

Supplementary Information

Environmental Emerging Contaminants Drive Bacterial Antimicrobial Resistance Evolution: Evidence, Mechanisms, and Challenges

Xinrui Yang, Qingbin Yuan *, Yaru Dai, Xiaolong Wang, Zhigang Yu, Mengxiong Wu and Yi Luo *

State Key Laboratory of Water Pollution Control and Green Resource Recycling, School of the Environment, Nanjing University, Nanjing 210023, China

* Correspondence: yuanqb@nju.edu.cn (Q.Y.); luoy@nju.edu.cn (Y.L.)

Table S1. PRISMA 2020 reporting checklist.

Item	Reporting topic	Location or status
1	Systematic review identification	Title; the manuscript is presented as a critical review based on a structured literature search.
2	Structured abstract	Abstract; relevant PRISMA abstract elements are reported where applicable.
3	Rationale	Introduction.
4	Objectives	End of Introduction.
5	Eligibility criteria	Literature-search Methodology; Table 1 note a.
6	Information sources and dates	Literature-search Methodology; Web of Science Core Collection; final search 13 August 2026.
7	Search strategies and filters	Literature-search Methodology; four TS strings and article/date limits.
8	Selection process	Literature-search Methodology; screening was conducted by four researchers working in two independent teams.
9	Data collection process	The extraction procedure for Table 1 is described in Table 1, Note a, and Tables S2–S5.
10a	Outcomes sought	Table 1 note a; ARG, HGT and MGE endpoints.
10b	Other variables and assumptions	Tables S2–S5 report source study, exposure, endpoint, comparator, and extracted value. Rules for ranges, midpoints, figure-derived estimates, and exposure contrasts are described in Table 1, Note a.
11	Study risk-of-bias methods	Not undertaken; no formal risk-of-bias assessment was performed.
12	Effect measures	Table 1 note a; fold change relative to the recorded comparator.
13a	Studies eligible for each synthesis	Literature-search Methodology; Table 1 note a; Tables S2–S5.
13b	Data preparation and conversions	Table 1 note a; introductory notes to Tables S2–S5.
13c	Presentation of study results	Table 1 and Tables S2–S5.
13d	Synthesis methods	Table 1, Note a; descriptive ranges, medians, and sample sizes were calculated; no pooled meta-analysis was performed.
13e	Exploration of heterogeneity	Not undertaken; no formal subgroup analysis or meta-regression was performed.
13f	Sensitivity analyses	Not undertaken.

Item	Reporting topic	Location or status
14	Reporting-bias assessment methods	Not undertaken; no formal assessment of publication or reporting bias was performed.
15	Certainty assessment methods	Table 1, Note b; qualitative evidence-strength criteria were applied. No formal certainty-of-evidence framework was used.
16a	Study selection results	Figure S1; the literature identification, deduplication, screening, and inclusion process is presented in the PRISMA 2020 flow diagram.
16b	Excluded near-eligible studies	A separate list of near-eligible full-text exclusions is not available from the original screening records.
17	Included study characteristics	Representative studies in Sections 3–4; extracted-study details in Tables S2–S5.
18	Risk-of-bias results	Not applicable because no formal risk-of-bias assessment was undertaken.
19	Individual study results	Tables S2–S5 give extracted effects; uncertainty intervals generally unavailable.
20a	Characteristics of contributing studies	Sections 3–4; Tables S2–S5.
20b	Results of statistical synthesis	Table 1 descriptive ranges, medians and n; no pooled meta-analysis.
20c	Heterogeneity investigations	Not undertaken.
20d	Sensitivity-analysis results	Not undertaken.
21	Reporting-bias results	Not applicable because no formal reporting-bias assessment was undertaken..
22	Certainty results	Table 1 reports qualitative evidence-strength ratings; no formal certainty-of-evidence assessment was performed.
23a	Interpretation	Sections 3–5 and Conclusion.
23b	Limitations of evidence	Current Research Gaps and Future Perspectives.
23c	Limitations of review process	Table 1, Note a, and Current Research Gaps and Future Perspectives; heterogeneity in organisms, matrices, exposure designs, comparators, and endpoints is acknowledged.
23d	Implications	Current Research Gaps and Future Perspectives; Conclusion.
24a	Registration	Not reported.
24b	Protocol access	Not reported.
24c	Protocol amendments	Not reported.
25	Support and funder role	Acknowledgment lists funding. The role of the funders is not separately specified.
26	Competing interests	Conflict of Interest Disclosure.
27	Availability of materials	Tables S2–S5 provide extracted values. Search log and analytic code not reported.

Table S2. Studies used for the quantitative summary of antibiotic effects on antimicrobial resistance in Table 1.

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
1	2013	Diverse and abundant antibiotic resistance genes in Chinese swine farms	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES	10.1073/pnas.1222743110	ARG	increase	1	S1-01-01 ARG In-feed/therapeutic antibiotics (swine farms) top 63 ARGs vs antibiotic-free manure/soil controls Extracted: median 192-fold (max 28,000-fold) Converted fold: 192; used: 192
2	2015	Effect from low-level exposure of oxytetracycline on abundance of tetracycline resistance genes in arable soils	ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH	10.1007/s11356-015-4099-1	ARG	increase	1	S1-02-01 ARG Oxytetracycline (low-level manure) tet(A/L/M/Q) relative abundance, arable soil vs control Extracted: 10-1000 times increase (abstract) Converted fold: 10-1000; used: 505
3	2015	Selective pressure of antibiotics on ARGs and bacterial communities in manure-polluted freshwater-sediment microcosms	FRONTIERS IN MICROBIOLOGY	10.3389/fmicb.2015.00194	ARG	increase	6	S1-03-01 ARG Tetracyclines tet resistance genes relative abundance, sediment vs control Extracted: 1.8-4.5-fold Converted fold: 1.8-4.5; used: 3.15 S1-03-02 ARG Sulfonamides sul1/2/3 relative abundance, sediment vs control Extracted: 4.5-7.2-fold Converted fold: 4.5-7.2; used: 5.85 S1-03-03 ARG Fluoroquinolones PMQR genes relative abundance, sediment vs control Extracted: 1.8-4.2-fold Converted fold: 1.8-4.2; used: 3 S1-03-04 ARG Tetracyclines tet resistance genes relative abundance, water vs control Extracted: 15.7-67.5-fold Converted fold: 15.7-67.5; used: 41.6 S1-03-05 ARG Sulfonamides sul resistance genes relative abundance, water vs control Extracted: 0.8-9.0-fold (reported overall increase) Converted fold: 0.8-9; used: 4.9 S1-03-06 ARG Fluoroquinolones PMQR genes relative abundance, water vs control Extracted: 1.7-7.7-fold Converted fold: 1.7-7.7; used: 4.7

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
4	2016	Long-term field application of sewage sludge increases the abundance of antibiotic resistance genes in soil	ENVIRONMENT INTERNATIONAL	10.1016/j.envint.2016.03.026	ARG	increase	1	S1-04-01 ARG Sewage sludge / chicken manure (long-term field) soil ARG abundance vs unamended control Extracted: up to 3845-fold (mexF; max of 108 enriched ARG/MGE) Converted fold: 3845; used: 3845
5	2016	Long-term antibiotic exposure in soil is associated with changes in microbial community structure and prevalence of class 1 integrons	FEMS MICROBIOLOGY ECOLOGY	10.1093/femsec/fiw159	HGT	increase	1	S1-05-01 HGT Veterinary antibiotics (tylosin+SMZ+CTC mixture) class 1 integron prevalence, long-term field plots vs control Extracted: 0.006% to 0.064% (~10.7-fold) Converted fold: 10.7; used: 10.7 Endpoint pooled under HGT/MGE (MGE abundance/prevalence).
6	2018	Combined impact of fishmeal and tetracycline on resistomes in mariculture sediment	ENVIRONMENTAL POLLUTION	10.1016/j.envpol.2018.07.101	ARG	increase	1	S1-06-01 ARG Tetracycline 0-100 mg/kg +/- fishmeal (mariculture sediment) total ARG abundance, day 14 Extracted: 1-1.4-fold Converted fold: 1-1.4; used: 1.2 Source: manual figure extraction.
7	2019	The dynamics of the antibiotic resistome in the feces of freshly weaned pigs following therapeutic administration of oxytetracycline	SCIENTIFIC REPORTS	10.1038/s41598-019-40496-8	ARG	increase	1	S1-07-01 ARG Oxytetracycline (therapeutic, pig gut) 41 enriched ARGs (tet/beta-lactam/multidrug) vs control diet Extracted: 3-25-fold at day 8 Converted fold: 3-25; used: 14 Source: manual figure extraction.
8	2020	Sulfamethoxazole affects the microbial composition and antibiotic resistance gene abundance in soil and accumulates in lettuce	ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH	10.1007/s11356-020-08902-1	ARG	increase	2	S1-08-01 ARG Sulfamethoxazole (100/200/300 mg/kg, soil-lettuce) sul1 relative abundance, day 120 vs CK Extracted: S1 11x; S2 15x; S3 10x Converted fold: 10-15; used: 12.5 Source: manual figure extraction. S1-08-02 ARG Sulfamethoxazole (100/200/300 mg/kg, soil-lettuce) sul2 relative abundance, day 120 vs CK Extracted: S1 2.8x; S2 3.0x; S3 1.7x Converted fold: 1.7-3; used: 2.35 Source: manual figure extraction.
9	2022	Manure application led to higher antibiotic resistance risk in red soil compared with black soil and fluvo-aquic soil	JOURNAL OF HAZARDOUS MATERIALS ADVANCES	10.1016/j.hazadv.2022.100209	ARG	increase	1	S1-09-01 ARG Chlortetracycline-manure (red soil) multidrug resistance genes relative abundance Extracted: 1.07-1.41 times Converted fold: 1.07-1.41; used: 1.24

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
10	2024	Elevated CO2 alters antibiotic resistome in soil amended with sulfamethazine via chemical-organic fertilization	ENVIRONMENTAL RESEARCH	10.1016/j.envres.2024.120416	ARG;HGT	increase	2	S1-10-01 ARG Sulfamethazine 0.1 vs 1 mg/kg (+CO2), soil 10 ARG subtypes abundance (1 mg/kg vs 0.1 mg/kg, ambient CO2) Extracted: about 1.4-fold Converted fold: 1.4; used: 1.4 Source: manual figure extraction. S1-10-02 HGT Sulfamethazine 0.1 vs 1 mg/kg (+CO2), soil intf1 and tnpA-05 abundance (1 mg/kg vs 0.1 mg/kg) Extracted: about 1.4-fold Converted fold: 1.4; used: 1.4 Source: manual figure extraction. Endpoint pooled under HGT/MGE (MGE abundance/prevalence).
11	2026	Field-scale isotope tracing reveals combined organic fertilizer-antibiotic effects in amplifying antimicrobial resistance in the soil-lettuce continuum	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2026.142415	ARG	increase	1	S1-11-01 ARG SMX + organic fertilizer (13C-SMX field) soil ARG relative abundance vs control Extracted: up to 5.35-fold (soils); 2.38-fold (roots) Converted fold: 5.35; used: 5.35
12	2025	Microbial Risks Triggered by Oral Administration of Antibiotics in Fish Aquaculture Persist Long after the Legally Mandated Antibiotic Withdrawal Time	Nature Water	10.1038/s44221-025-00502-y	ARG	increase	1	S1-12-01 ARG Florfenicol (carp farm) ARG abundance in carp intestines vs control Extracted: 4-fold (day 3); peaked >9-fold (day 10) Converted fold: 4–9; used: 6.5

Values are shown as extracted, followed by the stored converted fold value or interval and the single value used in Table 1. Each S1 record ID represents one statistical record; interval inputs use the arithmetic midpoint. Reported bounds are retained as bounds in the extracted-value text and used numerically as in the original extraction. Fold changes below 1 indicate decreases. HGT and MGE records are pooled for Table 1. Calculations use the displayed “used” values without further rounding. Six records (S1-06-01, S1-07-01, S1-08-01, S1-08-02, S1-10-01, and S1-10-02) were estimated manually from plotted values or bar heights using the displayed axes.

Table S3. Studies used for the quantitative summary of endocrine-disrupting chemicals (EDCs) effects on antimicrobial resistance in Table 1.

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
1	2016	Triclocarban Influences Antibiotic Resistance and Alters Anaerobic Digester Microbial Community Structure	Environmental Science & Technology	10.1021/acs.est.5b03080	ARG	increase	1	S2-01-01 ARG Triclocarban mexB relative abundance, anaerobic digesters vs control Extracted: at least an order of magnitude higher (30-850 mg/kg) Converted fold: 10; used: 10
2	2018	Triclosan at environmentally relevant concentrations promotes horizontal transfer of multidrug resistance genes within and across bacterial genera	Environment International	10.1016/j.envint.2018.10.040	HGT	increase	1	S2-02-01 HGT Triclosan RP4 conjugation intra/inter-genera vs control Extracted: intra up to 6.2-fold; inter ~2.3-fold at 2 ug/L Converted fold: 2.3–6.2; used: 4.25
3	2020	Preservatives accelerate the horizontal transfer of plasmid-mediated antimicrobial resistance genes via differential mechanisms	Environment International	10.1016/j.envint.2020.10.5544	HGT	increase	1	S2-03-01 HGT Triclocarban (preservative) plasmid conjugative transfer vs control Extracted: 2.17-4.31-fold Converted fold: 2.17–4.31; used: 3.24
4	2022	Environmentally relevant concentrations of triclosan exposure promote the horizontal transfer of antibiotic resistance genes mediated by <i>Edwardsiella piscicida</i>	Environmental Science and Pollution Research	10.1007/s11356-022-20082-8	HGT	increase	1	S2-04-01 HGT Triclosan RP4 conjugation mediated by <i>E. piscicida</i> vs control Extracted: 1.2-1.4-fold at 2-20 ug/L Converted fold: 1.2–1.4; used: 1.3
5	2022	双酚 A 促进粪肠球菌中信息素调控质粒 pCF10 介导的耐药基因接合转移 (Bisphenol A Promotes Conjugative Transfer of Antibiotic Resistance Genes Mediated by Pheromone-responsive Plasmid in <i>Enterococcus faecalis</i>)	Asian Journal of Ecotoxicology	10.7524/AJE.1673-5897.20211019001	HGT	increase	1	S2-05-01 HGT Bisphenol A pCF10 conjugation (<i>E. faecalis</i>) vs control Extracted: ~2.07-fold at 1 nmol/L Converted fold: 2.07; used: 2.07
6	2024	Exposure to bisphenol compounds accelerates the conjugative transfer of antibiotic resistance plasmid	Environmental Research	10.1016/j.envres.2024.12.0002	HGT	increase	1	S2-06-01 HGT Bisphenol AF (BPAF) RP4-7 conjugation in mouse gut vs control Extracted: 2.1-fold at 24 h (50 mg/kg) Converted fold: 2.1; used: 2.1
7	2022	Triclosan Promotes Conjugative Transfer of Antibiotic Resistance Genes to Opportunistic Pathogens in Environmental Microbiome	Environmental Science & Technology	10.1021/acs.est.2c05537	HGT	increase	1	S2-07-01 HGT Triclosan (activated sludge) RP4 conjugation vs control Extracted: up to 2.5-fold at 0.1 ug/L Converted fold: 2.5; used: 2.5

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
8	2022	Triclocarban Shifted the Microbial Communities and Promoted the Spread of Antibiotic Resistance Genes in Nitrifying Granular Sludge System	Bioresource Technology	10.1016/j.biortech.2021.126429	ARG;HGT	increase	2	S2-08-01 ARG Triclocarban (nitrifying granular sludge) mexF1 relative abundance vs control Extracted: up to 99.99-fold Converted fold: 99.99; used: 99.99 S2-08-02 HGT Triclocarban (nitrifying granular sludge) intI1/intI3 abundance vs control Extracted: 3.49-/5.08-fold Converted fold: 3.49–5.08; used: 4.285 Endpoint pooled under HGT/MGE (MGE abundance/prevalence).
9	2023	Phthalates Promote Dissemination of Antibiotic Resistance Genes: An Overlooked Environmental Risk	Environmental Science & Technology	10.1021/acs.est.2c09491	HGT	increase	1	S2-09-01 HGT Dimethyl phthalate (DMP) RP4 conjugation vs control Extracted: inter up to 4.96-fold; intra up to 3.82-fold Converted fold: 3.82–4.96; used: 4.39

Values are shown as extracted, followed by the stored converted fold value or interval and the single value used in Table 1. Each S2 record ID represents one statistical record; interval inputs use the arithmetic midpoint. Reported bounds are retained as bounds in the extracted-value text and used numerically as in the original extraction. Fold changes below 1 indicate decreases. HGT and MGE records are pooled for Table 1.

Table S4. Studies used for the quantitative summary of persistent organic pollutants (POPs) effects on antimicrobial resistance in Table 1.

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
1	2016	Polycyclic aromatic hydrocarbons (PAHs) enriching antibiotic resistance genes (ARGs) in the soils	Environmental Pollution	10.1016/j.envpol.2016.11.047	ARG	increase	1	S3-01-01 ARG PAHs total ARGs, PAH-contaminated vs less-contaminated soil Extracted: ~15 times more abundant Converted fold: 15; used: 15
2	2017	PAHs accelerate the propagation of antibiotic resistance genes in coastal water microbial community	Environmental Pollution	10.1016/j.envpol.2017.07.067	ARG;HGT;MGE	increase	3	S3-02-01 ARG PAHs (naphthalene / phenanthrene) sulI / aadA2 relative abundance vs no-PAH control Extracted: 10-56x (Nap 100 mg/L); 22-200x (Phe 10 mg/L) Converted fold: 10–200; used: 105 S3-02-02 MGE PAHs (naphthalene / phenanthrene) intI1 relative abundance vs no-PAH control Extracted: 26x (Nap 100 mg/L); up to 74x (Phe 10 mg/L) Converted fold: 26–74; used: 50 S3-02-03 HGT PAHs (naphthalene / phenanthrene) conjugative transfer vs control Extracted: at least 3-fold increase Converted fold: 3; used: 3
3	2020	Paradigm shift in antibiotic-resistome of petroleum hydrocarbon contaminated soil	Science of the Total Environment	10.1016/j.scitotenv.2020.143777	ARG	increase	1	S3-03-01 ARG Petroleum hydrocarbons functional abundance of resistance genes Extracted: up to 2-fold; fluoroquinolone genes up to 10-fold Converted fold: 10; used: 10
4	2023	Unrecognized risk of perfluorooctane sulfonate in promoting conjugative transfers of bacterial antibiotic resistance genes	Applied and Environmental Microbiology	10.1128/aem.00533-23	HGT	increase	1	S3-04-01 HGT PFOS plasmid conjugation frequency (E. coli MG1655 -> J53/soil community) Extracted: up to 3.25-fold Converted fold: 3.25; used: 3.25
5	2024	Fluoranthene slow down sulfamethazine migration in soil via z-z interaction to increase the abundance of antibiotic resistance genes	Environmental Pollution	10.1016/j.envpol.2024.124532	ARG	increase	1	S3-05-01 ARG Fluoranthene (PAH)+sulfamethazine total ARG abundance in surface soil Extracted: proliferation by 66.3%-125.8% Converted fold: 1.663–2.258; used: 1.9605

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
6	2024	Simultaneous volatile fatty acids promotion and antibiotic resistance genes reduction in fluoranthene-induced sludge alkaline fermentation: Regulation of microbial consortia and cell functions	Bioresource Technology	10.1016/j.biortech.2024.130367	ARG;HGT	decrease	2	S3-06-01 ARG Fluoranthene (200 mg/kg TSS, alkaline fermentation) total ARG abundance vs no-Flr fermentation control Extracted: further decreased by 12% Converted fold: 0.88; used: 0.88 S3-06-02 HGT Fluoranthene (200 mg/kg TSS) T4SS / Vir transfer-machinery genes in Flr reactors Extracted: reduced by 23%-54% Converted fold: 0.46-0.77; used: 0.615
7	2025	Synergistic effect of horizontal transfer of antibiotic resistance genes between bacteria exposed to microplastics and per/polyfluoroalkyl substances: An explanation from theoretical methods	Journal of Hazardous Materials	10.1016/j.jhazmat.2025.138208	HGT	increase	1	S3-07-01 HGT PFASs HGT risk between bacteria (E. coli-based) Extracted: up to 1.59 times Converted fold: 1.59; used: 1.59
8	2025	Perfluorooctane sulfonate (PFOS) promotes transformational transfer of antibiotic resistance genes and cross-resistance between antibiotics and PFOS	Water Research	10.1016/j.watres.2025.123868	HGT	increase	1	S3-08-01 HGT PFOS ARG natural transformation (E. coli DH5a, pBR322) Extracted: 1.5-1.7-fold; pre-exposure up to 7-fold Converted fold: 1.5-7; used: 4.25
9	2026	Striking a microbial balance: Rhizoremediation of crude oil-contaminated soils suppresses resistomes and reconstructs hydrocarbon-degrading microbial networks.	Science of the Total Environment	10.1016/j.scitotenv.2026.181586	ARG	decrease	1	S3-09-01 ARG Crude oil/PAH (rhizoremediation) ARG abundance under remediation Extracted: 10-fold reduction Converted fold: 0.1; used: 0.1
10	2017	TCDD Influences Reservoir of Antibiotic Resistance Genes in Murine Gut Microbiome	FEMS Microbiology Ecology	10.1093/femsec/fix058	ARG	increase	1	S3-10-01 ARG TCDD enriched ARGs in mouse gut Extracted: 14 ARGs enriched >=2-fold Converted fold: 2; used: 2
11	2024	Investigation of the Impact of Widely Used Pesticides on Conjugative Transfer of Multidrug Resistance Plasmids	Journal of Hazardous Materials	10.1016/j.jhazmat.2024.135436	HGT	increase	2	S3-11-01 HGT Cyprodinil / Kre (fungicides) RP4-7 conjugation, in vitro Extracted: 2.68-/2.97-fold vs control Converted fold: 2.68-2.97; used: 2.825 S3-11-02 HGT Cyprodinil / Kre (fungicides) conjugation in soil microbial model Extracted: 1.23-/1.28-fold Converted fold: 1.23-1.28; used: 1.255

Values are shown as extracted, followed by the stored converted fold value or interval and the single value used in Table 1. Each S3 record ID represents one statistical record; interval inputs use the arithmetic midpoint. Reported bounds are retained as bounds in the extracted-value text and used numerically as in the original extraction. Fold changes below 1 indicate decreases. HGT and MGE records are pooled for Table 1.

Table S5. Studies used for the quantitative summary of microplastics (MPs) effects on antimicrobial resistance in Table 1.

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
1	2020	Microplastics affect the ammonia oxidation performance of aerobic granular sludge and enrich the intracellular and extracellular antibiotic resistance genes	Journal Of Hazardous Materials	10.1016/j.jhazmat.2020.124981	ARG;MGE	increase	2	S4-01-01 ARG PVC / PA MPs (1 mg/L) tetW absolute abundance, AGS Extracted: +28.00% / +21.61% vs SBR-CK Converted fold: 1.216–1.28; used: 1.248 S4-01-02 MGE PVC / PA / PS / PE MPs (100 mg/L) int11 absolute abundance, AGS Extracted: +98.23% / +151.80% / +325.15% / +189.81% Converted fold: 1.982–4.252; used: 3.117
2	2020	Co-occurrence of microplastics and triclosan inhibited nitrification function and enriched antibiotic resistance genes in nitrifying sludge	Journal Of Hazardous Materials	10.1016/j.jhazmat.2020.123049	ARG	increase	1	S4-02-01 ARG PE/PS/PVC/PA MPs (day 14) selected ARG subtypes acrA-03 / adeA vs control Extracted: acrA-03 1.08-6.52x; adeA (PA) 9.03x Converted fold: 1.08–9.03; used: 5.055
3	2021	Enhanced propagation of intracellular and extracellular antibiotic resistance genes in municipal wastewater by microplastics*	Environmental Pollution	10.1016/j.envpol.2021.118284	HGT	increase	1	S4-03-01 HGT MPs (PE/PET/PP/PS adsorption system) max HGT frequency of iARG/eARG vs blank control Extracted: 1.5x (iARG conjugation) and 2.0x (eARG transformation) Converted fold: 1.5–2; used: 1.75
4	2021	Varying characteristics and driving mechanisms of antibiotic resistance genes in farmland soil amended with high-density polyethylene microplastics	Journal of Hazardous Materials	10.1016/j.jhazmat.2021.128196	ARG	decrease	1	S4-04-01 ARG HDPE MPs (phthalate-free) soil ARG relative abundance vs control Extracted: decreased by 13.1%-0.6% (time-dependent) Converted fold: 0.869–0.994; used: 0.9315
5	2021	Microplastics deteriorate the removal efficiency of antibiotic resistance genes during aerobic sludge digestion	Science of the Total Environment	10.1016/j.scitotenv.2021.149344	ARG	increase	1	S4-05-01 ARG PVC / PE / PET MPs total relative abundance of ARGs, aerobic digestion Extracted: +23.5% / +43.5% / +48.1% vs control Converted fold: 1.235–1.481; used: 1.358
6	2022	Effects comparison between the secondary nanoplastics released from biodegradable and conventional plastics on the transfer of antibiotic resistance genes between bacteria	Environmental Pollution	10.1016/j.envpol.2022.120680	HGT	increase	1	S4-06-01 HGT PLA/PHA secondary nanoplastics plasmid RP4 ARG transfer frequency vs control Extracted: ~28x (PLA, 8 h); 13.9x (PHA) Converted fold: 13.9–28; used: 20.95

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
7	2022	Nanoplastics promote the dissemination of antibiotic resistance through conjugative gene transfer: implications from oxidative stress and gene expression	ENVIRONMENTAL SCIENCE-NANO	10.1039/d2en01036d	HGT	increase	1	S4-07-01 HGT PS nanoplastics (10 mg/L) RP4 plasmid conjugative transfer Extracted: up to 1.51-fold Converted fold: 1.51; used: 1.51
8	2022	Different microplastics distinctively enriched the antibiotic resistance genes in anaerobic sludge digestion through shifting specific hosts and promoting horizontal gene flow	WATER RESEARCH	10.1016/j.watres.2022.119356	ARG	increase	1	S4-08-01 ARG PE / PVC MPs ARG abundance, anaerobic sludge digestion Extracted: +14.8% / +23.6% Converted fold: 1.148–1.236; used: 1.192
9	2022	Insight into effects of polyethylene microplastics in anaerobic digestion systems of waste activated sludge: Interactions of digestion performance, microbial communities and antibiotic resistance genes	ENVIRONMENTAL POLLUTION	10.1016/j.envpol.2022.119859	ARG	increase	1	S4-09-01 ARG PE MPs (180 um / 1 mm) ARG abundance, anaerobic digestion Extracted: 1.2-3.0x / 1.5-4.0x vs control Converted fold: 1.2–4; used: 2.6
10	2022	Deciphering the role of polyethylene microplastics on antibiotic resistance genes and mobile genetic elements fate in sludge thermophilic anaerobic digestion process	CHEMICAL ENGINEERING JOURNAL	10.1016/j.cej.2022.139520	ARG	increase	1	S4-10-01 ARG PE MPs ARG population relative abundance, AD reactors Extracted: enlarged by 0.41%-5.34% vs R0 control Converted fold: 1.004–1.053; used: 1.0285
11	2022	A neglected risk of nanoplastics as revealed by the promoted transformation of plasmid-borne ampicillin resistance gene by Escherichia coli	ENVIRONMENTAL MICROBIOLOGY	10.1111/1462-2920.16178	HGT	increase	1	S4-11-01 HGT PS nanoplastics (75 nm, 10-500 mg/L) plasmid pUC19 natural transformation efficiency (E. coli DH5a) Extracted: 2.5-5.4-fold vs control Converted fold: 2.5–5.4; used: 3.95
12	2022	Size-dependent effects of microplastics on antibiotic resistance genes fate in wastewater treatment systems: The role of changed surface property and microbial assemblages in a continuous exposure mode	SCIENCE OF THE TOTAL ENVIRONMENT	10.1016/j.scitotenv.2022.158264	ARG	increase	1	S4-12-01 ARG PA / PET MPs (mm / um) ARG abundance, wastewater treatment Extracted: mm +42.8%/+54.3%; um +31.3%/+39.4% Converted fold: 1.313–1.543; used: 1.428

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
13	2022	Microplastics affect nitrogen cycling and antibiotic resistance genes transfer of sediment	CHEMICAL ENGINEERING JOURNAL	10.1016/j.cej.2022.140193	ARG	increase	1	S4-13-01 ARG PE/PET/PVC MPs total ARG relative abundance vs control Extracted: +10.58% (PE), +26.37% (PET), +10.50% (PVC) Converted fold: 1.105–1.264; used: 1.1845
14	2022	Polyethylene terephthalate microplastic fibers increase the release of extracellular antibiotic resistance genes during sewage sludge anaerobic digestion	WATER RESEARCH	10.1016/j.watres.2022.118426	ARG	increase	1	S4-14-01 ARG Textile microfibers (MFs) total extracellular ARG (eARG) abundance vs control reactor Extracted: +50%; 14 eARG subtypes increased >100% Converted fold: 1.5; used: 1.5
15	2022	(Micro) nanoplastics promote the risk of antibiotic resistance gene propagation in biological phosphorus removal system	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2022.128547	ARG	increase	1	S4-15-01 ARG MP/NPs (four exposure levels) total tetracycline resistance gene relative abundance vs R0 control Extracted: 1.04–1.54x across R1–R4 Converted fold: 1.04–1.54; used: 1.29
16	2023	Nanoplastics promote the dissemination of antibiotic resistance genes and diversify their bacterial hosts in soil	ECO-ENVIRONMENT & HEALTH	10.1016/j.eehl.2023.09.005	ARG	increase	1	S4-16-01 ARG Polystyrene nanoplastics (1%) ARG abundance (copies/cell), soil Extracted: 0.26 vs 0.21 copies/cell (~1.24-fold) Converted fold: 1.24; used: 1.24
17	2023	Microplastics Enhance the Prevalence of Antibiotic Resistance Genes in Anaerobic Sludge Digestion by Enriching Antibiotic-Resistant Bacteria in Surface Biofilm and Facilitating the Vertical and Horizontal Gene Transfer	ENVIRONMENTAL SCIENCE & TECHNOLOGY	10.1021/acs.est.3c02815	ARG	increase	1	S4-17-01 ARG LDPE/PET/PS MPs ARG abundance, anaerobic sludge digestion Extracted: increase 4.5%–27.9% vs control (10–80 particles/g) Converted fold: 1.045–1.279; used: 1.162
18	2023	P, N, and C-related functional genes in SBR system promoted antibiotics resistance gene transmission under polystyrene microplastics stress	WATER RESEARCH	10.1016/j.watres.2023.119884	ARG	increase	1	S4-18-01 ARG PS MPs (low dose) aac(3)-II / blaTEM-1 / tetW; int11 Extracted: +27.13% / +38.36% / +9.57%; int11 nearly doubled Converted fold: 1.096–2; used: 1.548
19	2023	Charged nanoplastics differentially affect the conjugative transfer of antibiotic resistance genes	ENVIRONMENTAL SCIENCE-NANO	10.1039/d3en00229b	HGT	increase	1	S4-19-01 HGT PS-NH2 nanoplastics (500 mg/L) conjugative transfer of ARGs Extracted: 1.7 times vs control Converted fold: 1.7; used: 1.7
20	2023	Microplastic biofilm: An important microniche that may accelerate the spread of antibiotic resistance genes via natural transformation	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2023.132085	HGT	increase	1	S4-20-01 HGT Small / aged MPs ARG natural transformation frequency Extracted: up to 77.16-fold / 32.05-fold vs large/pristine Converted fold: 77.16; used: 77.16

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
21	2023	Tire particles and its leachates: Impact on antibiotic resistance genes in coastal sediments	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2023.133333	ARG;MGE	increase	2	S4-21-01 ARG TP tyre particles (0.3%-3% w/w, coastal sediment) total ARG abundance vs control Extracted: 1.19-/1.63-/2.82-fold at 0.3%/1%/3% Converted fold: 1.19-2.82; used: 2.005 S4-21-02 MGE TP tyre particles (0.3%-3% w/w) MGE number vs control Extracted: 1.14-/1.22-/1.53-fold at 0.3%/1%/3% Converted fold: 1.14-1.53; used: 1.335
22	2023	Microplastics exacerbate co-occurrence and horizontal transfer of antibiotic resistance genes	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2023.131130	HGT	increase	1	S4-22-01 HGT MPs bacterial conjugative transfer frequency Extracted: 1.4-1.7-fold Converted fold: 1.4-1.7; used: 1.55
23	2023	The critical role of microplastics in the fate and transformation of sulfamethoxazole and antibiotic resistance genes within vertical subsurface-flow constructed wetlands	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2023.133222	ARG	increase	1	S4-23-01 ARG MPs (constructed wetland) sul1 and sul2 abundance Extracted: +68.47% / +17.20% Converted fold: 1.172-1.685; used: 1.4285
24	2023	Effects and Mechanisms of Polystyrene Microplastics on Extracellular Antibiotic Resistance Genes in Wastewater	Huanjing Kexue	10.13227/j.hj.kx.202307246	ARG	increase	1	S4-24-01 ARG nm-level PS sul2 relative abundance, wastewater Extracted: increase 1.9-3.9 times Converted fold: 1.9-3.9; used: 2.9
25	2024	Metagenomic Analysis Reveals the Effects of Microplastics on Antibiotic Resistance Genes in Sludge Anaerobic Digestion	TOXICS	10.3390/toxics12120920	ARG	increase	1	S4-25-01 ARG PE / PET / PLA MPs ARG abundance, sludge anaerobic digestion Extracted: up to +29.90% / +18.64% / +14.15% Converted fold: 1.299; used: 1.299
26	2024	The effects of small plastic particles on antibiotic resistance gene transfer revealed by single cell and community level analysis	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2024.136271	HGT	increase	1	S4-26-01 HGT 15 / 20 um small plastic particles (500 mg/L) plasmid transfer frequency vs blank control Extracted: 14.31 / 11.29 times higher Converted fold: 11.29-14.31; used: 12.8
27	2024	Impact of polystyrene nanoplastics on primary sludge fermentation under acidic and alkaline conditions: Significance of antibiotic resistance genes	Chemosphere	10.1016/j.chemosphere.2024.142777	ARG	decrease	1	S4-27-01 ARG PS nanoplastics (alkaline) sul2 abundance Extracted: 2.4-fold decrease Converted fold: 0.417; used: 0.417

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
28	2024	Metagenomic insight into the enrichment of antibiotic resistance genes in activated sludge upon exposure to nanoplastics	ENVIRONMENTAL POLLUTION	10.1016/j.envpol.2024.125260	ARG	increase	1	S4-28-01 ARG PS nanoplastics (0.5/50 mg/L) ARG relative abundance, activated sludge Extracted: +58.68% / +46.52% Converted fold: 1.465–1.587; used: 1.526
29	2024	Effects of Tire Wear Particles on Seedling Growth of Kidney Bean (<i>Phaseolus vulgaris</i> L.) and Soil Antibiotic Resistance Gene Abundance	Huanjing Kexue	10.13227/j.hjlx.202410064	ARG	increase	1	S4-29-01 ARG Tire wear particles 0.1% ARG abundance, rhizosphere / non-rhizosphere soil Extracted: +13.58% / +14.83% Converted fold: 1.136–1.148; used: 1.142
30	2024	Microplastics accelerate nitrification, shape the microbial community, and alter antibiotic resistance during the nitrifying process	Science of The Total Environment	10.1016/j.scitotenv.2024.178306	MGE	increase	1	S4-30-01 MGE PLA / PE / PVC MPs intI1 abundance, nitrifying process Extracted: PLA +51.6% (PE 23.9%, PVC 21.4%) Converted fold: 1.214–1.516; used: 1.365
31	2024	Effects of polypropylene microplastics on digestion performance, microbial community, and antibiotic resistance during microbial anaerobic digestion	BIORESOURCE TECHNOLOGY	10.1016/j.biortech.2024.131358	ARG	increase	1	S4-31-01 ARG PP MPs parC abundance (max), anaerobic digestion Extracted: increase 35.5%-222.7% Converted fold: 1.355–3.227; used: 2.291
32	2024	Impacts of microplastic type on the fate of antibiotic resistance genes and horizontal gene transfer mechanism during anaerobic digestion	JOURNAL OF ENVIRONMENTAL MANAGEMENT	10.1016/j.jenvman.2024.121090	ARG	decrease	1	S4-32-01 ARG MPs (anaerobic digestion) ARG abundance Extracted: decreased 5.6%-24.6% Converted fold: 0.754–0.944; used: 0.849
33	2025	Bacterial communities and C-N cycling drive microplastic-specific trade-off between greenhouse gas emissions and antibiotic resistance genes during reductive soil disinfestation	APPLIED SOIL ECOLOGY	10.1016/j.apsoil.2025.106487	ARG	increase	1	S4-33-01 ARG PE MPs (soil) absolute ARG abundance vs CK Extracted: +58% Converted fold: 1.58; used: 1.58
34	2025	Reshaping the antibiotic resistance genes in plastsphere upon deposition in sediment-water interface: Dynamic evolution and propagation mechanism	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2025.139532	ARG	increase	1	S4-34-01 ARG PET MPs (plastsphere at SWI) ARG abundance after deposition Extracted: increase 45.71%-65.10% Converted fold: 1.457–1.651; used: 1.554

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
35	2025	The group-modified nanoplastics bring higher risk on promoting the antibiotic resistance genes dissemination by stimulate bacteria to generate more ROS under aerobic condition	JOURNAL OF ENVIRONMENTAL CHEMICAL ENGINEERING	10.1016/j.jece.2025.118876	HGT	increase	1	S4-35-01 HGT PS / PS-NH2 / PS-COOH nanoplastics natural transformation frequency of ARGs (natural water) Extracted: PS-base 2.0-2.9x; PS-NH2 4.2-13.5x; PS-COOH 2.6-5.5x Converted fold: 2–13.5; used: 7.75
36	2025	The combination of polystyrene microplastics and di (2-ethylhexyl) phthalate promotes the conjugative transfer of antibiotic resistance genes between bacteria	ECOTOXICOLOGY AND ENVIRONMENTAL SAFETY	10.1016/j.ecoenv.2025.117681	HGT	increase	1	S4-36-01 HGT PS MPs + DEHP ARG conjugative transfer rate Extracted: 3.0 times higher vs control (1 mg/L PS + 0.1 mg/L DEHP) Converted fold: 3; used: 3
37	2025	Polyester-based biodegradable microplastics drive shifts in antibiotic resistance genes in Pb and sulfamethazine co-contaminated soil: Exogenous bioavailable carbon enhanced enzyme activity and functional taxa proliferation	JOURNAL OF ENVIRONMENTAL CHEMICAL ENGINEERING	10.1016/j.jece.2025.120004	ARG	decrease	1	S4-37-01 ARG PBS MPs (soil) sulI / sulII relative abundance vs CK Extracted: reduced by 31.1% and 28.6% Converted fold: 0.689–0.714; used: 0.7015
38	2025	Real-world aged microplastics exacerbate antibiotic resistance genes dissemination in anaerobic sludge digestion via enhancing microbial metabolite communication-driven pilus conjugative transfer	WATER RESEARCH	10.1016/j.watres.2025.125056	ARG	increase	1	S4-38-01 ARG Aged MPs total ARG abundance, anaerobic sludge digestion Extracted: increase 2.59%-15.31%; MGE 0.22%-16.71% Converted fold: 1.026–1.153; used: 1.0895
39	2025	Different effects of bio/non-degradable microplastics on sewage sludge compost performance: Focusing on antibiotic resistance genes, virulence factors and key metabolic functions	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2025.137329	ARG	decrease	1	S4-39-01 ARG PLA/PP MPs (compost) ARG subtype relative abundance vs CK Extracted: decreased 4.22% (PLA) and 13.11% (PP) vs CK Converted fold: 0.869–0.958; used: 0.9135
40	2025	Microplastics enhance the prevalence of antibiotic resistance genes in mariculture sediments by enriching host bacteria and promoting horizontal gene transfer	ECO-ENVIRONMENT & HEALTH	10.1016/j.eehl.2025.100136	ARG	increase	1	S4-40-01 ARG PS / PVC MPs total ARG relative abundance, mariculture sediment Extracted: PS 1.41-2.50-fold; PVC 2.01-2.84-fold vs control Converted fold: 1.41–2.84; used: 2.125

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
41	2025	Dual roles of polystyrene nanoplastics in reshaping antibiotic resistance genes dynamics in soil-plant systems: Highlighting shifts in specific hosts and functions	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2025.140364	ARG	increase	1	S4-41-01 ARG PS nanoplastics (unplanted soil) soil ARG subtype relative abundance vs control Extracted: +11.68%-18.61% Converted fold: 1.117–1.186; used: 1.1515
42	2025	Microplastics promote conjugative transfer of antibiotic resistance genes via membrane protein interactions: Highlighting oxidative stress and energy supply	BIORESOURCE TECHNOLOGY	10.1016/j.biortech.2025.133793	HGT	increase	1	S4-42-01 HGT PE MPs (5 mg/L, 1000 nm) RP4 plasmid conjugative transfer frequency Extracted: 8.90-fold vs control Converted fold: 8.9; used: 8.9
43	2025	Effects of UV-aged tire wear particles (TWPs) on soil microorganisms: Microbial community, microbial metabolism, cell defense and repair, and transmission of ARGs	JOURNAL OF ENVIRONMENTAL CHEMICAL ENGINEERING	10.1016/j.jece.2025.115624	ARG;MGE	increase	2	S4-43-01 ARG Tire wear particles (pristine) total ARG abundance vs control Extracted: +29.54% Converted fold: 1.295; used: 1.295 S4-43-02 MGE Tire wear particles (pristine) total MGE abundance vs control Extracted: +62.71% Converted fold: 1.627; used: 1.627
44	2025	Wastewater discharges and polymer type modulate the riverine plastisphere and set the role of microplastics as vectors of pathogens and antibiotic resistance	JOURNAL OF WATER PROCESS ENGINEERING	10.1016/j.jwpe.2025.107419	ARG	increase	1	S4-44-01 ARG MPs (river plastisphere) ARG abundance on MPs after WWTP discharge Extracted: 2.3-fold vs pre-WWTP MPs Converted fold: 2.3; used: 2.3
45	2025	Surface-modified nanoplastics facilitate the dissemination and persistence of antibiotic resistance genes	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2025.140036	HGT	decrease;increase	2	S4-45-01 HGT PS-COOH / PS-NH2 (10 mg/L) ARG transformation frequency/efficiency Extracted: 2.04x/2.01x (COOH); 2.38x/3.58x (NH2) Converted fold: 2.01–3.58; used: 2.795 S4-45-02 HGT PS-COOH / PS-NH2 (1000 mg/L) ARG transformation frequency/efficiency Extracted: inhibited by 2.94-/5.59-fold Converted fold: 0.34; used: 0.34
46	2025	Microplastics enhance the enrichment and dissemination of antibiotic resistance genes in aquatic environments: A meta-analysis	JOURNAL OF ENVIRONMENTAL SCIENCES	10.1016/j.jes.2025.12.017	ARG	increase	1	S4-46-01 ARG MPs (meta-analysis) ARG / MGE abundance under MP exposure Extracted: +96.93% / +44.48% Converted fold: 1.445–1.969; used: 1.707

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
47	2025	Synergistic effect of horizontal transfer of antibiotic resistance genes between bacteria exposed to microplastics and per/polyfluoroalkyl substances: An explanation from theoretical methods	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2025.138208	HGT	increase	1	S4-47-01 HGT PP-MPs (with PFASs) HGT risk between bacteria Extracted: up to 1.57 times (MPs); PFASs 1.59x Converted fold: 1.57; used: 1.57
48	2025	Deciphering dose-dependent effects of polypropylene and polyethylene microplastics on digestion performance dynamics and antibiotic resistance development in sludge anaerobic digesters	CHEMICAL ENGINEERING JOURNAL	10.1016/j.cej.2025.172044	ARG	increase	1	S4-48-01 ARG PP MPs (300 mg/L) sul1 / qepA / int11, anaerobic digesters Extracted: 4.0-fold / 13.7-fold / +1990.8% Converted fold: 4–20.9; used: 12.45
49	2025	Influence and mechanism of polyethylene microplastics on antibiotic resistance genes and microbial community in sludge composting process	JOURNAL OF ENVIRONMENTAL CHEMICAL ENGINEERING	10.1016/j.jece.2025.118742	ARG	decrease;increase	2	S4-49-01 ARG PE MPs (compost) selected ARGs sul1/aac(6')-Ib-cr/tetA; ermF/sul2 (HPE) vs CK Extracted: 1.2-2.4x across doses; ermF/sul2 15.6-15.7x in HPE Converted fold: 1.2–15.7; used: 8.45 S4-49-02 ARG PE MPs (compost) blaTEM / tetW relative abundance vs CK Extracted: reduced by 68.7%-90.4% (blaTEM) and 48.0%-61.9% (tetW) Converted fold: 0.096–0.52; used: 0.308
50	2025	Microplastics mediates the spread of antimicrobial resistance plasmids via modulating conjugal gene expression	ENVIRONMENT INTERNATIONAL	10.1016/j.envint.2025.109261	HGT	increase	1	S4-50-01 HGT 4 common MPs conjugation rates of 4 clinical AMR plasmids Extracted: up to 200-fold vs non-exposed Converted fold: 200; used: 200
51	2025	Nanoplastics released from textile washing enrich antibiotic resistance and virulence genes in sewage sludge microbiomes	ENVIRONMENT INTERNATIONAL	10.1016/j.envint.2025.109611	ARG	increase	1	S4-51-01 ARG Textile-released nanoplastics (PA/PP/PET) total ARG abundance Extracted: 1.30-1.87-fold across NP treatments vs CK Converted fold: 1.3–1.87; used: 1.585
52	2025	Effects of aged microplastics on the abundance of antibiotic resistance genes in oysters and their excreta	MARINE ENVIRONMENTAL RESEARCH	10.1016/j.marenvres.2025.107284	ARG;MGE	decrease	2	S4-52-01 MGE PET MPs (oysters) int11 absolute abundance vs control (day 7) Extracted: decreased 4.1-fold Converted fold: 0.244; used: 0.244 S4-52-02 ARG PE MPs (oysters) fexA absolute abundance vs control (day 14) Extracted: reduced 4.1-fold Converted fold: 0.244; used: 0.244

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
53	2025	Biodegradable microplastics exacerbate the risk of antibiotic resistance genes pollution in agricultural soils	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2025.139490	ARG	increase	1	S4-53-01 ARG PLA/PBAT MPs (soil) total ARG relative abundance vs no-MP treatments Extracted: +21.5%-62.2% (PLA); +38.7%-78.0% (PBAT) Converted fold: 1.215-1.78; used: 1.4975
54	2025	Polyvinyl chloride microplastic triggers bidirectional transmission of antibiotic resistance genes in soil-earthworm systems	ENVIRONMENT INTERNATIONAL	10.1016/j.envint.2025.109414	ARG;MGE	decrease;increase	4	S4-54-01 ARG PVC MPs intestinal ARG abundance (21 d) Extracted: 1.38 times higher vs control Converted fold: 1.38; used: 1.38 S4-54-02 ARG PVC MPs selected soil ARG classes (e.g. MLS/tetracycline) Extracted: 1.17-9.04 times vs control Converted fold: 1.17-9.04; used: 5.105 S4-54-03 MGE PVC MPs total MGE abundance, earthworm-inoculated soil Extracted: 1.26-fold increase (21 d) Converted fold: 1.26; used: 1.26 S4-54-04 ARG PVC MPs other soil ARG classes (aminoglycoside/bacitracin etc.) Extracted: decreased by 14.88%-23.47% Converted fold: 0.765-0.851; used: 0.808
55	2025	Phage lysis-mediated reduction of antibiotic-resistant bacteria alleviates micro/nanoplastic-driven antimicrobial resistance dissemination in anaerobic digestion	WATER RESEARCH	10.1016/j.watres.2025.124046	ARG	increase	1	S4-55-01 ARG PP MPs / NPs ARG abundance, anaerobic digestion Extracted: increase 6.4%-17.8% Converted fold: 1.064-1.178; used: 1.121
56	2025	Polystyrene and its dissolved organic matter accelerate antibiotic resistance gene dissemination in anaerobic digestion by posing resistance pressure on functional microorganisms	WATER RESEARCH	10.1016/j.watres.2025.124997	ARG	increase	1	S4-56-01 ARG PS MPs / PS-DOM ARG+VF+MGE abundances, anaerobic digestion Extracted: 1.25-1.79-fold vs control Converted fold: 1.25-1.79; used: 1.52

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
57	2026	Polystyrene nanoparticles and phosphorus sources jointly modulate antibiotic resistance gene enrichment in microalgae-bacteria systems	JOURNAL OF HAZARDOUS MATERIALS	10.1016/j.jhazmat.2026.142791	ARG	decrease;increase	2	S4-57-01 ARG PS nanoplastics 10 mg/L (low) ARG abundance, microalgae-bacteria system vs PS-NP-free control Extracted: +2.42%-34.43% (avg +16.21%) Converted fold: 1.024–1.344; used: 1.184 S4-57-02 ARG PS nanoplastics 100 mg/L (high) ARG abundance vs PS-NP-free control Extracted: reduced by 2.31%-18.50% (avg 2.70%) Converted fold: 0.815–0.977; used: 0.896
58	2026	Plastic leachates drive conjugative transfer of antibiotic resistance genes	ENVIRONMENTAL SCIENCE AND ECOTECHNOLOGY	10.1016/j.es.2026.100705	HGT	increase	1	S4-58-01 HGT Plastic leachates transconjugant abundance / conjugation efficiency Extracted: up to 26.4-fold / 44.6-fold Converted fold: 44.6; used: 44.6
59	2026	Bio-based microplastics increase the horizontal transfer of antibiotic resistance genes in aquatic environments	NANOIMPACT	10.1016/j.impact.2026.100613	HGT	increase	1	S4-59-01 HGT Bio-based MPs HGT frequency (single strain / lake community) Extracted: 21-48-fold; 13-fold in lake community Converted fold: 13–48; used: 30.5
60	2026	PET hydrolase mitigated the accumulation of antibiotic resistance genes in plastisphere during high temperature sludge composting	CHEMICAL ENGINEERING JOURNAL	10.1016/j.cej.2026.172584	ARG	increase	1	S4-60-01 ARG PET MPs (composting) ARGs / int1 vs control day 50 Extracted: +262.3% / +747.0% Converted fold: 3.623–8.47; used: 6.0465
61	2026	Enhanced transformation of antibiotic resistance genes: a new environmental risk of tire wear particles and leachates	ENVIRONMENTAL POLLUTION	10.1016/j.envpol.2026.128004	HGT	increase	1	S4-61-01 HGT Tire wear particles / leachate ARG transformation frequency Extracted: up to 4.7-fold / 13.2-fold Converted fold: 13.2; used: 13.2
62	2026	Microplastics enhance the risk of cross-genus dissemination of carbapenemase resistance plasmids in ICU patients	FRONTIERS IN CELLULAR AND INFECTION MICROBIOLOGY	10.3389/fcimb.2026.1781149	HGT	increase	1	S4-62-01 HGT MPs + simulated diabetic urine plasmid transfer efficiency (carbapenemase) Extracted: >3.96-fold Converted fold: 3.96; used: 3.96
63	2026	Sodium hypochlorite residual in the environment facilitated the spread of antibiotic resistance genes: through microplastics as a medium	ENVIRONMENT INTERNATIONAL	10.1016/j.envint.2026.110048	ARG	increase	1	S4-63-01 ARG MPs (+NaClO) total ARG abundance Extracted: +11.83% (MPs); +17.89% (MPs+NaClO) Converted fold: 1.118–1.179; used: 1.1485
64	2026	Microplastics in soil drive the enrichment of antibiotic resistance genes and potential pathogenic bacteria	JOURNAL OF ENVIRONMENTAL CHEMICAL ENGINEERING	10.1016/j.jece.2026.122689	ARG	increase	1	S4-64-01 ARG MPs (soil) 44 ARGs / 15 MGEs abundance Extracted: +18.6% / +281% Converted fold: 1.186–3.81; used: 2.498

No.	Year	Title	Journal	DOI	Endpoint categories	Direction	No. of records	Extracted values and fold change used in Table 1
65	2026	Metagenomic Insights into Host-Associated Enrichment of Antibiotic Resistance Genes Under Oxygen-Limited Conditions Induced by PET Microplastics	WATER	10.3390/w18070875	ARG	increase	1	S4-65-01 ARG PET MPs (1-5 mg/L, oxygen-limited) total ARG abundance vs PET-free reactor Extracted: +14% (1 mg/L) and +17% (5 mg/L) vs PET-free reactor Converted fold: 1.14–1.17; used: 1.155
66	2024	Microplastic Diversity Increases the Abundance of Antibiotic Resistance Genes in Soil	Nature Communications	10.1038/s41467-024-54237-7	ARG	increase	1	S4-66-01 ARG Plastic diversity (1/3/6 types) total ARG abundance, grassland soil Extracted: ~2.4-fold (D6 vs D1) Converted fold: 2.4; used: 2.4

Values are shown as extracted, followed by the stored converted fold value or interval and the single value used in Table 1. Each S4 record ID represents one statistical record; interval inputs use the arithmetic midpoint. Reported bounds are retained as bounds in the extracted-value text and used numerically as in the original extraction. Fold changes below 1 indicate decreases. HGT and MGE records are pooled for Table 1