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TRANSFORMING AGRICULTURAL ORGANIC RESIDUES INTO FERTILISERS: COMPOSTING AND SOIL ORGANIC MATTER RETURN IN FRANCE AND ROMANIA

Camille DOUAY[1], Martin BLANCHARD[1], Enzo GOPOIS[1], Narcis BAGHINA[2], Alina LATO[2]
[1]Environmental Engineering, UniLaSalle, Franc; Erasmus mobility
[2]University of Life Sciences "King Mihai I", Timișoara, Romania
Corresponding author: Camille.Douay.ERASMUS@usvt.ro

Abstract. *Organic residues from crops, livestock and green-space management can return carbon and nutrients to soils, but they are not interchangeable and not all are suitable for composting. This article assesses how composting can support soil fertility and circular resource use in France and Romania through a targeted narrative review of scientific literature, EU and national legislation, French regulatory sources, Romania's Law No. 181/2020 and the Joint Research Centre biomass assessment. The most defensible quantitative comparison identified is the JRC estimate using a common 2006–2015 reference period: 83.6 million tonnes of dry matter per year for France and 35.4 million tonnes for Romania. These are modelled crop-residue generation estimates, not the quantities sustainably removable, collected or composted. The review distinguishes gross production from the fraction that can be sustainably removed and from residues actually collected for treatment. It also examines how source separation, aeration, maturation, laboratory testing and nutrient-based application influence whether compost becomes a safe, useful amendment. Mature compost can contribute to soil organic matter and improve some soil properties, although effects depend on feedstock, maturity, application rate, soil and crop. Nutrient losses, greenhouse-gas emissions and contaminants remain important risks. A national performance ranking is not justified because comparable data on agricultural residues actually composted, product quality and farm use are unavailable. The comparison therefore evaluates the strength and limits of available evidence rather than ranking national systems.*

Keywords: *agricultural residues, composting, soil organic carbon, organic amendments, circular economy, France, Romania*

INTRODUCTION

Crop residues provide organic matter and nutrients but also protect soil. Straw, stubble, maize stalks, prunings and manure may be incorporated, used as bedding or treated. Removing too much residue can weaken erosion protection and reduce carbon return, so total production is not the same as a sustainable surplus (GARCÍA-CONDADO et al., 2018).

Aerobic composting stabilises biodegradable material through a heat-producing active phase followed by maturation (BERNAL et al., 2009; AZIM et al., 2018). Mature compost can be used as a soil amendment, but its nutrient availability differs from that of mineral fertilisers and depends on feedstock, soil, climate and application history (DIACONO & MONTEMURRO, 2010).

A fair comparison separates total residue production, the amount that can be removed after soil-cover needs and competing uses are considered, and the amount actually collected for treatment. Residues left in fields protect soil and return carbon (SCARLAT et al., 2010). National biomass estimates therefore indicate resource scale, not composting performance. France and Romania share EU waste policy but differ in crop-residue profiles and national rules. Cereals dominate residues in both countries; maize is particularly important in Romania (GARCÍA-CONDADO et al., 2018). Romania's Law No. 181/2020 defines compost categories and uses, while France applies product standards to certain amendments and rules to composting installations (FRENCH REPUBLIC, 2003, 2008).

This review asks under what technical, environmental and regulatory conditions composting agricultural residues can support soil fertility, and what a balanced comparison of France and Romania can establish.

MATERIAL AND METHODS

This targeted review draws on peer-reviewed reviews and analyses, JRC biomass assessments, EU legislation, Légifrance and Romania's Portal Legislativ. Sources were selected for relevance rather than through a systematic search; therefore, the review is not exhaustive.

Indicators included crop-residue production, main residue groups, feedstock suitability, compost quality controls, product-use rules and process risks. Numerical comparisons use JRC estimates for both countries based on the same model and the 2006–2015 period (GARCÍA-CONDADO et al., 2018). Estimates from other periods were not combined where definitions and methods were not aligned.

Agricultural residue production does not equal the quantity collected for composting, as residues may remain in fields or serve other purposes. Under Directive 2008/98/EC, certain natural, non-hazardous agricultural materials may fall outside its scope under specific conditions. EU bio-waste rules do not require every crop residue to be collected for composting (EUROPEAN PARLIAMENT AND COUNCIL, 2008). In the sources reviewed, no sufficiently comparable national data were identified on quantities composted, compost quality or application to farmland in France and Romania. This limits direct comparison of national composting performance.

RESULTS AND DISCUSSION

Agricultural residue resources and their limits

The JRC estimated average crop-residue production at 83.6 Mt dry matter per year in France and 35.4 Mt in Romania for 2006–2015, about 19% and 8% of the EU-28 estimate of 442 Mt (GARCÍA-CONDADO et al., 2018; CAMIA et al., 2018). France ranked first and Romania fourth in this historical modelled comparison. These figures are estimates from crop data, not measurements of residues collected or composted, and carry uncertainty. The JRC's 2025 assessment is broader, but should not be combined with this series unless definitions and methods align (MUBAREKA et al., 2025).

Cereals account for about 70–75% of French crop residues and roughly 80% in Romania; oilseeds are also important, and maize contributes substantial biomass in Romania (GARCÍA-CONDADO et al., 2018). These differences may affect seasonality, structure and collection logistics, but do not indicate what share can sustainably be composted.

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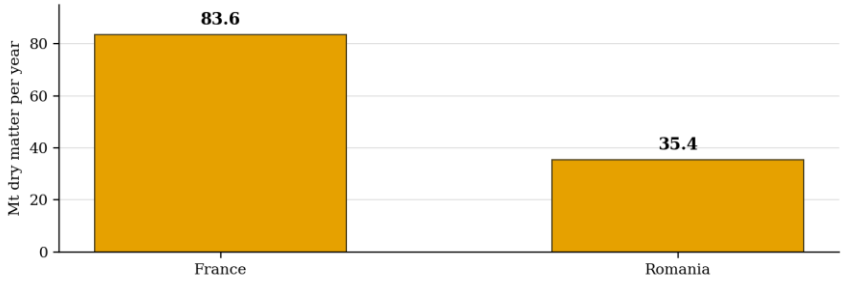


Figure 1. Estimated annual crop-residue production in France and Romania; mean values for 2006–2015. Data: García-Condado et al. (2018)

Table 1

Comparable crop-residue indicators and interpretation.

Indicator	France	Romania	Interpretation
Estimated crop residues	83.6 Mt dry matter/year	35.4 Mt dry matter/year	Same JRC model and reference period; not an estimate of compostable surplus.
Residue profile	Cereals about 70–75%; oilseeds next.	Cereals about 80%; oilseeds next; maize especially relevant.	Crop mix affects collection season, structure and carbon-to-nitrogen balance.
Suitable quantity for composting	Not quantified by the JRC estimate.	Not quantified by the JRC estimate.	Soil-cover needs and competing uses must be assessed locally.

Composting performance and agronomic function

Composting requires suitable moisture, porosity, oxygen, temperature, and carbon-to-nitrogen (C:N) balance. Practical starting ranges are around 50–60% moisture and an initial C:N ratio of 25:1–30:1, although suitable values vary by feedstock; these are not universal legal thresholds (MISRA et al., 2003; AZIM et al., 2018). Well-managed piles may reach 55–60 °C during the active phase, but hygienisation requirements depend on the process and applicable rules. Monitor temperature and moisture, then assess stability and maturity before use (BERNAL et al., 2009).

Organic amendments can increase soil organic carbon, but the response varies with material and site conditions. A global analysis of 1,972 comparisons from 424 articles reported a mean increase of 26.9% across the organic amendments studied (BAI et al., 2023); this is not a compost-only estimate or a guaranteed field outcome. Other reviews report improvements in soil structure and biological activity, with variable effects (DIACONO & MONTEMURRO, 2010; WANG, D. et al., 2024). Application should be based on compost analysis, soil tests, and crop needs, not a kilogram-for-kilogram substitution for mineral fertiliser.

Environmental risks and quality control

Composting can release methane, nitrous oxide, and ammonia. NORDAHL et al. (2023) found methane important for yard waste and nitrous oxide for nitrogen-rich materials such as manure. Aeration and pile management can reduce methane, although forced aeration may increase ammonia in some conditions (WANG, N. et al., 2024). Leachate, over-application,

contaminated inputs, immature compost and high salinity can cause nutrient losses or harm plants (TSABEDZE et al., 2025).

Safeguards include source separation, acceptance criteria, temperature and moisture records, runoff control, maturity and contaminant testing, traceability and nutrient-based applications. Clean residues are easier to characterise than mixed waste. Mulching or direct incorporation may be preferable for some materials because it avoids transport and maintains soil cover.

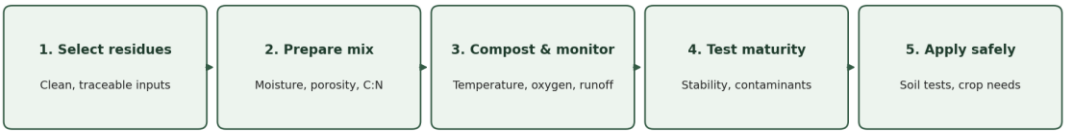


Figure 2. Quality-controlled route from organic residues to field application. Source: authors' synthesis based on MISRA et al. (2003), BERNAL et al. (2009) and AZIM et al. (2018)

Regulatory comparison: France and Romania

EU rules must be interpreted within their scope. Article 22 of Directive 2008/98/EC sets requirements for separate bio-waste collection or recycling at source; it does not require every crop residue to be collected. Regulation (EU) 2019/1009 provides one harmonised route for EU fertilising products, including input conditions for compost, but other national routes may apply.

Table 2

Comparison of relevant regulatory pathways in France and Romania

Issue	France	Romania
National product framework	NF U 44-051 is the reference for certain organic amendments; the product route depends on the material.	Law No. 181/2020 defines compost categories A, B and C and links each category to permitted uses.
Facility control	ICPE heading 2780 rules apply according to facility type and regulatory status.	Environmental authorisation applies; sizing rules and the authorisation procedure are set in technical norms under the law.
Quality assurance	Standard, authorisation and facility obligations must be checked case by case.	Certification and an accredited in-house or authorised external laboratory are required by the law.
Shared EU provisions	Directive 2008/98/EC covers bio-waste; Regulation (EU) 2019/1009 offers the harmonised EU fertilising-product route.	Same EU legislation; national categories and routes are not directly interchangeable.
Limit to comparison	National rules describe compliance routes, not measured average compost performance.	No matched national data were found for tonnes of agricultural residues composted and product quality.

In France, NF U 44-051 provides a product-standard route for certain organic amendments; its applicability and any end-of-waste status depend on the material, intended use and applicable legal requirements. Facilities subject to ICPE heading 2780 must follow the technical rules applicable to their authorisation status (French Republic, 2003, 2008). Romania's Law No. 181/2020 establishes compost categories A, B and C and links quality to permitted uses. It also provides for quality certification and accredited laboratory testing; implementation details should be checked against the current technical norms (PARLIAMENT OF ROMANIA, 2020).

These systems differ in standards; facility controls, and end-use categories. This is an institutional difference, not evidence that one country produces better compost; performance comparisons require matched data on quality, contaminants, inputs, and intended uses.

Economics, cooperation and evidence gaps

Because residues are bulky, transport distance, seasonality and demand are likely to affect logistics and costs (LIM et al., 2016). On-farm systems may suit clean, locally available flows; shared facilities can spread equipment and testing costs but require reliable outlets. This review did not identify comparable national data on agricultural composting volumes, quality, use or costs.

CONCLUSIONS

Composting suitable residues can return organic carbon and nutrients to the soil. However, its benefits depend on the materials used, process control, compost maturity, application rates and crop needs. Nutrient losses, greenhouse gas emissions, leachate and contaminants must be controlled through appropriate sorting, monitoring, testing and traceability.

JRC estimates for 2006–2015 indicate annual crop-residue production of 83.6 Mt of dry matter in France and 35.4 Mt in Romania. This difference partly reflects the countries' different sizes and agricultural areas, as well as differences in cropping systems and yields. These figures indicate the scale of the estimated residue resource, not the quantity composted or the effectiveness of composting.

Three priorities emerge: first, determine how much residue can be collected without harming soil protection or competing uses; second, improve data collection on composted quantities, compost quality, emissions and final uses; third, conduct comparable field trials in both countries to assess effects on soil quality using the same sampling methods and indicators.

BIBLIOGRAPHY

AZIM, K., SOUDI, B., BOUKHARI, S., PERISSOL, C., ROUSSOS, S., & THAMI ALAMI, I. (2018). Composting parameters and compost quality: A literature review. Organic Agriculture, 8, 141–158. https://link.springer.com/article/10.1007/s13165-017-0180-z

BAI, X., TANG, J., WANG, W., MA, J., SHI, J., & REN, W. (2023). Organic amendment effects on cropland soil organic carbon and its implications: A global synthesis. Catena, 231, 107343. https://www.sciencedirect.com/science/article/abs/pii/S0341816223004344?via%3Dihub

BERNAL, M. P., ALBURQUERQUE, J. A., & MORAL, R. (2009). Composting of animal manures and chemical criteria for compost maturity assessment: A review. Bioresource Technology, 100(22), 5444–5453. https://www.sciencedirect.com/science/article/abs/pii/S0960852408009917?via%3Dihub

CAMIA, A., ROBERT, N., JONSSON, K., PILLI, R., GARCÍA-CONDADO, S., LÓPEZ-LOZANO, R., VAN DER VELDE, M., RONZON, T., GURRÍA, P., M'BAREK, R., TAMOSIUNAS, S., FIORE, G., ARAUJO, R., HOEPFFNER, N., MARELLI, L., & GIUNTOLI, J. (2018). Biomass production, supply, uses and flows in the European Union: First results from an integrated assessment. Joint Research Centre, EUR 28993 EN. https://op.europa.eu/en/publication-detail/-/publication/358c6d4b-1783-11e8-9253-01aa75ed71a1/language-en

DIACONO, M., & MONTEMURRO, F. (2010). Long-term effects of organic amendments on soil fertility: A review. Agronomy for Sustainable Development, 30, 401–422. https://hal.science/hal-00886539v1/document

GARCÍA-CONDADO, S., LÓPEZ-LOZANO, R., VAN DER VELDE, M., LUSSER, M., SÁNCHEZ LÓPEZ, J., KLINKENBERG, M., AVRAAMIDES, M., & CAMIA, A. (2018). Brief on agricultural biomass production. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/40ff478c-4769-11e8-be1d-01aa75ed71a1/language-en

LIM, S. L., LEE, L. H., & WU, T. Y. (2016). Sustainability of using composting and vermicomposting technologies for organic solid waste biotransformation: Recent overview, greenhouse gases emissions and economic analysis. Journal of Cleaner Production, 111, 262–278. https://www.sciencedirect.com/science/article/abs/pii/S0959652615011749?via%3Dihub

MISRA, R. V., ROY, R. N., & HIRAOKA, H. (2003). On-farm composting methods. FAO, Rome. https://www.fao.org/4/y5104e/y5104e00.htm

MUBAREKA, S. B., RENNER, A., ACOSTA NARANJO, R., et al. (2025). EU biomass supply, uses, governance and regenerative actions: 10-year anniversary edition. Publications Office of the European Union, JRC140117. https://op.europa.eu/en/publication-detail/-/publication/97ebf16d-4dbf-11f0-a9d0-01aa75ed71a1/language-en

NORDAHL, S. L., PREBLE, C. V., KIRCHSTETTER, T. W., & SCOWN, C. D. (2023). Greenhouse gas and air pollutant emissions from composting. Environmental Science & Technology, 57(6), 2235–2247. https://pubs.acs.org/esthag/article/57/6/2235/1726014/Greenhouse-Gas-and-Air-Pollutant-Emissions-from

SCARLAT, N., MARTINOV, M., & DALLEMAND, J.-F. (2010). Assessment of the availability of agricultural crop residues in the European Union: Potential and limitations for bioenergy use. Waste Management, 30(10), 1889–1897. https://www.sciencedirect.com/science/article/abs/pii/S0956053X10002436?via%3Dihub

TSABEDZE, S. A., OTIENO, B., THOMAS, A. R., & GETAHUN, S. T. (2025). Phytotoxicity and quality in compost: A concise review of sewage sludge and green waste applications. Journal of Material Cycles and Waste Management, 27(6), 4041–4058. https://link.springer.com/article/10.1007/s10163-025-02334-0

WANG, D., LI, S., SUN, X., HAO, D., LI, Y., & WANG, H. (2024). Effects of compost application of green waste on soil properties: A meta-analysis. Sustainability, 16(20), 8877. https://www.mdpi.com/2071-1050/16/20/8877

WANG, N., HE, Y., ZHAO, K., LIN, X., HE, X., CHEN, A., WU, G., ZHANG, J., YAN, B., LUO, L., & XU, D. (2024). Greenhouse gas emission characteristics and influencing factors of agricultural waste composting process: A review. Journal of Environmental Management, 354, 120337. https://www.sciencedirect.com/science/article/abs/pii/S0301479724003232?via%3Dihub

*** European Parliament and Council. (2008, consolidated text). Directive 2008/98/EC of 19 November 2008 on waste and repealing certain Directives. EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02008L0098-20251016

*** European Parliament and Council. (2019, consolidated 1 July 2026). Regulation (EU) 2019/1009 laying down rules on the making available on the market of EU fertilising products. EUR-Lex. https://eur-lex.europa.eu/eli/reg/2019/1009/2026-07-01/eng

*** French Republic. (2003, amended). Arrêté du 5 septembre 2003 portant mise en application obligatoire de normes. Légifrance. https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000796890

*** French Republic. (2008, amended). Arrêté du 22 avril 2008 fixant les règles techniques auxquelles doivent satisfaire les installations de compostage ou de stabilisation biologique aérobie soumises à autorisation en application du titre Ier du livre V du code de l'environnement. Légifrance. https://www.legifrance.gouv.fr/loda/id/JORFTEXT000018800981/

*** Parliament of Romania. (2020). Law No. 181 of 19 August 2020 on the management of non-hazardous compostable waste. Portal Legislativ. https://legislatie.just.ro/Public/DetaliiDocument/229273