71	128±3	115±2	131±5	66±0.4	1.30	4.32
SAL	TBD-D_4	53±13	92±4	**49±0.4**	0.24	0.78	57±8	84±3	78±6	74±1	0.76	2.53
NAR	TBD-D_4	**49±15**	78±4	54±0.7	0.21	0.71	58±3	68±3	61±3	51±2	1.10	3.66
MON	TBD-D_4	62±5	70±10	76±2	0.36	1.20	65±14	104±5	111±5	114±4	1.36	4.55
CEFT	TBD-D_4	121±8	**153±1**	116±14	1.15	3.85	**159±4**	**196±6**	**197±12**	133±4	19.7	65.8
CLOX	TBD-D_4	75±11	103±8	54±3	1.76	5.88	53±6	51±1	**42±5**	**13±0.9**	18.4	61.4
OMP	TMP-D_3	113±13	100±4	99±1	0.52	1.72	114±3	111±0.6	112±3	116±1	0.93	3.10
TMP	TMP-D_3	105±1	96.±3	99±2	0.25	0.82	110±2	103±1	102±2	105±3	1.38	4.61
NOV	ETM-^{13}C-D_3	63±18	59±11	96±9	0.30	1.01	71±24	64±6	76±6	129±4	5.94	19.8
BACI	ETM-^{13}C-D_3	**49±14**	**36±4**	117±7	1.20	4.00	121±6	55±7	63±9	63±1	13.0	43.5
LIN	LIN-D_3	124±4	137±12	103±1	1.01	3.37	111±6	118±9	124±7	79±2	12.9	43.0
FF	CAP-D_5	113±3	80±6	92±3	0.65	2.17	62±7	57±3	53±2	63±4	4.67	15.6
CAP	CAP-D_5	103±7	89±9	97±2	0.77	2.57	72±3	68±2	65±1	69±2	1.62	5.40

[a] Internal standards. [b] The three spiked levels for SMM, SMZ and LIN were 2 , 10 and 20 μg/L; the other analytes were 200, 1000 and 2000 ng/L in lagoon wastewater. [c] >100% means matrix enhancement effect, <100% means matrix suppression effect. [d] Mean(%)±standard deviation (%).[e] Bold letters in the table represent those recoveries or matrix effect outside the range of 50—150%.

Table S4
Recoveries (n = 3), method detection limits (MDLs), and method quantitation limits (MQLs) of the antibiotics from manure and sludge.

Analyte	Manure						Sludge [a]					
	40 ng/g	200 ng/g	1000 ng/g	matrix% [b]	MDLs (ng/g)	MQLs (ng/g)	40 ng/g	200 ng/g	1000 ng/g	matrix%	MDLs (ng/g)	MQLs (ng/g)
SCT	**15±1**[c,d]	**14±1**	**12±0.2**	52±1	2.63	8.77	**19±1**	**15±0.2**	**34±6**	96±10	2.51	8.37
SCP	89±7	92±6	52±3	82±4	2.35	7.88	90±9	100±4	89±8	103±1	2.54	8.47
SDZ	97±18	55±3	66±14	115±2	0.45	1.50	127±22	68±10	103±0.7	119±8	0.64	2.12
SDO	123±4	116±7	83±3	56±1	0.67	2.23	89±4	81±5	93±2	94±5	0.59	1.97
SDM	68±4	81±7	64±7	58±1	0.55	1.83	81±2	70±1	90±6	96±6	0.64	2.13
SMZ	81±2	83±1	58±4	104±2	0.46	1.53	104±6	88±2	85±1	99±1	0.66	2.22
SMX	70±0.5	88±8	80±1	99±0.7	0.49	1.63	88±4	100±1	99±0.7	98±2	0.51	1.70
SM	111±1	121±7	92±5	121±2	0.53	1.77	82±6	95±4	109±7	123±4	0.52	1.73
SMM	130±14	128±24	86±6	75±5	0.96	3.20	78±0.9	90±16	94±4	124±3	0.71	2.37
SPD	72±14	66±8	62±0.8	99±0.2	0.40	1.35	122±9	131±9	112±5	123±12	0.63	2.10
SQX	52±3	**47±8**	**36±1**	**34±1**	1.44	4.80	66±6	54±2	68±5	82±4	2.07	6.90
SX	119 ±4	110±2	81±6	108±1	0.49	1.65	84±5	81±8	83±10	110±14	0.57	1.90
STZ	110±4	96±4	85±0.3	83±1	0.40	1.33	109±4	109±6	117±2	118±9	0.79	2.62
CTC	105±14	124±28	80±17	**364±28**	2.49	8.31	129±11	73±8	88±2	128±2	4.06	13.5
DC	110±4	108±10	138±12	**204±9**	2.79	9.30	117±15	132±21	142±24	94±5	3.18	10.6
MT	67±10	99±11	73±9	**166±22**	0.97	3.23	120±7	57±10	56±5	55±5	1.39	4.63
OTC	**259±12**	**170±35**	**182±34**	**203±7**	0.95	3.18	**189±32**	**163±13**	**198±17**	65±16	1.07	3.57
TC	120±18	96±12	96±26	**265±18**	1.78	5.94	114±16	135±22	82±14	102±7	1.32	4.40
CFX	120±4	136±14	97±7	102±1	1.14	3.80	92±10	121±19	136±7	95±3	1.39	4.63
DAN	93±4	129±15	88±1	78±0.2	0.97	3.22	123±8	**157±12**	**168±10**	86±13	0.45	1.50
DIF	51±8	72±3	**45±3**	**40±0.5**	0.73	2.44	93±3	62±19	56±3	52±2	0.64	2.12
EFX	**162±13**	**218±27**	**153±3**	105±0.1	0.66	2.19	**193±13**	**235±29**	**225±9**	108±9	1.19	3.95
FL	81±9	59±17	51±9	54±0.2	0.68	2.27	104±14	61±8	106±6	67±5	0.71	2.37
LFX	54±11	80±16	55±4	62±1	0.42	1.41	133±2	108±9	84±6	51±0.8	0.56	1.87
MAR	119±21	63±3	81±22	69±0.3	0.55	1.82	104±7	75±3	130±8	69±6.4	0.88	2.94
NFX	108±11	131±10	93±7	138±1	1.02	3.40	72±5	79±9	93±8	89±6	0.81	2.70
OFX	108±19	99±5	88±14	67±3	0.94	3.13	76±5	74±8	75±12	80±3	1.29	4.38
PEF	**180±21**	**169±31**	148±13	108±1	1.02	3.39	116±31	141±9	**191±9**	117±17	0.45	1.50
SAR	68±5	51±4	60±2	69±0.7	1.59	5.29	89±1	66±11	63±6	59±5	0.71	2.38
CAR	51±6	**45±8**	**42±3**	115±4	1.58	5.26	62±7	74±12	86±1	137±6	0.55	1.84
CTM	70±7	93±6	61±5	122±4	0.54	1.80	108±11	80±6	65±11	109±2	0.89	2.97

ETM-H_2O	132±28	82±13	104±6	91±12	0.47	1.57	143±12	84±8	110±13	124±9	0.93	3.11
LCM	123±5	119±6	89±5	93±2	0.59	1.96	72±7	66±3	69±0.6	91±2	0.91	3.03
ODM	**261±13**	**251±13**	**164±2**	**191±1**	0.42	1.39	137±5	147±8	127±6	133±0.7	0.69	2.29
RTM	**198±8**	**210±18**	116±9	**239±10**	0.52	1.73	128±7	85±7	64±7	134±4	0.55	1.83
TYL	137±12	130±5	97±3	**158±0.6**	0.52	1.72	84±12	88±8	83±2	89±7	0.61	2.03
SAL	**<10**	**<10**	**<10**	**45±1**	--- [e]	---	**<10**	**<10**	**<10**	69±2	---	---
NAR	**<10**	**<10**	**<10**	**46±1**	---	---	**<10**	**<10**	**<10**	60±2	---	---
MON	**<10**	**<10**	**<10**	64±0.6	---	---	**<10**	**<10**	**<10**	77±6	---	---
CEFT	133±19	110±21	54±39	136±12	5.22	17.4	132±17	146±25	144±19	**233±2**	4.62	15.4
CLOX							**<10**	**<10**	**<10**	79±13	---	---
OMP	123±24	134±25	96±6	109±0.1	0.97	3.23	122±24	119±10	67±8	77±3	0.52	1.74
TMP	134±7	139±13	112±8	109±1	0.52	1.73	111±2	100±5	92±0.2	99±3	0.86	2.85
NOV	**<10**	**<10**	**<10**	127±2	---	---	**19±11**	**29±4**	**18±1**	53±2	5.77	19.3
BACI	70±18	69±21	66±7	125±5	5.22	17.4	**47±19**	58±23	122±12	74±5	8.57	28.6
LIN	110±14	117±11	63±6	103±1	4.10	13.7	**160±28**	118±10	88±5	106±3	2.66	8.87
FF	**43±7**	**34±3**	56±6	**41±3**	2.03	6.77	59±3	77±4	54±6	98±5	1.99	6.63
CAP	56±7	59±2	61±6	73±2	1.17	3.90	63±3	79±3	75±10	86±3	2.32	7.73

[a] The three spiked levels for NFX, OFX, TC and OTC were 0.5, 1 and 2 μg/g; the other analytes: 40 , 200 and 1000 ng/g in sludge samples.

[b] >100% means matrix enhancement effect, <100% means matrix suppression effect.

[c] Mean(%)±standard deviation (%). [d] Bold letters in the table represent those recoveries or matrix effect outside the range of 50—150%.

[e] Recoveries from spiked samples in manure and sludge samples were low, and those compounds were only used for qualitative analysis.

Table S5
Recoveries (n = 3), method detection limits (MDLs), and method quantitation limits (MQLs) of the antibiotics from sediment.

Analyte	Sediment					
	10 ng/g	50 ng/g	100 ng/g	Matrix% [a]	MDLs	MQLs
SCT	**20±4** [b,c]	**21±4**	**16±3**	88±5	1.02	3.40
SCP	82±5	72±6	51±1	133±4	1.67	5.57
SDZ	117±3	107±3	102±12	104±1	0.57	1.90
SDO	60±1	70±2	78±4	75±5	0.49	1.63
SDM	65±1	73±2	79±4	75±5	0.54	1.80
SMZ	72±1	90±3	92±2	101±1	0.31	1.03
SMX	64±1	91±2	89±3	103±1	0.30	1.00
SM	111±3	124±4	120±2	119±3	0.39	1.30
SMM	105±1	123±5	97±1	105±8	0.47	1.57
SPD	63±2	68±2	78±2	76±0.8	0.20	0.67
SQX	53±4	55±2	64±2	72±2	0.41	1.36
SX	95±2	79±2	79±1	107±5	0.35	1.17
STZ	131±7	126±2	143±6	133±6	0.33	1.09
CTC	53±5	56±9	**45±2**	108±1	1.01	3.36
DC	121±13	117±8	116±2	78±3	0.92	3.07
MT	63±6	66±7	53±3	83±2	0.43	1.43
OTC	82±15	94±12	62±5	108±21	0.75	2.50
TC	68±16	68±11	58±2	92±13	0.45	1.49
CFX	122±12	117±8	116±2	78±3	1.21	4.03
DAN	126±13	135±13	126±12	85±0.5	1.14	3.80
DIF	**158±17**	140±12	**176±8**	56±0.2	0.35	1.17
EFX	**284±8**	**280±8**	**343±32**	120±3	0.58	1.92
FL	147±10	144±6	**159±17**	76±3	0.32	1.06
LFX	113±18	122±25	130±24	67±1	0.41	1.35
MAR	124±5	116±7	127±14	80±3	0.54	1.79
NFX	113±7	129±3	90±14	114±3	0.85	2.83
OFX	134±19	129±16	145±14	76±3	0.28	0.95
PEF	143±16	**152±12**	142±13	101±3	0.71	2.36
SAR	134±13	131±6	148±13	80±5	0.98	3.26
CAR	134±17	141±5	129±1	139±2	0.88	2.94
CTM	96±5	109±3	92±9	89±3	0.35	1.17

ETM-H_2O	127±20	109±13	87±26	112±10	0.51	1.69
LCM	134±4	135±10	89±4	134±4	0.26	0.87
ODM	117±7	138±13	139±8	122±3	0.25	0.82
RTM	96±3	123±8	119±3	114±5	0.37	1.23
TYL	120±5	130±9	80±3	132±3	0.50	1.66
SAL	122±17	112±4	112±10	101±1	0.44	1.47
NAR	98±17	90±6	86±6	89±2	0.42	1.39
MON	70±8	81±4	102±29	120±7	0.91	3.04
CEFT	72±14	**44±18**	**12±0.8**	**254±4**	1.75	5.83
CLOX						
OMP	93±7	102±10	112±20	97±0.8	0.22	0.75
TMP	86±3	100±10	101±2	100±0.3	0.19	0.64
NOV	**33±8**	**45±11**	57±17	64±0.3	2.00	6.67
BACI	**<10**	**<10**	**<10**	130±2	---[d]	---
LIN	92±12	118±12	128±6	104±2	1.33	4.43
FF	83±5	73±4	68±1	98±1	1.06	3.50
CAP	98±6	71±2	69±1	95±1	0.49	1.63

[a] >100% means matrix enhancement effect, <100% means matrix suppression effect. [b] Mean(%)±standard deviation (%).
[c] Bold letters in the table represent those recoveries or matrix effect outside the range of 50—150%.
[d] Recoveries from spiked samples in sediment sample were low, and the compound was only used for qualitative analysis.

Table S6 Concentrations of antibiotics in aqueous phase (ng/L), particle phase (ng/g), and sludge phase (ng/g) in the lagoons of Part A and Part B

Compound	Lagoon 1			Lagoon 2			Lagoon 3		
	Aqueous phase [a] (ng/L)	Suspended particles [a] (ng/g)	Sludge [b] (ng/g)	Aqueous phase [a] (ng/L)	Suspended particles [a] (ng/g)	Sludge [b] (ng/g)	Aqueous phase [a] (ng/L)	Suspended particles [a] (ng/g)	Sludge [b] (ng/g)
Sulfonamides									
Sulfadiazine	160±10.7	19.9±3.43	<MQL[c]	77.4±4.98	4.35±0.61	ND[d]	1260±39.5	72.9±10.2	ND
Sulfaguanidine	ND	ND	ND	ND	ND	ND	<MQL	ND	ND
Sulfamethazine	2030±64.2	103±17	63.0±1.96	1480±11.9	33.0±3.32	4.16±0.17	69500±2730	2270±639	28.7±1.16
Sulfamethoxazole	ND	ND	ND	ND	ND	ND	705±26.0	ND	ND
Sulfamonomethoxine	5480±367	28.2±4.08	50.3±0.44	3270±97.8	18.2±1.96	<MQL	46700±975	1220±383	2.39±0.11
Sulfanilamide	ND	ND	ND	ND	ND	ND	<MQL	ND	ND
Tetracyclines									
Chlortetracycline	18000±293	12100±768	87900±19600	21300±7940	40800±1870	2530±108	3060±12.7	20000±691	1250±271
Doxycycline	7590±546	1800±365	9100±1110	11600±4550	8240±459	340±4.76	5790±1830	11400±1150	531±5.78
Oxytetracycline	1200±45.0	1080±50.2	930±9.87	927±8.81	680±53.7	96.0±3.92	2410±330	28800±1240	493±18.2
Tetracycline	111±5.30	1620±632	1220±131	201±2.12	1740±13.4	99.3±4.22	62.9±6.41	3600±28.4	62.8±3.63
Fluoroquinolones									
Ciprofloxacin	182±16.6	1700±338	861±30.4	207±30.0	1600±111	435±41.5	ND	159±4.36	8.82±0.20
Enrofloxacin	ND	5.35±1.57	7.34±0.22	ND	8.47±0.48	5.63±0.51	ND	29.3±3.43	4.35±0.28
Norfloxacin	34.2±12.3	21.1±7.74	ND	77.1±9.58	5.54±3	ND	<MQL	23.6±3.88	ND
Ofloxacin	110±6.65	87.6±10.2	64.8±2.76	124±10.1	69.4±5.74	50.0±4.85	350±33.7	473±23.3	26.8±2.94
Pefloxacin	ND	21.1±9.86	20.6±1.61	ND	25.3±3.80	7.64±0.58	ND	ND	ND
Macrolides									
Anhydro erythromycin	1590±4.37	104±12.3	37.5±1.49	2770±29.3	148±7.60	6.07±0.07	ND	ND	ND
Leucomycin	ND	1.43±0.3	<MQL	ND	3.91±0.39	ND	ND	ND	ND
Ionophores									
Salinomycin	ND	ND	ND	ND	ND	ND	4.38±0.46	259±18.0	ND
Diaminopyrimidines									
Trimethoprim	ND	ND	ND	ND	ND	ND	13.6±1.01	ND	ND
Polypeptides									
Bacitracin	ND	3080±370	3100±540	ND	4540±323	ND	ND	3200±32.4	ND
Lincosamides									
Lincomycin	5500±358	215±77.9	109±8.02	5730±148	104±32	14.7±2.47	44500±3570	1160±398	38.9±4.56
Chloramphenicol derivatives									
Florfenicol	ND	ND	ND	ND	ND	ND	153±33.9	14.4±2.05	ND

[a] Mean ± standard deviation (n=2, replicate samples at the same time);
[b] Mean ± standard deviation (n=3, replicate samples at the same time);
[c] Below method quantitation limit;
[d] Not detected.

Estimation of excretion masses based on feeds. Mass estimation of antibiotics excreted by pigs after in-feed administration in the farm was applied to assess the contribution of antibiotics by feed additives.

$$\mathbf{q_{i,j,f} = C_{i,j} \times W_j \times k_i}$$

$q_{i,j,f}$: excretion mass of active ingredient *i* per pig in the stage *j* after feed consumption, μg/d/pig; $C_{i,1}$, $C_{i,2}$, $C_{i,3}$, $C_{i,4}$ and $C_{i,5}$ are the concentrations of the active ingredient *i* in the feeds for freshly weaned piglets, piglets, growing pigs, finishing pigs and sows, respectively, μg/kg; when the actual concentration was below corresponding method quantitation limit (MQLs), half of MQLs was used for calculation. W_1, W_2, W_3, W_4 and W_5 are the weight of the feeds eaten by freshly weaned piglets (1 kg/d), piglets (2 kg/d), growing pigs (3 kg/d), finishing pigs (5 kg/d) and sows (5 kg/d), respectively; k_i is excretion constant (%) of the active ingredient *i* from the pigs after oral administration, which is listed in Table S7.

$$\mathbf{Q_{i,j,f} = q_{i,j,f} \times N_j}$$

$$\mathbf{Q_{i,f} = Q_{i,1,f} + Q_{i,2,f} + Q_{i,3,f} + Q_{i,4,f} + Q_{i,5,f}}$$

$Q_{i,j,f}$: daily excretion mass of active ingredient *i* from the stage *j* of pigs after feed consumption in the swine farm, μg/d; N_1, N_2, N_3, N_4 and N_5 are the numbers of freshly weaned piglets, piglets, growing pigs, finishing pigs and sows in the swine farm, respectively; $Q_{i,f}$: the total daily excretion mass of active ingredient *i* from all the pigs in the swine farm after feed consumption, μg/d; $Q_{i,1,f}$,$Q_{i,2,f}$, $Q_{i,3,f}$, $Q_{i,4,f}$ and $Q_{i,5,f}$ are daily excretion masses of active ingredient *i* from freshly weaned piglets, piglets, growing pigs, finishing pigs and sows, separately, μg/d.

Table S7 Estimated daily excretion masses of antibiotics per pig (μg/d/pig) based on feeds in the swine farm

Compound	Approximate excretion in parent compound (%)		Excretion masses of antibiotics after in-feed administration (μg/d/pig)				
	Urine or feces	Reference	Freshly weaned piglets	Piglets	Growing pigs	Finishing pigs	Sows
Sulfonamides							
Sulfamethazine	20%	(14)	0.47	0.00	0.00	0.00	0.00
Sulfamonomethoxine	20%	(14)	0.00	0.00	3.61	0.00	0.00
Tetracyclines							
Chlortetracycline	70% (according to human excretion)	(15)	18300	17800	0.00	0.00	56400
Oxytetracycline	80% (according to human excretion)	(15)	0.87	1.74	0.00	0.00	4.36
Tetracycline	72%	(16)	1290	2680	0.00	0.00	5540
Fluoroquinolones							
Enrofloxacin	40%	(17)	4.28	0.00	0.00	0.00	0.00
Ionophores							
Salinomycin	85%	(18)	0.00	34.7	0.00	0.00	0.00
Diaminopyrimidines							
Trimethoprim	60% (according to human excretion)	(15)	0.00	1.04	1.57	0.00	0.00
Polypeptides							
Bacitracin	95% (all the forms)	(19)	0.00	103000	175000	0.00	32900
Lincosamides							
Lincomycin	32%	(20)	5920	0.00	42.1	0.00	0.00
Chloramphenicol derivatives							
Florfenicol	50%	(21)	1.14	0.00	3.42	19.3	16.7
Sum of all antibiotics			**25500**	**124000**	**175000**	**19.3**	**94900**

Table S8 Estimated daily excretion masses of antibiotics after in-feed administration in the swine farm

Compound	Excretion masses of antibiotics after in-feed administration (mg/d)					
	Freshly weaned piglets	Piglets	Growing pigs	Finishing pigs	Sows	Sum
Sulfonamides						
Sulfamethazine	0.47	0.00	0.00	0.00	0.00	**0.47**
Sulfamonomethoxine	0.00	0.00	7.22	0.00	0.00	**7.22**
Tetracyclines						
Chlortetracycline	18300	17800	0.00	0.00	28200	**64300**
Oxytetracycline	0.87	1.74	0.00	0.00	2.18	**4.79**
Tetracycline	1290	2680	0.00	0.00	2770	**6740**
Fluoroquinolones						
Enrofloxacin	4.28	0.00	0.00	0.00	0.00	**4.28**
Ionophores						
Salinomycin	0.00	34.7	0.00	0.00	0.00	**34.7**
Diaminopyrimidines						
Trimethoprim	0.00	1.04	3.13	0.00	0.00	**4.17**
Polypeptides						
Bacitracin	0.00	103000	351000	0.00	16500	**471000**
Lincosamides						
Lincomycin	5920	0.00	84.3	0.00	0.00	**6000**
Chloramphenicol derivatives						
Florfenicol	1.14	0.00	6.84	15.4	8.36	**31.7**
Sum of all antibiotics	**25500**	**124000**	**351000**	**15.4**	**47500**	**548000**

Calculation of daily excretion masses of antibiotics base on measured concentrations in feces, flush water and suspended particles

After administration, a large proportion of parent compounds and metabolites were excreted in feces and urine. In the swine farm, the feces were collected for sale, without any further treatment. After the feces were collected, the floors of the pig houses were flushed daily with clean well water to clean the residual feces, urine and other wastes. In all, the antibiotics excreted from the pig houses were mainly by feces, flush water and suspended particles. So the feces, flush water and suspended particles samples collected from different houses were used for calculating the excretion masses of antibiotics from pigs at different stages.

Daily excretion masses of antibiotics per pig in feces, flush water and suspended particles:

$$q_{i,j,fe} = C_{i,j,fe} \times W_{j,fe}$$

$$q_{i,j,w} = C_{i,j,w} \times V$$

$$q_{i,j,ss} = C_{i,j,ss} \times V \times W_{j,ss}$$

$$q_{i,j} = q_{i,j,fe} + q_{i,j,w} + q_{i,j,ss}$$

$q_{i,j,fe}$ is daily excretion mass of active ingredient *i* per pig in the stage *j* by feces, μg/d/pig; $q_{i,j,w}$ is daily excretion mass of active ingredient *i* per pig in the stage *j* by flush water, μg/d/pig; $q_{i,j,ss}$ is daily excretion mass of active ingredient *i* per pig in the stage *j* by suspended particles, μg/d/pig; $C_{i,j,fe}$ is the concentration of the active ingredient *i* in feces of pigs in the stage *j*, μg/kg; $W_{j,fe}$ is the dry weight of feces of pigs in the stage *j*, (kg/d/pig). The average dry weights of feces were: 110.8 g/d/ piglet, 282.21 g/d/growing or finishing pig, 423.08 g/d/sow [22]; $C_{i,j,w}$ is the concentration of the active ingredient *i* in flush water from the type *j* of pig houses, μg/L; V is the maximum volume of flush water permitted to discharge from pig houses in winter, 12 L/d/pig [23]; $C_{i,j,ss}$ is the concentration of the active ingredient in suspended particles along with flush water from the type *j* of pig houses, μg/kg; $W_{j,ss}$ is the weight of

suspended particles corresponding water sample, kg/L; weights of suspended particular matter in piglet flush water, growing/finishing flush water and sow flush water were 0.43, 1.01 and 1.17 g/L, respectively. $q_{i,j}$ is total daily excretion masses of active ingredient *i* per pig in the stage *j*, μg/d/pig; When the actual concentration was below corresponding method quantitation limits (MQLs), half of MQLs was used for calculation.

The daily excretion masses for piglets, growing pigs, finishing pigs and sows (μg/d/pig) were calculated based on the equations above. The daily excretion masses of antibiotics per freshly weaned piglet were not calculated, because feces and flush water for freshly weaned piglets were not sampled. Freshly weaned piglets were regarded as piglets in all the calculation of daily excretion masses based feces, flush water and suspended particles. The total daily excretion masses for growing pigs were calculated based on growing pigs feces, mixed flush water and suspended particles from growing and finishing pigs. The total daily excretion masses for finishing pigs were calculated based on growing pigs feces, mixed flush water and suspended particles from growing and finishing pigs.

The total daily excretion masses of antibiotics in feces, flush water and suspended particles in the selected swine farm:

$$\mathbf{Q}_{i,j,fe} = \mathbf{q}_{i,j,fe} \times \mathbf{N}_j$$

$$\mathbf{Q}_{i,j,w} = \mathbf{q}_{i,j,w} \times \mathbf{N}_j$$

$$\mathbf{Q}_{i,j,ss} = \mathbf{q}_{i,j,ss} \times \mathbf{N}_j$$

$$\mathbf{Q}_{i,j} = \mathbf{q}_{i,j} \times \mathbf{N}_j$$

$Q_{i,j,fe}$ is daily excretion mass of active ingredient *i* from all the pigs in the stage *j* by feces, μg/d; $Q_{i,j,w}$ is daily excretion mass of active ingredient *i* from all the pigs in the stage *j* by flush water, μg/d; $Q_{i,j,ss}$ is daily excretion mass of active ingredient *i* from all the pigs in the stage *j* by suspended particles, μg/d; N_j is the number of pigs in the stage *j*, the numbers of the

freshly weaned piglets, piglets, growing pigs, finishing pigs and sows are 1000, 1000, 2000, 800 and 500, respectively. The daily excretion masses for freshly weaned piglets were not calculated, because feces and flush water for freshly weaned piglets were not sampled; freshly weaned piglets were regarded as piglets in all the calculation of daily excretion masses based feces, flush water and suspended particles.

The total daily excretion masses of the antibiotics from the selected farm:

$$Q_i = \mathbf{q}_{i,1} \times \mathbf{N}_1 + \mathbf{q}_{i,2} \times \mathbf{N}_2 + \mathbf{q}_{i,3} \times \mathbf{N}_3 + \mathbf{q}_{i,4} \times \mathbf{N}_4 + \mathbf{q}_{i,5} \times \mathbf{N}_5$$

$$\mathbf{Q}_{i,\,normalized} = \mathbf{Q}_i / (\mathbf{N}_1 + \mathbf{N}_2 + \mathbf{N}_3 + \mathbf{N}_4 + \mathbf{N}_5)$$

Q_i is the total excretion mass of active ingredient *i* from the swine farm, μg /d; $q_{i,1}$, $q_{i,2}$, $q_{i,3}$, $q_{i,4}$ and $q_{i,5}$ mean the total excretion masses of active ingredient *i* from the freshly weaned piglets, piglets, growing pigs, finishing pigs and sows, respectively. N_1, N_2, N_3, N_4 and N_5 mean the numbers of the freshly weaned piglets (1000 heads), piglets (1000 heads), growing pigs (2000 heads), finishing pigs (800 heads) and sows (500 heads), respectively. $Q_{i,\,normalized}$ is average excretion masses of active ingredient *i* per pig per day, μg/d/pig.

Table S9 Calculated daily excretion masses of antibiotics per pig in feces, flush water, suspended particles (μg/d/pig), and the normalized daily excretion per pig (μg/d/pig) in the swine farm

Compound	Piglets [a]				Growing pigs [b]				Finishing pigs [c]				Sows			
	Feces	Flush water	Suspended particles	Sum	Feces	Flush water	Suspended particles	Sum	Feces	Flush water	Suspended particles	Sum	Feces	Flush water	Suspended particles	Sum
Sulfonamides																
Sulfamethazine	0.00	1.03	0.04	**1.07**	0.21	0.15	0.03	**0.39**	0.00	0.15	0.03	**0.18**	0.75	0.53	0.17	**1.45**
Sulfamethoxazole	0.00	0.14	0.00	**0.14**	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	**0.00**	0.00	0.07	0.00	**0.07**
Sulfamonomethoxine	0.00	12.4	0.15	**12.5**	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	**0.00**	0.00	7.20	1.60	**8.8**
Tetracyclines																
Chlortetracycline	15600	48.2	27.6	**15700**	131	282	800	**1210**	182	282	800	**1260**	46500	283	122	**46900**
Doxycycline	90.2	0.34	0.16	**90.7**	226	7.22	9.91	**243**	0.00	7.22	9.91	**17.1**	84.2	5.24	7.20	**96.6**
Oxytetracycline	70.5	0.27	0.09	**70.8**	3.05	4.98	1.90	**9.93**	0.00	4.98	1.90	**6.88**	12.8	0.44	0.35	**13.6**
Tetracycline	1960	3.89	1.60	**1970**	2.08	18.8	19.3	**40.2**	0.00	18.8	19.3	**38.1**	1090	20.4	1.74	**1110**
Fluoroquinolones																
Ciprofloxacin	0.00	0.00	0.00	**0.00**	0.00	0.85	0.27	**1.12**	0.00	0.85	0.27	**1.12**	0.00	0.00	0.00	**0.00**
Norfloxacin	0.00	0.45	0.05	**0.50**	0.00	0.77	0.57	**1.34**	0.00	0.77	0.57	**1.34**	2.73	2.92	0.22	**5.87**
Ofloxacin	0.49	0.00	0.12	**0.61**	0.00	0.55	0.80	**1.35**	0.00	0.55	0.80	**1.35**	0.66	10.1	3.71	**14.5**
Macrolides																
Anhydro erythromycin	0.00	0.00	0.00	**0.00**	0.00	5.20	0.15	**5.35**	0.00	5.20	0.15	**5.35**	0.00	1.26	0.00	**1.26**
Leucomycin	0.55	0.00	0.00	**0.55**	0.00	0.10	0.08	**0.18**	0.00	0.10	0.08	**0.18**	0.00	0.00	0.00	**0.00**
Tylosin	0.00	0.00	0.00	**0.00**	0.00	0.12	0.00	**0.12**	0.00	0.12	0.00	**0.12**	0.00	0.00	0.00	**0.00**
Diaminopyrimidines																
Trimethoprim	0.25	2.38	0.05	**2.68**	0.00	0.15	0.01	**0.16**	0.00	0.15	0.01	**0.16**	0.00	8.46	0.46	**8.92**
Polypeptides																
Bacitracin	71.6	614	386	**1070**	5360	46.7	74.8	**5480**	0.00	46.7	74.8	**121**	0.00	22.9	4.75	**27.7**
Lincosamides																
Lincomycin	5.54	1.51	0.48	**7.53**	0.00	2.04	0.18	**2.22**	2.14	2.04	0.18	**4.36**	50.4	4.32	1.52	**56.2**
Chloramphenicol derivatives																
Florfenicol	0.00	1.40	0.12	**1.52**	0.00	16.2	0.05	**16.3**	0.00	16.2	0.05	**16.3**	0.00	4.52	0.17	**4.69**
Sum	**17800**	**686**	**417**	**18900**	**5720**	**386**	**908**	**7010**	**184**	**386**	**908**	**1470**	**47800**	**372**	**144**	**48300**

[a] The daily excretion masses for freshly weaned piglets were not calculated, because feces and flush water for freshly-weaned piglets were not sampled; Freshly-weaned piglets were regarded as piglets in all the calculation of daily excretion masses based feces, flush water and suspended particles; [b] The total daily excretion masses for growing pigs were calculated based on growing pig feces, mixed flush water and suspended particles from growing and finishing pig buildings; [c] The total daily excretion masses for finishing pigs were calculated based on finishing pig feces, mixed flush water and suspended particles from growing and finishing pig buildings.

Table S10 Daily excretion masses of antibiotics from different stages of pigs (mg/d) in feces, flush water, suspended particles and the total daily excretion from the swine farm (mg/d)

Compound	Feces					Flush water				Suspended particle				Total daily excretion from the swine farm [a]				
	Piglets	Growing pigs	Finishing pigs	Sows	**Sum**	Piglets	Growing & finishing pigs	Sows	**Sum**	Piglets	Growing & finishing pigs	Sows	**Sum**	Piglets	Growing pigs	Finishing pigs	Sows	Sum
Sulfonamides																		
Sulfamethazine	0.00	0.42	0.00	0.37	**0.79**	2.05	0.43	0.27	**2.75**	0.08	0.08	0.09	**0.25**	2.14	0.79	0.15	0.73	**3.79**
Sulfamethoxazole	0.00	0.00	0.00	0.00	**0.00**	0.27	0.00	0.03	**0.31**	0.00	0.00	0.00	**0.00**	0.27	0.00	0.00	0.03	**0.31**
Sulfamonomethoxine	0.00	0.00	0.00	0.00	**0.00**	24.7	0.00	3.60	**28.3**	0.31	0.00	0.80	**1.11**	25.0	0.00	0.00	4.40	**29.4**
Sum of sulfonamides	**0.00**	**0.42**	**0.00**	**0.37**	**0.79**	**27.1**	**0.43**	**3.90**	**31.4**	**0.39**	**0.08**	**0.89**	**1.36**	**27.4**	**0.79**	**0.15**	**5.16**	**33.5**
Tetracyclines																		
Chlortetracycline	31300	262	146	23300	**55000**	96.5	790	142	**1030**	55.2	2240	61.2	**2360**	31400	2430	1010	23500	**58400**
Doxycycline	180	453	0.00	42.1	**675**	0.67	20.2	2.62	**23.5**	0.33	27.7	3.60	**31.7**	181	487	13.7	48.3	**730**
Oxytetracycline	141	6.10	0.00	6.39	**153**	0.54	13.9	0.22	**14.7**	0.19	5.32	0.18	**5.68**	142	19.9	5.50	6.79	**174**
Tetracycline	3930	4.17	0.00	544	**4470**	7.78	52.8	10.2	**70.7**	3.19	53.9	0.87	**58.0**	3930	80.4	30.5	555	**4600**
Sum of tetracyclines	**35500**	**725**	**146**	**23900**	**60000**	**105**	**877**	**155**	**1140**	**58.9**	**2330**	**65.9**	**2450**	**35700**	**3010**	**1060**	**24100**	**63900**
Fluoroquinolones																		
Ciprofloxacin	0.00	0.90	0.00	0.39	**1.30**	0.00	2.39	0.00	**2.39**	0.00	0.75	0.00	**0.75**	0.00	3.14	0.90	0.39	**4.43**
Fleroxacin	0.00	0.00	0.00	0.00	**0.00**	0.00	0.85	0.11	**0.96**	0.00	0.00	0.00	**0.00**	0.00	0.61	0.24	0.11	**0.96**
Norfloxacin	0.00	0.00	0.00	1.36	**1.36**	0.90	2.14	1.46	**4.51**	0.10	1.59	0.11	**1.79**	1.00	2.66	1.07	2.93	**7.66**
Ofloxacin	0.98	0.00	0.00	0.33	**1.32**	0.00	1.54	5.04	**6.58**	0.23	2.24	1.85	**4.32**	1.21	2.70	1.08	7.23	**12.2**
Sum of fluoroquinolones	**0.98**	**0.90**	**0.00**	**2.09**	**3.98**	**0.90**	**6.92**	**6.61**	**14.4**	**0.33**	**4.58**	**1.96**	**6.87**	**2.22**	**9.11**	**3.28**	**10.7**	**25.3**
Macrolides																		
Anhydro erythromycin	0.00	0.00	0.00	0.00	**0.00**	0.00	14.6	0.63	**15.2**	0.00	0.42	0.00	**0.42**	0.00	10.69	4.28	0.63	**15.6**
Leucomycin	1.09	0.25	0.00	0.00	**1.34**	0.00	0.27	0.00	**0.27**	0.00	0.21	0.00	**0.21**	1.09	0.59	0.14	0.00	**1.82**
Tylosin	0.00	0.00	0.00	0.00	**0.00**	0.00	0.32	0.00	**0.32**	0.00	0.00	0.00	**0.00**	0.00	0.23	0.09	0.00	**0.32**
Sum of macrolides	**1.09**	**0.25**	**0.00**	**0.00**	**1.34**	**0.00**	**15.1**	**0.63**	**15.8**	**0.00**	**0.63**	**0.00**	**0.63**	**1.09**	**11.5**	**4.51**	**0.63**	**17.7**
Diaminopyrimidines																		
Trimethoprim	0.49	0.00	0.00	0.00	**0.49**	4.75	0.43	4.23	**9.42**	0.11	0.02	0.23	**0.35**	5.35	0.32	0.13	4.46	**10.3**
Polypeptides																		
Bacitracin	143	10700	0.00	0.00	**10900**	1230	131	11.3	**1370**	773	209	2.38	**985**	2140	11000	97.2	13.8	**13200**
Lincosamides																		
Lincomycin	11.1	0.00	1.72	25.2	**38.0**	3.02	5.71	2.16	**10.9**	0.96	0.50	0.76	**2.22**	15.1	4.44	3.49	28.1	**51.1**
Chloramphenicol derivatives																		
Florfenicol	0.00	0.00	0.00	0.00	**0.00**	2.81	45.5	2.26	**50.5**	0.24	0.15	0.08	**0.47**	3.05	32.6	13.0	2.34	**51.0**
Sum of all the antibiotics	**35700**	**11400**	**148**	**23900**	**71200**	**1370**	**1080**	**186**	**2640**	**834**	**2540**	**72.2**	**3450**	**37900**	**14000**	**1180**	**24100**	**77300**

[a] The daily excretion masses for freshly weaned piglets were included in the excretion masses for piglets, due to the limited samples (feces and flush water) for freshly weaned piglets. The total daily excretion masses for growing pigs were calculated based on growing pigs feces, mixed flush water and suspended particles from growing and finishing pigs. The total daily excretion masses for finishing pigs were calculated based on finishing pigs feces, mixed flush water and suspended particles from growing and finishing pigs.

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