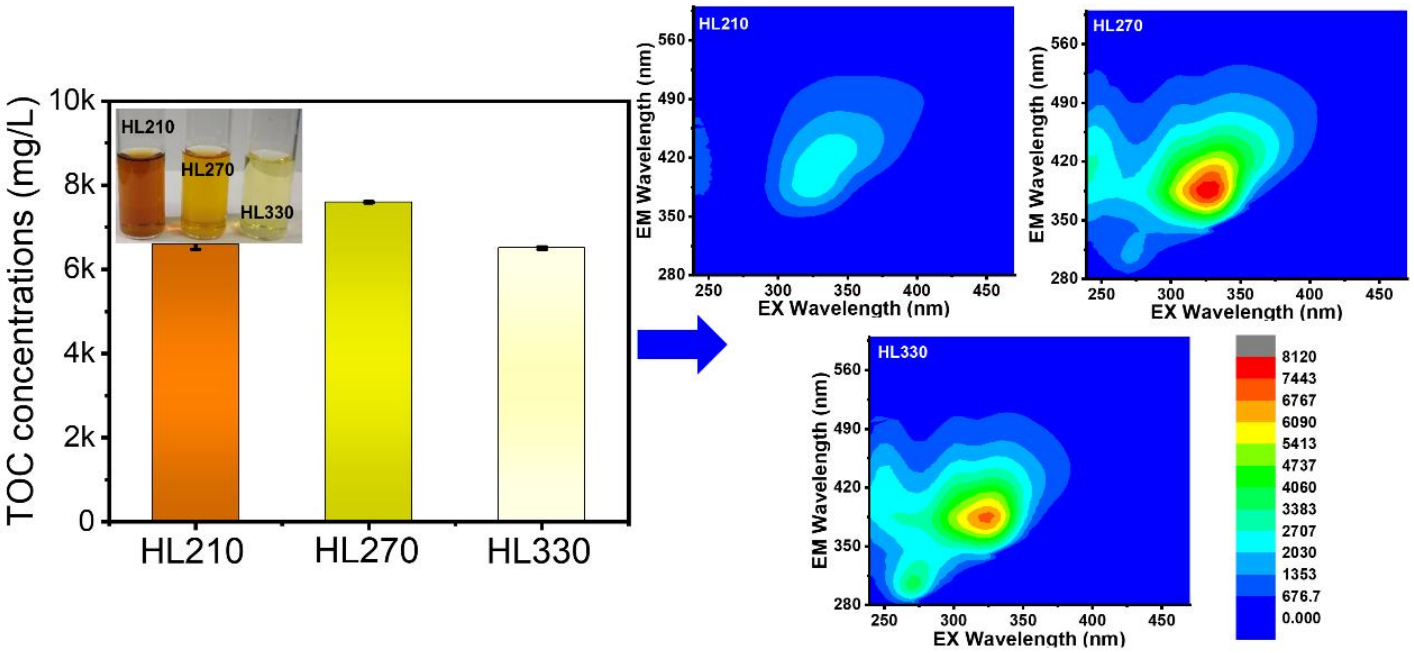
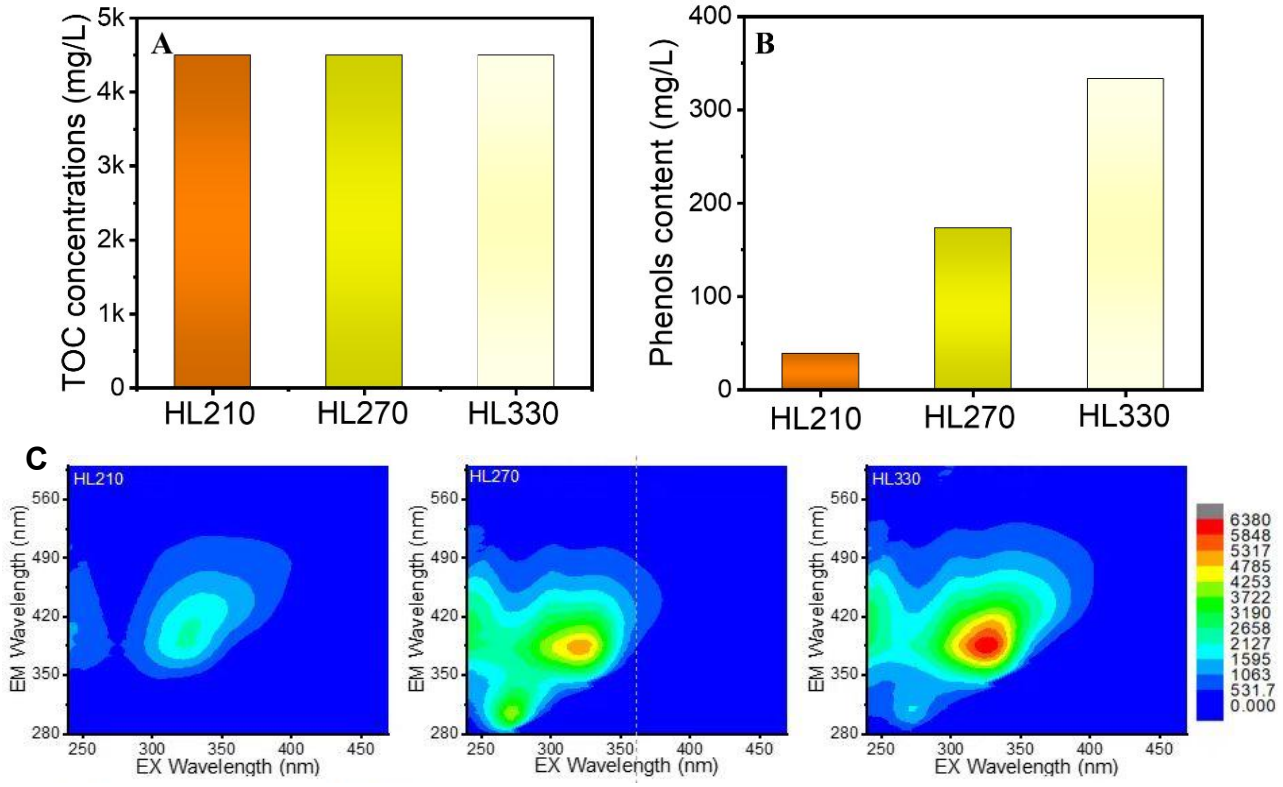
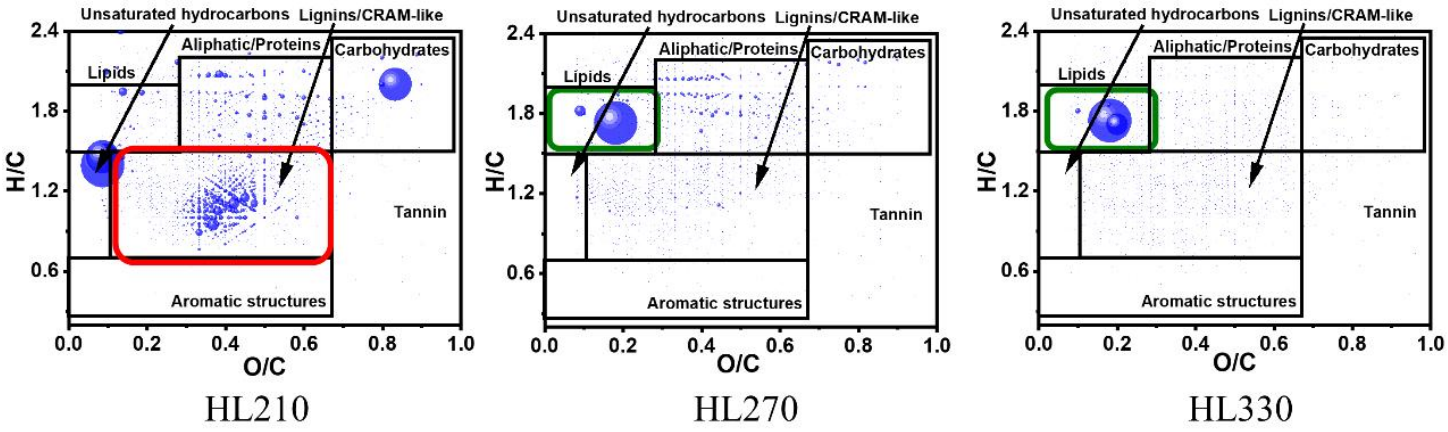


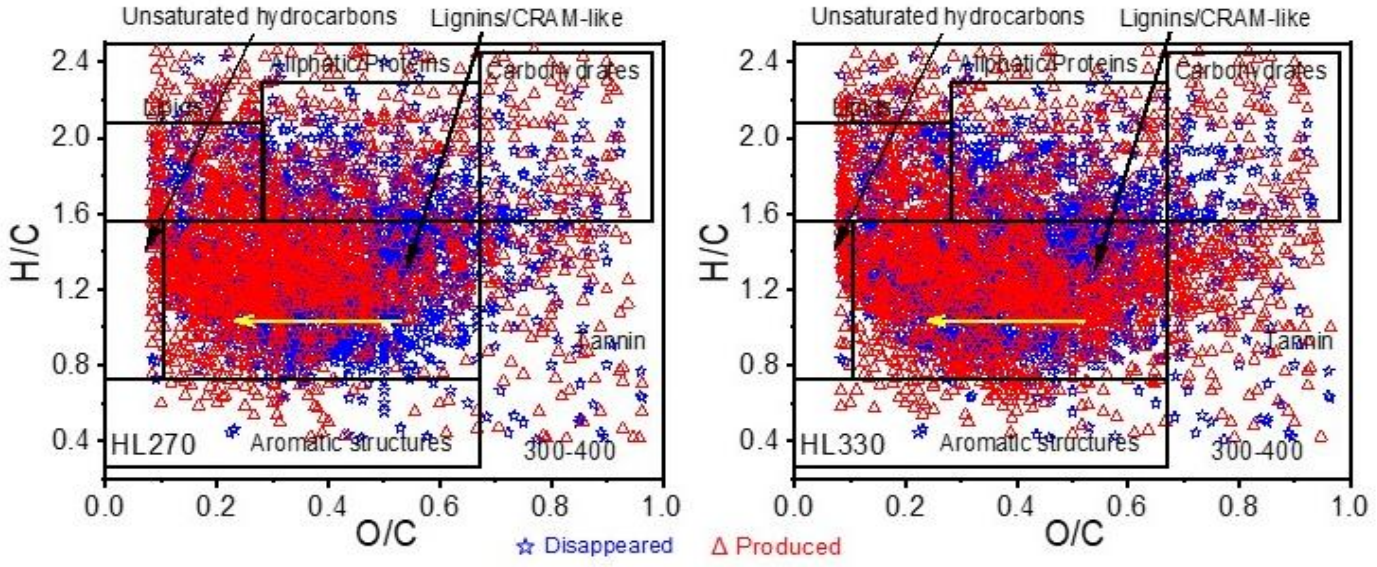
Supplementary Fig. S1 Artificial humic substances prepared by hydrothermal liquefaction from rice straw. HLX represent the artificial humic substances prepared by hydrothermal liquefaction at different temperatures, and X represents temperature.



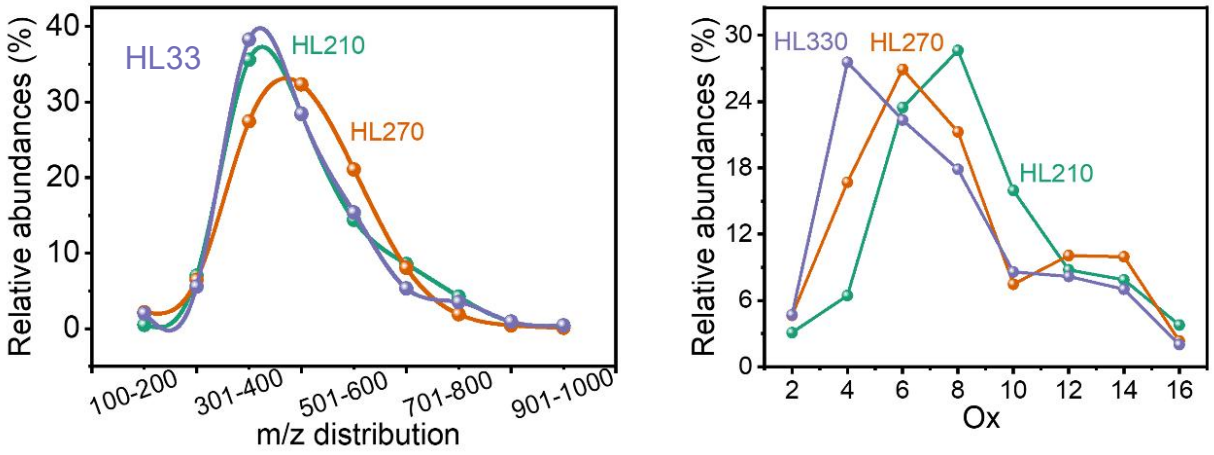
Supplementary Fig. S2 (**a**) TOC, (**b**) phenols concentration, and (**c**) EEMs results of artificial humic substances prepared by hydrothermal liquefaction from rice straw for simulating the humification process in soil.



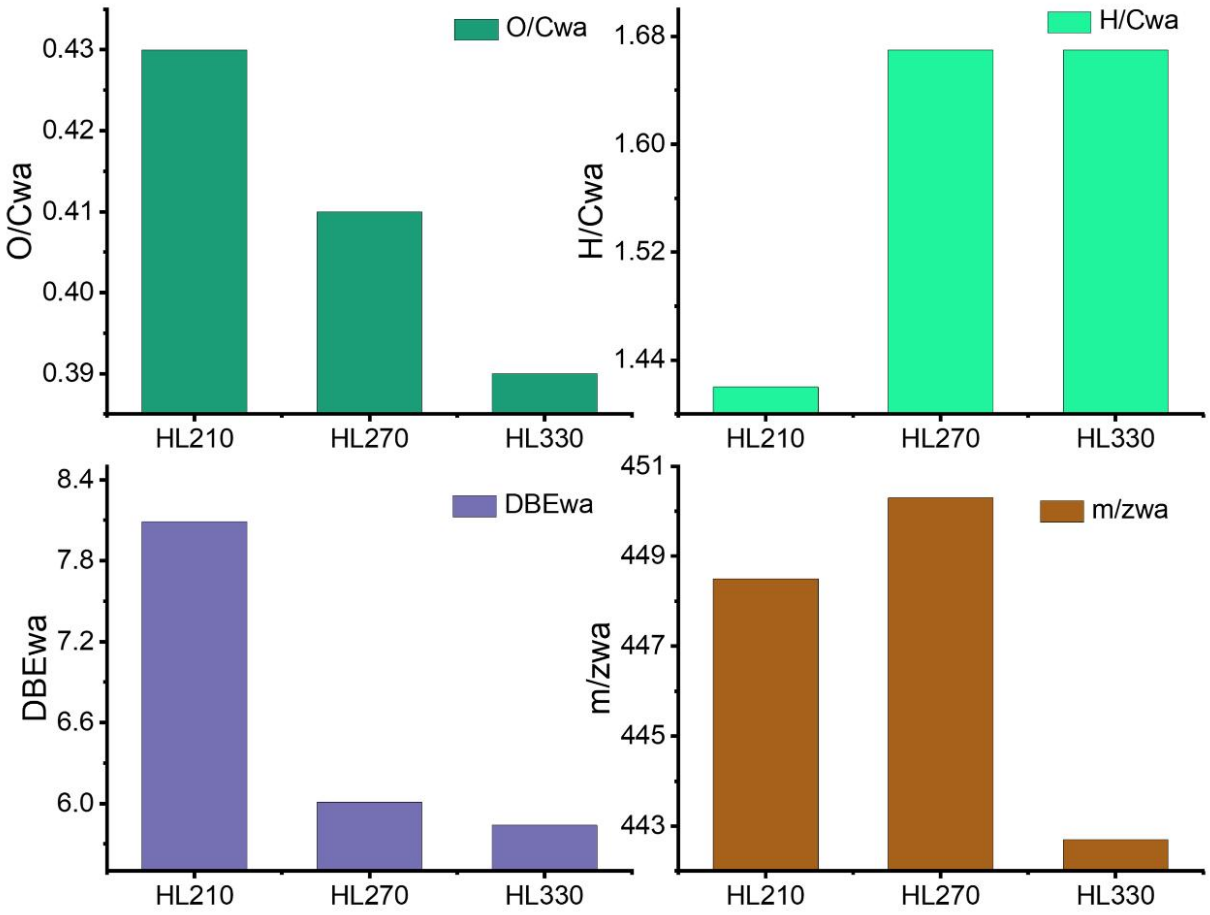
Supplementary Fig. S3 Van Krevelen diagrams of CHO for the artificial humic substances prepared by hydrothermal liquefaction from rice straw.



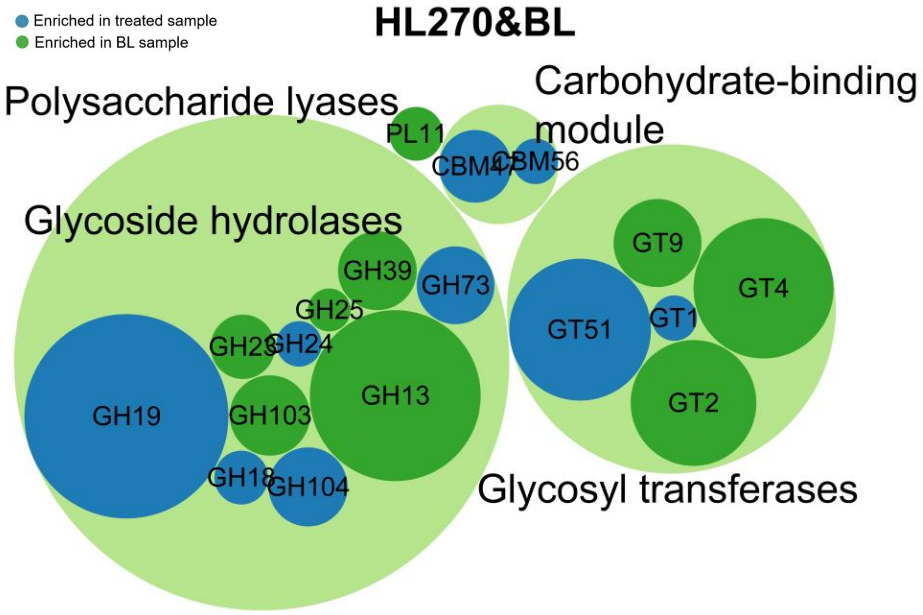
Supplementary Fig. S4 Van Krevelen diagrams of CHO for the artificial humic substances prepared by 270 °C and 330 °C from rice straw, compared to 210 °C.



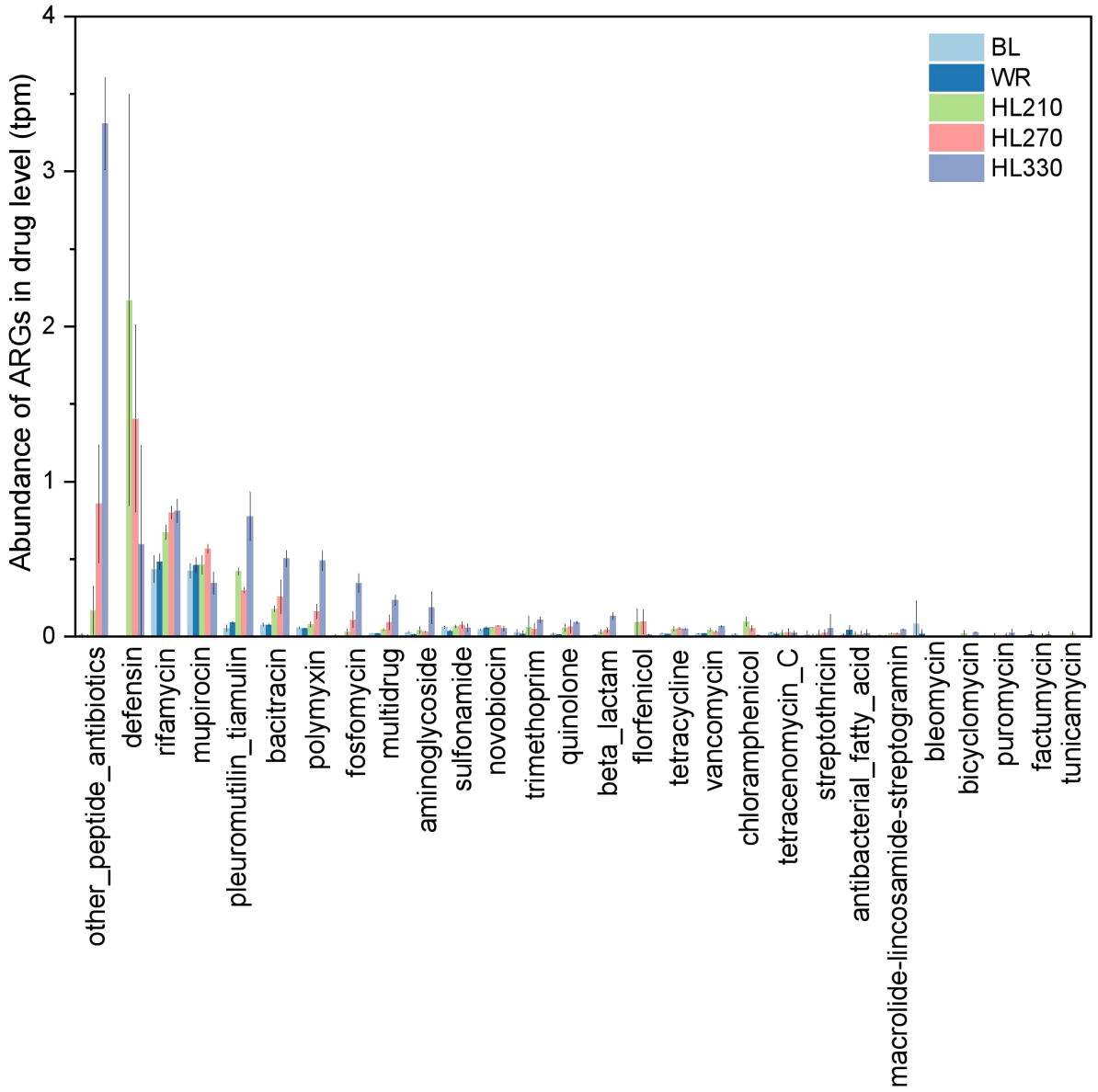
Supplementary Fig. S5 The relative abundance of m/z and Ox distribution for the artificial humic substances prepared by hydrothermal liquefaction from rice straw.



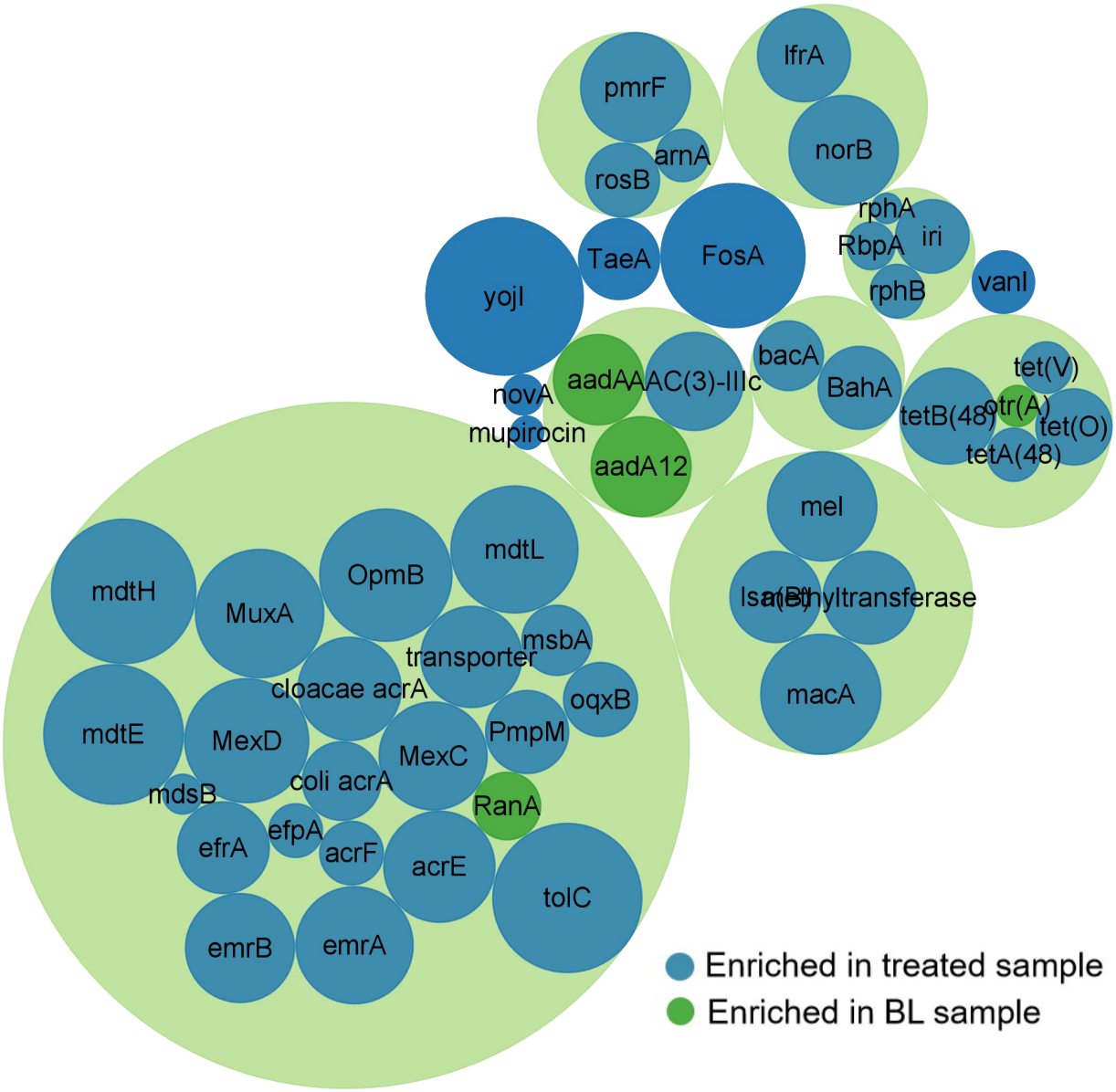
Supplementary Fig. S6 The O/C_{wa}, H/C_{wa}, DBE_{wa}, and m/z_{wa} distribution for the artificial humic substances prepared by hydrothermal liquefaction from rice straw.



Supplementary Fig. S7 Enriched CAZyme genes in treated soils by artificial humic substances. The response ratio was determined by calculating the natural logarithm of the ratio of the mean gene abundances between treated and untreated soils.



Supplementary Fig. S8 Abundance of ARGs at the drug level. The annotation of antibiotic resistance genes was based on the Comprehensive Antibiotic Resistance Database using open reading frames (ORFs) from metagenomics.



Supplementary Fig. S9 Enriched ARGs in treated soils by artificial humic substances. The response ratio was determined by calculating the natural logarithm of the ratio of the mean gene abundances between treated and untreated soils.

Supplementary Table S1. The components of different artificial humic substances

Components	HL210 (Peak area)	HL270 (Peak area)	HL330 (Peak area)
Cyclopentanone	-	14.49	51.05
2-methyl-2-cyclopenten-1-one	-	46.00	105.58
5-methylfurfural	12.87	23.52	72.13
phenol	11.25	31.89	62.30
2-methylphenol	-	18.54	13.89
2-methoxyphenol	20.89	56.27	65.39
4-ethylphenol	6.61	20.55	30.73
2-methoxy-4-methylphenol	-	-	110.75
4-ethyl-2-methoxyphenol	-	24.40	21.80
2-methoxy-4-propylphenol	-	21.64	28.20

Supplementary Table S2. Soil properties treated by artificial humic substances include the organic carbon contents, pH, Fe contents, and CEC.

Samples	pH	Fe contents (g/Kg)	CEC cmol (+) /kg
BK	6.50	36.23	16.80
WR	6.57	36.19	17.23
HL210	6.51	37.73	16.78
HL270	6.50	38.21	16.17
HL330	6.33	37.67	16.25

The average value of soil properties was provided by three repeated experiments. CEC: Cation exchange capacity.

Supplementary Table S3. Information of families of Carbohydrate-Active enZYmes (CAZymes) analyzed with significance in this study.

CAZy family	Enzyme class	Process description	ECs in Family	Note
GH1	Glycoside hydrolases	Cleave various carbohydrate	β-glucosidase (EC 3.2.1.21); β-galactosidase (EC 3.2.1.23); βmannosidase (EC 3.2.1.25); β-glucuronidase (EC 3.2.1.31); βxylosidase (EC 3.2.1.37); β-D-fucosidase (EC 3.2.1.38); phlorizin hydrolase (EC 3.2.1.62); exo-β-1,4-glucanase (EC 3.2.1.74); 6phospho-β-galactosidase (EC 3.2.1.85); 6-phospho-β-glucosidase (EC 3.2.1.86); strictosidine β-glucosidase (EC 3.2.1.105); lactase (EC 3.2.1.108); amygdalin β-glucosidase (EC 3.2.1.117); prunasin β-glucosidase (EC 3.2.1.118); vicianin hydrolase (EC 3.2.1.119); raucaffricine β-glucosidase (EC 3.2.1.125); thioglucosidase (EC 3.2.1.147); β-primeverosidase (EC 3.2.1.149); isoflavonoid 7O-β-apiosyl-β-glucosidase (EC 3.2.1.161); ABA-specific βglucosidase (EC 3.2.1.175); DIMBOA β-glucosidase (EC 3.2.1.182); hydroxyisourate hydrolase (EC 3.-.-.-); βrutinosidase /α-L-rhamnose-(1,6)-β-D-glucosidase (EC 3.2.1.-); protodioscin 26-O-Î²-D-glucosidase (EC 3.2.1.186); α-L- arabinopyranosidase (EC 3.2.1.-); isoflavone 7-O-glucosyl β glucosidase (EC 3.2.1.-).	NA
GH13	Glycoside hydrolases	Oligo-saccharides and starch degradation	α-amylase (EC 3.2.1.1); pullulanase (EC 3.2.1.41); cyclomaltodextrin glucanotransferase (EC 2.4.1.19); cyclomaltodextrinase (EC 3.2.1.54); trehalose-6-phosphate hydrolase (EC 3.2.1.93); oligo-α-glucosidase (EC 3.2.1.10); maltogenic amylase (EC 3.2.1.133); neopullulanase (EC 3.2.1.135); α-glucosidase (EC 3.2.1.20); maltotetraose-forming α-amylase (EC 3.2.1.60); isoamylase (EC 3.2.1.68); glucodextranase (EC 3.2.1.70); maltohexaose-forming α-amylase (EC 3.2.1.98); maltotriose-forming α-amylase (EC 3.2.1.116); branching enzyme (EC 2.4.1.18); trehalose synthase (EC 5.4.99.16); 4-αglucanotransferase (EC 2.4.1.25); maltopentaose-forming αamylase (EC 3.2.1.-) ; amylosucrase (EC 2.4.1.4) ; sucrose phosphorylase (EC 2.4.1.7); malto-oligosyltrehalose trehalohydrolase (EC 3.2.1.141); isomaltulose synthase (EC 5.4.99.11); malto-oligosyltrehalose synthase (EC 5.4.99.15); amylo-α-1,6-glucosidase (EC 3.2.1.33); α-1,4-glucan: phosphate αmaltosyltransferase (EC 2.4.99.16); amino acid transporter; [retaining] sucrose 6(F)-phosphate phosphorylase (EC 2.4.1.329); [retaining] glucosylglycerol phosphorylase (EC 2.4.1.359); ; Glucosylglycerate phosphorylase (EC 2.4.1.352); [retaining] sucrose α-glucosidase (EC 3.2.1.48); oligosaccharide α-4- glucosyltransferase (EC 2.4.1.161);	New: many members have been assigned to subfamilies as described by Stam et al. (2006) Protein Eng Des Sel. 19, 555-562 (PMID: 17085431).

			[retaining] α-amylase (EC 3.2.1.1).	
GH16	Glycoside Hydrolases	Hemi-cellulose, GH16 Glycoside Hydrolases chitin and cell wall components degradation	xyloglucan:xyloglucosyltransferase (EC 2.4.1.207); keratan-sulfate endo-1,4-β-galactosidase (EC 3.2.1.103); endo-1,3-β-glucanase / laminarinase (EC 3.2.1.39); endo-1,3(4)-β-glucanase (EC 3.2.1.6); licheninase (EC 3.2.1.73); β-agarase (EC 3.2.1.81); κ-carrageenase (EC 3.2.1.83); xyloglucanase (EC 3.2.1.151); endo-β-1,3galactanase (EC 3.2.1.181); [retaining] β-porphyranase (EC 3.2.1.178); hyaluronidase (EC 3.2.1.35); endo-β-1,4galactosidase (EC 3.2.1.-); chitin β-1,6-glucanosyltransferase (EC 2.4.1.-); β-transglycosidase (EC 2.4.1.-); β-glycosidase (EC 3.2.1.-); β-carrageenase (EC 3.2.1.-).	Many members have been assigned to subfamilies as described by Viborg et al. (2019) J Biol Chem. 2019 Sep 9 (PMID: 31501245).
GH18	Glycoside hydrolases	Amino polysaccharides	chitin endo-b-1,4-N-acetylglucosaminidase (3.2.1.14); b-N-acetylhexosaminidase (3.2.1.52); mannosyl-oligosaccharide endo-b-1,4-N-acetylglucosaminidase (3.2.1.96); chitosan endo-b-1,4-N-glucosaminase (3.2.1.132); chitin exo-b-1,4-N-acetylglucobiosaminidase (3.2.1.200); reducing end chitin exo-b-1,4-N-acetylglucosaminidase (3.2.1.201); mannosyl-oligosaccharide exo-b-1,4-N-acetylglucosaminidase (3.2.1.-); chitin exo-b-1,4-N-acetylglucosaminidase (3.2.1.-); peptidoglycan endo-b-1,4-N-acetylglucosaminidase (3.2.1.-); Nod factor endo-b-1,4-N-acetylglucosaminidase (3.2.1.-).	Contains chitinases of classes III and V. Contains non-catalytic proteins such as xylanase inhibitor; concanavalin B; narbonin
GH19	Glycoside hydrolases	Hydrolyze glycosidic bonds within chitin	Chitinase (EC 3.2.1.14); Lysozyme (EC 3.2.1.17); [reducing end] exo-chitinase (EC 3.2.1.201).	Contains chitinases of classes I, II, and IV.
GH23	Glycoside hydrolases	Cleave the β-1,4-linkage between N-acetylmuramyl and N-acetylglucosaminyl residues in peptidoglycan	Chitinase (EC 3.2.1.14); Lysozyme (EC 3.2.1.17); Peptidoglycan lytic transglycosylase/peptidoglycan lyase (EC 4.2.2.29).	Corresponds to family 1 of the peptidoglycan lytic transglycosylases described by N.T. Blackburn and A.J. Clarke (2001) J. Mol. Evol. 52, 78-84; Note that 'peptidoglycan lytic transglycosylases' cleave peptidoglycan without intervention of a water molecule.
GH24	Glycoside hydrolases	Hydrolyse the glycosidic bond between two or more carbohydrates, or between a	Lysozyme (EC 3.2.1.17).	NA

		carbohydrate and a non-carbohydrate moiety		
GH25	Glycoside hydrolases	Cell wall degradation	Lysozyme (EC 3.2.1.17).	NA
GH28	Glycoside hydrolases	Hydrolyse the glycosidic bond	Xylogalacturonan hydrolase (EC 3.2.1.-); Endo-polygalacturonase (EC 3.2.1.15); Rhamnogalacturonase (EC 3.2.1.171); Rhamnogalacturonan α-1,2-galacturonohydrolase (EC 3.2.1.173); Galacturonan α-1,4-galacturonidase (EC 3.2.1.67); Exo-poly-α-digalacturonosidase (EC 3.2.1.82).	NA
GH39	Glycoside hydrolases	Hydrolyse the glycosidic bond between two or more carbohydrates, or between a carbohydrate and a non-carbohydrate moiety	2-O-α-D-galactosyl-α-L-arabinofuranosidase / D-galacto-(α-1,2)-L-arabinosidase (EC 3.2.1.-); 3-O-β-L-arabinopyranosyl-α-L-arabinofuranosidase (EC 3.2.1.-); Exo-α-L-(β-1,2)-arabinofuranobiosidase (EC 3.2.1.-); β-glucosidase (EC 3.2.1.21); 3-O-α-D-galactosyl-α-L-arabinofuranosidase (EC 3.2.1.215); β-galactosidase (EC 3.2.1.23); Xylan β-1,4-xylosidase (EC 3.2.1.37); Exo-β-1,4-glucanase / cellodextrinase (EC 3.2.1.74); α-L-iduronidase (EC 3.2.1.76);	NA
GH73	Glycoside hydrolases	Hydrolyse the glycosidic bond between two or more carbohydrates, or between a carbohydrate and a non-carbohydrate moiety	Peptidoglycan endo-β-1,4-N-acetylglucosaminidase (EC 3.2.1.-); Mannosyl-glycoprotein endo-β-N-acetylglucosaminidase (EC 3.2.1.96).	The 3-D structure of Sphingomonas sp. strain A1 FlgJ protein of this family has recently been solved (Hashimotoa et al., BBRC 2009); there is only one, unconfirmed, report of b-1,4-N-acetylmuramoylhydrolase (EC 3.2.1.17) activity.
GH84	Glycoside hydrolases	Hydrolyse the glycosidic bond	[protein]-3-O-(GlcNAc)-L-Ser/Thr β-N-acetylglucosaminidase (EC 3.2.1.169);Hyaluronidase / hyaluronoglucosaminidase (EC 3.2.1.35); β-N-acetylhexosaminidase (EC 3.2.1.52).	Mechanism shown in Macauley et al. (2005) JBC 280:25313-25322
GH103	Glycoside hydrolases	Accommodates a single catalytic residue	Peptidoglycan lytic transglycosylase / peptidoglycan lyase (EC 4.2.2.29).	Corresponds to family 3 of the peptidoglycan lytic transglycosylases.
GT1	Glycosyl transferases	Biosynthesis of cell membrane and cell	C-glycosyltransferase (EC 2.4.-.-); Hexosyltransferases (EC 2.4.1.-); TDP-D-desosamine:macrolide D-desosaminyltransferase (EC 2.4.1.-); UDP-Arap: flavone-C-	Distantly related to family GT28; several members of this family are

	wall components	arabinosytransferase (EC 2.4.1.-); UDP-Glc: 6-hydroxyflavone β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: 7-deoxyloganetic acid β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: 7-deoxyloganetin β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: anthocyanin 5-O-β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: cinnamoyl O-β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: ecdysteroid β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: flavone 3'-O-β-gluosyltransferase (EC 2.4.1.-); UDP-Glc: flavone 4'-O-β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: flavone-C-glucosytransferase (EC 2.4.1.-); UDP-Glc: flavonol-3-O-glucoside β-1,2-glucosyltransferase (EC 2.4.1.-); UDP-Glc: gallic acid 1-O-β-glycosyltransferase (EC 2.4.1.-); UDP-Glc: hydroxycinnamic acid O-β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: oleandomycin β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: resveratrol O-β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: salicylic acid β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: steviol β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: steviolbioside β-glucosyltransferase (EC 2.4.1.-); UDP-Glc: stevioside β-glucosyltransferase (EC 2.4.1.-); UDP-GlcA: (exopolysaccharide) β-1,4-glucuronosyltransferase (EC 2.4.1.-); UDP-GlcA: anthocyanin-3-O-glucoside β-glucuronosyltransferase (EC 2.4.1.-); [inverting] UDP-Glc: geraniol O-β-glucosyltransferase (EC 2.4.1.-); [inverting] UDP-GlcA: [flavone] scutellarein 7-O-β-glucuronosyltransferase (EC 2.4.1.-); [inverting] UDP-GlcA: flavone 7-O-β-glucuronyltransferase (EC 2.4.1.-); [inverting] UDP-L-Rha: flavonoid α-L-rhamnosyltransferase (EC 2.4.1.-); [inverting] β-1,6-glucosyltransferase (EC 2.4.1.-); [inverting] dTDP-L-Rha: α-L-rhamnosyltransferase (EC 2.4.1.-); α-L-rhodinosyltransferase (EC 2.4.1.-); β-olivosyltransferase (EC 2.4.1.-); Anthocyanidin 3-O-glucosyltransferase (EC 2.4.1.115); UDP-Glc: sinapate 1,O-β-glucosyltransferase (EC 2.4.1.120); Indole-3-acetate β-glucosyltransferase (EC 2.4.1.121); UDP-Glc: scopoletin β-glucosyltransferase (EC 2.4.1.128); Flavonol-3-O-glucoside L-rhamnosyltransferase (EC 2.4.1.159); UDP-GlcA: β-glucuronosyltransferase (EC 2.4.1.17); Isoflavone 7-O-glucosyltransferase (EC 2.4.1.170); UDP-Glc: sterol β-1,3-glucosyltransferase (EC 2.4.1.173); UDP-Glc: cinnamate β-glucosyltransferase (EC 2.4.1.177); [inverting] UDP-Glc: flavanone 7-O-β-glucosyltransferase (EC 2.4.1.185); [inverting] UDP-GlcA: [flavone] luteolin 7-O-β-glucuronosyltransferase (EC 2.4.1.189); UDP-Glc: 4-hydroxybenzoate 4,O-β-glucosyltransferase (EC 2.4.1.194); UDP-Glc: N-	made of two subunits (for instance Alg13 and Alg14 in Saccharomyces); the complete enzyme has been reconstituted whenever possible, and appears with the two subunit names separated by a + sign and with the N-terminal subunit followed by the C-terminal one.

			hydroxythioamide S-β-glucosyltransferase (EC 2.4.1.195); UDP-Glc: benzoxazinoid β-glucosyltransferase (EC 2.4.1.202); UDP-Glc: trans-zeatin O-β-glucosyltransferase (EC 2.4.1.203); UDP-Glc: limonoid β-glucosyltransferase (EC 2.4.1.210); UDP-Glc: cis-zeatin O-β-glucosyltransferase (EC 2.4.1.215); Kaempferol 3-O-galactosyltransferase (EC 2.4.1.234); [inverting] UDP-Glc: flavonol 7-O-β-glucosyltransferase (EC 2.4.1.237); UDP-Glc: anthocyanin 3'-O-β-glucosyltransferase (EC 2.4.1.238); [inverting] UDP-GlcA: [flavone] baicalein 7-O-β-glucuronosyltransferase (EC 2.4.1.253); UDP-Glc: zeaxanthin glucosyltransferase (EC 2.4.1.276); UDP-Glc: chalcone 4â€²-O-β-glucosyltransferase (EC 2.4.1.286); α-L-noviosyltransferase (EC 2.4.1.302); [inverting] UDP-Glc: phenol β-glucosyltransferase (EC 2.4.1.35); 2-hydroxyflavanone C-glucosyltransferase (EC 2.4.1.360); [inverting] UDP-Glc: protopanaxadiol-type ginsenoside 3-O-glucosyltransferase (EC 2.4.1.364); [inverting] UDP-Glc: 3-O-glucosyl-protopanaxadiol-type ginsenoside 2'-O-glucosyltransferase (EC 2.4.1.365); [inverting] UDP-Gal: N-acylsphingosine 1-β-galactosyltransferase (EC 2.4.1.47); UDP-Glc: flavone 7-O-β-glucosyltransferase (EC 2.4.1.81); UDP-Glc: p-hydroxymandelonitrile-O-glucosyltransferase (EC 2.4.1.85); UDP-Glc: flavonol 3-O-β-glucosyltransferase (EC 2.4.1.91); Pentosyltransferases (EC 2.4.2.-); UDP-Xyl: gentisic acid O-β-xylosyltransferase (EC 2.4.2.-); [inverting] UDP-Xyl: geranyl-β-glucopyranoside β-1,6-xylosyltransferase (EC 2.4.2.-); UDP-Apif: flavone β-apiosyltransferase (EC 2.4.2.25); UDP-Xyl: zeatin O-β-xylosyltransferase (EC 2.4.2.40).	
GT2	Glycosyl transferases	Biosynthesis of cell membrane and cell wall components	cellulose synthase (EC 2.4.1.12); chitin synthase (EC 2.4.1.16); dolichyl-phosphate β-D-mannosyltransferase (EC 2.4.1.83); dolichyl-phosphate β-glucosyltransferase (EC 2.4.1.117); Nacetylglucosaminyltransferase (EC 2.4.1.-); Nacetylgalactosaminyltransferase (EC 2.4.1.-); hyaluronan synthase (EC 2.4.1.212); chitin oligosaccharide synthase (EC 2.4.1.-); β-1,3-glucan synthase (EC 2.4.1.34); β-1,4-mannan synthase (EC 2.4.1.-); β-mannosylphosphodecaprenol-mannooligosaccharide α-1,6-mannosyltransferase (EC 2.4.1.199); UDP-Galf: rhamnopyranosylN-acetylglucosaminyl-PP-decaprenol β-1,4/1,5-galactofuranosyltransferase (EC 2.4.1.287); UDP-Galf: galactofuranosyl-galactofuranosyl-rhamnosyl-Nacetylglucosaminyl-PP-decaprenol β-1,5/1,6-galactofuranosyltransferase (EC 2.4.1.288); dTDP-L-Rha: Nacetylglucosaminyl-PP-decaprenol α-1,3-L-rhamnosyltransferase (EC 2.4.1.289); alternating β-1,3/4-N-acetylmannan synthase (2.4.1.-); UDP-GlcA: N-	Distant similarity to families GT12, GT21, GT27, GT55, GT81 etc.

			acetylglucosaminyl-proteoglycan β-1,4-glucuronosyltransferase (EC 2.4.1.225); [inverting] UDP-Glc: glycocin S-β-glucosyltransferase (EC 2.4.1.-); [inverting] UDP-Glc: protein O-β-glucosyltransferase (EC 2.4.1.-).	
GT4	Glycosyl transferases	Biosynthesis of cell membrane and cell wall components	sucrose synthase (EC 2.4.1.13); sucrose-phosphate synthase (EC 2.4.1.14); α-glucosyltransferase (EC 2.4.1.52); lipopolysaccharide N-acetylglucosaminyltransferase (EC 2.4.1.56); phosphatidylinositol α-mannosyltransferase (EC 2.4.1.57); GDPMan: Man1GlcNAc2-PP-dolichol α-1,3-mannosyltransferase (EC 2.4.1.132); GDP-Man: Man3GlcNAc2-PPdolichol/Man4GlcNAc2-PP-dolichol α-1,2-mannosyltransferase (EC 2.4.1.131); digalactosyldiacylglycerol synthase (EC 2.4.1.141); 1,2-diacylglycerol 3-glucosyltransferase (EC 2.4.1.157); diglucosyl diacylglycerol synthase (EC 2.4.1.208); trehalose phosphorylase (EC 2.4.1.231); NDP-Glc: α-glucose α-glucosyltransferase / α,α-trehalose synthase (EC 2.4.1.245); GDP-Man: Man2GlcNAc2-PPdolichol α-1,6-mannosyltransferase (EC 2.4.1.257); UDP-GlcNAc: 2-deoxystreptamine α-N-acetylglucosaminyltransferase (EC 2.4.1.283); UDP-GlcNAc: ribostamycin α-Nacetylglucosaminyltransferase (EC 2.4.1.285); UDP-Gal α-galactosyltransferase (EC 2.4.1.-); UDP-Xyl α-xylosyltransferase (EC 2.4.2.-); UDP-GlcA α-glucuronyltransferase (EC 2.4.1.-); UDP-Glc α-glucosyltransferase (EC 2.4.1.-); UDP-GalNAc: GalNAc-PP-Und α-1,3-N-acetylgalactosaminyltransferase (EC 2.4.1.306); UDP-GalNAc: N,N'-diacetylbacillosaminyl-PPUnd α-1,3-N-acetylgalactosaminyltransferase (EC 2.4.1.290); ADPdependent α-maltose-1-phosphate synthase (2.4.1.342); [retaining] UDP-GlcNAc: polypeptide α-N-acetylglucosaminyltransferase (EC 2.4.1.-); UDP-GlcNAc: α-N-acetylglucosaminyltransferase (EC 2.4.1.-); GDP-Man : α-1,4-mannosyltransferase (EC 2.4.1.-).	NA
GT9	Glycosyl transferases	Biosynthesis of cell membrane and cell wall components	LPS β-N-acetylglucosaminyltransferase (EC 2.4.1.56); LOS α-1,6-heptosyltransferase (EC 2.4.99.-); LPS α-1,6-heptosyltransferase (EC 2.4.99.-); Heptosyltransferase (EC 2.4.99.-).	NA
GT35	Glycosyl transferases	Biosynthesis of disaccharides, oligosaccharides and polysaccharides	[retaining] α-1,4-glucan phosphorylase (EC 2.4.1.1)	NULL
GT51	Glycosyl transferases	Biosynthesis of Cell wall	Peptidoglycan glycosyltransferase (EC 2.4.1.129).	There are two categories of enzymes in this family : monofunctional (just

				the GT51 module) or bifunctional (GT51 module attached to a penicillin-binding transpeptidase module). These enzymes utilise Und-PP-MurAc-(GlcNAc)-pentapeptide as the sugar donor.
GT105	Glycosyl transferases	Biosynthesis of Cell wall	Dol-P-Man:protein mannosyltransferase (EC 2.4.1.109).	Family of a-mannosyltransferases using Dol-P-Man as the likely donor; first described by Larsen and colleagues [Proc Natl Acad Sci USA 2017 - PMID=28973932]
AA1	Auxiliary activities	Catalytic modules involved in plant cell wall degradation	[copper-containing] dihydrogeodin oxidase (EC 1.10.3.-); Laccase / p-diphenol:oxygen oxidoreductase (EC 1.10.3.2).	The characterized AA1 enzymes are multicopper oxidases that use diphenols and related substances as donors with oxygen as the acceptor. The AA1 family is currently divided into 3 subfamilies including laccases, ferroxidases and laccase-like multicopper oxidases.
AA4	Auxiliary activities	Catalyze the conversion of phenolic compounds	Vanillyl-alcohol oxidase (EC 1.1.3.38)	Family AA4 contains vanillyl-alcohol oxidases (VAO) that catalyze the conversion of a wide range of phenolic compounds bearing side chains at the para-position of the aromatic ring.
CE1	Carbohydrate esterases	Biodegradation of oligo-saccharides and hemi-cellulose	acetyl xylan esterase (EC 3.1.1.72); cinnamoyl esterase (EC 3.1.1.-); feruloyl esterase (EC 3.1.1.73); carboxylesterase (EC 3.1.1.1); S-formylglutathione hydrolase (EC 3.1.2.12); diacylglycerol O-acyltransferase (EC 2.3.1.20); trehalose 6-Omycolyltransferase (EC 2.3.1.122).	Family CE1 also contains lots of other esterases such as PHB depolymerases.
CE4	Carbohydrate esterases	Biodegradation of hemi-cellulose, chitin and cell wall components	acetyl xylan esterase (EC 3.1.1.72); chitin deacetylase (EC 3.5.1.41); chitooligosaccharide deacetylase (EC 3.5.1.-); peptidoglycan GlcNAc deacetylase (EC 3.5.1.-); peptidoglycan Nacetylmuramic acid deacetylase (EC 3.5.1.-).	NA

PL11	Polysaccharide lyase	Cleave glycoside bonds between rhamnose and galacturonic acid residues	Rhamnogalacturonan endolyase (EC 4.2.2.23); Rhamnogalacturonan exolyase (EC 4.2.2.24)	NA
CBM56	Carbohydrate-Binding Module	Integration of carbohydrates and enzyme	β-1,3-glucan binding function demonstrated by Yamamoto et al. (1998) FEBS Letters 433:41-43 [PMID: 9738929]	NA

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Supplementary Table S4. Compared to BL soil, the information of enriched ARGs in HL210 treated soil.

ARGs_types	ARGs_subtypes	AMR Gene Family	Drug Class	Resistance
aminoglycosid	amrB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminoglycoside antibiotic;macrolide antibiotic	antibiotic efflux
bacitracin	BahA	Bah amidohydrolase	peptide antibiotic	antibiotic inactivation
bacitracin	bacA	undecaprenyl pyrophosphate related proteins	peptide antibiotic	antibiotic target alteration
beta_lactam	beta_lactam__L1 beta-lactamase	L1 family beta-lactamase	cephalosporin	antibiotic inactivation
chloramphenicol	Agrobacterium fabrum chloramphenicol acetyltransferase	chloramphenicol acetyltransferase (CAT)	phenicol antibiotic	antibiotic inactivation
chloramphenicol	Pseudomonas aeruginos catB7	chloramphenicol acetyltransferase (CAT)	phenicol antibiotic	antibiotic inactivation
macrolide	macrolide-lincosamide-streptogramin__LlmA 23S ribosomal RNA methyltransferase	Llm 23S ribosomal RNA methyltransferase	lincosamide antibiotic	antibiotic target alteration
macrolide	macrolide-lincosamide-streptogramin__lsa(B)	lsa-type ABC-F protein	pleuromutilin antibiotic, streptogramin antibiotic, lincosamide antibiotic	antibiotic target protection
macrolide	macrolide-lincosamide-streptogramin__mel	msr-type ABC-F protein	streptogramin antibiotic, macrolide antibiotic	antibiotic target protection
multidrug	MexB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;carbapenem;cephalosporin;diaminopyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;monobactam;penicillin beta-lactam;peptide antibiotic;phenicol antibiotic;sulfonamide antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	MexC	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;cephalosporin;diaminopyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	MexD	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;cephalosporin;diaminopyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	MuxA	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux

multidrug	MuxB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	MuxC	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	OpmB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	OprJ	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;cephalosporin;diaminopyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	OprM	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;carbapenem;cephalosporin;diaminopyrimidine antibiotic;disinfecting agents and antiseptics;fluoroquinolone antibiotic;macrolide antibiotic;monobactam;penicillin beta-lactam;peptide antibiotic;phenicol antibiotic;sulfonamide antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	Other_major_facilitator_superfamily_transporter	-	-	-
multidrug	PmpM	multidrug and toxic compound extrusion (MATE) transporter	aminoglycoside antibiotic;disinfecting agents and antiseptics;fluoroquinolone antibiotic	antibiotic efflux
multidrug	adeF	resistance-nodulation-cell division (RND) antibiotic efflux pump	fluoroquinolone antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	bpeF	-	-	-
multidrug	ceoB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminoglycoside antibiotic;fluoroquinolone antibiotic	antibiotic efflux
multidrug	efrA	ATP-binding cassette (ABC) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;rifamycin antibiotic	antibiotic efflux
multidrug	emrB	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
multidrug	mexW	resistance-nodulation-cell division (RND) antibiotic efflux pump	disinfecting agents and antiseptics, phenicol antibiotic, tetracycline antibiotic, macrolide antibiotic, fluoroquinolone antibiotic	antibiotic efflux
multidrug	oprC	-	-	-
multidrug	sdeY	-	-	-
multidrug	tap	major facilitator superfamily (MFS) antibiotic efflux pump	tetracycline antibiotic	antibiotic efflux
novobiocin	novobiocin__novA	ATP-binding cassette (ABC) antibiotic efflux pump	aminocoumarin antibiotic	antibiotic efflux

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pleuromutilin	pleuromutilin_tiamulin__TaeA	ATP-binding cassette (ABC) antibiotic efflux pump	pleuromutilin antibiotic	antibiotic efflux
polymyxin	rosA	major facilitator superfamily (MFS) antibiotic efflux pump	peptide antibiotic	antibiotic efflux
polymyxin	rosB	major facilitator superfamily (MFS) antibiotic efflux pump	peptide antibiotic	antibiotic efflux
quinolone	norB	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
rifamycin	rphA	rifampin phosphotransferase	rifamycin antibiotic	antibiotic inactivation
rifamycin	rphB	rifampin phosphotransferase	rifamycin antibiotic	antibiotic inactivation
tetracycline	tet(M)	tetracycline-resistant ribosomal protection protein	tetracycline antibiotic	antibiotic target protection
tetracycline	tet(W)	tetracycline-resistant ribosomal protection protein	tetracycline antibiotic	antibiotic target protection
tetracycline	tetA(48)	-	-	-
tetracycline	tetA(P)	major facilitator superfamily (MFS) antibiotic efflux pump	tetracycline antibiotic	antibiotic efflux
tetracycline	tetB(48)	-	-	-
tetracycline	tetB(P)	tetracycline-resistant ribosomal protection protein	tetracycline antibiotic	antibiotic target protection
vancomycin	vanHF	glycopeptide resistance gene cluster, vanH	glycopeptide antibiotic	antibiotic target alteration

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Supplementary Table S5. Compared to BL soil, the information of enriched ARGs in HL270 treated soil.

ARGs_types	ARGs_subtypes	AMR Gene Family	Drug Class	Resistance Mechanism
aminoglycoside	AAC(3)-IIIc	AAC(3)	aminoglycoside antibiotic	antibiotic inactivation
bacitracin	BahA	Bah amidohydrolase	peptide antibiotic	antibiotic inactivation
bacitracin	bacA	undecaprenyl pyrophosphate related proteins	peptide antibiotic	antibiotic target alteration
fosfomycin	FosA	fosfomycin thiol transferase	phosphonic acid antibiotic	antibiotic inactivation
macrolide	LlmA 23S ribosomal RNA methyltransferase	Llm 23S ribosomal RNA methyltransferase	lincosamide antibiotic	antibiotic target alteration
macrolide	lsa(B)	lsa-type ABC-F protein	pleuromutilin antibiotic, streptogramin antibiotic, lincosamide antibiotic	antibiotic target protection
macrolide	macA	ATP-binding cassette (ABC) antibiotic efflux pump	macrolide antibiotic	antibiotic efflux
macrolide	mel	msr-type ABC-F protein	macrolide antibiotic;streptogramin antibiotic	antibiotic target protection
multidrug	Enterobacter cloacae acrA	resistance-nodulation-cell division (RND) antibiotic efflux pump	tetracycline antibiotic, penicillin beta-lactam, cephalosporin, disinfecting agents and antiseptics, phenicol antibiotic, rifamycin antibiotic, glycylcycline, fluoroquinolone antibiotic	antibiotic efflux
multidrug	Escherichia coli acrA	resistance-nodulation-cell division (RND) antibiotic efflux pump	tetracycline antibiotic, penicillin beta-lactam, cephalosporin, disinfecting agents and antiseptics, phenicol antibiotic, rifamycin antibiotic, glycylcycline, fluoroquinolone antibiotic	antibiotic efflux
multidrug	MexC	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;cephalosporin;diaminopyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	MexD	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;cephalosporin;diaminopyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	MuxA	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	OpmB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	Other_major_facilitator_superfamily_transporter	-	-	-

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multidrug	PmpM	multidrug and toxic compound extrusion (MATE) transporter	aminoglycoside antibiotic;disinfecting agents and antiseptics;fluoroquinolone antibiotic	antibiotic efflux
multidrug	acrE	resistance-nodulation-cell division (RND) antibiotic efflux pump	penicillin beta-lactam, cephalosporin, fluoroquinolone antibiotic	antibiotic efflux
multidrug	acrF	resistance-nodulation-cell division (RND) antibiotic efflux pump	penicillin beta-lactam, cephalosporin, fluoroquinolone antibiotic	antibiotic efflux
multidrug	efpA	major facilitator superfamily (MFS) antibiotic efflux pump	isoniazid-like antibiotic;rifamycin antibiotic	antibiotic efflux
multidrug	efrA	ATP-binding cassette (ABC) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;rifamycin antibiotic	antibiotic efflux
multidrug	emrA	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
multidrug	emrB	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
multidrug	mdsB	resistance-nodulation-cell division (RND) antibiotic efflux pump	carbapenem;cephalosporin;monobactam;penicillin beta-lactam;phenicol antibiotic	antibiotic efflux
multidrug	mdtE	resistance-nodulation-cell division (RND) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam	antibiotic efflux
multidrug	mdtH	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
multidrug	mdtL	-	-	-
multidrug	msbA	ATP-binding cassette (ABC) antibiotic efflux pump	nitroimidazole antibiotic	antibiotic efflux
multidrug	oqxB	resistance-nodulation-cell division (RND) antibiotic efflux pump	diaminopyrimidine antibiotic;fluoroquinolone antibiotic;glycylcycline;nitrofuran antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	tolC	resistance-nodulation-cell division (RND) antibiotic efflux pump, major facilitator superfamily (MFS) antibiotic efflux pump, ATP-binding cassette (ABC) antibiotic efflux pump	peptide antibiotic, tetracycline antibiotic, penicillin beta-lactam, cephalosporin, aminoglycoside antibiotic, disinfecting agents and antiseptics, phenicol antibiotic, rifamycin antibiotic, aminocoumarin antibiotic, glycylcycline, carbapenem, fluoroquinolone antibiotic, macrolide antibiotic	antibiotic efflux
mupirocin	Bifidobacteria intrinsic ileS conferring resistance to mupirocin	antibiotic-resistant isoleucyl-tRNA synthetase (ileS)	mupirocin-like antibiotic	antibiotic target alteration
novobiocin	novA	ATP-binding cassette (ABC) antibiotic efflux pump	aminocoumarin antibiotic	antibiotic efflux
other_peptide_antibiotics	other_peptide_antibiotics__microcin efflux pumu gene yojI	ATP-binding cassette (ABC) antibiotic efflux pump	peptide antibiotic	antibiotic efflux

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pleuromutilin	tiamulin__TaeA	ATP-binding cassette (ABC) antibiotic efflux pump	pleuromutilin antibiotic	antibiotic efflux
polymyxin	arnA	pmr phosphoethanolamine transferase	peptide antibiotic	antibiotic target alteration
polymyxin	pmrF	pmr phosphoethanolamine transferase	peptide antibiotic	antibiotic target alteration
polymyxin	rosB	major facilitator superfamily (MFS) antibiotic efflux pump	peptide antibiotic	antibiotic efflux
quinolone	lfrA	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
quinolone	norB	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
rifamycin	RbpA	RbpA bacterial RNA polymerase-binding protein	rifamycin antibiotic	antibiotic target protection
rifamycin	iri	rifampin monooxygenase	rifamycin antibiotic	antibiotic inactivation
rifamycin	rphA	rifampin phosphotransferase	rifamycin antibiotic	antibiotic inactivation
rifamycin	rphB	rifampin phosphotransferase	rifamycin antibiotic	antibiotic inactivation
tetracycline	tet(O)	tetracycline-resistant ribosomal protection protein	tetracycline antibiotic	antibiotic target protection
tetracycline	tet(V)	major facilitator superfamily (MFS) antibiotic efflux pump	tetracycline antibiotic	antibiotic efflux
tetracycline	tetA(48)	-	-	-
tetracycline	tetB(48)	-	-	-
vancomycin	vanI	Van ligase;glycopeptide resistance gene cluster	glycopeptide antibiotic	antibiotic target alteration

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Table S6 Compared to BL soil, the information of enriched ARGs in HL330 treated soil.

ARGs_types	ARGs_subtypes	AMR Gene Family	Drug Class	Resistance Mechanism
aminoglycoside	APH(3')-IIc	APH(3')	aminoglycoside antibiotic	antibiotic inactivation
aminoglycoside	amrB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminoglycoside antibiotic;macrolide antibiotic	antibiotic efflux
bacitracin	bacA	undecaprenyl pyrophosphate related proteins	peptide antibiotic	antibiotic target alteration
bacitracin	bcrA	ATP-binding cassette (ABC) antibiotic efflux pump	peptide antibiotic	antibiotic efflux
beta_lactam	L1 beta-lactamase	L1 family beta-lactamase	cephalosporin	antibiotic inactivation
beta_lactam	OXA-275	OXA beta-lactamase;OXA-274-like beta-lactamase	carbapenem;penicillin beta-lactam	antibiotic inactivation
fosfomycin	FosA	fosfomycin thiol transferase	phosphonic acid antibiotic	antibiotic inactivation
macrolide	lsa(B)	lsa-type ABC-F protein	pleuromutilin antibiotic, streptogramin antibiotic, lincosamide antibiotic	antibiotic target protection
macrolide	macA	ATP-binding cassette (ABC) antibiotic efflux pump	macrolide antibiotic	antibiotic efflux
macrolide	macB	ATP-binding cassette (ABC) antibiotic efflux pump	macrolide antibiotic	antibiotic efflux
macrolide	mel	msr-type ABC-F protein	macrolide antibiotic;streptogramin antibiotic	antibiotic target protection
multidrug	Enterobacter cloacae acrA	resistance-nodulation-cell division (RND) antibiotic efflux pump	tetracycline antibiotic, penicillin beta-lactam, cephalosporin, disinfecting agents and antiseptics, phenicol antibiotic, rifamycin antibiotic, glycylcycline, fluoroquinolone antibiotic	antibiotic efflux
multidrug	Escherichia coli acrA	resistance-nodulation-cell division (RND) antibiotic efflux pump	tetracycline antibiotic, penicillin beta-lactam, cephalosporin, disinfecting agents and antiseptics, phenicol antibiotic, rifamycin antibiotic, glycylcycline, fluoroquinolone antibiotic	antibiotic efflux
multidrug	Klebsiella pneumoniae acrA	resistance-nodulation-cell division (RND) antibiotic efflux pump	tetracycline antibiotic, penicillin beta-lactam, cephalosporin, disinfecting agents and antiseptics, phenicol antibiotic, rifamycin antibiotic, glycylcycline, fluoroquinolone antibiotic	antibiotic efflux
multidrug	MexA	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;carbapenem;cephalosporin;diamino pyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;monobactam;penicillin beta-lactam;peptide antibiotic;phenicol antibiotic;sulfonamide antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	MexB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;carbapenem;cephalosporin;diamino	antibiotic efflux

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multidrug	MexC	resistance-nodulation-cell division (RND) antibiotic efflux pump	pyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;monobactam;penicillin beta-lactam;peptide antibiotic;phenicol antibiotic;sulfonamide antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	MexD	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;cephalosporin;diaminopyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	MexE	resistance-nodulation-cell division (RND) antibiotic efflux pump	diaminopyrimidine antibiotic;fluoroquinolone antibiotic;phenicol antibiotic	antibiotic efflux
multidrug	MexF	resistance-nodulation-cell division (RND) antibiotic efflux pump	diaminopyrimidine antibiotic;fluoroquinolone antibiotic;phenicol antibiotic	antibiotic efflux
multidrug	MuxA	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	MuxB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	MuxC	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	OpmB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;macrolide antibiotic;monobactam;tetracycline antibiotic	antibiotic efflux
multidrug	OpmH	resistance-nodulation-cell division (RND) antibiotic efflux pump	disinfecting agents and antiseptics	antibiotic efflux
multidrug	OprJ	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;cephalosporin;diaminopyrimidine antibiotic;fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	OprM	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminocoumarin antibiotic;aminoglycoside antibiotic;carbapenem;cephalosporin;diamino pyrimidine antibiotic;disinfecting agents and antiseptics;fluoroquinolone antibiotic;macrolide antibiotic;monobactam;penicillin beta-lactam;peptide antibiotic;phenicol antibiotic;sulfonamide antibiotic;tetracycline	antibiotic efflux

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multidrug	OprN	resistance-nodulation-cell division (RND) antibiotic efflux pump	antibiotic diaminopyrimidine antibiotic;fluoroquinolone antibiotic;phenicol antibiotic	antibiotic efflux
multidrug	Other_major_facilitator_superfamily_transporter	-	-	-
multidrug	PmpM	multidrug and toxic compound extrusion (MATE) transporter	aminoglycoside antibiotic;disinfecting agents and antiseptics;fluoroquinolone antibiotic	antibiotic efflux
multidrug	acrE	resistance-nodulation-cell division (RND) antibiotic efflux pump	penicillin beta-lactam, cephalosporin, fluoroquinolone antibiotic	antibiotic efflux
multidrug	acrF	resistance-nodulation-cell division (RND) antibiotic efflux pump	penicillin beta-lactam, cephalosporin, fluoroquinolone antibiotic	antibiotic efflux
multidrug	adeF	resistance-nodulation-cell division (RND) antibiotic efflux pump	fluoroquinolone antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	amrB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminoglycoside antibiotic;macrolide antibiotic	antibiotic efflux
multidrug	bpeF			
multidrug	ceoB	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminoglycoside antibiotic;fluoroquinolone antibiotic	antibiotic efflux
multidrug	efrA	ATP-binding cassette (ABC) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;rifamycin antibiotic	antibiotic efflux
multidrug	efrB	ATP-binding cassette (ABC) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;rifamycin antibiotic	antibiotic efflux
multidrug	emrA	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
multidrug	emrB	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
multidrug	mdtE	resistance-nodulation-cell division (RND) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam	antibiotic efflux
multidrug	mdtF	resistance-nodulation-cell division (RND) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;penicillin beta-lactam	antibiotic efflux
multidrug	mdtH	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
multidrug	mdtK	multidrug and toxic compound extrusion (MATE) transporter	fluoroquinolone antibiotic	antibiotic efflux
multidrug	mdtL	-	-	-
multidrug	mexJ	resistance-nodulation-cell division (RND) antibiotic efflux pump	disinfecting agents and antiseptics, tetracycline antibiotic, macrolide antibiotic	antibiotic efflux
multidrug	mexK	resistance-nodulation-cell division (RND) antibiotic efflux pump	disinfecting agents and antiseptics, tetracycline antibiotic, macrolide antibiotic	antibiotic efflux
multidrug	mexN	resistance-nodulation-cell division (RND) antibiotic efflux pump	phenicol antibiotic	antibiotic efflux
multidrug	mexQ	resistance-nodulation-cell division (RND) antibiotic efflux pump	carbapenem;diaminopyrimidine antibiotic;disinfecting agents and antiseptics;macrolide antibiotic;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	mexW	resistance-nodulation-cell division	disinfecting agents and antiseptics, phenicol	antibiotic efflux

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		(RND) antibiotic efflux pump	antibiotic, tetracycline antibiotic, macrolide antibiotic, fluoroquinolone antibiotic	
multidrug	msbA	ATP-binding cassette (ABC) antibiotic efflux pump	nitroimidazole antibiotic	antibiotic efflux
multidrug	mtrD	resistance-nodulation-cell division (RND) antibiotic efflux pump	macrolide antibiotic	antibiotic efflux
multidrug	oprA	resistance-nodulation-cell division (RND) antibiotic efflux pump	aminoglycoside antibiotic, tetracycline antibiotic, carbapenem, fluoroquinolone antibiotic, macrolide antibiotic	antibiotic efflux
multidrug	oprC	-	-	-
multidrug	oqxA	resistance-nodulation-cell division (RND) antibiotic efflux pump	diaminopyrimidine antibiotic;fluoroquinolone antibiotic;glycylcycline;nitrofuran antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	oqxB	resistance-nodulation-cell division (RND) antibiotic efflux pump	diaminopyrimidine antibiotic;fluoroquinolone antibiotic;glycylcycline;nitrofuran antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	sdeY			
multidrug	smeD	resistance-nodulation-cell division (RND) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	smeE	resistance-nodulation-cell division (RND) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	smeF	resistance-nodulation-cell division (RND) antibiotic efflux pump	fluoroquinolone antibiotic;macrolide antibiotic;phenicol antibiotic;tetracycline antibiotic	antibiotic efflux
multidrug	tolC	resistance-nodulation-cell division (RND) antibiotic efflux pump, major facilitator superfamily (MFS) antibiotic efflux pump, ATP-binding cassette (ABC) antibiotic efflux pump	peptide antibiotic, tetracycline antibiotic, penicillin beta-lactam, cephalosporin, aminoglycoside antibiotic, disinfecting agents and antiseptics, phenicol antibiotic, rifamycin antibiotic, aminocoumarin antibiotic, glycylcycline, carbapenem, fluoroquinolone antibiotic, macrolide antibiotic	antibiotic efflux
other_peptide_antibiotics	other_peptide_antibiotics__microcin efflux pumu gene yojI	ATP-binding cassette (ABC) antibiotic efflux pump	peptide antibiotic	antibiotic efflux
pleuromutilin	tiamulin__TaeA	ATP-binding cassette (ABC) antibiotic efflux pump	pleuromutilin antibiotic	antibiotic efflux
polymyxin	arnA	pmr phosphoethanolamine transferase	peptide antibiotic	antibiotic target alteration
polymyxin	pmrF	pmr phosphoethanolamine transferase	peptide antibiotic	antibiotic target alteration
polymyxin	rosA	major facilitator superfamily (MFS) antibiotic efflux pump	peptide antibiotic	antibiotic efflux
polymyxin	rosB	major facilitator superfamily (MFS) antibiotic efflux pump	peptide antibiotic	antibiotic efflux
polymyxin	ugd	pmr phosphoethanolamine	peptide antibiotic	antibiotic target alteration

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		transferase		
quinolone	norB	major facilitator superfamily (MFS) antibiotic efflux pump	fluoroquinolone antibiotic	antibiotic efflux
rifamycin	rphB	rifampin phosphotransferase	rifamycin antibiotic	antibiotic inactivation
tetracycline	tet(M)	tetracycline-resistant ribosomal protection protein	tetracycline antibiotic	antibiotic target protection
tetracycline	tet(W)	tetracycline-resistant ribosomal protection protein	tetracycline antibiotic	antibiotic target protection
tetracycline	tetB(P)	tetracycline-resistant ribosomal protection protein	tetracycline antibiotic	antibiotic target protection
vancomycin	vanHF	glycopeptide resistance gene cluster, vanH	glycopeptide antibiotic	antibiotic target alteration
vancomycin	vanI	Van ligase;glycopeptide resistance gene cluster	glycopeptide antibiotic	antibiotic target alteration
vancomycin	vanJ	vanJ membrane protein	glycopeptide antibiotic	antibiotic target alteration
vancomycin	vanXI	glycopeptide resistance gene cluster, vanX	glycopeptide antibiotic	antibiotic target alteration
aminoglycoside	APH(3')-IIc	APH(3')	aminoglycoside antibiotic	antibiotic inactivation