Data Article

Life cycle inventory data on French organic waste treatments yielding organic amendments and fertilisers

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Article info

Article history:
Received 13 November 2019
Received in revised form 3 December 2019
Accepted 6 December 2019
Available online 16 December 2019

Keywords:
Chemical composition
Life cycle inventories
Organic amendments
Organic fertilisers
Organic waste treatments

Abstract

To inform the modelling of organic waste treatments yielding organic amendments and fertilisers in France, published as “Screening LCA of French organic amendments and fertilisers” [1], we compiled data pertaining to the chemical characteristics of both raw and treated organic residues, as well as inventory data on the most common organic waste treatments. The majority of these life cycle inventory data was obtained from reports and other literature, but primary data was also compiled, notably for commercial organic fertiliser production. The data presented here can be used by future life cycle assessment studies on organic waste treatments, as well as to inform agricultural modelling.

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1. Data

To inform the modelling of organic waste treatments yielding organic amendments and fertilisers in France, published as “Screening LCA of French organic amendments and fertilisers” [1], we compiled data pertaining to the chemical characteristics of both raw and treated organic residues, as well as inventory data on the most common organic waste treatments.

Table 1 presents the criteria currently applied in France for the classification of products from organic residues treatments as amendments or fertilisers. These criteria are related to the products' composition.

The data (see the Supplementary Material), consists of tables presenting the mean composition of a large list of organic waste treatment products, as well as the life cycle inventories for the concerned organic waste treatments.

Composition data is presented per general product category, and includes uncertainty data (e.g. a range of values). For each parameter, three values are presented: the first value of each table cell is the
Table 1
Criteria, relative to composition, for the classification of products from organic residues treatments as amendments or fertilisers, in France.

| Products explicitly classified in French standards | French standard | N (%) | Organic N (%) | NO₃ + NH₄ + ureaic N (%) | P₂O₅ (%) | K₂O (%) | N + P₂O₅ + K₂O (%) | C/N | Organic matter (%) | Dry matter (%) |
|---------------------------------------------------|----------------|-------|---------------|-------------------------|----------|---------|---------------------|-----|------------------|--------------|
| **Organic amendments**                              |                |       |               |                         |          |         |                     |     |                  |              |
| Manure (solid)                                      | NFU 44-051    | <3    | --            | <33 of N               | <3       | <3      | <7                  | >8  | >20              | >30          |
| Composted manure and litter (except poultry litter)| NFU 44-051    | <3    | --            | <33 of N               | <3       | <3      | <7                  | >8  | >20              | >30          |
| Composted green waste                              | NFU 44-051    | <3    | --            | <33 of N               | <3       | <3      | <7                  | >8  | >20              | >30          |
| Composted biowaste                                 | NFU 44-051    | <3    | --            | <33 of N               | <3       | <3      | <7                  | >8  | >20              | >30          |
| Composted animal and/or vegetal matter              | NFU 44-051    | <3    | --            | <33 of N               | <3       | <3      | <7                  | >8  | >20              | >30          |
| Vegetal and/or animal materials, raw or treated    | NFU 44-051    | <3    | --            | <33 of N               | <3       | <3      | <7                  | >8  | >25              | >30          |
| Composts and digestates containing dewatered sewage sludge | NFU 44-095  | <3    | --            | --                     | <3       | <3      | <7                  | --  | --               | --           |
| **Organic fertilisers**                             |                |       |               |                         |          |         |                     |     |                  |              |
| Press cakes                                         | NFU 42-001    | >3    | --            | <1                     | --       | --      | --                  | --  | --               | --           |
| N organic fertiliser of animal and/or vegetal origin| NFU 42-001    | >3    | --            | <1                     | --       | --      | --                  | --  | --               | --           |
| Poultry droppings (dried)                           | NFU 42-001    | >3    | >1            | --                     | >2.5     | --      | >7                  | --  | >75              | --           |
| Slurry-based products (phase separated, composted, digested) | NFU 42-001 | >1.5 | >1           | --                     | >3       | --      | >6                  | --  | 40               |              |
| Composted poultry litter                            | NFU 42-001    | >2    | >1            | --                     | >2       | >2      | >7                  | --  | >50              | --           |
| NPK organic fertiliser of animal and/or vegetal origin | NFU 42-001 | --    | >1            | --                     | --       | --      | >7                  | --  | --               | --           |
| N organo-mineral fertiliser                          | NFU 42-001    | >3    | >1            | --                     | --       | --      | --                  | --  | --               | --           |
| NPK organo-mineral fertiliser                       | NFU 42-001    | >2    | >1            | --                     | >2       | >2      | >7                  | --  | --               | --           |

Source [2–4].¹
| Table numbering | Title                                                                 | Fields                                                                 |
|-----------------|----------------------------------------------------------------------|----------------------------------------------------------------------|
| Table A         | Composition of organic fertilisers                                   | Residual organic amendments and fertilisers, C/N, DM (%), NTK (g/kg), N−NH4 (g/kg), P (g/kg), K (g/kg), C (g/kg), MFE, KeqN, Sources of organic matter. |
| Table B         | Trace elements in organic fertilisers                                | Residual organic amendments and fertilisers, Cd (mg/kg), Cr (mg/kg), Cu (mg/kg), Hg (mg/kg), Ni (mg/kg), Pb (mg/kg), Zn (mg/kg), As (mg/kg), Se (mg/kg) |
| Table C         | Composition of French commercial organic fertilisers                | 6 ingredients (expressed as percentages of the total product mass) for 7 products: 1 organic amendment, 3 organic fertilisers and 3 organo-mineral fertilisers |
| Table D         | Abridged life cycle inventories for stocking of organic residues    | Infrastructure, energy, chemicals and emission factors associated with 10 systems: Liquid sewage sludge, in silo Solid sewage sludge, in concrete area Swine slurry, in silo Swine slurry, in concrete pit Cattle slurry, in silo Cattle slurry, in concrete pit Cattle manure, in concreted area or pit Poultry manure, in concreted area or pit Swine manure, in heap Digestate, agricultural, stocked in silo |
| Table E         | Abridged life cycle inventories for dewatering/phase separation     | Infrastructure, energy, chemicals and emission factors associated with 5 systems: Digestate, by centrifugal decanter Swine slurry, by centrifugal decanter Sewage sludge, by centrifugation Sewage sludge, by belt filter Sewage sludge, by filter press |
| Table F         | Abridged life cycle inventories for composting organic residues     | Infrastructure, energy, chemicals and emission factors associated with 8 systems: Sewage sludge + green waste Green waste Biofertiliser + green waste Biofertiliser Solid fraction of agricultural digestate Solid fraction of mixed slurry Swine slurry + straw Cattle manure + wool + press cakes |
| Table G         | Abridged life cycle inventories for anaerobic digestion of organic  | Infrastructure, energy, chemicals and emission factors associated with 8 systems: Sewage sludge Swine slurry + solid fraction of swine slurry Cattle slurry Mixed manure + swine slurry Maize silage Maize silage (5%) + swine slurry (95%) Maize silage (19%) + swine slurry (81%) Biowaste |
| Table H         | Life cycle inventories for processed agricultural residues (in fresh mass) | Raw materials, energy and water associated with 7 systems, including mass and economic allocation keys for coproducts: Coffee processing Cocoa processing Olive processing Pomace processing Greasy wool scouring Greasy wool skirting Rendering of animal by-products |
| Table I         | Emission factors for composting processes (per 1 t fresh mass input) | Emission factors for CO2, CH4, N2O, NH3, and VOC associated with the composting systems listed in Table F. Uncertainty data is provided as a recommended value plus a minimum and maximum values. |
recommended value, the second the minimum reported and the third the maximum reported. Missing values are indicated by a dash (—). Parameters presented include those of agricultural relevance (e.g. nutrients) as well as trace elements.

Composition and trace element content data is expressed (except for certain indicated exceptions) per unit of fresh mass. We chose to express all data in terms of fresh mass to prevent bias and uncertainty associated with expressing composition data in terms of dry matter, because the water content of organic amendments and fertilisers is distributed along a wide range.

The composition (in terms of ingredients) of commercial organic fertilisers is presented. These compositions are representative of French practices, simpler cattle manure composts were also used to compute the minimum range of KeqN values in the composition data.

Life cycle inventories of specific treatment processes, namely i) stocking of organic residues, solid and liquid, ii) dewatering/phase separation of liquid organic residues, iii) composting of organic residues, including substrate mixtures, iv) anaerobic digestion of organic residues, including substrate mixtures, v) processing of agricultural residues into inputs to organic fertilisers, and vi) additional emission factors for composting processes, including uncertainty data; are presented.

Life cycle inventory data is predominantly presented per unit of fresh mass input to a process, except for certain cases in which data is presented per unit of dry mass (i.e. dewatering/phase separation processes on substrates such as sludge and slurries). In all cases, the relevant functional/reference unit is indicated.

All data table headers are presented in Table 2. All background data was sourced from ecoinvent v.3.5.

### Table 3
| Guiding questions | Expected response type |
|-------------------|------------------------|
| What products and types/categories of products are produced in your facility? | Narrative numeric data (production volumes and proportions) |
| Please describe the site's infrastructure, including built area, main equipment and machinery, installed capacity, life span of all items, etc. | Narrative with a list of items and numeric data |
| Please describe the characteristic processes resulting in the main product types. | Narrative, flow diagram including numeric data (masses, durations) |
| Do you measure any direct emissions? If so, please provide historic or representative measurements. | Narrative with numeric data |
| Please provide detailed data per process and per product type, including raw materials, waste streams including wastewater, products, energy consumption, water consumption, chemicals consumption, transported distances of all inputs. | Tables of numeric data, assumption on allocation of energy and water, formulation of multi-input product types |
| Please describe the wastewater and waste treatment pathways | Narrative with numeric data |
| Please describe frequency and interventions associated with site maintenance. | Narrative with numeric data |

2. Experimental design, materials, and methods

The data on the criteria currently applied in France for the classification of products from organic residues treatments as amendments or fertilisers was obtained via literature review, where a handful of sources [2,4,5] contributed the bulk of up to date data.

The data on commercial organic amendments and fertilisers were obtained by means of interviews with two anonymous French producers (two of the largest organic producers among ~50 producers

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1 Technically “materials of agronomic interest from wastewater treatment”, referred to among French institutions and researchers as “matières d’intérêt agronomique issues du traitement des eaux” (MIATE).
associated with the Union of Fertilisation Industries - UNIFA, https://www.unifa.fr/qui-sommes-nous/les-adherents-de-lunifa), based on the structured questionnaire depicted in Table 3. The annual output of one of the two surveyed producers represents ~18% of the total French production of commercial organic amendments and fertilisers.

Data on composition of treatment products and on treatment processes were sought and obtained, predominantly representing French conditions, yet generally valid at the European level. When specific French data was not found for specific processes, other central European data were retained.

The product composition data was also obtained via literature review, and occasionally adjusted to harmonise units. Sources for basic composition included technical, research and commercial product reports, as well as theses and scientific publications. Two detailed reports associated with large research projects provided all data for trace element contents [6,7]. Data sources for informing life cycle inventories were also retrieved from grey and scientific literature.

Table 4 presents a quality assessment of the collected secondary data, following the ecoinvent pedigree approach, consisting of a decreasing 1–5 ranking of data reliability, completeness, temporal correlation, geographical correlation and further technological correlation [8].

**Acknowledgments**

This work, which is a deliverable of the ACV-MAFOR project (https://ur-recyclage-risque.cirad.fr/principaux-projets/acv-mafor), was partly supported by the French Environment and Energy Management Agency (ADEME), under the AGRIBALYSE 2 research programme (https://rebrand.ly/agribalyse). The authors moreover thanks the following colleagues for their valuable contributions: Amandine Foulet (IRSTEA), Armelle Gac (IDELE), Aurélie Perrin (ESA), Aurélie Tailleur (ARVALIS),

| Data | Pedigree score | Key sources | Comments |
|------|----------------|-------------|----------|
| Product composition data | 2-2-3-2-1 | [6,7,9–11] | The majority of sources were published after 2010. The majority of sources are specific to the French context, but a few present data of European validity. Routes are France-specific, but undoubtedly also common in Europe. |
| Dominant treatment routes | 1-2-3-1-2 | [7,9,11–14] | Data is representative of the French context. |
| Treatment processes: Substrate stocking | 2-2-3-2-2 | [14,15] | The majority of emission factors were sourced from Ref. [15], which is a recent collection of emission factors from organic waste stoking, in France and Europe. |
| Treatment processes: Dewatering/phase separation of substrates | 2-2-3-2-2 | [9,11,14] | Data is representative of the French context. |
| Treatment processes: Composting of substrates | 2-3-3-3-2 | Processes [14,16]; Emissions [17,18]; | Some process and emission data represent European conditions. |
| Treatment processes: Anaerobic digestion of substrates | 2-3-3-3-2 | Processes [14,19]; Emissions: expertise IRSTEA | Some process and emission data represent European conditions. |
| Substrate processes: Processing of agricultural residues | 2-3-3-3-2 | [20] | Data represent European conditions. |

* The full list of data sources is presented in the Supplementary Material.

b https://www.irstea.fr/fr/recherche/unites-de-recherche/opaale.
Aurore Vigan (INRA), Blaise Leclerc (ITAB), Christian Bockstaller (INRA), Hayo van der Werf (INRA), Jean-Marie Paillat (CIRAD), Laurent Largant (AFAIL), Méllynda Hassouna (INRA), Paul Robin (INRA), Sabine Houot (INRA), Sandrine Espagnol (IFIP), Vincent Colomb (ADEME), Virginie Parnaudeau (INRA), and two anonymous representatives of the organic fertiliser industry.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.105000.

References

[1] A. Avadí, Screening LCA of French organic amendments and fertilisers, Int. J. Life Cycle Assess. (2019) in press.
[2] SATS, Fiche 2: Seuils réglementaires des normes, Chambre d'agriculture du Nord-Pas de Calais. https://nord-pas-de-calais.chambre-agriculture.fr/fileadmin/user_upload/Hauts-de-France/028_Instit-Nord-Pas-de-Calais/Teleshurgens/Recyclage/fiche2-seuils-reglementaires-fixes-par-les-normes.pdf, 2016.
[3] A. Colin, A. Thivolle, Disponibilité en bois d’origine forestière à l’horizon 2035. Tome 1: rapport, ADEME/IGN/FCBA, Paris, 2016.
[4] S. Houot, M.N. Pons, M. Pradel, Valorisation des matières fertilisantes d’origine résiduaire sur les sols à usage agricole ou forestier, in: Impacts agronomiques, environnementaux, socio-économiques, 2014.
[5] ADEME, Epandage, Fiche technique, Angers: ADEME, direction Economie Circulaire et Décêts/Service Mobilisation et Valorisation des Décêts. https://www.ademe.fr/sites/default/files/assets/documents/fiche-technique-epandage-201608.pdf, 2016.
[6] P. Koch, T. Salou, AGRIBAISYSE ® : Rapport Méthodologique - Version 1.3, ART, INRA, ADEME, 2016.
[7] P. Benoît, H. Brugère, M. Casellas, P. Dabert, J. Fuchs, L. Giamberini, D. Patureau, M.-N. Pons, A.-M. Pourcher, E. Topp, Chapitre 2. Caractéristiques physico-chimiques et biologiques des Mafor, INRA-CNRS-Irstea. https://www6.paris.inra.fr/depe/content/download/3807/36278/file/ESCoMforrapport_Chap2_oct2014.pdf, 2014.
[8] A. Ciroth, S. Muller, B.P. Weidema, Refining the pedigree matrix approach in ecoinvent: Towards empirical uncertainty factors. http://jeca-net.com/p/1653, 2012.
[9] IFIP, Gestion et traitement des digestats issus de méthanisation, IFIP. Chambre d’agriculture de Bretagne, Idele, Trame, Ministère de l’agriculture de l’agroalimentaire et de la forêt, 2017.
[10] P. Levasseur, Compte rendu final du projet METERRI: Conforter l’autonomie énergétique des zones à forte densité d’élevage par des projets de méthanisation agricole durables, en harmonie dans leur territoire, Le cas de la Bretagne, IFIP - Institute du Porc, 2017.
[11] M. Richard, M. Pradel, Les filières de traitement et de valorisation des boues d’épuration en France: Rapport d’enquête, Irstea-ONEMA, 2014.
[12] M. Pradel, Guide pour la réalisation d’Analyses du Cycle de Vie pour les filières de traitement et de valorisation des boues d’épuration urbaine. Rapport final, Irstea-ONEMA, 2016.
[13] A. Vigan, M. Hassouna, N. Guingand, C. Brameç, N. Edouard, T. Eglin, S. Espagnol, M. Eugène, S. Générmont, S. Lagadec, E. Lorinquer, L. Loyon, P. Ponchant, P. Robin, Development of a database to collect emission values for livestock systems, J. Environ. Qual. 48 (2019) 1899–1906, https://doi.org/10.2134/jeq2019.01.0007.
[14] D. Oudart, Modélisation de la stabilité de la matière organique et des émissions gazeuses au cours du compostage d’effluents d’élevage, INSa de Toulouse, 2013. https://tel.archives-ouvertes.fr/tel-00935691v1/document.
[15] ADEME, Programme de recherche de, l'ADEME sur les émissions atmosphériques du compostage. Connaissances acquises et synthèse bibliographique, ADEME, Angers, 2012. https://www.ademe.fr/sites/default/files/assets/documents/20120701_programme-de-recherche-de-l-ademe-sur-les-emissions-atmospheriques-du-compostage_ademe.pdf.
[16] C. Déchaux, M. Pradel, LCA applied to residual organic fertilizing materials - an overview of emission inventory data at the spreading operation, in: U. Arena, T. Astrup, P. Lettieri (Eds.), Life Cycle Assess. Other Assess. Tools Waste Manag. Resour. Optim. ECI Symp. Ser., 2016. http://dc.engconfintl.org/lca_waste/40.
[17] F. Ardolino, F. Parrillo, U. Arena, Biowaste-to-biomethane or biowaste-to-energy? An LCA study on anaerobic digestion of organic waste, J. Clean. Prod. 174 (2018) 462–476, https://doi.org/10.1016/j.jclepro.2017.10.320.
[18] C.H. Gooding, Data for the carbon footprinting of rendering operations, J. Ind. Ecol. 16 (2012) 223–230, https://doi.org/10.1111/j.1530-9290.2011.00430.x.