Supplementary Material

# Supplementary Figures and Tables

## Supplementary Figures



**Supplementary Figure S1.** Manure management strategies and sampling points. Red stars (\*) represent untreated manures; Blue stars (\*) represent treated manures. Farm 2 operated under an antibiotic-free regime. BRU: bedding recovery unit. MAD: mesophilic anaerobic digester.

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**Supplementary Figure S2.** Microbial communities by respiration type (A) and Gram stain (B). Archaea and bacteria with non-defined stain were grouped as none in panel B.

## Supplementary Tables

**Supplementary Table S1.** Physicochemical properties of untreated and treated manures.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   | **Sample** | **COD** | **dCOD** | **TS** | **VS** | **Alkalinity**  |
| *farm* |   | *g/L* | *g/L* | *g/L* | *g/L* | g/L |
| Farm 1 | F1M1 |  73.6 ± 6.1  |  17.8 ± 1.2  |  76.9 ± 0.20  |  65.1 ± 0.1  |  6.20 ± 0.1  |
| F1M2 |  44.5 ± 5.1  |  14.6 ± 0.2  |  39.0 ± 0.3  |  29.2 ± 0.4  |  8.5 ± 0.1  |
| F1D1 |  40.1 ± 2.8  |  7.2 ± 0.5  |  46.5 ± 0.1  |  36.1 ± 0.1  |  11.3 ± 0.1  |
| F1D2 |  25.3 ± 3.6  |  6.2 ± 0.3  |  30.0 ± 0.2  |  20.0 ± 0.2  |  20.5 ± 0.1  |
| Farm 2 | F2M1 |  |  | 53.8 ± 0.7 | 42.5 ± 0.6 |  |
| F2M2 |  54.5 ± 3.7  |  16.9 ± 0.10  |  49.8 ± 0.8  |  41.2 ± 1.5  |  9.1 ± 0.10  |
| F2S1 |  55.0 ± 1.0  |  24.0 ± 0.3  |  44.7 ± 0.8  |  34.1 ± 1.8  |  |
| F2S2 |  65.6 ± 3  |  22.9 ± 0.1  |  55.9 ± 0.4  |  40.2 ± 0.3  |  10.6 ± 0.10  |
| Farm 3 | F3M1 |  63.7 ± 1.1  |  18.6 + 0.2  |  57.0 ± 0.5  |  46.5 ± 0.5  |  9.7 ± 0.1  |
| F3M2 |  53.6 ± 3.7  |  14.6 ± 0.3  |  46.8 ± 1.1  |  37.0 ± 1.0  |  7.5 ± 0.1  |
| F3D1 |  41.8 ± 2.0  |  8.2 ± 0.1  |  40.9 ± 0.2  |  30.3 ± 0.6  |  14.2 ± 0.1  |
| F3D2 |  33.7 ± 4.0  |  6.7 ± 0.5  |  34.2 ± 0.5  |  24.3 ± 0.6  |  10.7 ± 0.2  |
| F3L1 |  |  |  |  |  |
| F3L2 |  |  |  |  |  |
| F3S1 |  |  |  |  |  |
| F3S2 |   |   |   |   |   |

**Supplementary Table S2.** ARGs in untreated and treated manures.

|  |  |  |  |
| --- | --- | --- | --- |
| **Farm** | **Treatment** | **No. ARGs** | **ARG** |
| Farm 1 | Fresh | 52 | *aad(6), aadA11, aadA17, aadA24, aadA6, adeJ, ANT(6)-Ia, ANT(9)-Ia, APH(3’)-IIIa, APH(6)-Id, CfxA, CfxA2, CfxA4, cmx, efrB, Erm(35), ErmQ, ErmX, evgS, ileS, lnuA, lnuB, lnuC, lnuG, LnuP, lsaE, mel, mexK, mphO, mtrA, rpoB, rpoB2, spd, sul1, sul2, tet(40), tet(W/N/W), Tet(X4), tet(Z), tet32, tet36, tet44, tetA(P), tetB(P), tetM, tetO, tetQ, tetS, tetT, tetW, tetX, ugd* |
| MAD | 45 | *aad(6), aadA11, aadA16, aadA23, aadA24, aadA6/aadA10, aadS, ANT(6)-Ia, ANT(9)-Ia, APH(3’‘)-Ib, APH(3’)-IIIa, APH(6)-Id, Erm(33), Erm(47), ErmA, ErmB, ErmF, ErmG, linG, lnuA, lnuB, lnuC, lnuD, lnuF, lnuG, LnuP, lsaE, mefB, mel, mphB, rphB, rpoB, rpoB2, SAT-4, sul2, tet(W/N/W), Tet(X4), tetA(P), tetB(P), tetM, tetO, tetQ, tetT, tetW, tetX* |
| Farm 2 | Fresh | 77 | *aad(6), aadA13, aadA17, aadA2, aadA23, aadA24, aadA25, aadS, acrS, adeJ, ANT(6)-Ia, ANT(6)-Ib, ANT(9)-Ia, APH(2’‘)-If, APH(3’’)-Ib, APH(6)-Id, baeS, CARB-1, CARB-6, CfxA, CfxA2, CfxA3, CfxA4, CfxA5, CfxA6, cmx, dfrD, Erm(33), Erm(35), ErmA, ErmB, floR, ileS, LlmA, lnuA, lnuB, lnuC, lnuG, LnuP, lsaE, macB, mdfA, Mef(En2), mel, mexW, mphB, msbA, pp-flo, rphB, rpoB, rpoB2, smeE, sul1, sul2, tet(31), tet(40), tet(H), tet(J), tet(W/N/W), Tet(X3), Tet(X4), tet32, tet36, tet44, tetA(P), tetB(P), tetM, tetO, tetQ, tetS, tetT, tetW, tetX, VEB-3, VEB-5, vga(E), vgaE* |
| Storage | 64 | *aad(6), aadA, aadA15, aadA23, aadA24, adeJ, ANT(3’‘)-IIa, ANT(6)-Ia, ANT(6)-Ib, ANT(9)-Ia, APH(3’’)-Ib, APH(6)-Id, catQ, CfxA2, CfxA4, CfxA6, EreB, Erm(33), Erm(A), ErmA, ErmF, lnuA, lnuB, lnuC, lnuG, LnuP, lsaE, Mef(En2), mefB, mel, mexK, mphM, optrA, OXA-209, OXA-226, OXA-296, OXA-34, OXA-347, OXA-36, rphB, rpoB, rpoB2, smeE, sul1, tet(31), tet(40), tet(H), tet(J), tet(W/N/W), Tet(X3), Tet(X4), Tet(X6), tet(Y), tet32, tet36, tet44, tetA(P), tetM, tetO, tetQ, tetS, tetT, tetW, tetX* |
| Farm 3 | Fresh | 86 | *aad(6), aadA23, aadA24, aadS, acrD, adeF, adeJ, ANT(6)-Ia, ANT(9)-Ia, APH(3’‘)-Ib, APH(3’)-IIIa, APH(6)-Id, CARB-14, CARB-16, CARB-5, catQ, cfr(D), cfrA, cfrC, CfxA2, CfxA4, cmlA9, cmx, efrB, EreD, Erm(33), Erm(42), Erm(47), ErmA, ErmB, ErmF, ErmQ, evgS, fexA, floR, ileS, lnuA, lnuB, lnuC, lnuD, lnuG, LnuP, lsaE, mdtM, Mef(En2), mefB, mel, mexK, mphB, mphG, msrE, mtrA, optrA, oqxB, poxtA, pp-flo, qacE, qacEdelta1, rpoB, rpoB2, SAT-1, smeE, sul2, tet(33), tet(A), tet(G), tet(K), tet(W/N/W), Tet(X3), Tet(X4), Tet(X6), tet(Y), tet32, tet36, tet44, tetA(P), tetB(P), tetM, tetO, tetQ, tetS, tetT, tetW, tetX, ugd, vanRO* |
| MAD | 45 | *aad(6), aadA, aadA15, aadA17, aadA23, aadA24, aadS, ANT(3’‘)-IIa, ANT(6)-Ia, ANT(6)-Ib, APH(3’‘)-Ib, APH(3’)-IIIa, APH(6)-Id, cfr(D), Erm(47), ErmB, ErmF, ErmG, ErmQ, lnuB, lnuC, lnuG, LnuP, lsaE, mefB, mel, rpoB, rpoB2, SAT-4, sul1, sul2, tet(W/N/W), Tet(X3), Tet(X4), tet36, tet44, tetA(48), tetA(P), tetB(P), tetM, tetO, tetQ, tetT, tetW, tetX* |
| BRU-liquids | 102 | *aad(6), aadA, aadA15, aadA17, aadA23, aadA24, aadA8, aadA8b, aadS, acrB, adeF, adeJ, ANT(3’‘)-IIa, ANT(6)-Ia, ANT(6)-Ib, ANT(9)-Ia, APH(3’‘)-Ib, APH(3’)-Ia, APH(3’)-IIIa, APH(6)-Id, BahA, CARB-14, CARB-5, catQ, ceoB, cfr(B), cfr(D), cfrA, CfxA, CfxA2, CfxA4, CfxA6, cmlA9, cmx, CRP, efrB, emeA, Erm(33), Erm(35), ErmA, ErmB, ErmF, ErmT, fexA, floR, ileS, lmrD, lnuA, lnuB, lnuC, lnuG, LnuP, lsaE, mdtC, mdtF, mdtG, mdtM, Mef(En2), mefE, mel, MexB, mexW, mphC, msrE, MuxB, optrA, OXA-209, OXA-347, poxtA, pp-flo, qacE, qacEdelta1, rpoB, rpoB2, smeE, sul1, sul2, tet(A), tet(G), tet(H), tet(J), tet(W/N/W), Tet(X3), Tet(X4), Tet(X5), Tet(X6), tet36, tet44, tetA(P), tetB(P), tetM, tetO, tetQ, tetS, tetT, tetW, tetX, ugd, vanE, vanRD, vga(E), vgaE* |
| BRU-solids | 93 | *aad(6), aadA, aadA15, aadA2, aadA23, aadA24, aadA6, aadA6/aadA10, aadS, abeM, ACI-1, adeJ, adeK, ANT(3’‘)-IIa, ANT(6)-Ia, ANT(9)-Ia, APH(3’‘)-Ib, APH(3’)-Ia, APH(3’)-IIIa, APH(6)-Id, CARB-10, CARB-14, CARB-16, CARB-5, cfr(D), cfrA, cmx, dfrD, efrA, efrB, emeA, Erm(33), ErmA, ErmB, ErmC, ErmT, ErmX, ErmY, fexA, floR, ileS, IMP-11, IMP-27, lmrD, lnuA, lnuB, lnuC, lnuE, lnuG, LnuP, lsaE, mdtB, Mef(En2), mefC, mefE, mel, MexB, mexK, msrE, mupA, optrA, oqxB, OXA-347, poxtA, pp-flo, rpoB, rpoB2, SAT-1, smeE, sul1, sul2, TEM-117, TEM-118, TEM-192, tet(31), tet(39), tet(40), tet(L), tet(W/N/W), Tet(X3), Tet(X4), Tet(X6), tet32, tet36, tet44, tetA(P), tetM, tetQ, tetS, tetT, tetW, tetX, ugd* |

**Supplementary Table S3.** BacMet genes in untreated and treated manures.

|  |  |  |  |
| --- | --- | --- | --- |
| **Farm** | **Treatment** | **No. genes** | **BacMet genes** |
| Farm 1 | Fresh | 18 | *acn, cadD, mco, silP, tcrB, arsB, merA, tcrY, tcrA, tcrZ, adeJ, evgS, fabK, mexK, smrA, copA, pcoA, copG* |
| MAD | 3 | *tcrB, tcrA, copB* |
| Farm 2 | Fresh | 31 | *acn, adeJ, czcA, czrA, fabI, gadC/xasA, merR, mexW, nreB, ruvB, rpoS, smeE, srpB, tbtB, tcrB, ttgH, yodD, bcrC, copA, tcrY, tcrA, baeS, gadA, gadB, mdfA/cmr, ompD/nmpC, ziaA, kdeA, nfsA, marR, sodB* |
| Storage | 10 | *tcrB, adeJ, cusA/ybdE, mexK, silA, ruvB, recG, smeE, copA, tcrA* |
| Farm 3 | Fresh | 37 | *acn, acrD/yffA, bepE, cadC, emrD, golT, mdtM/yjiO, mexK, nczA, qacE, qacEdelta1, silP, smrA, tcrB, acrD, arsB, copA, pcoA, tcrY, tcrA, copG, adeG, adeJ, cusA/ybdE, evgS, fabK, oqxB, pstA, rpoS, sdeB, silA, smeE, smeT, G2alt, copF, copD, copC* |
| MAD | 8 | *tcrB, arsB, copB, bcrC, tcrA, acn, ziaA, copA* |
| BRU-liquids | 39 | *adeJ, cadC, cusA/ybdE, gadC/xasA, mexW, ruvB, rpoS, sdeY, silA, recG, smeE, srpB, tcrB, terD, ttgH, vmeB, arsB, merA, tcrY, tcrA, tcrZ, acn, actP, adeG, bexA, dpr/dps, emeA, fabI, mdtC/yegO, mdtG/yceE, mdtM/yjiO, mexB, mexF, qacE, qacEdelta1, copA, mdtC, pcoA, copG* |
| BRU-solids | 40 | *acn, adeJ, adeK, arsH, cadC, golT, merA, mexB, mexK, ruvB, pstB, rpoS, recG, tcrB, terC, ALU1-P, G2alt, actS, arsB, merB3, merP, merR1, merT, tcrY, tcrA, tcrZ, copG, copD, abeM, emeA, emhB, mdtB/yegN, oqxB, sdeB, smeE, srpB, tbtB, mdtB, bcrC, chtR* |

**Supplementary Table S4.** MGE-related genes in untreated and treated manures.

| **Farm** | **Treatment** | **No. MGEs** | **MGEs** |
| --- | --- | --- | --- |
| Farm 1 | Fresh | 167 | *uvrB, recA, Q5HMP5, ftsK1, trbE, tnsD, oppC, Q54944, repD, Q06238, tnpC1, hsdM, nisX1, tnpA\_IS6100, tnp, repC, groL, mobE, rep, EF\_0125, repE, ISS1N, WP\_000351512.1, zeta, tnpA, mod, tnpA\_1, dnaK, tnpB, hflB, traF, WP\_002321882.1, traA, tnpA1, ftsK, hsdR\_2, dcm, clpX, polC, dnaB, dnaX, clpB, topA, mutS2, smc, noc, uvrA, umuC, hsdM\_1, gyrB, gyrA, pcrA, ltrA\_2, parA, topB, alkA, ltrA\_1, ssb\_2, groEL, mutS, uvrC, dnaG, topB\_1, clpC, mutL, higA, dnaE, hsdR, mobC, dpnA, helD, polA, traG, ltrA, clpP\_2, cas2, clpP, virE, recR, hin, uvrA\_2, tnpR, dnaA, ruvB, istB, uvrA\_1, recJ, hin\_1, F7LRR2, ung, radA, prrC, gp56, orf17, ardA, int, IS1216, repA, tnpA6100, mob, traC\_2, traI, mobN1, A5UJT3, tnpAISAba125cp2, WP\_001284311.1, parB, repB, int1, WP\_001186919.1, Int-Tn, tra8, WP\_002293753.1, uvrB\_2, tnp1, xerD, recF, tnpB1, mobA, pre, IS1086, Q06237, bin3, WP\_010890867.1, mutS\_2, recT, ruvC, xerC, clpP1, rarA, rnr, rnhA, traK, rad50, hhaIM\_3, umuD, nucS, recN, mcrB, nusA, hhaIM\_2, ssb, holA, rdgB, recQ, bamA, hpaIIM, pinR, priA, ORF20, ORF21, ORF32, ISPpu12, virB4, lys, ORF, trbL, traC\_1, tnpX, traN\_1, tnpC, pilT\_3, tsrF, mobB, dnaC, P03862, gp6* |
| MAD | 89 | *clpP, tnpA\_IS6100, tnp, mobE, dnaK, recA, hflB, tnpA, polC, uvrB, mutS\_2, clpB, uvrA, polA, mutS2, umuC, dnaB, clpX, groL, gyrA, ltrA\_2, dnaX, rarA, smc, clpC, mutS, dpnA, hin, ltrA, gyrB, dcm, hsdM, recQ, tnpR, dnaA, ltrA\_1, traG, istB, uvrA\_1, pinR, mcrB, ORF1, ORF2, ORF20, ORF21, ORF32, topB, eexR, eexS, hsdR, traE, rteB, int, IS1216, tnpZ, nikA, tnpA6100, traC\_1, traC\_2, repA, tnpB, Int-Tn, ftsK, xhlA, tnsD, Q57231, trbJ, parA, traA, noc, ssb\_2, groEL, uvrC, dut, dnaE, ltrA\_5, recR, hin\_1, xerD\_4, dinB, traK, prrC, A0A0M9FEW5, orf17, mob, topB\_1, uvrD, A5UJT3, tnpB1* |
| Farm 2 | Fresh | 169 | *clpP, clpX, uvrB, recA, tnpA, tnsB, tnsA, intN1, Q57231, Q54944, tnpC1, gyrA, repF, WP\_012816704.1, tnp, insI, parA, mobE, repE, EF\_0125, tnpB, repA, mrr\_2, ssb, rep, dnaK, hflB, WP\_000798699.1, hsdR, uvrC, recO, hsdM, recJ, dnaB, groL, pcrA, uvrA, mutS2, smc, traG, lexA, comM, ltrA, hsdM\_1, gyrB, dnaA, ltrA\_2, clpB, xerD, dnaX, topB, groEL, mutS, parC, rex, dnaG, clpC, cinA, xerD\_3, ssb\_2, traK, rad50, ruvC, dnaE, dpnA, recQ, terL, hhaIM\_2, polA, ydiP, recN, ltrA\_5, ftsK, holA, ruvB, ung2, xerD\_1, rarA, recR, hin, tnpR, mutY, uvrA\_2, bamA, dcm, mazG, priA, istB, uvrA\_1, hin\_1, ligA, traM, hhaIM\_3, topB\_1, ung, dnaN, s035, ORF2, ORF21, ORF32, ISPpu12, traD, fic, prrC, traE, gp56, pglX, orf17, orf23, int, IS1216, tnpZ, mobA, mob, traC\_1, traI, mobN1, traC\_4, traC\_2, Int-Tn, tnpX, exc, traN\_1, istA, tnpC, WP\_001284311.1, pilT\_3, recG, tsrF, int1, repB, radA, dnaC, parE, tnpB1, Q99338, tnpA1, 23, gp23, B, insE3, P16943, pre, ISS1N, mutL, polC, pilT\_1, topA, recT, sbcD, mcrB, vsr, mug, oppF, rnhA, F7LRR2, clpP1, hipA, hpaIIM\_1, hsdR\_2, A0A2X2IGH7, WP\_087879933.1, traI\_1, repR, tra8, mukF, uvrB\_2, insE4, repN* |
| Storage | 156 | *uvrB, dpnA, clpP, 20, nisX1, repF, tnp, tnpR, tnpA, insF, dnaK, recA, tnpB, hflB, dinB, recJ, dnaB, groL, mutS2, uvrA, traG, lexA, gyrA, clpX, dcm, hsdM\_1, gyrB, hsdM, ltrA\_2, clpP1, clpB, dnaX, rarA, topB, groEL, mutS, rnr, topB\_1, xerD\_3, mutL, traK, clpC, hhaIM\_1, ltrA, umuD, umuC, dnaE, ung, ssb\_2, ruvC, rep, polA, xerD, P, dut, hhaIM\_3, ftsK, ung2, xerD\_1, recQ, xerS, pcrA, mazG, ltrA\_1, priA, uvrA\_1, hin\_1, ruvB, F7LRR2, hhaIM\_2, hsdR, ydiP, prrC, traE, orf17, orf23, lys, traQ, traH, rteB, hpaIIM\_1, int, Int-Tn, IS1216, mobA, traC\_1, traC\_2, mobN1, traC\_4, tnpX, mobC, traN\_1, pilT\_3, topA, recR, dnaN, tnpB1, dam, ftsK1, trbE, tnsE, tnsA, oppA, tnpC1, hsdS, insB, tnpA\_1, insI, pre, ISS1N, zeta, trbEB, insA, brxL, repC, polC, cas1, repA, hin, smc, ssb, hsdR\_2, dpnM\_2, Q79DZ0, yafQ\_1, yafQ, clpP\_2, ligA, virE, holA, dnaA, haeIIIM\_1, pemK, higA, intS\_4, ISPpu12, mobI, hipA, gp56, traP, nikA, mob, virB4\_3, ardA, istA, kfrA, traA, repB, traN, repR, traM, ecoRIR, tra8, radA, parC, tnpA1* |
| Farm 3 | Fresh | 231 | *mutS, tnp, motB, 28, rIIB, NGR\_a00240, NGR\_a03160, xis, pre, trbF, tnsE, tnsA, oppD, repS, repR, P0A4M1, Q06238, Q06237, truncated-tnp, tnpC1, P0A4M2, traL, recN, hsdM, nisX1, EF\_0125, transposase, tnpA, dinB, tnpA\_1, groL, tnpR, rep, traA, tnpB, ISS1N, WP\_000351512.1, zeta, mobA, hsdR, ruvB, dnaK, traG, recA, hflB, WP\_002321882.1, brxL, parA, higB, ftsK, repB, uvrC, polC, dnaB, cas2, cas1, clpB, mutS2, smc, noc, dnaG, uvrB, uvrA, pcrA, comM, clpX, ltrA, hhaIM, gyrB, gyrA, radC, dnaA, ltrA\_2, dnaX, dut, topB, ltrA\_1, hup, ssb\_2, groEL, rex, recR, xerD\_3, addA, ruvC, mutL, clpC, nucS, intS, dnaE, dpnA, dcm, recQ, xerD, traK, clpP\_2, hsdM\_1, xerD\_1, hhaIM\_2, rarA, mutY, uvrA\_2, hupB, repA, mazG, priA, istB, uvrA\_1, recJ, F7LRR2, terL, ung, dnaN, radA, ORF2, ORF20, soj, prrC, hsdS1, soj\_2, traM, orf23, traQ, rteB, traD, int, Xis-Tn, IS1216, topB\_1, traC\_1, traI, mobN1, traC\_4, traC\_2, traN\_1, A5UJT3, WP\_141194616.1, Q7BQ53, WP\_011727856.1, A0A0P0CPN4, A0A3Q9IGW5, tnpAISAba125cp2, tnpC, tsrF, hsdS, trbL, mobL, mobB, tniR\_3, hfq, traO, WP\_001186919.1, Int-Tn, WP\_002293753.1, ligA, uvrB\_2, virB11, tnp1, tnpB1, tnpA1, A0A514DJL2, 7, gp16, gp18, gp42, gp13, 6, 18, g159, clpP, F, ftsK1, oppC, intN1, traJ, mobE, traR, mod, WP\_010890867.1, traX\_2, traF, traI\_2, WP\_000798699.1, traX, traI\_1, insA, clpA, nth, cas9, umuC, xerC, hhaIM\_3, rnr, ycbY, rad50, ssb, pilT, polA, insC1, pcrA\_2, holA, ung2, hin, recT, gp26, ssb\_1, virB4, ISPpu12, ORF, traE, gp56, orf17, traH, tnpX, parA1, A0A2Z3N9D2, ORF1, pilT\_3, mob, mobC, dnaJ, int1, tra8, dnaC, parC, Q99338, ompA, rph, P03862, gp37, holB* |
| Farm 3 | MAD | 92 | *clpX, clpP, A, Q57231, gyrA, tnp, traA, dnaK, tnpB, hflB, ltrA, hsdR, hsdR\_2, dnaX, ftsK, groL, uvrA, dnaB, traG, hhaIM\_1, ltrA\_2, clpB, tnpA, uvrB, tnpR, recA, groEL, mutS, clpC, dcm, dnaE, dpnA, hhaIM\_2, gyrB, clpP\_2, hsdM, virE, recQ, hin, uvrA\_2, dnaA, uvrA\_1, hin\_1, ruvB, ORF1, ORF2, ORF20, ORF32, topB, prrC, traE, orf17, orf23, rteB, int, mob, traC\_1, uvrD, repA, A5UJT3, WP\_127822567.1, A0A1W7AEW0, tnsE, tnpB1, mobA, tnpA1, 41, ftsK1, parB, Q06237, tnpA\_IS6100, ligD, insI, brxL, rarA, alkA, ltrA\_1, smc, hsdS, dut, polA, xerD\_4, traK, topB\_1, traC\_2, istB, WP\_011727856.1, ligB, traM, WP\_001186919.1, Int-Tn, hfq* |
| BRU-liquids | 218 | *uvrB, dpnA, recA, groL, tnpB, ftsK1, yubI, tnsE, tnsD, tnsC, repD, tnpC1, ligA, EF\_0125, tnp, tnpA, insI, mobE, rumB, parA, repE, dnaK, dnaG, hflB, ftsK, rep, brxL, tnpR, hsdR\_2, uvrC, clpA, clpX, hsdM, polC, dnaB, dnaX, mutS\_2, cas2, cas1, clpB, polA, mutS2, smc, ruvC, uvrA, traG, pcrA, gyrB, gyrA, umuC, hsdM\_1, hhaIM\_1, dnaA, ltrA\_2, dut, dcm, topB, ssb, dinD, groEL, rex, rdgB, topB\_1, recR, addA, mutL, traK, rad50, clpC, mutS, ltrA, umuD, A0A0R5RPQ5, Q79DZ0, hsdR, rarA, recQ, dnaE, ung, mobC, hin, hhaIM\_2, pilT\_2, ruvA, hhaIM\_3, ltrA\_5, recJ, clpP, virE, holA, ung2, mutY, mrr, priA, ruvB, istB, uvrA\_1, dnaN, mazG, xerC, hin\_1, xerD, dinB, mecB, F7LRR2, ydiP, ORF21, ISPpu12, traH, fic, trhF, prrC, hipA, soj\_2, traO, gp56, pglX, int, mobA, mob, mobN1, traC\_4, traC\_2, tnpX, traN\_1, A5UJT3, tnpAISAba125cp2, pilT\_3, sit, cpl, int1, repR, traM, radA, hda, pilB, parE, parC, tnpB1, tnpA1, repN, S’, tnsA, oppA, oppF, intN1, repS, traA, Q06238, Q06237, truncated-tnp, hsdS, nisX1, insI3, insB, insI1, repA1, ISS1N, pifA, traI, insA, insL3, repB, repC, cas9, comM, radC, lexA, ssbB, ltrA\_1, rnr, xerD\_3, recN, hhaIM, lexA\_1, tnsB, recT, xerD\_1, uvrA\_2, ssb3, gp26, ssb\_1, ssb\_2, dinG, recE\_1, ORF2, ORF20, ORF32, parB, traR, traV, traE, orf17, orf23, lys, rteB, ardA, IS1216, traQ, yhhI, tra905, istA, tnpC, WP\_127822567.1, rep3, tnpA\_IS6100, A0A1W7AEW0, mobL, topA, mobB, hfq, dpnB, WP\_001186919.1, Int-Tn, tra8, WP\_002293753.1, tnp1, S* |
| BRU-solids | 222 | *uvrB, hupB, ssb2, groL, clpP, tnp, Q5HMP5, dnaB, NGR\_a00240, trbE, insA8, tnsE, tnsC, tnsA, repS, Q57231, Q54944, rlx, parB, parA, repR, orf19, Q06238, Q06237, truncated-tnp, cas3, tnpC1, traL, repA, mutS, hsdM, nisX1, gyrA, tnpR, EF\_0125, repF, EDI97729.1, repB, tnpA, insB, insI, pre, repA1, insF, bin3, mobE, insA\_1, tnpB, ISS1N, WP\_000351512.1, ssb, zeta, insB6, hsdR, mod, tnpA\_1, recD2, dnaK, recA, hflB, trbEB, traI, traF, traE, traD, WP\_002321882.1, rep, brxL, traA, IS26, WP\_000798699.1, insA\_3, ftsK, hsdR\_2, clpX, mutS2, traG, pcrA, dnaA, ltrA\_2, clpB, ruvC, dnaX, topB, alkA, hup, groEL, rex, parC, recR, clpC, uvrA, gyrB, Q79DZ0, ung, dnaE, clpP\_2, ltrA, sbcC, hsdM\_1, hflD, rarA, recT, sbcB, mazG, priA, istB, uvrA\_1, traK, dcm, smc, ruvB, F7LRR2, radA, ORF21, prrC, sth368IM, A0A3L8G246, soj\_2, gp56, pglX, orf17, orf23, s035, int, IS1216, mob, traC\_4, mobC, traN\_1, A0A2Z3N9D2, A0A178TR40, Q7BQ53, tnpAISAba125cp2, tnpC, WP\_001284311.1, WP\_127822567.1, rep3, pilT\_3, tsrF, dnaJ, trhW, mobL, mobB, pilR, int1, traM, dpnB, WP\_001186919.1, Int-Tn, tra8, WP\_002293753.1, addA, polB, seqA, ligA, uvrB\_2, tnp1, P14506, cas1-1, dnaC, comEB, tnpB1, Q99338, tnpA1, ompA, mobA, polC, gp42, 10, orf14, ftsK1, tnsD, tnsB, insH\_1, oppC, repE, traO, rumB, insH6, insA, traC\_5, uvrC, clpA, ltrA\_1, clpP1, recJ, lexA, comM, dnaG, topB\_1, xerD\_3, dinG, pilT, recQ, pilT\_2, hin, xerD\_1, uvrD, polA, hin\_1, hhaIM, recN, xerD, dnaN, ORF32, intS\_4, traN, traU, hipA, trbL, ardA, soj\_7, traC\_1, mobN1, recG, A0A1W7AEW0, pilB, parE, rph, ORF06, ORF16* |

**Supplementary Table S5.** Microbial genera associated with ARGs and MGEs.

| **Genus** | **Phylum** | **Genes**  |
| --- | --- | --- |
| *Glutamicibacter* | Actinomycetota | *adeJ, floR, pp-flo, smeE, optrA, CARB-14, CARB-5, fexA, EF\_0125, Q06238, radA, tnpC1, traI, tnpC, tsrF, ligA, parC, pglX, tnsA, traD, repR, mobL, repS, soj\_2, truncated-tnp, tnsC, BAC0018, BAC0293, BAC0335, BAC0359, BAC0373, BAC0056* |
| *Comamonas* | Pseudomonadota | *Tet(X3), floR, pp-flo, smeE, CARB-14, CARB-5, fexA, tnpC1, traI, ung, xerD, priA, recN, ruvC, tnpC, comM, ligA, mazG, mutY, rex, tnsA, xerD\_3, addA, repS, clpA, BAC0293, BAC0335, BAC0359, BAC0373* |
| *Staphylococcus* | Bacillota | *efrB, optrA, fexA, EF\_0125, IS1216, ISS1N, Q06238, WP\_001186919.1, WP\_002293753.1, WP\_002321882.1, mod, tnp1, tnpC1, uvrB\_2, Q06237, mobB, recT, tnpC, tsrF, mobL, repS, truncated-tnp, BAC0003, BAC0740* |
| *Psychrobacter* | Pseudomonadota | *efrB, floR, pp-flo, optrA, poxtA, CARB-14, CARB-5, fexA, Q06238, WP\_000351512.1, WP\_001186919.1, WP\_002293753.1, traI, Q06237, tnpC, comM, traD, repR, addA, mobL, repS, truncated-tnp, BAC0056* |
| *Amylolactobacillus* | Bacillota | *efrB, EF\_0125, IS1216, ISS1N, Q06238, WP\_001186919.1, WP\_002293753.1, WP\_002321882.1, mod, tnp1, tnpC1, Q06237, mobB, recT, tnpC, tsrF, repS, BAC0003, BAC0740* |
| *Carnobacterium* | Bacillota | *efrB, tetS, adeJ, EF\_0125, IS1216, Q06238, WP\_001186919.1, WP\_002293753.1, WP\_002321882.1, int1, parA, radA, rep, tnp1, tnpC1, tnpC, tsrF, BAC0740, BAC0018* |
| *Empedobacter* | Bacteroidota | *APH(6)-Id, adeJ, Tet(X3), optrA, radA, tnpC, ligA, parC, traD, tnsE, BAC0018, BAC0335, BAC0355, BAC0056* |
| *Advenella* | Pseudomonadota | *floR, pp-flo, poxtA, CARB-14, CARB-5, fexA, WP\_000351512.1, traI, comM, repR, addA, mobL, repS* |
| *Macrococcus* | Bacillota | *floR, pp-flo, poxtA, CARB-14, CARB-5, fexA, traI, comM, addA, mobL, repS* |
| *Myroides* | Bacteroidota | *Tet(X3), floR, pp-flo, traI, recN, comM, mazG, rex, tnsA, xerD\_3, addA* |
| *Petrocella* | Bacillota | *floR, optrA, CARB-14, CARB-5, fexA, Q06238, WP\_002293753.1, Q06237, tnpC, mobL, repS* |
| *Thermus* | Deinococcota | *pp-flo, optrA, Q06238, WP\_000351512.1, WP\_002293753.1, traD, repR, truncated-tnp, BAC0056* |
| *Erysipelothrix* | Bacillota | *efrB, IS1216, WP\_002293753.1, int1, radA, rep, pilT\_3, BAC0740* |
| *Moraxella* | Pseudomonadota | *floR, optrA, CARB-14, CARB-5, fexA, tnpC, addA, repS* |
| *Brevibacterium* | Actinomycetota | *floR, pp-flo, WP\_000351512.1, nisX1, repB, mobB, BAC0003* |
| *Caldimonas* | Pseudomonadota | *floR, pp-flo, recN, comM, xerD\_3, addA* |
| *Parabacteroides* | Bacteroidota | *Mef(En2), ung, hhaIM\_2, rad50, ung2, xerD\_1* |
| *Paracoccus* | Pseudomonadota | *floR, pp-flo, cfr(D), poxtA, mobB, trbL* |
| *Brucella* | Pseudomonadota | *floR, pp-flo, cfr(D), poxtA, addA* |
| *Oligella* | Pseudomonadota | *ugd, cas2, nisX1, tnpC1, uvrC* |
| *Phocaeicola* | Bacteroidota | *CfxA2, CfxA4, Mef(En2), ISPpu12, ung2* |
| *Dietzia* | Actinomycetota | *ugd, poxtA, mobB, BAC0003* |
| *Enterococcus* | Bacillota | *tetS, hsdM\_1, mobN1, traC\_4* |
| *Halopseudomonas* | Pseudomonadota | *pglX, BAC0293, BAC0355, BAC0373* |
| *Jeotgalicoccus* | Bacillota | *tetS, ssb, ligA, parC* |
| *Paracholeplasma* | Mycoplasmatota | *Mef(En2), OXA-347, Tet(X6), xerD\_1* |
| *Pseudoxanthomonas* | Pseudomonadota | *floR, pp-flo, cfr(D), addA* |
| *Acholeplasma* | Mycoplasmatota | *Mef(En2), Tet(X3), mobA* |
| *Amphibacillus* | Bacillota | *fexA, traI, recT* |
| *Latilactobacillus* | Bacillota | *ileS, tet(40), tnp1* |
| *Mycolicibacterium* | Actinomycetota | *floR, pp-flo, poxtA* |
| *Pseudomonas* | Pseudomonadota | *ligA, traC\_4, BAC0355* |
| *Rhodococcus* | Actinomycetota | *cfr(D), poxtA, addA* |
| *Acetivibrio* | Bacillota | *ErmF, ORF1* |
| *Acinetobacter* | Pseudomonadota | *Tet(X3), tnpC1* |
| *Aerococcus* | Bacillota | *lnuG, tetS* |
| *Aliarcobacter* | Pseudomonadota | *traH, insA* |
| *Aminipila* | Bacillota | *rteB, traQ* |
| *Flaviflexus* | Actinomycetota | *cas2, mutL* |
| *Gudongella* | Bacillota | *ErmF, ORF1* |
| *Haploplasma* | Mycoplasmatota | *Mef(En2), traC\_4* |
| *Lactobacillus* | Bacillota | *rad50, parE* |
| *Lactococcus* | Bacillota | *tet44, nisX1* |
| *Limosilactobacillus* | Bacillota | *BAC0574, BAC0575* |
| *Mammaliicoccus* | Bacillota | *nisX1, BAC0003* |
| *Micromonospora* | Actinomycetota | *cfr(D), poxtA* |
| *Paucilactobacillus* | Bacillota | *insB, truncated-tnp* |
| *Pediococcus* | Bacillota | *ileS, tnp1* |
| *Porphyromonas* | Bacteroidota | *traH, traQ* |
| *Pseudoclostridium* | Bacillota | *ErmF, ORF1* |
| *Ruminiclostridium* | Bacillota | *ErmF, ORF1* |
| *Streptococcus* | Bacillota | *nisX1, uvrC* |
| *Syntrophomonas* | Bacillota | *ErmF, ORF1* |
| *Thermoclostridium* | Bacillota | *ErmF, ORF1* |
| *Ureibacillus* | Bacillota | *floR, pp-flo* |
| *Aminobacterium* | Synergistota | *ErmF* |
| *Bacteroides* | Bacteroidota | *traK* |
| *Blautia* | Bacillota | *topB\_1* |
| *Dehalobacterium* | Bacillota | *mefB* |
| *Dehalococcoides* | Chloroflexota | *mefB* |
| *Herbinix* | Bacillota | *ORF1* |
| *Kocuria* | Actinomycetota | *noc* |
| *Ligilactobacillus* | Bacillota | *repE* |
| *Luteimonas* | Pseudomonadota | *cas2* |
| *Methanosarcina* | Euryarchaeota | *mefB* |
| *Paeniclostridium* | Bacillota | *uvrA\_2* |
| *Proteiniphilum* | Bacteroidota | *mefB* |
| *Pseudoprevotella* | Bacteroidota | *ANT(6)-Ib* |
| *Thermobacillus* | Bacillota | *sul2* |
| *Thermobispora* | Actinomycetota | *poxtA* |
| *Weissella* | Bacillota | *cas2* |
| *Xanthomonas* | Pseudomonadota | *ANT(6)-Ib* |