EUROPEAN COMMISSION

Directorate-General for Agriculture
and Rural Development

Expert Group for Technical Advice on Organic Production

EGTOP

FINAL REPORT

on

CRITERIA FOR THE USE OF ANIMAL-DERIVED FERTILISERS FROM CONVENTIONAL FARMING REPLACING THE TERM 'factory farming'

The EGTOP adopted this technical advice at the plenary meeting of June 10th 2024

About the setting up of an independent expert panel for technical advice

Regulation (EU) 2018/848[1] requires that authorisation of products and substances used in organic production may only be authorised if they comply with the principles, criteria and objectives of organic production described in that Regulation. The Commission has decided that when taking decisions on these authorisations it will take account of scientific advice by a group of independent experts. For that purpose the Commission has set up the Expert Group for Technical Advice on Organic Production by Commission Decision 2021/C343/03 of 4 August 2021.

EGTOP

The Group’s tasks are:

(a) to assist the Commission in evaluating technical matters of organic production, including products, substances, methods and techniques that may be used in organic production, taking into account the objectives and principles laid down in Regulation (EU) 2018/848 and additional policy objectives with regard to organic production;

(b) to assist the Commission in improving existing rules and developing new rules related to Regulation (EU) 2018/848;

(c) to stimulate an exchange of experience and good practices in the field of technical issues related to organic production.

EGTOP Permanent Group

MICHELONI Cristina (Chair), OUDSHOORN Frank Willem (Vice-Chair), BLANCO PENEDO Maria Isabel (Vice-Chair), AUTIO Sari, BESTE Andrea, BOURIN Marie-Christine, GORACCI Jacopo, KOESLING Matthias, KRETZSCHMAR, Ursula, MALUSÁ Eligio, SPEISER Bernhard, VAN DER BLOM Jan, WÄCKERS Felix

Contact

European Commission
DG Agriculture and Rural Development
Directorate B: Sustainability
Unit B4 – Organic Farming
Office L130
B-1049 Brussels
Functional mailbox: AGRI-B4@ec.europa.eu

http://ec.europa.eu/agriculture/organic/home_en

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0848&from=EN

ACKNOWLEDGMENTS

Members of the Group are acknowledged for their valuable contribution to this technical advice. The members are:

Permanent Group members:

MICHELONI Cristina (Chair), OUDSHOORN Frank Willem (Vice-Chair), BLANCO PENEDO Maria Isabel (Vice-Chair), AUTIO Sari, BESTE Andrea, BOURIN Marie, GORACCI Jacopo, KOESLING Matthias, KRETZSCHMAR, Ursula, MALUSÁ Eligio, SPEISER Bernhard, VAN DER BLOM Jan, WÄCKERS Felix

Sub-Group members:
OUDSHOORN Frank Willem (Chair), MALUSÁ Eligio (Rapporteur), BESTE Andrea, BLANCO PENEDO Maria Isabel, BOURIN Marie, GORACCI Jacopo, KOESLING Matthias, MICHELONI Cristina, SPEISER Bernhard

External experts:
BARREIRO Ana, GUERRA GOROSTEGUI Nagore, SANCHEZ MONEDERO Miguel Angel,

Observers:
DRUKKER Bastiaan

All declarations of interest of Permanent Group members are available at the following webpage:

http://ec.europa.eu/agriculture/organic/home_en

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Expert Group for Technical Advice on Organic Production (EGTOP) was requested to advise on the replacement of the wording 'factory farming' in Regulation (EU) 2021/1165[2], Annex II.

The opinion of the Group is that the wording 'factory farming' is not appropriate to express which animal-derived fertilisers are allowed, restricted, or forbidden to be used in organic farming, as currently defined in Annex II of the Regulation (EU) 2021/1165. Therefore, following an in-depth analysis of possible criteria suitable for defining a method to differentiate animal-derived fertilisers for which use are currently acceptable in organic farming, two major criteria were selected to this purpose: origin of the fertiliser and the occurrence of processing. Depending on the application of these two criteria, the amount of total nitrogen applicable per year and per hectare from conventional animal-derived fertilisers is restricted or not allowed. This restriction is meant to reduce the risk of introducing pollutants into the soil of organic farms. These criteria and their implementation were considered to fulfil the pragmatic approach taken by the Group for not substantially increasing the burden to organic farmers, allowing verification by certifying bodies, and, at the same time, fostering the adoption of other practices of soil fertilization and supporting the reputation of the organic farming sector. A multicriteria approach can be implemented to regulate the use of animal-derived fertilisers in organic farms, to replace the wording 'factory farming origin forbidden'.

Moreover, even though animal by-products are out of the scope of the point 1.9.4 in Annex II of Regulation (EU) 2018/848, the need of a consistent approach to the use of animal-derived fertilising products and considering that these kinds of products are used as a source of nitrogen, the Group recommends including them in the same quantitative approach and resulting restrictions proposed for farmyard manure and its derivatives.

Recommendations:

The Group proposes the following amendments to Annex II of Regulation (EU) 2021/1165:

- The currently three entries related to different types of farmyard manure, all presenting the restriction 'factory farming origin forbidden' should be combined into one single entry named 'farmyard manure',
- The restriction 'factory farming origin forbidden' should be replaced by the authorization and quantitative restriction of use, depending on origin of the raw material and processing status (processed or not), as following described:
  - from organic production: maximum 170 kg nitrogen per year/hectare;
  - from non-organic production, when origin from fur farms and animal husbandry method using lifelong caging (in the case of poultry) or crates (in the case of pigs) is clearly excluded:
    - product composted or digested following the requirements set for CMC3 and CMC5, respectively, defined by Regulation (EU) 2019/1009 or national legal provisions: maximum 170 kg nitrogen per year/hectare;
    - unprocessed product: maximum 125 kg nitrogen per year/hectare;
  - from non-organic production, when animal husbandry method is unknown:
    - product composted or digested following the requirements set for CMC3 and CMC5, respectively, defined by Regulation (EU) 2019/1009 or national legal provisions: maximum 100 kg nitrogen per year/hectare;
    - unprocessed product: not allowed;
  - from fur farming or from animal husbandry method using lifelong caging (in the case of poultry) or crates (in the case of pigs): not allowed.

[2] Commission Implementing Regulation (EU) 2021/1165 of 15 July 2021 authorising certain products and substances for use in organic production and establishing their lists, OJ L 253,16.7.2021, p.13.

ELI: http://data.europa.eu/eli/reg_impl/2021/1165/2023-11-15

- For the entry "liquid animal excrements", the restriction 'factory farming origin forbidden' should be replaced by the reference to the conditions and quantitative restrictions described for farmyard manure.
- For the entry 'Egg shells', the restriction 'factory farming origin forbidden' should be replaced by the reference to the conditions and quantitative restrictions described for farmyard manure.
- For the entry 'Recovered struvite and precipitated phosphate salts', the restriction 'factory farming origin forbidden' should be replaced by the reference to the conditions and quantitative restrictions described for farmyard manure.
- For the entry 'Products or by-products of animal origin [...]', which currently has no restriction about 'factory farming origin', it is proposed to introduce the conditions and quantitative restriction described for farmyard manure.

Finally, the Group emphasizes that an appropriate transitional period (3 to 5 years) should be foreseen for the implementation of the proposed criteria.

Notwithstanding this proposal, a possible future development of the proposed authorization scheme is also suggested, which, with the potential development of an animal husbandry welfare label, similar to labelling eggs in regard to the welfare of laying hens, would provide a better classification of animal welfare in different livestock rearing systems, allowing (or not) different amounts of animal-derived fertilisers for use in organic farming.

1. BACKGROUND

The Member States and the Commission have requested the EGTOP group to address the following issues:

(I) To analyse and advise on all comments by the Member States and stakeholder(s) on the EGTOP report.

(II) To analyse if the wording 'factory farming origin forbidden' is appropriate for describing the restrictions regarding the origin of manure and similar fertilising products used in organic farming.

(III) Propose a definition for 'factory farming' or alternative wording or propose to only mention the relevant mention/chosen/selected criteria.

(IV) Propose simple and verifiable criteria (positive or negative list of elements and techniques) for the restriction to use fertilisers from certain origins earlier discussed. Verifiable by controlling bodies (CBs) and in the scope of farmers to control.

(V) Recommend for each of the following entries in Regulation (EU)1165/2021 appropriate restrictions of use, or recommend that restrictions are not needed, not feasible or not possible to verify (in particular entries 5, 6, 7 and 8).

These issues are a follow-up to the conclusions of the EGTOP report from August 2021 on 'factory farming' (FF)[3], namely:

EGTOP recommends leaving out the designation factory farming, but instead define a required positive and/or a negative list of elements and techniques to fulfil for allowance of animal products, by-products, and waste from conventional farming in organic plant production.

EGTOP suggests that the new permanent group assigns experts to conclude on the final list of these inputs that can be used in organic plant production. It is important in this work to assess all the topics linked to the use of manure and waste. The main areas to address are contamination risks due to the import of manure or animal products from conventional farming, including the techniques that should be used, and the ethical barriers of some conventional livestock systems to be cut off as source for import to organic farming.

2. TERMS OF REFERENCE

The Expert Group for Technical Advice on Organic Production (EGTOP) is mandated to examine the above-mentioned questions, in the light of the most recent technical and scientific information available. It shall conclude in line with the objectives, criteria and principles as well as the general rules laid down in Regulation (EU) 2018/848[4].

[3] EGTOP Annex II Draft/Final Report (europa.eu)

[4] Consolidated text: Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007, OJ L 150, 14.6.2018, p.1.

ELI: http://data.europa.eu/eli/reg/2018/848/2023-02-21

3. CONSIDERATIONS

3.1 Introduction to the topic of 'factory farming'

According to EU legislation on organic farming (Regulation (EU) 2018/848; Article.5, g, (iii)), organic farmers are not allowed to fertilise their soils and plants with easily soluble mineral fertilisers. In stable natural ecosystems, the material and nutrient cycles are closed. Humus decomposition and humus build-up from dead plant parts and animal excrement roughly balance each other out. Organic farms endeavour to close material cycles, either at farm level or at territorial level. However, this is not possible for all material cycles on the farm due to the sale of plant and animal products and some losses. Introduction and use of organic fertilisers (i.e. from biological origin) in organic farms can compensate for exporting and loosing nutrients and other materials, but is strictly regulated, especially from conventional sources. At the same time, the concept of recycling organic matter and nutrients is a recognised value within the principles of organic farming. This can become more important for individual farms and in areas/regions where organic livestock farming is very limited for several reasons.

3.1.1 History in the term 'factory farming' in the Organic Regulation

From a historical perspective, the first EU regulation dealing with organic farming (Regulation (EEC) No 2092/91[5]) did not put any restriction in the use of animal-derived fertilisers (e.g. manure, slurry etc.). This was likely due to the fact that the Regulation was dealing only with plant production. Regulation (EEC) No 2381/94[6] foresaw a restriction in using farmyard manure (only from 'extensive husbandry' as defined by Regulation (EEC) No 2328/91[7], i.e. considering the number of livestock units/ha) and introducing the restriction of 'factory farming origin' for liquid and composted manure, though without definition of the term. After introducing rules for organic animal production, with Regulation (EC) No 889/2008[8] the wording 'only from extensive husbandry' was replaced by the exclusion of products from 'factory farming' for any animal-derived fertiliser (fresh or dried farmyard manure, dehydrated poultry manure, any kind of composted manure).

---

[5] Council Regulation (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs, OJ L 198, 22.7.1991, p.1.

ELI: http://data.europa.eu/eli/reg/1991/2092/2009-01-01

[6] Commission Regulation (EC) No 2381/94 of 30 September 1994 amending Annex II to Council Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs, OJ L 255, 1.10.1994, p. 84.

ELI: http://data.europa.eu/eli/reg/1994/2381/oj

[7] Council Regulation (EEC) No 2328/91 of 15 July 1991 on improving the efficiency of agricultural structures, OJ L 218, 6.8.1991, p. 1,ELI: http://data.europa.eu/eli/reg/1991/2328/oj

[8] Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control, OJ L 250, 18.9.2008, p. 1.

ELI: http://data.europa.eu/eli/reg/2008/889/oj

To date, the use of different types of farmyard manure, as raw material or after processing (i.e. composting, drying, fermentation), and other kinds of organic fertilising products derived from manure, animal by-products (both as defined in the Animal by-products Regulation (EC) No. 1069/2009[9]), bio-wastes and by-products (both as defined in the Waste Framework Directive 2008/98/EC[10]) from processing (e.g. biodigestate, hydrolysed proteins, compost) from conventional agriculture as fertilisers has been restricted. These restrictions pertain only to the products listed in Annex II of Regulation (EU) 2021/1165, which do not originate from 'factory farming'. The term 'factory farming' is not defined in more detail in the EU Regulation, nor in any other legal provision. However, the EU Commission issued guidelines in 1995 allowing Member States to define the term, which is a clearly unsatisfactory situation, because the definitions between countries differ. Indeed, beside the lack of harmonisation, organic fertilisers from conventional origin can also contain contaminants even if they do not originate from 'factory farming', which make this term not fulfilling the purpose of precaution set in the organic farming legislation. Moreover, regarding animal welfare, it is not given that larger farms have poorer animal welfare than smaller ones and vice versa (see Annex II of the present report).

3.1.2 Concerns over the use of manure from 'factory farming' origin

3.1.2.1 Concerns relating to animal welfare

Poorly managed animals (e.g. stressed) are more likely to develop certain diseases and lesions. Moreover, areas of high animal density and habitat fragmentation, without concomitant improvements in biosecurity measures and control tools, can increase both the likelihood and the impact of outbreaks of emerging diseases, including zoonoses. However, only a limited amount of animal welfare data is routinely collected across the EU and most of it is related to animal health or food safety issues. The main barriers to the collection of welfare data are the lack of standardisation of animal-based measures.

Several aspects related to livestock rearing can affect animal welfare (see Annex I of the present report). The farm size, use of cages, crates or slatted floors, and air quality in livestock housing could be considered as criteria for discriminating between 'industrial' and other animal farming systems. Cages cause severe welfare problems (poor bone strength due to lack of exercise, feather loss, restriction of natural behaviour), together with potential food safety concerns. Intensive production processes can induce non communicable diseases in various animals. For example, the length of the feeding period and the feeding behaviour itself, as well as the composition of the feed, are important for cow welfare since they can induce diverse metabolic disorders and disfunctions leading to non-communicable diseases. Moreover, intensive livestock production increases the risk of zoonotic pandemics due to long-distance animal movements, high animal densities, poor animal health and welfare, low disease resistance and low genetic diversity. Their use has changed the evolutionary dynamics of microorganisms, causing widespread genetic mobilization, selection, transfer, and environmental

---

[9] Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation), OJ L 300, 14.11.2009, p. 1.

ELI: http://data.europa.eu/eli/reg/2009/1069/oj

[10] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, OJ L 312, 22.11.2008, p.3.

ELI: http://data.europa.eu/eli/dir/2008/98/2024-02-18

dissemination of antibiotic resistance genes. It should also be considered that the 'One Health principle' recognises that human, animal, including fish, plant and environmental health are closely linked.

The complex behavioural needs of wild species cannot be met on fur factory farms, making it impossible to improve the welfare of animals on fur farms. Some types of breeding and intensive production require the systematic and continuous culling of a category of animals for economic reasons (e.g. male chickens of laying hens and male calves of dairy cattle and buffalo), which represents a morally unacceptable system and an important parameter demonstrating the weakness of a production system.

3.1.2.2 Concerns relating to pollutants

In view of the often-high levels of pollutants in conventional organic fertilisers (see Annex I of the present report), their use prompts major concerns regarding the quality of the manure and by-products derived from them and conformity of these products with the principles of organic farming in terms of promoting the soil health and fertility, including its microbiome, and the welfare of the animals. The risk of soil contamination associated with the use of conventional organic fertilisers, and, consequently, of the environment, food and feed with undesirable substances (e.g. inorganic and organic substances, antibiotic-resistant microorganisms, residues from genetically modified feed) poses problems for organic farming in terms of soil fertility and consumer acceptance, with possible implications also to climate change and eutrophication. Moreover, intensive livestock production systems are often characterised by overuse of antibiotics. Therefore, the dependency of organic farming from conventional breeding systems aiming primarily for productivity, is a serious risk for the credibility and the future development of the sector.

3.1.2.3 Necessity for animal derived organic fertilisers

Nevertheless, the need and demand to compensate for "exporting" and loosing nutrients from the farm and to compensate by "importing" external organic fertilisers from animal husbandry and/or recycled by-products and waste seems necessary to close the nutrient cycle and to maintain plant yields in organic farms. This is particularly relevant considering the intended expansion of organic farming areas as part of the Farm to Fork strategy[11] or the Organic Farming Action Plan. The definition of the term 'factory farming' was addressed by the EGTOP 2021 report, proposing general exclusion criteria that could replace the different definitions of the Member States. However, the Member States found them too complicated for practicable implementation (see below, Section 4). The present report is addressing the above-mentioned dilemma between needs and compliance with the organic principles by providing more practicable criteria for dealing with it.

The group is generally of the opinion that animal-derived fertilisers from conventional production should only be authorized for a transitional period, aiming at their replacement by fertilisers of organic farming origin or other sources more in line with the principle of organic farming.

In the long term, the group emphasises the urgent need to adapt/modify the criteria for animal husbandry in the conventional sector to account for the current state of knowledge regarding pollutant emissions into the environment, consumer protection and animal welfare, as also announced in the Green Deal, Farm to Fork Strategy, and the EU Zero Pollution Action Plan. Numerous reports (e.g. Zalewska et al.

[11] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS
A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system
COM/2020/381 final

2021; Xu et al. 2020; Sanz et al. 2022; Cresto et al. 2023) show that the current legal regulations are not sufficient to ensure adequate precaution and protection of consumer, animals, and the environment.

The Farm to Fork Strategy (EU Commission 2020) states: "*As such, even though the EU's transition to sustainable food systems has started in many areas, food systems remain one of the key drivers of climate change and environmental degradation. There is an urgent need to reduce dependency on pesticides and antimicrobials, reduce excess fertilisation, increase organic farming, improve animal welfare, and reverse biodiversity loss.*"

3.1.3 Advice and comments from Member States and stakeholders

Member States (MS) are concerned with the real applicability of possible proposed definitions or restrictions with respect to the definition of 'factory farming' and the outcomes of the previous report. The possibility to inspect and verify characteristics of materials that often are collected, transported, and processed in bulk and not separated at source is a main concern. As production systems broadly differ across EU, some MS prefer either the use of common guidelines that each MS can implement with the needed flexibility, or the identification of a few simple features or characteristics into a list. The list can be positive or negative, but it should be short and clear, not offering space for misinterpretation but also realistic in terms of what can be controlled to identify the source of materials and their processing. Comments reported in the table below highlight how certain criteria are not pertinent to the definition of what can be used or not, but are more subject for "good agriculture practices" and, as such, regulated in other parts of the Regulation (EU) 2018/848 or left to National rules. It is the Group opinion that the latter could hamper the harmonization process.

Whatever the final solution will be, it is a common request, to grant a transition period in case restrictions would be put into place. The following table lists the comments and the MS raising them.

Comment	Member State
Too complicated proposal. Negative and positive list already mentioned in the EGTOP report, we believe it will not be easy to put this into practice, as for each kind of animals or category a limit of stocking density should be defined. Transport distances cannot be controlled. We think it will be difficult to find a solution that fits all MS and therefore flexibility is needed.	BE, NO, DE, DK, ES, SE
Distinction between species/by products in treated manure is not feasible For biogas production: separation of faeces by animal species is not feasible Manure from ovine must also be subject to different conditions than manure from pigs, chickens or bovines. In some cases, these fertilisers come from different sources for which there are no separate collection streams, e.g.: o Biogas digestate containing animal by-products co-digested with material of plant or animal origin o Products or by-products of animal origin, o Composted or fermented mixture of household waste o Egg shells and o Composted animal excrements, including poultry manure and composted farmyard manure included.	BE, DE, DK, SE

Comment	Member State
Preference for short NEGATIVE LIST Support the idea that the term should be defined by a limited number of clear, simple and controllable criteria, mainly basing the requirements on horizontal regulation. A set of "no go" criteria could help to find a common understanding that reflects the principles of organic farming: No full slatted floors No cage keeping No fur production No livestock keeping denying outdoor areas to the animals No GMO-feed Setting a maximum amount kg N/ha/year seems reasonable	AT, NO, CZ, DE, DK, ES, FR (prefer simple but positive list), LUX
Non-organic manure important: the use of conventional waste products and animal manure in organic plant production is important when the nutritional needs of plants cannot be met by use of organic fertilisers. Highly dependent on organic matter of animal origin from non-organic livestock	NO, ES, DK
Generally, specify organic fertilisers and their treatment in terms of quality. The list of techniques to improve the quality of farm manure should be put to the text as a whole.	DE, ES, FR
Transition period in case of tightening the rules	DK, ES
Not treatment We do not support the idea that criteria concerning the treatment (e. g. min. temp., min. durations) should be linked to the term 'factory farming' as this issue belongs to good agricultural practice and should be seen as a horizontal matter (MS have as well national laws on compost production which would possibly lead to complex implementation of EU & national legal provisions).	AT
Difficult to prove and in particular to control misuse (systematic and for prevention) of antibiotics.	BE
Prefer a guideline	SE

3.2 Position and approach taken by the Group

Simplicity

The Member States have explicitly asked for simple criteria.

Do not substantially increase the burden for organic farmers

The Group does not want to propose any criteria which are excessively complicated or excessively expensive to verify. In particular, the Group objects to any criteria which would require an additional certification system for conventional farms for the sole purpose of delivering manure to organic farms.

Pragmatism versus ambition

The term 'factory farming' has been introduced to protect organic production from contaminants and pollution, derived from the use of animal organic fertilisers from conventional farming, and to avoid use of manure from rearing systems where practices affecting animal welfare can be applied. The 'factory farming' approach considered the impact of these practices on the reputation of organic farming. However, the introduction of the term 'factory farming' has not fully achieved this effect (see Section

3.3 of the present report). The Group believes that de-blocking this situation is far from simple, and a pragmatic proposal has better chances of being adopted than an (over-)ambitious proposal.

A step-by-step approach

Although the Group proposes a pragmatic approach with a transition period for implementing the restrictions of conventional manure and by-products in this report, it would clearly welcome further, more ambitious steps being taken in the future.

Consideration for all regions of the EU

The availability of manure varies greatly in different regions of the EU. As a consequence, certain limitations may be relatively easy to be implemented in one region, while posing great problems in other regions. Considering the importance of sufficient nutrient supply, the Group advises taking an approach which is suitable for regions with limited manure supply.

3.2.1 Reflections on applying a more harmonized approach to all animal-derived fertilizers

At the moment, 'factory farming origin' is forbidden for manure and a few other animal-derived fertilizers, but no such restriction applies to other animal by-products such as blood, feather, and horn meal. The Group assumes that this is mainly due to the fact that for animal by-products, the origins in terms of animal housing cannot be determined in most cases.

In this report, the Group proposes quantitative limitations to animal-derived organic fertilisers (see Section 3.4.4 below). These limitations should also be applied to other animal by-products for reasons of consistency, and because the group fears that the restrictions on import of conventional manure or processed manure, might increase the use of animal by-products from conventional sources, so missing the aim of the restrictions.

3.2.2 Word of caution

The organic sector has been struggling for decades to find an adequate, more precise definition which could replace the term 'factory farming'. It would be presumptuous to claim that the present report contains the perfect solution. Nevertheless, the Group hopes that the proposals outlined here can make a substantial contribution to stepping further in the process of proper fertilization practices, so that a growing organic sector can develop solutions by finding different ways for a balanced organic production.

3.3 Suitability of the term 'factory farming'

Member states interpret this clause of the EU Regulation differently. In some countries, livestock farming on slatted floors is considered as 'factory farming' practice, whereas in other countries, all conventional poultry farming falls in this category. The (large) number of livestock on farms was also mentioned as a parameter of 'factory farming'. Besides, fish and insect farming have not been discussed, and could often also be considered as 'factory farming'. Ultimately, this means **that the argument to reduce unfair competition between EU countries is not met and the consumers of organic products cannot rely on a common interpretation**.

Using the designation 'factory farming' is confusing and may mislead farmers and consumers. Prohibiting fertilisers originating from 'factory farming' in the annexes of the implementing regulation 2021/1165 does not:

1. Harmonize fertilisation levels among the MS or at field level,
2. Protect the soil from contaminants such as antibiotic resistant organisms, GMO materials, heavy metals, several persistent organic contaminants (e.g. PFAS) etc.,
3. Promote use of local resources,
4. Ensure animal welfare in conventional farming,
5. Guarantee quality of organic fertilisers,
6. Increase carbon inputs to the organic system,
7. Guarantee fair economic competition at national or international level,
8. Reduce the dependence of organic farming from conventional systems.

Furthermore, the production on an organic farm could also be perceived as 'factory farming' if it is carried out through rational, mechanized, digitalized practices, or on a large-scale basis.

It is therefore **the opinion of the Group that the wording 'factory farming' is not appropriate to express which animal-derived fertiliser is allowed or forbidden to be used in organic farming, as currently defined in Annex II of the Regulation (EU) 2021/1165,** which is **in line with the conclusion of the previous EGTOP report** (August 2021), recommending "leaving out the designation factory farming".

The group advises, instead, to replace the wording 'factory farming' by defining relevant criteria that would be more suitable to differentiate among fertiliser products derived from conventional production, allowing their use in organic farming or not. These criteria are related to the rearing systems in conventional farms, their processing, and consequently restricting the annual fertilisation rates from that origin, which are possible to be controlled by both the certifying bodies and competent authorities.

Following, several aspects that are considered important to support the proposed approach are presented and discussed. They are covering both technical and ethic domains, as well as some economic aspects.

3.4 Elements to be considered for a functional definition that could replace the wording 'factory farming'

3.4.1 Review of key aspects relevant in the context of 'factory farming'

A detailed review of the scientific and technical knowledge has been carried out to allow considering possible criteria for discriminating among fertilisers derived from conventional animal production that could be allowed for use in organic farming. The review is presented in Annexes I, II and III of the present report. The following aspects have been taken into account:

a) Soil health and quality, and plant growth;

b) Animal welfare and industrialization related to livestock rearing (i.e. farm size, presence of cages, crates and stalls, air quality in livestock housing, production-related non communicable diseases, risks of zoonosis emergence, antimicrobial and antiparasitic veterinary medicinal products and risk of development of resistance, fish and fur farming, systematic slaughtering and culling, selective breeding, feed origin, as well as energy consumption);

c) Contaminants of animal-derived fertilising products and their possible reduction.

Based on this review, the following criteria were considered of potential use for a functional definition that could replace the wording 'factory farming':

a) Criteria related to animal rearing and breeding

Farm Size: measured as number of animals per holding;

Cages: presence/absence (considering that the entry into force of banning the use of cages in EU is postponed);

Crates & Stalls: presence/absence (promoting systems without such structures);

Slatted floor: presence/absence (fostering a phasing-out of housing systems with fully slatted floors);

Air quality in livestock housing: presence/absence of control of indoor environment (according to the list of Best Available Techniques - BAT) in intensive poultry or pig production;

Feedstuff Origin: presence/absence of a plan of sourcing raw materials for feed composition (limit of dry matter sourced from other countries) (considering the carbon footprint and CO_2 emissions due to raw materials for feed composition);

Animal Pharmaceuticals: presence/absence of a monitoring plan to avoid calendar treatments without prior diagnosis (to consider not routinely use of anthelmintics and antibiotics);

Animal life threshold: limit considering "longevity" as an indicator of animal welfare and a constitutive element of high-quality animal life on farm;

Systematic slaughtering: presence/absence (to eliminate the utilization of products from farms using systematic culling);

Energy use indicator: indicator considering a direct relation between industrial production ('factory farming') and energy use (excluding alternative methods, i.e. windmills, solar panels, biogas, etc.).

b) Criteria related to reduction of contaminants in animal-derived fertilising products

Composting: required (in line with the requirements set for CMC3 defined in the FPR Regulation (EU) 2019/1009[12] or national legal provisions);

Anaerobic digestion: required (in line with the requirements set for CMC5 defined in the FPR Regulation (EU) 2019/1009 or national legal provisions);

Anaerobic digestion associated with adequate manure handling and storage: required (to further improve the reduction of antibiotics).

c) Criteria related to agronomic practices

[12] Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 2003/2003, OJ L 170, 25.6.2019, p. 1.

ELI: http://data.europa.eu/eli/reg/2019/1009/oj

Reduction of total nitrogen applied through external organic fertilisers originating from conventional livestock farming: required to exclude on one side the use of organic fertilisers from conventional livestock practices, involving possible animal cruelty and lack of natural behaviour and on the other side to foster integration of practices that can naturally increase soil fertility (e.g. rotations, cover crops, etc.).

However, after a thorough analysis and discussion, the Group considered two major criteria (origin of the fertiliser and the occurrence of processing) as feasible to be implemented according to the approach mentioned in point 3.2 and, depending on the application of these two criteria, restricting the amount of total nitrogen applicable per year and per hectare from conventional animal-derived fertilisers. Accordingly, they have been selected and further specified and described in the following points.

3.4.2 Origin of animal-based fertiliser from sources where the animal husbandry system is known or is not known

When animal-based fertiliser, mainly manure, is obtained directly from farms, it should be simple and straightforward to obtain information on the animal husbandry system it originates from.

On the contrary, when animal-based fertiliser is obtained from composting or digestion (biogas) plants or from traders, it is not always possible to obtain such information. The Group, for the moment, recommends that the use of such material should be possible, but under the condition that it is composted or digested (see chapter 3.4.3).

3.4.3 Processing of animal-based fertilisers as a method to reduce the risk of pollution

Both composting and biodigestion have the potential to reduce the content of certain contaminants present in animal-derived organic fertilisers, while other contaminants may not be reduced (see Annex II of the present report). The reduced risk of soil pollution in case of application of the processed products was thus deemed a factor to be taken into consideration in the definition of quantitative limits for the use of the products.

3.4.4 Consequent quantitative restriction, depending on origin and processing

The rules for organic plant production impose a quantitative restriction of 170 kg nitrogen per year and hectare (see Regulation (EU) 2018/848, Annex II, point. 1.9.4). However, this restriction applies only for manure as it derives from the Nitrate Directive (Directive 91/676/EEC[13]). The Group proposes:

- to apply the value of maximum 170 kg nitrogen per year per hectare only for those animal-derived materials with high acceptability for organic farming,
- to apply a value of maximum 125 kg nitrogen per year per hectare for animal-derived materials where animal welfare is assured without processing,
- to apply a value of maximum 100 kg nitrogen per year per hectare for animal-derived materials with lower acceptability, when the husbandry system is unknown, but the material is processed,

[13] Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, OJ L 375, 31.12.1991, p. 1.

ELI: http://data.europa.eu/eli/dir/1991/676/oj

- not to allow animal-derived materials originating from fur farming and lifelong use of cages (in the case of poultry) or crates (in the case of pigs),
- widening the concept of quantitative limitation to all fertilizers of animal origin (i.e. also to egg shells, struvite and other animal by-products such as blood and horn meal), allowing to apply a value of maximum 125 kg nitrogen per year per hectare.

The Group is aware that lower limits apply in some MS or Regions, for various reasons. The Group has no intentions to 'override' such limits, but it has no overview over all limitations imposed by national and regional legislation. Therefore, the Group has based its considerations on the limit given by the EU organic legislation and suggests that MS can consider lowering, proportionally, the national or regional limits, in agreement with the organic sector.

The following table shows how materials of different acceptability could be combined in a fertilization strategy to result in a total supply of 170 kg N/ha per year. For simplicity, only one material of each acceptability level is shown, and only three combinations are given. Colours match those in figure 1.

	Composted manure, animal husbandry unknown	Unprocessed manure, not from fur farming or lifelong use of cages/crates	Manure from organic farming	Sum per year
Proposed restriction	100 kg N/ha	125 kg N/ha	170 kg N/ha	
Combination 1			170 kg N/ha	170 kg N/ha
Combination 2		125 kg N/ha	45 kg N/ha	170 kg N/ha
Combination 3	100 kg N/ha	25 kg N/ha	45 kg N/ha	170 kg N/ha

Comment on the three levels chosen

The level of 170 kg nitrogen per year per hectare derives from the rules for organic plant production, as given in Regulation (EU) 2018/848, Annex II, point. 1.9.4. The level given there originates from the nitrate directive (Directive 91/676/EEC). If either of these levels should change in the future, it may be necessary to adapt the value also for the animal-derived fertilisers from conventional farming.

A reduction of the amount of off-farm conventional manure or animal by-products will reduce the risk of pollution with contaminants and pollutions, but not eliminate it. The level of 125 and 100 kg nitrogen per year and hectare are arbitrary but they were considered by the Group to be a value that are high enough to contribute to a sufficient production, but also a signal to act as an incentive for organic farmers to choose other nitrogen sources, where possible, as well as to promote the implementation of practices supporting animal welfare.

The Group introduces the concept of applying different maximum fertilization levels using off-farm animal-derived fertilisers, depending on the acceptability of the material according to the proposed criteria and describing fertilisers not allowed to use. For reasons of simplicity and controllability, only three levels are proposed (170, 125 and 100 kg nitrogen per year and hectare), even though more levels were pondered to be introduced. The Group remains open to the idea that more differentiated levels might be more suitable to achieve the desired effects, which could be introduced with further reductions in the use of the total off-farm nitrogen from animal-derived origin. Annex IV of the present report shows two examples of calculation for nitrogen needs and their fulfilment by different kinds of animal-derived fertilisers implementing the proposed restrictions.

Comment on the expanding the quantitative restriction to other animal by-products

The Group is aware of animal by-products being currently out of the scope of the point. 1.9.4 in Annex II to Regulation (EU) 2018/848. However, besides the need of a consistent approach to the use of animal-derived fertilising products mentioned in point 3.1.5, these kinds of products can be used as a source of nitrogen and therefore the group considered it as relevant to include them in the same quantitative restrictions.

4. PROPOSAL FOR THE APPLICATION OF A MULTI-CRITERIA APPROACH FOR THE USE OF ANIMAL-BASED ORGANIC FERTILISERS

Based on the above-mentioned reflections and considerations, a decision-making scheme (see Figure 1) was developed introducing the multicriteria approach to regulate the use of animal-derived fertilisers.

The described approach can replace the wording 'factory farming origin forbidden'.

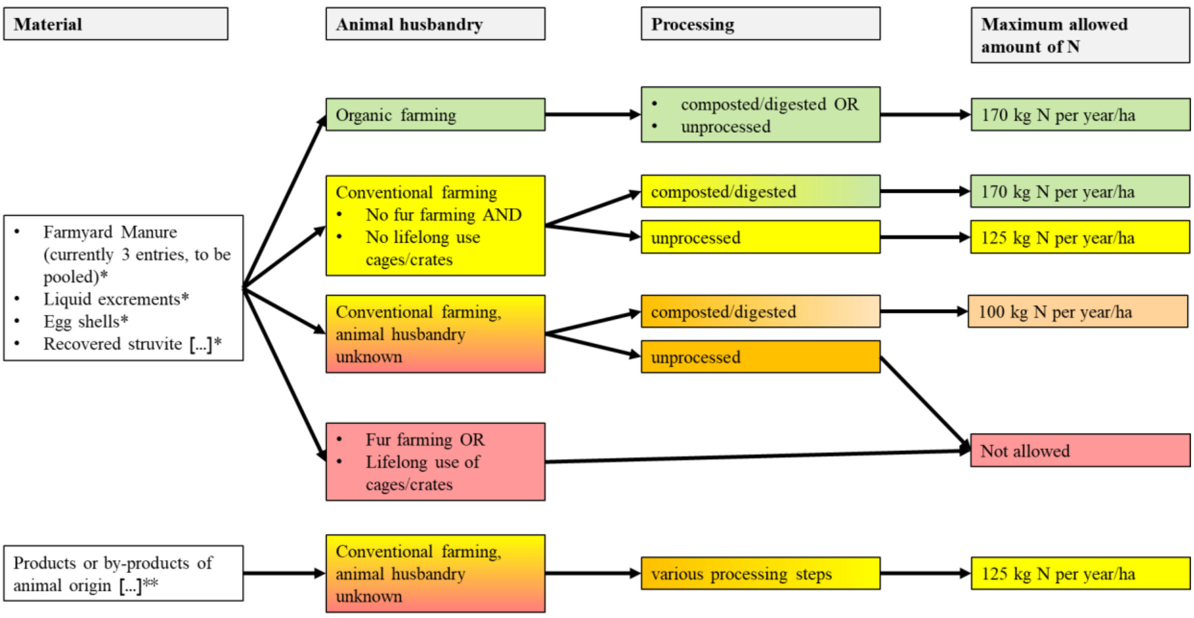

Figure 1: Scheme to define the proposed acceptability and quantitative restriction of animal-based fertilisers, depending on animal husbandry systems and processing. First column: materials, as shown in Annex II to Regulation (EU) 2021/1165 (*factory farming origin forbidden; **no restrictions regarding factory farming origin); Second column: animal husbandry systems, including origins for which the husbandry system is unknown; Third column: processing option; Fourth column: quantitative limit of nitrogen from animal-derived fertilisers based on acceptability of the source.

4.1 Recommended changes in Annex II to Regulation 2021/1165

The Group proposes the following changes in Annex II:

Firstly, the three entries relating to different types of farmyard manure should be combined into one single entry named 'farmyard manure'. The restriction 'factory farming origin forbidden', currently applying to all these types, should be replaced by the new approach described in this report, as follows:

Name Compound products or products containing only materials listed hereunder	Description, specific conditions and limits
Farmyard manure	product comprising a mixture of animal excrements and vegetable matter (animal bedding and feed material), fresh, dried, dehydrated, composted or fermented. Authorization and quantitative restriction, depending on origin and processing: • from organic production: maximum 170 kg nitrogen per year/hectare; • from non-organic production, where origin from fur farms and lifelong use of cages (for poultry) and crates (for pigs) is clearly excluded, – processed (composted or digested following the requirements set for CMC3 and CMC5, respectively, defined by Regulation (EU) 2019/1009 or national legal provisions): maximum 170 kg nitrogen per year/hectare; – unprocessed: maximum 125 kg nitrogen per year/hectare; • from non-organic production, where animal husbandry method is unknown, - processed (composted or digested following the requirements set for CMC3 and CMC5, respectively, defined by Regulation (EU) 2019/1009 or national legal provisions): maximum 100 kg nitrogen per year/hectare; - unprocessed: not allowed; from fur farming or from animal husbandry method using lifelong cages/crates: not allowed.
~~Dried farmyard manure and dehydrated poultry manure~~	~~factory farming origin forbidden~~
~~Composted animal excrements, including poultry manure and composted farmyard manure included~~	~~factory farming origin forbidden~~

Secondly, in all remaining entries with the restriction 'factory farming origin forbidden', this restriction should be replaced by a reference to the authorization and quantitative restrictions set for farmyard manure, as follows:

Name Compound products or products containing only materials listed hereunder	Description, specific conditions and limits
Liquid animal excrements	authorization and quantitative restriction: see farmyard manure
Egg shells	authorization and quantitative restriction: see farmyard manure
Recovered struvite and precipitated phosphate salts	products must meet the requirements laid down in Regulation (EU) 2019/1009 authorization and quantitative restriction for animal manure as a source material: see farmyard manure

Thirdly, for products and by-products of animal origin, a quantitative restriction of 125 kg nitrogen per year/hectare shall be set, as follows:

Name Compound products or products containing only materials listed hereunder	Description, specific conditions and limits
Products or by-products of animal origin as below: Blood meal Hoof meal Horn meal Bone meal or degelatinised bone meal Fish meal Meat meal Feather, hair and skin meal ('chiquette') Wool Fur (1) Hair Dairy products Hydrolysed proteins (2)	maximum 125 kg nitrogen per year/hectare (1) Maximum concentration in mg/kg of dry matter of chromium (VI): not detectable (2) Not to be applied to edible parts of the crop

4.2 Note on the transitional period

The recommendations made here may obviously have a profound effect on plant nutrients supply for certain farms. Therefore, the Group emphasizes that an appropriate transitional period (3 to 5 years) should be foreseen for the implementation of the proposed criteria.

5. POSSIBLE FUTURE DEVELOPMENT OF THE SCHEME FOR THE AUTHORIZATION OF THE USE OF ANIMAL-BASED FERTILISING PRODUCTS FROM CONVENTIONAL LIVESTOCK HUSBANDRY

The proposal stems from the current legal framework on the protection of farmed animals. After the first legal provision on this subject enacted in the 1970s, a directive laying down general protection standards for animals (including fish, reptiles and amphibians) bred or kept for the production of food, wool, hides or skins or for other agricultural purposes was enacted on 1998 (Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes[14]). The Directive was based on the 1978 European Convention for the Protection of Animals kept for Farming Purposes and mainly concerns farm animals (i.e. their rearing, transport and slaughter), but also wild and laboratory animals, and pets. The EU approach is recognised as a pioneer in animal welfare, with some of the highest global animal welfare standards, setting an example also on legislation of third countries. The relevance of the legislation can be expressed by a recent Eurobarometer survey (May 2021), which showed that 82 per cent of respondents thought that the welfare of farm animals should be better protected compared to current standards. Consequently, the EU Commission has carried out a "fitness check" of all EU legislation on the protection of animals and has announced new legislative proposal on the protection of animals at the time of transport while the impact assessment of the legislation on the protection of animals on farms is on-going[15] . This is also the result of a broader appraisal of the One Health approach, which it is based on the understanding that human, animal and environmental health are closely interlinked.

A possible scenario for a regulation on animal welfare in line with the Farm to Fork Strategy could foresee something like an animal husbandry welfare label, similar to the current egg labelling system, which would be easier to understand by consumers, and many experts consider being an appropriate classification. The implementation of such classification would allow a much easier identification of livestock rearing systems allowed (or not) as source of fertilisers for organic farming.

An example of such classification in Germany defines five different types of animal husbandry methods, four of which are conventional, as following described.

1. **Stable**: The animals are kept in accordance with the minimum legal requirements during fattening.
2. **Stable + space**: The animals have more space available compared to the legal minimum standard, varying in relation to the species. Pigs have at least 12.5 per cent more space available. The hens must have roughage, which is given in addition to the feed, and are structured with various elements.

[14] Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes, OJ L 221, 8.8.1998, p.23.

ELI: http://data.europa.eu/eli/dir/1998/58/2019-12-14

[15] Revision of the animal welfare legislation - European Commission (europa.eu)

Improved pens can, for example have, partition walls, different levels, different temperature or light areas.

3. **Fresh air barn**: The outdoor climate in each pen has a significant influence on the barn climate. The pigs have access to different climatic areas at all times.
4. **Outdoor run/pasture**: The pigs have access to an outdoor run throughout the day or are kept outdoor without a fixed stable building during this period. The exercise area may be reduced for the necessary duration of cleaning or for short periods if this is absolutely necessary in individual cases for animal welfare reasons.
5. **Organic**: Animal husbandry complies with the requirements of the EU Organic Farming Regulation.

The classification could consider also other aspects (e.g. related to welfare and ethics) selected among the criteria mentioned under point 3.4.1 (e.g. those derived from current legislation). This solution would thus address concerns from consumers, farmers and other stakeholders, and be verifiable by certifying bodies.

6. MINORITY OPINIONS

None.

7. LIST OF ABBREVIATIONS / GLOSSARY

None.

8. REFERENCES

EU Commission 2020. Farm to Fork Strategy. https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf

See also the list in the relevant Annexes

ANNEX I: Scientific and technical review of key aspects relating to soil health and quality, and plant growth

Plant production depends on nutrients, which are removed from the soil through the harvested crops and possible other losses, requiring thus replenishment to maintain an adequate soil fertility. These nutrients can derive from agronomical practices (e.g. cover crops, intercropping, rotation, etc.) as well as from recycling nutrient-rich organic resources, mining them, collecting them or synthesizing them, and adding them to the soil, as a source for soil organisms and the plants to improve growth and production. Animal manure can provide these nutrients. However, even on a farm or co-operation between farms with circulation of nutrients and self-sufficiency of feed, there will be a loss and export of nutrients from the farm cropping/production system.

Currently, organic farming is often specialised, with either livestock or crop production, usually carried out on different farms; vegetable and fruit farms, particularly, have in general no livestock production. As a result, the insufficient availability of nutrients from organic farming sources makes the use of nutrient elements derived from conventional farming or recycled sources necessary. However, in some cropping systems characterized by limited nutrients' needs (e.g. grape or some fruit crops) agronomic practices (e.g. green manure, intercrop) can sufficiently provide a large share of the necessary nutrient elements. Moreover, the relatively small share of organic livestock production within the total agricultural production, makes it more difficult to balance the nutrient supply based on animal manure or by-product (Bünemann et al., 2024). Focusing particularly on recycled products from the food industry (waste or by-products) can alleviate the problem.

Soil as living medium

Farming is highly dependent on the fertility of the soil, which is based on its structure, water content, mineral nutrients and organic matter content, and the soil biome which is at the basis of the overall soil functions. For this reason, agriculture, and especially organic agriculture cannot accept fertilising products that contain contaminants such as highly persistent chemicals, pharmaceutical residues, solid litter (glass, plastic), as these may endanger the soil health and fertility, depleting its biodiversity and pose risks also for the whole environment.

Organic farming prefers to use agronomic measures and organic fertilizer because the organic material feeds the soil biome. Synthetic fertilizers disrupt soil life balances due to the direct availability of easily soluble mineral nutrients like Nitrogen, Potassium and Phosphorous. They can affect the soil composition and microbiome. This affects plant nutrition, health and water balance (Khan et al., 2007, Solanki, 2020, Beste and Lorentz, 2022).

As already underlined in the EGTOP report Fertilisers VI[16], soils are dynamic ecosystems, on which a whole food web lives. In such a complex food web, microorganisms and soil animals decompose organic material and form new substances, which are nutrients for other soil organisms and plants or, as humic substances, have a favourable influence on soil structure and nutrients exchange. The symbiosis between plants and some soil microorganisms (mostly fungi and bacteria) facilitates the plants' access to nutrients and protects them from diseases and pests. These comprehensive functions cannot be provided by artificially composed nutrient substrates (Kendzior et al., 2022). In conclusion, a 'living soil' was proposed to be defined in the mentioned EGTOP report VI as 'a soil providing ecosystem services derived from a healthy, complex web of organisms living in it and characterised by an organic matter content that supports the soil life and its uses'.

[16] a4561074-266c-40dd-881b-c27f150e3d8a_en (europa.eu)

The importance of a healthy soil can be highlighted considering the conclusions drawn from a long term trial with accelerated application of human urine, sewage sludge and composted household (corresponding to an amount applied within 100-200 years, according to legal limits): the ecosystem's capacity for processing these quantities of wastes was remarkable with beneficial effects with regard to physical soil quality (Peltre et al., 2015), plant uptake of PTEs (Lopez-Rayo et al., 2016), soil microbial diversity and survival of multiresistance to antibiotics (Riber et al., 2014) and soil organic matter quality (Peltre et al., 2017).

References

Beste, A., Lorentz, N. (2022): Ecosystem Soil – Bringing nature-based solutions on climate change and biodiversity conservation down to earth. (Ed.): giz/BMUV.

Kendzior, J., Warren Raffa, D. and Bogdanski, A. 2022. The soil microbiome: a game changer for food and agriculture – Executive summary for policymakers and researchers. Rome, FAO. https://doi.org/10.4060/cc0717en.

Khan SA, Mulvaney RL, Ellsworth TR, Boast CW. The myth of nitrogen fertilization for soil carbon sequestration. J Environ Qual. 2007 Oct 24;36(6):1821-32. doi: 10.2134/jeq2007.0099. PMID: 17965385.

López-Rayo, S; Laursen, KH.; Lekfeldt, J.D.S.; Grazie, FD. and Magid, Jakob (2016) Long-term amendment of urban and animal wastes equivalent to more than 100 years of application had minimal effect on plant uptake of potentially toxic elements. Agriculture, Ecosystems and Environment, 231, pp. 44-53.

Peltre C, Nyord T, Bruun S, Jensen LS, Magid J (2015) Repeated soil application of organic waste amendments reduces draught force and fuel consumption for soil tillage, Agriculture, Ecosystems & Environment, 211, 94-101, https://doi.org/10.1016/j.agee.2015.06.004.

Peltre, Clément & Gregorich, E. & Bruun, Sander & Jensen, Lars & Magid, Jakob. (2017). Repeated application of organic waste affects soil organic matter composition: Evidence from thermal analysis, FTIR-PAS, amino sugars and lignin biomarkers. Soil Biology and Biochemistry. 104. 117-127. 10.1016/j.soilbio.2016.10.016.

Riber, Leise & Poulsen, Pernille & Abu Al-Soud, Waleed & Hansen, Lea & Bergmark, Lasse & Brejnrod, Asker & Norman, Anders & Hansen, Lars & Magid, Jakob & Sørensen, Søren. (2014). Exploring the immediate and long-term impact on bacterial communities in soil amended with animal and urban organic waste fertilizers using pyrosequencing and screening for horizontal transfer of antibiotic resistance. FEMS Microbiology Ecology. 90. 10.1111/1574-6941.12403.

Solanki, M.K. (2020). Mycorrhizal fungi and its importance in plant health amelioration. In: Solanki, M.K., Kashyap, P., Ansari, R. & Kumari, B. (Eds). Microbiomes and plant health. https://doi.org/10.1016/C2019-0-00466-9.

ANNEX II: Scientific and technical review of key aspects relating to animal welfare and industrial animal husbandry

The decades-long intensification of livestock production has led to a number of concerns about the impact of production practices on animal welfare, resulting in legislative and/or non-legislative efforts in many developed countries to regulate or strengthen the oversight of production practices (Mench, 2019). There is strong evidence that human life (improved health, less hunger) has improved in recent times. However, the same cannot be said for concerning animal husbandry, particularly in light of the growing prevalence of unethical industrial animal production.

The 2009 Treaty on the Functioning of the European Union (TFEU) recognised animals as sentient beings (Article 13 of Title II), claiming that humans must fulfil farm animals' natural needs. However, achieving this goal has the potential to conflict with what is considered the overarching goal of economics, often camouflaged as efficiently providing food for people.

Industrial animal production for food is characterised by dense animal housing, high throughput, specialisation, vertical integration and profit. Research has documented negative impacts on public health, the environment, and animal welfare (Mench, 2019; Hernandez et al., 2022).

There is a link between animal health, animal welfare, and production conditions that research has not sufficiently addressed. While poor animal health is obviously detrimental to animal welfare, poorly managed animals (e.g. stressed) are more likely to develop certain diseases and lesions. Faster animal turnover, areas of high animal density and habitat fragmentation without concomitant improvements in biosecurity measures and control tools, can increase both the likelihood and the impact of outbreaks of emerging diseases, including zoonoses (EU partnership, 2022). In this sense, the use of antibiotics to compensate for inadequate husbandry and poor hygiene is now prohibited according to Regulation (EU) 2019/6 on veterinary medicinal products [17].

The organisation Eurogroup for animals writes that "*Up to 300 million farm animals, including hens, quails, rabbits, sows and ducks, are confined in cages on EU farms each year. Many of them are kept this way for all or most of their lives. Caged animals are severely restricted in their movements (inability to fully extend their limbs or spread their wings) and prevented from performing their natural behaviours (inability to engage in natural behavior), with detrimental effects on their health and welfare*" (https://www.eurogroupforanimals.org/what-we-do/areas-of-concern/cages-animal-farming, accessed 2024.02.28) - animals may endure prolonged physical and psychological harm. Ample scientific evidence indicates that intensively confined farm animals feel frustrated, distressed and suffer conclusively substantiating battery cages and crates are simply not appropriate environments.

There is a significant lack of data on the state of animal welfare in the European Union and the prevalence of welfare problems. At present, only a limited amount of animal welfare data is routinely collected and most of it is related to animal health or food safety issues. The main barriers to the collection of welfare data are the lack of standardisation of animal-related measures (although significant progress has been made through EU-funded projects such as Welfare Quality® or AWIN) and the time and costs required to collect them (EU partnership, 2022).

---

[17] Regulation (EU) 2019/6 of the European Parliament and of the Council of 11 December 2018 on veterinary medicinal products and repealing Directive 2001/82/EC, OJ L 004, 7.1.2019, p.43.

ELI: http://data.europa.eu/eli/reg/2019/6/2022-01-28

Issues that are usually connected to 'factory farming' and that should be addressed when deleting the wording in the Annex II of Regulation (EU) 2021/1165[18] include the followings items:

Farm size

The size of the farm could be a criterium for discrimination. Among the methods used for this scope the following have been used at the EU level before:

- intensive animal farming (Lusk, 2016);
- industrial livestock production (Directive 2010/75/EU and other national regulations referring to other EU and national legislation, e.g. "Spécification technique n° B1-18-07 du 4 Mai 2007, applicable aux abats et aux viandes de volailles, de cailles et de lapins, en carcasses ou piécées" of the French Ministry of Economy, Finances and Industry, 2007)
- macro-farms (Grillotti Di Giacomo and De Felice, 2022);
- concentrated Animal Feeding Operations (CAFOs) (EPA 2012).

A comparison showing the categories and/or limits defined by some of these methods is presented in the following table.

Animal sector	EU Dir 2010/75	EPA 2012 – Large CAFOs	French specification
	number of animals		
Cattles or cows/calf pairs		>1.000	
Mature dairy cattle		>700	
Production pigs	>2.000	>2.500	>3.000
Sows	>750		>900
Poultry	>40.000		
Laying hens or broilers		>30.000	>60.000
Chickens other than laying hens		>125.000	>85.000
Turkeys		>55.000	

It shall be specified that according to the EPA (Environmental Protection Agency) document, a CAFOs is a farm in which "animals are kept and raised in confined situations. CAFOs congregate animals, feed, manure and urine, dead animals and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields or on rangeland". This is consistent also with Robbins et al. (2016), which underlined that there is not a simple relationship between farm size and animal welfare: even though larger farms could permit a more specialized and professional management of animal health, they can make more difficult to accommodate outdoor access, a pillar for animal welfare in organic certification.

Cages

[18] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial and livestock rearing emissions (integrated pollution prevention and control) (Recast)

ELI: http://data.europa.eu/eli/dir/2010/75/2024-08-04

Animals kept in cages represent a common way to farm, but that system causes severe welfare problems (poor bone strength due to lack of exercise, feather loss, restriction of natural behaviour), together with potential food safety concerns (Shields and Greger, 2016).

The Commission has been working for a potential legislative proposal to ban the use of cages for a range of farm animal species. The proposal of phasing out of cages for farm animals may be part of the future review of animal welfare legislation. From that potential review, the transition process to implement these new rules, the associated technical knowledge and practical solutions to adopt and accept new husbandry and management practices will take time and resources, which may not be readily available within the sector or individual Member States. Individual MS are allowed to introduce their own bans.

Crates & Stalls

Recent research has shown that free lactation pens can benefit sow welfare (increased freedom of movement and locomotory health, improved tear stain scores, etc.) if compared with conventional farrowing crates (Kinane et al., 2022), making it necessary to consider such aspect when dealing with 'factory farming'.

Slatted Floor

In intensive cattle production, animals are usually reared with fully slatted floors, many times even with low space allowances (beef finishing heads). Results of several recent studies testing fully slatted floors with rubber covering indicate that this type of flooring is an acceptable alternative to concrete slats, with positive effects on animal behaviour and leg lesions (Wechsler, 2011).

Air quality in livestock housing

Presence of several air pollutants such as ammonia, dust (dust particles below 10 and 2.5 micrometres, or PM10 and PM2.5) or bacterial load in barns are considered a major environmental risk to animal health due to diseases in the respiratory track. In fact, they have been correlated with animal welfare and respiratory diseases in calves and pigs (van Leenen et al., 2020, Vissers et al., 2021).

The main source of ammonia emissions in livestock, is the ammoniacal nitrogen in livestock excreta, which tends to be volatilized easily under certain conditions. Livestock housing factors such as the temperature, ventilation rate, humidity, stocking density and animals' activity, litter quality and bedding, feed composition (crude protein) and pH of the excreta are the main identified factors affecting ammonia levels in barns. Dust can be considered a contaminant that can affect both the respiration of the animals and the farmer and workers. Their origin can be non-organic (soil-material) or organic (plants and animals or microorganisms such as bacteria, fungi, viruses, generally known as "bioaerosols") (Giner Santonja et al., 2017).

The Directive 2007/43/EC[19] laying down minimum rules for the protection of chickens kept for meat production, established a maximum ammonia concentration in holdings used for chicken production and requires that the concentration of ammonia does not exceed 20 ppm and the concentration of carbon dioxide does not exceed 3 000 ppm measured at the level of the chickens' heads.

For years, empirical guidelines and recommendations exist, aiming at a healthy barn climate satisfying the needs for thermal comfort and fresh air supply for livestock (van Leenen et al., 2020). In this regard,

[19] Consolidated text: Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production, OJ L 182, 12.7.2007, p.19.

ELI: http://data.europa.eu/eli/dir/2007/43/2019-12-14

the Italian "ClassyFarm" protocol to assess animal welfare gives specific indications on the microclimatic conditions of livestock indoor environments (temperature, relative humidity, dustiness) and air quality, especially regarding harmful gases such as ammonia and carbon dioxide (Buoio et al., 2023). In addition, the Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs (Giner Santonja et al., 2017) published under the umbrella of Directive 2010/75 on industrial emissions, lists a set of activities and techniques towards the control of indoor environment in poultry and pig housing systems as well as manure collection and storage techniques.

Production-related diseases

One of the most devastating conditions affecting animal production on a massive scale is the emergence of leg disorders and lameness (the inability to walk properly) among broiler chickens, turkeys, pigs, and dairy cows (Grandin, 2022; Grandin, 2020). The overemphasis on artificial selection for milk yield, to the neglect of health traits, has resulted in an unbalanced allocation of the cow's energy and resources to milk production. If a cow is genetically programmed to devote most of her metabolic energy to milk production, she may be more susceptible to stress and disease (Jones et al., 1994). Additionally, selective breeding for increased milk yield has resulted in a rise in the occurrence of clinical mastitis (Marle-Köstera and Visser, 2021). Other diet-problems have shown that the length of the feeding period and the feeding behavior itself, as well as the composition of the feed, are important for cow welfare. As a result of genetic selection for high milk yield, cows used in today's dairy industry are unable to obtain all the energy required to sustain their abnormally high milk production from their diet alone. As a result, the diets of industrially reared dairy cows have become highly concentrated in energy-dense nutrients. However, cattle are naturally herbivores. Therefore, abnormally concentrated diets can lead to rumen acidosis in cows. Another problem closely associated with concentrates is laminitis, a painful inflammation of the skin layers inside the hoof that can lead to lameness (Marle-Köstera and Visser, 2021). This huge metabolic drain can leave cows with a negative energy balance, unable to eat enough to keep up with the calorie loss. Excessive mobilisation of fat stores can lead to ketosis, which in severe cases can cause signs of neurological dysfunction such as circling, excessive grooming, wandering and excessive salivation. Another common condition in high yielding cows is milk fever. The sudden loss of calcium from the milk at the onset of lactation may not be adequately compensated for by dietary intake or skeletal calcium reserves.

Risks of zoonosis emergence and planet health: One Health-One Welfare

Intensive livestock production increases the risk of zoonotic pandemics due to long-distance animal movements, high animal densities, poor animal health and welfare, low disease resistance and low genetic diversity. However, more data on many of these factors are needed, and analyses to date typically ignore how land use affects the risk of emerging infectious diseases (EIDs) and how these risks might vary between systems with different yields (production per unit area). Extensive, lower-yielding systems typically involve larger livestock, poorer biosecurity, more labour and more land, resulting in different, but not necessarily lower, EID risks than higher-yielding systems producing the same amount of food. Significant knowledge gaps for all potential risk factors make it inconclusive whether lower- or higher-yielding systems would better limit the risk of future pandemics.

The One Health principle recognises that human, animal including fish, plant and environmental health are closely linked (One Health Commission, 2024). If one group is affected, this influences the health of the other. In a One Health perspective, certain EID have an impact, directly or indirectly, on public health. Indeed, the majority of emerging EID are zoonotic (Jones et al., 2008), i.e. transmissible between animals and humans, directly or indirectly (e.g. food borne and vector-borne zoonoses).

One Welfare emphasises the link between animal welfare, human well-being and ecosystem health. Furthermore, as animal welfare is linked to animal health, the One Welfare approach complements the One Health approach. Incorporating this concept into future perspectives will encourage interdisciplinary collaboration to improve human and animal welfare and help to raise global standards of both human and animal welfare.

Antimicrobial and antiparasitic veterinary medicinal products and risk of development of resistance

The massive use of antibiotics, first in human medicine and later in livestock production and aquaculture, has changed the evolutionary dynamics of microorganisms, causing widespread genetic mobilization, selection, transfer, and environmental dissemination of antibiotic resistance genes (ARGs) (Gillings, 2013; Zhu et al., 2018). Even though a decreasing trend in use/sales of antibiotics for veterinary purposes has been observed in all EU Member States (on average about 53% reduction in the period 2011-2022 for 25 countries), the total amount of antibiotics sold in 2022 in EU and associated countries (31 countries) valued about 4.5 thousand tonnes, with a total aggregated sales across all reporting countries of 73.9 mg active substance/PCU (1 PCU, Population Correction Unit = 1 kg animal biomass) (EMA 2023).

Antibiotics can be difficult to break down. Livestock excrete antibiotics in faeces and urine, resulting in the accumulation of unmodified or still active antimicrobials in manure and environmental samples. This can lead to the spread of antibiotic resistant bacteria and ARGs. Animal manure and other fertilizers derived from faecal or contaminated materials (e.g. sewage sludge) have frequently been reported to constitute hotspots for the terrestrial dissemination of antibiotic resistance (He et al., 2017; Zhao et al., 2010). Apart from antibiotic resistant bacteria and ARGs, organic fertilizers can also contain mobile genetic elements (MGEs), antibiotic residues and other selecting agents (e.g. copper, zinc or veterinary drugs) that collectively may facilitate the transfer and selection of ARGs in agroecosystems. It is for instance common to find MGEs conferring resistance to both antibiotics and metals in organic fertilizers implying a risk for co-selection of ARGs in soil (Fang et al., 2014). This is important, as antibiotic residues only rarely build up to toxic levels even in soils amended with manure or sewage sludge, as antibiotics often are either rapidly degraded or inactivated in soil (Brandt et al., 2015). By contrast, metals such as copper and zinc may inflict a persistent selection pressure on soil bacterial communities and cause co-selection of antibiotic resistance (Murray et al., 2024; Song et al., 2020;). Waste management to mitigate antibiotic resistance in micro-organisms is a major challenge, highlighting the need for effective waste management technologies. The measurement of antibiotics in complex matrices such as biological sludge and soil is not standardised, making comparisons between studies difficult. The liquid/solid distribution of antibiotics influences the results. In contrast to the total concentration, sampling of leached manure shows the percentage of antibiotics in the solid phase. During storage, most antibiotic residues in manure combine to form stable compounds with soluble organic matter. Some antibiotics become mobile when manure is applied to fields and contaminate the soil and groundwater in the area. The fact that most of the manure applied in Europe does not go through any type of pre-application management or treatment (Foged et al., 2011) increases this pollution risk. The properties of the antibiotic, the soil and the hydrological effects all play a role. More research is needed to understand the rates of biodegradation and the potency of the degraded antibiotics in different situations (soils, manure and wastewater) (Cycoń et al., 2019).

Many scientific works have highlighted the need for better control of licensing use of antibiotics (Barton, 2000) because of the effects they have on the environment (see above). Recent regulation (Regulation (EU) 2019/6 on veterinary medicinal products) banned all forms of routine farm antibiotic use, including prophylactic group treatments. The ionophore antibiotics, mainly used to control the disease coccidia in poultry, have been excluded from this ban and are the only antibiotics that the EU allows to be used, completely routinely, without a veterinary prescription. However, this category of drugs does not represent the only one with possible negative impacts on the agroecosystem. Antiparasitic drugs represent a medicine also used extensively in organic livestock: among all, avermectins (belonging to anthelmintics) are pharmaceutical drugs widely used mainly in livestock to combat both ectoparasites and endoparasites. When administered, between 80 and 98% of the drug is estimated to leave the body without being metabolized in faeces, thus reaching the soil: it is therefore possible to consider this compound as harmful to non-target organisms, and its prudent use is also recommended in order to reduce negative effects on the environment (Barton, 2000).

The spread of ARGs into adjacent ecosystems and their subsequent emergence as contaminants can lead to environmental contamination as antibiotic-resistant bacteria (ARBs) are shed by animals into receptive environments such as soil and water, increasing the risk of human exposure, especially for agricultural workers and residents (Aus der Beek et al., 2016). The association of ARGs in the soil-plant system highlights a potential pathway for transmission of ARGs into the human microbiome and pathogens via the food chain. The continuous increase of prevalence of antibiotic resistance is a growing concern. The implementation of effective treatment strategies is urgently needed. In recent years, the international community has made important commitments to address this global health threat. One of these is to phase out the use of antimicrobials to promote growth in healthy animals. The misuse of antimicrobials in various sectors is accelerating antimicrobial resistance. The animal health sector must play its part in curbing this global scourge, which threatens animal, human and plant health, and adopt sustainable practices.

Scientific experts have identified changes in parasitic infections (in terms of parasite genetics, biology, robustness and management) and increased parasiticide resistance as immediate and emerging concerns in many species (Sanz et al., 2022). These changes affect animal health and productivity and require veterinarians and animal owners to rethink strategies, programmes and drug choices for parasite assessment and control. The geographical extent of parasite species with documented parasiticide resistance varies widely, and treatment strategies should be based on local conditions, experience and, where possible, antiparasitic drug susceptibility testing. Diagnosis of parasiticide resistance remains a challenge. Education and research efforts in parasitology are needed to provide the most up-to-date knowledge.

An additional risk is posed by the possibility of antibiotics uptake by the crop (Tasho and Cho, 2016). Different kinds of antibiotics were found in plant tissues, though their translocation mainly depended on their physicochemical properties, crop species, and the concentrations of antibiotics applied to the soil. A higher accumulation of antibiotics can be observed in crop tissues under wastewater treatments than under manure treatment, likely due to differences in adsorption in soil and uptake by crops. However, the levels of antibiotics ingested through the consumption of edible crops under the different treatments were much lower than the acceptable daily intake (ADI) levels.

Last but not least, microorganisms are constantly evolving, spontaneously or under the influence of environmental factors, including other micro-organisms, the host, treatments, chemical compounds, residues or biocides, increasing water temperatures, etc. These conditions favour the emergence of populations with new ecological characteristics and pathogenic microorganisms may become less or more virulent or develop resistance to treatments (e.g. AMR, anthelmintic resistance) (EU Partnertship, 2022).

Fish farming

Fish farming, a prominent form of aquaculture, involves the controlled rearing of fish in captivity. In Europe fish farming is currently dominated by open sea cages for cultivation. The practice varies, with hatchery fish like juvenile salmon being produced on land in either salt or freshwater environments. Finishing appears mainly in open sea cages, while there is a development to closed sea cages and land-based tanks, allowing a better control of the environment. Fish farming controls the fish life cycle and efficiently utilizes feed, although concerns persist regarding fish mortality, diseases, and environmental impacts, such as the use of unsustainable feed ingredients and the potential threat to wild salmon from escapes and inbreeding. Slaughter waste and manure have the potential to be used as a nutrient source.

Because the main production today is in open sea cages, only by-products from slaughtering can be utilised as a nutrient source, mainly containing nitrogen and phosphorus. There are plans to build closed systems on land (Recirculating Aquaculture Systems, RAS) for a more environmentally friendly production. In these systems, both feed loss and excreta will be collected. Most of the feed shall be re-used directly as feed, thus the main resource which could be used in addition to slaughter waste as possible nutrient source could be fish excreta.

Fur farming

The complex behavioural needs of fur animals species cannot be met on fur factory farms. It is impossible to improve the welfare of animals on fur farms. While no animal should live in a caged environment, the confinement of inherently wild species in cages can only be defined as cruelty. The confinement and killing of animals solely for the purpose of fur production is ethically unacceptable. Fur farming may also pose public health risk.

Following its commitments under the EU Farm to Fork Strategy, the European Commission is currently preparing legislative proposals to update and extend the scope of EU animal welfare legislation. Campaigners argue that this is the perfect opportunity to include an EU-wide ban on the fur trade.

Feed origin

Global food miles (i.e. transport) generate nearly 20% of all CO_2 emissions from food (Li et al., 2022). In addition, the production of feed outside the EU, often has large environmental consequences (rain forest destruction, soil degradation, erosion), and moreover leads to accumulation of nutrients (Nitrogen, Phosphorous) in the countries with intensive livestock farming (Van der Ploeg, 2023).

Systematic killing and culling

Some types of breeding require the systematic and continuous culling of a category of animals for reasons of low profitability only (scale economy and genetic selection): this is the case with male chicks of laying hens and male calves of dairy cattle and buffalo, for example. This represents a morally unacceptable system and an important parameter demonstrating the weakness of a production system: some EU companies developed "no-kill eggs". The possible phase-out of that practice could be included in the revision of EU animal welfare legislation. However, it shall be considered that there seems to be viable solutions to reduce the impact of this practice (screening machine for in-ovo sexing through a biomarker, endocrinological sexing hatching eggs, software able to control the incubation process for chicken embryos, inducing the expression of the feminine gene, and so on).

Selective breeding while endangering rustic and local breeds

Domesticated animals have been selectively bred over many generations to improve productivity and food efficiency. Breeders have been highly successful in creating genetic lines of animals that gain weight faster, grow to unprecedented sizes, lay more eggs, produce more milk and give birth to larger litters. With the selective breeding of farm animals for fast growth and high egg production rates, most commercially raised breeds are able to reproduce and produce eggs, even when confined and experiencing compromised welfare. In livestock production, there are numerous examples where animals are extremely productive but still experience suffering. For instance, a hen laying eggs may extract calcium from her bones, even though minerals are so depleted that her skeletal structure becomes compromised, leading to bone fractures (Zhao et al., 2020).

Favouring productivity over welfare has had major consequences for farm animals. One of the biggest threats to their well-being is rapid growth according to EGTOP experts. Broiler chickens for example suffer from gait defects severe enough to impair their ability to walk and additional research strongly suggests that birds at this level of lameness are in pain (joints). Large litter size is a significant cause of many welfare problems for both sows and piglets, including higher piglet mortality and prolonged labour (additional care of physiological weakness of the smallest piglets at birth and sick animals). Very large litters have contributed to the use of farrowing crates to confine sows. In addition, in large litters the number of piglets born alive is typically greater than the number of functional teats, leading to the use of nurse sows and artificial rearing systems to manage surplus piglets, both of which are associated with serious welfare problems. In practice the weakest piglets are often killed, which is cheaper than using extra effort to raise them. Therefore, the organic production guidelines define acceptable conditions for organic production, but where to lay the boundary for the conditions of conventional animal production to allow that their manure can be used in organic farming?

Energy consumption

In order to define the parameters common to all 'factory farming' systems, we can consider what characterizes industrial systems in general: high investment of start-up capital, topsoil being sealed in concrete, automation and technology-based systems, high production per unit area (building space), low cost per production unit (commodities), low workload per production unit, high dependence on external inputs, high overall amount of work (external inputs included), and, specifically, a general high energy demand and consumption. On the contrary, a review showed that ruminant livestock production systems tend to be more energy efficient under organic management due to the production of forage in grass–clover leys, so that most organic farming systems inspected are more energy efficient than their conventional counterparts (Smith et al., 2015). An extensive study analysing the consumption of energy along the whole supply chain for agricultural products, surprisingly showed that agricultural production intensification and modernization, has increased the net energy consumption in GJ/kg, from 1960 to 2018 (Smit, 2018).

Long transportation of live animals

Every year, pigs, cattle, sheep (including unweaned calves and lambs), goats and horses are transported long distances within Europe and internationally as part of the EU's long-distance trade of farmed animals. Animals often suffer greatly during long journeys and they become increasingly exhausted. Suffering is inherent in long journeys even when carried out in compliance with the law (e.g. stressful processes, motion sickness). Animals are transported on long journeys for a variety of reasons. Some are being sent to distant slaughterhouses. Others are being transported for further fattening, such as young calves being sent to veal farms and weaned pigs being sent from northern to southern or eastern Europe to be raised until they are ready for slaughter. Others are breeding animals being sent to farms where they will be used to produce offspring (e.g. by exporting breeding sows that have been genetically selected for very large litters, being more than the functional teats).

The transnational nature of live exports makes it particularly difficult to protect animal welfare, even in case of animals raised under organic farming rules. Replacing live exports with exports of meat and carcasses is not only better for the animals, but also has huge economic and environmental benefits.

It is important to stress that the Commission has proposed the biggest reform of EU rules on animal welfare during transport in 20 years. The new rules reflect the latest scientific knowledge and technological developments. Today's proposal therefore focuses on key areas that are essential to ensure good animal welfare during transport: 1) travel times to be shortened, 2) minimum space for the different animals will be increased and adapted to each species, 3) transport in extreme temperatures will be subjected to strict conditions, 4) Rules for the exports of live animals from the Union will be tightened and 5) more digital tools to facilitate the enforcement of transport rules.

References

Animal welfare

Barton, M. D. (2000). Antibiotic use in animal feed and its impact on human healt. Nutrition research reviews, 13(2):279-299. https://doi.org/10.1079/095442200108729106

Buoio, E., Cialini, C., Costa, A. (2023). Air Quality Assessment in Pig Farming: The Italian Classyfarm. Animals, 13(14): 2297. https://doi.org/10.3390/ani13142297

Brandt, K.K., Amézquita, A., Backhaus, T., Boxall, A., Coors, A., Heberer, T., Lawrence, J.R., Lazorchak, J., Schönfeld, J., Snape, J.R., Zhu, Y.G., Topp, E. (2015). Ecotoxicological assessment of antibiotics: A call for improved consideration of microorganisms. Environ. Int., 85:189-205. https://doi.org/10.1016/j.envint.2015.09.013

Cycoń, M., Mrozik, A., Piotrowska-Seget, Z. (2019). Antibiotics in the Soil Environment—Degradation and Their Impact on Microbial Activity and Diversity. Front. Microbiol., 10:412419. https://doi.org/10.3389/fmicb.2019.00338

Hernandez, E., Llonch, P., Turner, P.V. (2022). Applied animal ethics in industrial food animal production: exploring the role of the veterinarian. Animals, 12(6):678. https://doi.org/10.3390/ani12060678

Fang, H., Han, Y., Yin, Y., Pan, X., Yu, Y. (2014). Variations in dissipation rate, microbial function and antibiotic resistance due to repeated introductions of manure containing sulfadiazine and chlortetracycline to soil. Chemosphere, 96:51–56. https://doi.org/10.1016/j.chemosphere.2013.07.016

Gillings, M.R. (2013). Evolutionary consequences of antibiotic use for the resistome, mobilome and microbial pangenome. Frontiers in microbiology, 4, 4. https://doi.org/10.3389/fmicb.2013.00004

Giner Santonja, G., Georgitzikis, K., Scalet, B.M., Montobbio, P., Roudier, S., Delgado Sancho, L., (2017). Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs. EUR 28674 EN, 11: 898. https://doi.org/10.2760/020485

Grandin, T. (2020). Improving Animal Welfare: A Practical Approach. In: CABI Publishing; Wallingford: Oxford, UK.

Grandin, T. (2022). Bad Becoming Normal is Detrimental to Beef Cattle Welfare. Journal of Applied Animal Ethics Research, 4:151-157. https://doi.org/10.1163/25889567-bja10031

He, X., Xu, Y., Chen, J., Ling, J., Li, Y., Huang, L., Zhou, X., Zheng, L., Xie, G. (2017). Evolution of corresponding resistance genes in the water of fish tanks with multiple stresses of antibiotics and heavy metals. Water Res., 124:39–48. https://doi.org/10.1016/j.watres.2017.07.048

Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A., Balk, D., Gittleman, J.L. Daszak, P. (2008). Global trends in emerging infectious diseases. Nature, 451(7181):990-993. https://doi.org/10.1038/nature06536

Marle-Koester, E., Visser, C. (2021). Unintended consequences of selection for increased production on animal health and welfare. Arch. Anim. Breed. 64(1):177–185. https://doi.org/10.5194/aab-64-177-2021

Mench, J.A. (2019). Animal welfare—is intensification the problem? In: The Routledge handbook of animal ethics (Ed. B Fischer). New York, NY: Routledge. pp. 141–153.

Murray, L.M., Hayes, A., Snape, J., Kasprzyk-Hordern, B., Gaze, W.H., Murray, A.K. (2024). Co-selection for antibiotic resistance by environmental contaminants. npj Antimicrobials and Resistance, 2(1):9. https://doi.org/10.1038/s44259-024-00026-7

One Health Commission (2024). Available at: https://www.onehealthcommission.org/en/why_one_health/what_is_one_health/

Partnership on Animal Health and Welfare (PAHW). (2022) European Partnerships under Horizon Europe. 50 pp. Available at: https://research-and-innovation.ec.europa.eu/system/files/2022-04/ec_rtd_he-partnership-pahw.pdf

Shields, S., Greger, M. (2013). Animal welfare and food safety aspects of confining broiler chickens to cages. Animals, 3(2):386-400. https://doi.org/10.3390/ani3020386

Song, T., Zhu, C., Xue, S., Li, B., Ye, J., Geng, B., Li, L., Sardar, M.F., Li, N., Feng, S., Li, H. (2020). Comparative effects of different antibiotics on antibiotic resistance during swine manure composting. Bioresource Technology, 315:123820. https://doi.org/10.1016/j.biortech.2020.123820

Tasho, R.P., Cho, J.Y. (2016). Veterinary antibiotics in animal waste, its distribution in soil and uptake by plants: A review. The Science of The Total Environment 563-564(2):366-376. https://doi.org/10.1016/j.scitotenv.2016.04.140

van Leenen, K., Jouret, J., Demeyer, P., Van Driessche, L., De Cremer, L., Masmeijer, C. Boyen, F., Deprez, P., Pardon, B. (2020). Associations of barn air quality parameters with ultrasonographic lung lesions, airway inflammation and infection in group-housed calves. Preventive veterinary medicine, 181:105056. https://doi.org/10.1016/j.prevetmed.2020.105056

Vissers, L.S., Saatkamp, H.W., Lansink, A.G.O. (2021). Analysis of synergies and trade-offs between animal welfare, ammonia emission, particulate matter emission and antibiotic use in Dutch broiler production systems. Agricultural Systems, 189:103070. https://doi.org/10.1016/j.agsy.2021.103070

Zhao, L., Dong, Y.H., Wang, H. (2010). Residues of veterinary antibiotics in manures from feedlot livestock in eight provinces of China. Sci. Total Environ., 408:1069–1075. https://doi.org/10.1016/j.scitotenv.2009.11.014

Zhu, Y., Wang, Y., Zhou, S., Jiang, X., Ma, X., & Liu, C. (2018). Robust performance of a membrane bioreactor for removing antibiotic resistance genes exposed to antibiotics: role of membrane foulants. Water research, 130:139-150. https://doi.org/10.1016/j.watres.2017.11.067

Livestock production

Barton, M. D. (2000). Antibiotic use in animal feed and its impact on human healt. Nutrition research reviews, 13(2):279-299. https://doi.org/10.1079/095442200108729106

Environmental Health: Concentrated Animal Feeding Operations (CAFOs). Winsconsin Department of Health Services. Available at: https://www.dhs.wisconsin.gov/environmental/cafo.htm

Environmental Protection Agency (EPA). (2012). NPDES Permit Writers' Manual for Concentrated Animal Feeding Operations (Report). Washington, D.C.: U.S. EPA 833-F-12-001. Available at: https://www.epa.gov/npdes/npdes-permit-writers-manual-concentrated-animal-feeding-operations

European Parliament. (2022). Male chick culling. Available at: https://www.europarl.europa.eu/RegData/etudes/ATAG/2022/739246/EPRS_ATA(2022)739246_EN.pdf

Eurostat. (2022). Farms and farmland in the European Union – statistics. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics

Farms and farmland in the European Union - statistics. Data extracted in November 2022. Planned article update: 24 November 2025. Available at: https://ec.europa.eu/eurostat/statistics-explained/SEPDF/cache/73319.pdf

Grillotti Di Giacomo, M.G., De Felice, P. (2022). COVID-19 pandemic: warning for the sustainability of European agri-food systems. Belgeo, 4:1-25. https://doi.org/10.4000/belgeo.58211

Jones, W.P., Hansen, L.B., Chester-Jones, H. (1994). Response of health care to selection for milk yield of dairy cattle. Journal of Dairy Science, 77(10):3137-3152.

Kinane, O., Butler, F., O'Driscoll, K. (2022). Freedom to move: Free lactation pens improve sow welfare. Animals, 12(14):1762. https://doi.org/10.3390/ani12141762

Li, M., Jia, N., Lenzen, M., Malik, A., Wei, L., Jin, Y., Raubenheimer, D. (2022) Global food-miles account for nearly 20% of total food-systems emissions. Nature Food, 3(6):445–453. https://doi.org/10.1038/s43016-022-00531-w

Lusk J. (2016). Why Industrial Farms Are Good for the Environment. New York Times. Industrial livestock production. Boston University. Available at: https://sphweb.bumc.bu.edu/otlt/mph-modules/ph/livestockproduction/LivestockProduction_print.html

Robbins, J.A., Von Keyserlingk, M.A.G., Fraser, D., Weary, D.M. (2016). Invited review: Farm size and animal welfare. Journal of Animal Science, 94(12):5439-5455. https://doi.org/10.2527/jas2016-0805

Sanz, C., Casado, M., Navarro-Martin, L., Cañameras, N., Carazo, N., Matamoros, V., Bayona, J.M., Piña B. (2022). Implications of the use of organic fertilizers for antibiotic resistance gene distribution in agricultural soils and fresh food products. A plot-scale study. Science of The Total Environment, 815:151973. https://doi.org/10.1016/j.scitotenv.2021.151973

Shields, S., Greger, M. (2013). Animal welfare and food safety aspects of confining broiler chickens to cages. Animals, 3(2):386-400. https://doi.org/10.3390/ani3020386

Smit, H. (2018). The sustainability of Dutch agriculture 1950-2015-2040. In Dutch with English summary. Wageningen University, Wageningen, Netherlands, 214 pp.

Smith, L.G., Williams, A.G., Pearce, B.D. (2015). The energy efficiency of organic agriculture: A review. Renewable agriculture and Food systems, 30(3):280-301. https://doi.org/10.1017/S1742170513000471

United States of Environmental Protection Agency. Regulatory definition of Large, medium and Small CAFOs. Available at: https://www.epa.gov/sites/default/files/2015-08/documents/sector_table.pdf

Van der Ploeg, J.D. (2023). Gesloten vanwege stikstof. In Dutch with English summary. Ed. Noordboek. Biojournaal. Varkensbedrijf.nl. 184 pp.

Wechsler, B. (2011). Floor quality and space allowance in intensive beef production: a review. Animal Welfare, 20(4):497-503. https://doi.org/10.1017/S0962728600003134

Xu Y., Li H., Shi R., Lv J., Li, B., Yang F., Zheng X and Xu J. (2020). Antibiotic resistance genes in different animal manures and their derived organic fertilizer. Environ. Sci. Eur. 32:102. https://doi.org/10.1186/s12302-020-00381-y

Zalewska, M., Błazejewska, A., Czapko, A., Popowska, M. (2021). Antibiotics and Antibiotic Resistance Genes in Animal Manure – Consequences of Its Application in Agriculture. Front. Microbiol. 12:610656. https://doi.org/10.3389/fmicb.2021.610656

Zhao, S.C., Teng, X.Q., Xu, D.L., Chi, X., Ge, M., Xu, S.W. (2020). Influences of low level of dietary calcium on bone characters in laying hens. Poultry science, 99(12):7084-7091. https://doi.org/10.1016/j.psj.2020.08.057

ANNEX III Scientific and technical review of key aspects relating to contaminants of animal-derived fertilising products and their possible reduction

Two major contaminants can be introduced in soils of organic farms through application of organic fertilizing products derived from conventional farming and processing of by-products: antibiotics and microplastics.

Antibiotics have been extensively used as animal growth promoters, therapeutics, and prophylactics in the livestock industry. High concentrations of numerous antibiotic classes have been detected in different animal manures (e.g. Martínez-Carballo et al., 2007; Rasschaert et al., 2020).

Due to an abuse of plastics, at least 300 million t are produced annually, from which large parts end up in the environment (Blasing and Amelung, 2018), microplastics (i.e. products deriving from plastic degradation that are less than 5 mm in diameter) already pose a severe threat to the safety of ecosystems and food chains. There is growing evidence that microplastics have negative effects on the soil microbial community, by modifying the microbial community and promoting the persistence of antibiotic resistance genes (ARGs) as well as carriers of other pollutants, including antibiotics (Li et al., 2018), persistent organic contaminants (Rodrigues et al., 2019), and heavy metals (Gao et al., 2021). Standards regarding threshold of microplastics content in organic amendments exist but differ between countries and do not concern the same microplastic size classes.

The possible methods for the removal or reduction of these contaminants from organic fertilisers are described in the following.

Antibiotics

The physicochemical properties, the structure of antibiotics and their degradation by-products determine whether they degrade during biological treatment. The tendency of some antibiotics to adsorb on particles reduces their bioavailability (Wu et al. 2009; Ingerslev et al., 2001) and results in low degradation rates. Indeed, the removal rates for different antibiotic classes can vary from complete removal (e.g. for the macrolides) to no removal (e.g. for the fluoroquinolones).

Beside the antibiotic's chemical properties, manure-related matrix characteristics (i.e. C/N, total organic carbon content, moisture) modify the antibiotics' reluctance to biodegradation and play a significant role in antibiotic removal (Storteboom et al., 2007). Addition of different bulking agents (sawdust, rice husk, mushroom residues) resulted also to enhance the removal of antibiotics (by 14.9%–33.4% in swine manure, lower in chicken manure where fluoroquinolone is dominant) and decrease of ARGs during manure composting (Zhang et al. 2019a). Sawdust was the most efficient enhancer for antibiotic removal in both manures, and rice husk exhibited the best performance on ARGs reduction in chicken manure. Similarly, addition of 9% (w/w) bamboo charcoal during pig manure composting decreased the concentration of ciprofloxacin residues by 98.9% and decreased the content of norfloxacin and chlorotetracycline below detection limits in less than 2 weeks. Moreover, composting of chicken manure with the addition of other compounds (zeolite, superphosphate, or zeolite and ferrous sulphate simultaneously) resulted in impacting the behaviours of ARGs (Peng et al., 2018).

The method of manure processing (mainly affecting temperature and oxygen availability) can also impact on the degradation efficacy. Generally, antibiotics are degraded with the following capacity of the manure management process: composting > anaerobic digestion > manure storage > soil (Massè et al., 2014).

Composting, has been found to promote the degradation of antibiotics in livestock manure up to 60-70%, mainly during the thermophilic phase (Zhang et al., 2019b; Selvam et al., 2013, Wang et al., 2016), even at high initial concentrations. The removal ranges from 47.3% to 98.8% (average value = 84.72%)

for different types of manure (i.e. cattle, swine, poultry, and mixed manures) (Gaballah et al., 2021). A seasonal variation has been observed in the degradation efficiency, with tetracyclines and sulfonamides more degraded in summer than winter (Liu et al., 2018).

Even though different composting processes have different effects on the removal of antibiotics in manure, an optimized composting process (composting time, 30 d; temperature, 50ºC; water content, 50%; pH 9.0; heavy metal passivators and wheat straw) was able to reduce the antibiotic level by 28.8-77.8%, also decreasing the presence of ARGs and mobile genetic elements in the compost by 45% and 27.3%, and their relative abundance by 33.9% and 36.9%, respectively (Lu, Lu, 2019). Consequently, different types of biological processes affect antibiotic persistence differently: for example, chlortetracycline half-life has been found to increase in the order: composting > manure storage > soil (Massè et al., 2014). Even though manure storage does not affect tetracyclines and sulfadiazine degradation (Chen et al., 2012), the methods used to manage manure can affect the degradation of antibiotics. Manures subjected to high-intensity management (i.e. with amending, watering, and turning) resulted to promote degradation of different antibiotics (chlortetracycline, tylosin, and monensin) more than a low-intensity management (with no amending, watering, or turning), almost halving the time needed for degradation (Storteboom et al., 2007). In some cases (i.e. erythromycin, roxithromycin and salinomycin, tetracycline, doxycycline, clindamycin, and clarithromycin), persistence under anaerobic conditions was longer than under aerobic conditions (Schlüsener et al., 2006), suggesting that aerobic degradation might be a more important mechanism to eliminate these compounds. Indeed, the removal of oxytetracycline varied from as low as 55%–70% in (soil) to 55%–75% (after anaerobic digestion) to 85%–99% (after composting) (Massè et al., 2014). Decline of enrofloxacin (up to 74 %), ciprofloxacin and doxycycline (90%) was observed after composting poultry manure for 3 weeks under field conditions (Esperón et al., 2020), similarly to what observed with chicken (Shi et al. 2016) and broiler manures (Yang et al., 2018, Slana et al., 2017). The high removals generally observed during composting are likely due to the effects of the additional aerobic bioactivity compared to anaerobic digestion alone. Although both soil and composting share the same aerobic-anoxic conditions, composting higher removals could be explained by the presence of good/high inoculum compared to soil conditions.

Even though the effect of temperature on antibiotic removal is variable, in some cases it appeared to be an important factor for their degradation. For example, mesophilic and thermophilic anaerobic digestion showed higher removals of chlortetracycline than psychrophilic operation, while for monensin both psychrophilic and mesophilic showed low removals compared to thermophilic (Massè et al., 2014). In general, tetracyclines group (except for doxycycline) and the sulfonamides group have been found easy to degrade at a high temperature. The fluoroquinolones group has a variable behaviour, while the macrolides class is generally degraded at normal temperatures (Gaballah et al., 2021).

Heat treatments have been proved to reduce the content of some antibiotics in bones. Tetracyclines bound to the bones were reduced by about 50% by a treatment at 133ºC, while the same temperature brought a reduction of 90-100% of chlortetracycline. However, treatments at 100 ºC did not result to any real reduction (Kühne et al., 2001).

Anaerobic digestion can degrade and remove antibiotics to various extents depending on the concentration and class of antibiotic, bioreactor operating conditions, type of feedstock and inoculum sources. Antibiotics found in manures (from pig and cattle farms) were still detected in the digestates deriving from them, sometimes at a lower amount (Widyasari-Mehta et al., 2016, Spielmeyer et al., 2014, 2015), sometimes not (LNV, 2018). The North Rhine-Westphalia State Office for Nature, Environment and Consumer Protection in Germany (LANUV NRW 2009) investigated the contamination of 34 manure and 35 digestate samples with the most important veterinary antibiotics in terms of quantity. Antibiotic residues were detected in 71% of all samples (digestate samples 80%, manure samples 62%). In the digestate samples, antibiotic levels were found more frequently and tended to be higher than in the liquid manure samples. However, the decreasing concentrations of the antibiotics from the manures to the digestates may be only partly caused by anaerobic biotransformation, as irreversible sorption to digested and post-digested materials cannot be disregarded. Indeed, sorption was considered the major removal route for tetracyclines occurring in full-scale advanced anaerobic digester, considering that degradation of chlortetracycline and tetracycline in manure solids was limited by their desorption ratio (Wallace et al. 2018). In another study, no biodegradation was found for sulfadiazine and sulfamethizole after anaerobic digestion of pig manure and only erythromycin was clearly removed and probably degraded (up to 99% under thermophilic conditions) (Feng et al. 2017). Nevertheless, the mesophilic phase may be the best temperature regime for this process. In principle, a significant dilution factor has to be taken into account because the biogas plants are normally fed with other substrates (e.g. maize silage) and due to the mass balance derived from the time between the moment the manure entry into the digesters to the transfer of the digestate into the silos (about 60 to 100 days). Similarly to the composting process, the matrix can play a significant role: antibiotic residues were absent or present to a lower extent when matrixes derived from cattle manure were digested compared to pig manure (slurry) (Spielmeyer et al., 2014). Therefore, it clearly appears that antibiotics introduced into biogas plants via contaminated manures cannot be completely removed by the anaerobic digestion process. Indeed, the removal efficiency of antibiotics from manure and animal wastewater through anaerobic digestion ranges from 17.8% to 100% (average value = 73%), from 0% to 98% (average value = 73.4%) for cattle manure and swine manure respectively (Gaballah et al., 2021).

An integrated approach could lead to a better degradation rate. Anaerobic digestion could be associated with manure handling and storage to improve the reduction of antibiotics (Gurmessa et al., 2020). Using sedimentation tanks as a post-treatment of biogas slurry enhanced the removal of different antibiotics, especially in summer, by over 90% (Jin et al., 2016). The remaining, undegraded, amount of antibiotic residues could be degraded by separating the liquid part of the digestate from the solid fraction, treating the latter by aerobic or anaerobic composting and improving the solid fraction's storage.

Among other methods tested for degradation or removal of antibiotics from animal-derived fertilizing products can be mentioned phytoremediation through artificial constructed wetlands, chemical oxidation and electrochemical enhancement of microbial activity.

Phytoremediation of antibiotics in sewage, sludges and liquid manures, particularly from poultry and swine livestock, facilitated through structures that simulate wetlands has been explored in a growing number of studies (McCorquodale-Bauer et al., 2023). Structures that simulate wetlands are artificial complexes designed to simulate natural wetlands and exploit their capacity to remove antibiotics from liquid wastes or fractions by different mechanisms (microbial biodegradation, rhizoremediation, chemical degradation) (Nguyen et al., 2019). Several systems have been designed for structures that simulate wetlands, which perform differently in antibiotics removal: the integrated wetland system is able on average to remove about 72% of them, surface flow systems about 85% on average, and up to 95-98% on average for vertical or horizontal wetland flow systems (Gaballah et al., 2021). The removal capacity of these systems is also not the same for the different antibiotics groups: sulfonamides are the least effectively removed (on average 77%), followed by fluoroquinolones (on average 86%) and by tetracyclines and macrolides, both removed on average for 92%.

The different performances are due to several factors, mainly the plant species used in the system, the substrate and its aeration, and the wastewater characteristics. Phragmites australis, Thypa, Juncus effuses and Canna indica are among the most studied species used in these systems because showing high ability to uptake antibiotics because of their long root system which can promote rhizobacteria development (Gaballah et al., 2020) and antibiotics accumulation in their tissues (Rosa et al., 2019; Chung et al., 2017). Media substrates with small pore sizes (e.g. clay-rich or zeolite media), which are more conducive to mechanical filtration and microorganisms development, perform better (Liu et al., 2019; Chen et al., 2016). However, studies on large scale on-site livestock farms are still limited, requiring thus an optimization of the technique before it could be fully recommended.

With regards to chemical oxidation, more than 90% removal of oxytetracyclines was obtained with application of hydrogen peroxide alone or in combination with an iron salt, as well as after 1 hour ozonation on cow manure, which was pretreated with magnesium salt to increase the antibiotic desorption from organic matter (Uslu and Balcıoğlu 2009). The oxidant dose was a significant factor for the efficiency of the chemical treatment but not for the ozone treatment. An enhanced mineralization (degradation) of a specific group of antibiotics (sulfamethazine) was achieved in microbial electrochemical reactors, a system which is improving the microbial metabolism, allowing a total degradation for 43.5% of the active substance in a short time (Quejigo et al., 2019).

From the above-mentioned literature, it appears that biodegradation pathways associated with different methods of processing animal-derived manure, excrements and wastes have a significant variance of efficacy. A recent comprehensive analysis has shown that when considering the processing method, anaerobic digestion has a capacity to remove on average 73% of antibiotic residues while manure composting and structures that simulate wetlands can remove on average 85% and 90% of them, respectively (Gaballah et al., 2021). Biodegradation is higher for sulfonamides and macrolides (on average 73% and 90%, respectively), lower for tetracyclines (about 65%), and fluctuates for fluoroquinolones (from 0% to 96%, on average 55%).

Microplastics

Even though organic fertilisers may be a source of microplastics contamination in agroecosystems (Nizzetto et al., 2016), the knowledge about the nature and accumulation of microplastics in agricultural soils due to application of different types of these products is still limited (Corradini et al., 2019; El Hayany et al., 2022; Weithmann et al., 2018; Yang et al., 2021). However, a recent study evaluating the impact of a 22-year long application of an amount of compost that was twice the common practice concluded that no major impacts on the soil bio-physic-chemical parameters have been noted so far, but a better overall evaluation was advised (Colombini et al., 2022).

Sieving and sifting procedures can significantly reduce, but never completely remove microplastics, but correct procedures to produce high quality fertilizing products can strongly affect their content. Fertilizer samples from processing plants converting biowaste contained plastic particles, but amounts differed significantly with substrate pretreatment, plant unit, and waste (for example, household versus commerce) type. In contrast, digestates from agricultural energy crop digesters tested for comparison contained only isolated particles, if any (Weithmann et al., 2018).

Among the processes that have been tested to reduce the content of microplastics in organic fertilisers, microbial-based processes like composting and anaerobic digestion have been studied. During the composting process, the degradation of microplastics was positively related to the composting condition (e.g., temperature, enzyme and microbial community, etc.) (Ali et al., 2021; Gui et al., 2021). Utilization of hyperthermophilic composting technology to improve the temperature and microbial activity of composting improved their degradation in sewage sludge (Chen et al., 2020). Addition of livestock manure biochar during composting significantly promoted microplastics derived from bioplastics and promoted the enrichment of microplastic-degrading microbial genera (e.g., Bacillus, Thermobacillus, Luteimonas, Chryseolinea, Aspergillus and Mycothermus) (Sun et al., 2022).

Considering the still limited knowledge on the input of microplastics through organic fertilizing products and their distribution in the different products, as well as about the efficacy of different processing methods in removal/degradation, it is considered that the presence of this contaminant cannot be fully addressed yet.

References

Ali, S.S., Elsamahy, T., Al-Tohamy, R., Zhu, D.C., Mahmoud, Y., Koutra, E., Metwally, M.A., Kornaros, M., Sun, J.Z., 2021. Plastic wastes biodegradation: mechanisms, challenges and future prospects. Sci. Total Environ., 780:146590. https://doi.org/10.1016/j.scitotenv.2021.146590

Aus der Beek, T., Weber, F. A., Bergmann, A., Hickmann, S., Ebert, I., Hein, A., Küster, A. (2016). Pharmaceuticals in the environment—Global occurrences and perspectives. Environmental toxicology and chemistry, 35(4):823-835. https://doi.org/10.1002/etc.3339

Blasing, M., Amelung, W. (2018). Plastics in soil: analytical methods and possible sources. Sci. Total Environ., 612:422-435. https://doi.org/10.1016/j.scitotenv.2017.08.086

Bünemann, E.K., Reimer M., Smolders, E., Smith, S.R., Bigalke, M., Palmqvist, A., Brandt, K.K., Möller, K., Harder, R., Hermann, L., Speiser, B., Oudshoorn, F., Løes, A.K., Magid, J. (2024). Do contaminants compromise the use of recycled nutrients in organic agriculture? A review and synthesis of current knowledge on contaminant concentrations, fate in the environment and risk assessment. Science of the Total Environment. 912,168901. https://doi.org/10.1016/j.scitotenv.2023.168901

Chen, Y., Zhang, H., Luo, Y., Song, J. (2012). Occurrence and assessment of veterinary antibiotics in swine manures: A case study in east China. Chin. Sci. Bull., 57:606–614. https://doi.org/10.1007/s11434-011-4830-3

Chen, J., Ying, G., Wei, X., Liu, Y., Liu, S., Hu, L., He, L., Chen, Z., Chen, F., Yang, Y. (2016). Removal of antibiotics and antibiotic resistance genes from domestic sewage by constructed wetlands: Effect of flow configuration and plant species. Sci. Total Environ. 571:974–982. https://doi.org/10.1016/j.scitotenv.2016.07.085

Chen, Z., Zhao, W.Q., Xing, R.Z., Xie, S.G., Yang, X.G., Gui, P., Lü, J., Liao, H.P., Yu, Z., Wang, S.H., Zhou, S.G. (2020). Enhanced in situ biodegradation of microplastics in sewage sludge using hyperthermophilic composting technology. J. Hazard Mater., 384:121271. https://doi.org/10.1016/j.jhazmat.2019.121271

Chung, H.S., Lee, Y., Rahman, M.M., Abd El-Aty, A.M., Lee, H.S., Kabir, M.H., Kim, S.W., Park, B., Kim, J., Hacimuftuoglu, F., Nahar, N., Shin, H., Shim, J.H. (2017). Uptake of the veterinary antibiotics chlortetracycline, enrofloxacin, and sulphathiazole from soil by radish. Sci. Total Environ., 15:22–331. https://doi.org/10.1016/j.scitotenv.2017.06.231

Colombini, G., Rumpel, C., Houot, S., Biron, P., Dignac, M.F. (2022). A long-term field experiment confirms the necessity of improving biowaste sorting to decrease coarse microplastic inputs in compost amended soils. Environmental Pollution, 315:120369. https://doi.org/10.1016/j.envpol.2022.120369

Corradini, F., Meza, P., Eguiluz, R., Casado, F., Huerta-Lwanga, E., Geissen, V. (2019). Evidence of microplastic accumulation in agricultural soils from sewage sludge disposal. Sci. Total Environ., 671:411–420. https://doi.org/10.1016/j.scitotenv.2019.03.368

Cresto, N., Forner-Piquer, I., Baig A., Chatterjee, M., Perroy, J., Goracci, J., Marchi, N. (2023). Pesticides at brain borders: Impact on the blood-brain barrier, neuroinflammation, and neurological risk trajectories. Chemosphere, 24:138251. https://doi.org/10.1016/j.chemosphere.2023.138251

Cycoń, M., Mrozik, A., Piotrowska-Seget, Z. (2019). Antibiotics in the Soil Environment—Degradation and Their Impact on Microbial Activity and Diversity. Front. Microbiol., 10:412419. https://doi.org/10.3389/fmicb.2019.00338

El Hayany, B., Rumpel, C., Hafidi, M., El Fels, L. (2022). Occurrence, analysis of microplastics in sewage sludge and their fate during composting: a literature review. J. Environ. Manag., 317:115364. https://doi.org/10.1016/j.jenvman.2022.115364

Esperón, F., Albero, B., Ugarte-Ruíz, M., Domínguez, L., Carballo, M., Tadeo, J.L. del Mar Delgado, M., Moreno, M.A., de la Torre, A. (2020). Assessing the benefits of composting poultry manure in reducing antimicrobial residues, pathogenic bacteria, and antimicrobial resistance genes: a field-scale study. Environmental Science and Pollution Research, 27:27738–27749. https://doi.org/10.1007/s11356-020-09097-1

European Medicines Agency (EMA). (2023). Sales of veterinary antimicrobial agents in 31 European countries in 2022. European Medicines Agency. Available at: https://www.ema.europa.eu/en/documents/report/sales-veterinary-antimicrobial-agents-31-european-countries-2022-trends-2010-2022-thirteenth-esvac-report_en.pdf

Feng, L., Escolà Casas, M., Mørck Ottosen, L.D., Bjarne Møller, H., Bester, K. (2017). Removal of antibiotics during the anaerobic digestion of pig manure. Science of The Total Environment, 603–604:219-225. https://doi.org/10.1016/j.scitotenv.2017.05.280

Foged, H., Flotats, X., Blasi, A.B., Palatsi, J., Magri, A., Schelde, K.M. (2011). Inventory of manure processing activities in Europe. Technical Report No. I Manure Processing Activities in Europe. European Commission, Directorate-General Environment. 138 pp.

Gaballah, M.S., Abdelwahab, O., Barakat, K.M., Aboagye, D. (2020). A novel horizontal subsurface flow constructed wetland planted with Typha angustifolia for treatment of polluted water. Environ. Sci. Pollut. Res., 27:28449–28462. https://doi.org/10.1007/s11356-020-08669-5

Gaballah, M.S., Guo, J., Sun, H., Aboagye, D., Sobhi, M., Muhmood, A., Dong, R. (2021). A review targeting veterinary antibiotics removal from livestock manure management systems and future outlook. Bioresource Technology, 333:125069. https://doi.org/10.1016/j.biortech.2021.125069

Gao, X., Hassan, I., Peng, Y.T., Huo, S.L., Ling, L. (2021). Behaviors and influencing factors of the heavy metals adsorption onto microplastics: a review. J. Clean. Prod. 319,128777. https://doi.org/10.1016/j.jclepro.2021.128777

Gui, J.X., Sun, Y., Wang, J.L., Chen, X., Zhang, S.C., Wu, D.L. (2021). Microplastics in composting of rural domestic waste: abundance, characteristics, and release from the surface of macroplastics. Environ. Pollut,. 274:116553. https://doi.org/10.1016/j.envpol.2021.116553

Gurmessa, B., Pedretti, E.F., Cocco, S., Corti, G. (2020). Manure anaerobic digestion effects and the role of pre- and posttreatments on veterinary antibiotics and antibiotic resistance genes removal efficiency. Sci. Total Environ., 137532. https://doi.org/10.1016/j.scitotenv.2020.137532

Jin, H.M., Huang, H.Y., Guan, Y.X., Xu, C.Y., Chang, Z.Z., Quian, Y.T. (2016). Characteristics of Degradation Tetracyclines and Sulfonamides During Wastewater Treating Processes in an Intensive Swine Farm. J. Ecol. Nat. Environ., 32:978–985.

Kühne, M., Körner, U., Wenzel, S. (2001). Tetracycline residues in meat and bone meals. Part 2: The effect of heat treatments on bound tetracycline residues, Food Additives & Contaminants, 18:593-600, https://doi.org/10.1080/02652030118164

Ingerslev, F., Halling-Sorensen, B. (2001). Biodegradability of metronidazole, olaquindox, and tylosin and formation of tylosin degradation products in aerobic soil-manure slurries. Ecotoxicol. Environ. Safety, 48:311–320. https://doi.org/10.1006/eesa.2000.2026

Li, J., Zhang, K., Zhang, H. (2018). Adsorption of antibiotics on microplastics. Environ. Pollut., 237: 460–467. https://doi.org/10.1016/j.envpol.2018.02.050

Liu, H., Pu, C., Yu, X., Sun, Y., Chen, J. (2018). Removal of tetracyclines, sulfonamides, and quinolones by industrial-scale composting and anaerobic digestion processes. Environ. Sci. Pollut. Res., 25:35835–35844. https://doi.org/10.1007/s11356-018-1487-3

Liu, X., Guo, X., Liu, Y., Lu, S., Xi, B., Zhang, J., Wang, Z., Bi, B., 2019. A review on removing antibiotics and antibiotic resistance genes from wastewater by constructed wetlands: Performance and microbial. Environ. Pollut., 254:112996. https://doi.org/10.1016/j.envpol.2019.112996

LNV. (2018). Antibiotika-Resistenzen und Antibiotika Rückstände in Gärresten von Biogasanlagen. INFO 2. Available at: https://lnv-bw.de/wp-content/uploads/2018/09/2-2018-LNV-Info-Antibiotika-Resistenz.pdf

Lu, X.M., Lu, P.Z. (2019). Synergistic effects of key parameters on the fate of antibiotic resistance genes during swine manure composting. Environmental Pollution, 252:1277-1287. https://doi.org/10.1016/j.envpol.2019.06.073

Martínez-Carballo, E., Gonzalez-Barreiro, C., Scharf, S., Gans, O. (2007). Environmental monitoring study of selected veterinary antibiotics in animal manure and soils in Austria. Environ. Pollut., 148:570e579. https://doi.org/10.1016/j.envpol.2006.11.035

Massé, D.I., Cata Saady, N.M., Gilbert, Y. (2014). Potential of Biological Processes to Eliminate Antibiotics in Livestock Manure: An Overview. Animals, 4:146-163. https://doi.org/10.3390/ani4020146

McCorquodale-Bauer, K., Grosshans, R., Zvomuya, F., Cicek, N. (2023). Critical review of phytoremediation for the removal of antibiotics and antibiotic resistance genes in wastewater. Sci. Total Environ., 20:161876. https://doi.org/10.1016/j.scitotenv.2023.161876

Nizzetto, L., Futter, M., Langaas, S., 2016. Are agricultural soils dumps for microplastics of urban origin? Environ. Sci. Technol., 50:10777–10779. https://doi.org/10.1021/acs.est.6b04140

Nguyen, H.T.T., Chao, H.R., Chen, K.C. (2019). Treatment of organic matter and tetracycline in water by using constructed wetlands and photocatalysis. Appl. Sci., 9:1–16. https://doi.org/10.3390/app9132680

Peng, S., Li, H.J., Song, D., Lin, X.G., Wang, Y.M. (2018). Influence of zeolite and superphosphate as additives on antibiotic resistance genes and bacterial communities during factory-scale chicken manure composting. Bioresour. Technol., 263:393-401. https://doi.org/10.1016/j.biortech.2018.04.107

Quejigo, J.R., Tejedor-Sanz, S., Schroll, R., Esteve-Núñez, A. (2019). Electrodes boost microbial metabolism to mineralize antibiotics in manure. Bioelectrochemistry, 128:283–290. https://doi.org/10.1016/j.bioelechem.2019.04.008

Rasschaert, G., Elst, D.V., Colson, L., Herman, L., Ferreira, H.C.C., Dewulf, J., Decrop, J., Meirlaen, J., Heyndrickx, M., Daeseleire, E. (2020). Antibiotic residues and antibiotic-resistant bacteria in pig slurry used to fertilize agricultural fields. Antibiotics, 9:34. https://doi.org/10.3390/antibiotics9010034

Rodrigues, J.P., Duarte, A.C., Santos-Echeandia, J., Rocha-Santos, T. (2019). Significance of interactions between microplastics and POPs in the marine environment: a critical overview. Trac. Trends Anal. Chem., 111:252–260. https://doi.org/10.1016/j.trac.2018.11.0

Rosa, J., Leston, S., Crespo, D., Freitas, A., Sofia, A., Pouca, V., Lemos, M.F.L., Pardal, M.A., Ramos, F. (2019). Uptake of enrofloxacin from seawater to the macroalgae Ulva and its use in IMTA systems. Aquaculture, 516:734609. https://doi.org/10.1016/j.aquaculture.2019.734609

Schlüsener, M., von Arb, M., Bester, K. (2006). Elimination of macrolides, tiamulin, and salinomycin during manure storage. Arch. Environ. Contam. Toxicol., 51:21–28. https://doi.org/10.1007/s00244-004-0240-8

Selvam, A., Zhao, Z., Li, Y., Chen, Y., Leung, K.S-, Wong, J.W. (2013). Degradation of tetracycline and sulfadiazine during continuous thermophilic composting of pig manure and sawdust. Environ. Technol., 34:2433-41. https://doi.org/10.1080/09593330.2013.772644

Shi, H., Wang, X.C., Li, Q., Jiang, S. (2016). Degradation of typical antibiotics during human feces aerobic composting under different temperatures. Environ. Sci. Pollut. Res., 23:15076–15087. https://doi.org/10.1007/s11356-016-6664-7

Slana, M., Zigon, D., Sollner-Dolenc, M. (2017). Enrofloxacin degradation in broiler chicken manure under field conditions and its residuals effects to the environment. Environ. Sci. Pollut. Res., 24:13722–13731. https://doi.org/10.1007/s11356-017-8722-1

Spielmeyer, A., Ahlborn, J., Hamscher, G. (2014). Simultaneous determination of 14 sulfonamides and tetracyclines in biogas plants by liquid-liquid extraction and liquid chromatography tandem mass spectrometry. Anal. Bioanal. Chem., 406:2513-2524. https://doi.org/10.1007/s00216-014-7649-3

Spielmeyer, A., Breier, B., Groißmeier, K., Hamscher, G. (2015). Elimination patterns of worldwide used sulfonamides and tetracyclines during anaerobic fermentation. Bioresour. Technol., 193:307-314. https://doi.org/10.1016/j.biortech.2015.06.081

Storteboom, H.N., Kim, S.C., Doesken, K.C., Carlson, K.H., Davis, J.G., Pruden, A. (2007). Response of antibiotics and resistance genes to high-intensity and low-intensity manure management. J. Environ. Qual. 36:1695-1703. https://doi.org/10.2134/jeq2007.0006

Sun, Y., Shaheen, S.M., Ali, E.F., Abdelrahman, H., Sarkar, B., Song, H., Rinklebe, J., Ren, X., Zhang, Z., Wang, Q. (2022). Enhancing microplastics biodegradation during composting using livestock manure biochar. Environmental Pollution, 306:119339. https://doi.org/10.1016/j.envpol.2022.119339

Uslu, M.Ö., Balcıoğlu, I.A. (2009). Comparison of the ozonation and Fenton process performances for the treatment of antibiotic containing manure. Science of the Total Environment, 407:3450–3458. https://doi.org/10.1016/j.scitotenv.2009.01.045

Wallace, J.S., Garner, E., Pruden, A., Aga, D.S. (2018). Occurrence and transformation of veterinary antibiotics and antibiotic resistance genes in dairy manure treated by advanced anaerobic digestion and conventional treatment methods. Environ. Pollut., 236:764-772. https://doi.org/10.1016/j.envpol.2018.02.024

Wang, L, Chen, G., Owens, G., Zhanga, J. (2016). Enhanced antibiotic removal by the addition of bamboo charcoal during pig manure composting. RCS Advances, 6(33):27575-27583. https://doi.org/10.1039/C5RA27493A

Weithmann, N., Möller, J.N., Löder, M.G. J., Piehl, S., Laforsch, C., Freitag, R. (2018). Organic fertilizer as a vehicle for the entry of microplastic into the environment. Sci. Adv., 4(4):eaap8060. https://doi.org/10.1126/sciadv.aap8060

Widyasari-Mehta, A., Hartung, S., Kreuzig, R. (2016). From the application of antibiotics to antibiotic residues in liquid manures and digestates: A screening study in one European center of conventional pig husbandry. Journal of Environmental Management, 177:129-137. https://doi.org/10.1016/j.jenvman.2016.04.012

Wu, C., Spongberg, A.L., Witter, J.D. (2009). Sorption and biodegradation of selected antibiotics in biosolids. J. Environ. Sci. Health A, 44:454–461. https://doi.org/10.1080/10934520902719779

Yang, B., Meng, L., Xue, N. (2018). Removal of five fluoroquinolone antibiotics during broiler manure composting. Environ. Technol., 39:373–381. https://doi.org/10.1080/09593330.2017.1301568

Yang, J., Li, R., Zhou, Q., Li, L., Li, Y., Tu, C., Zhao, X., Xiong, K., Christie, P., Luo, Y. (2021). Abundance and morphology of microplastics in an agricultural soil following long-term repeated application of pig manure. Environ. Pollut., 272:116028. https://doi.org/10.1016/j.envpol.2020.116028

Zhang, J., Lin, H., Ma, J.W., Sun, W.C., Yang, Y.Y., Zhang, X. (2019a). Compost-bulking agents reduce the reservoir of antibiotics and antibiotic resistance genes in manures by modifying bacterial microbiota. Sci. Total Environ., 649:396-404. https://doi.org/10.1016/j.scitotenv.2018.08.212

Zhang, M., He, L.Y., Liu, Y.S., Zhao, J.L., Liu, W.R., Zhang, J.N., Chen, J., He, L.K., Zhang, Q.Q., Ying, G.G. (2019b). Fate of veterinary antibiotics during animal manure composting. Sci. Total Environ., 650:1363-1370. https://doi.org/10.1016/j.scitotenv.2018.09.147

ANNEX IV Examples of calculations of nitrogen needs and their fulfilment with different animal-derived fertilisers

The following tables are showing two examples of calculation for nitrogen demand and their fulfilment by different kinds of conventional animal-derived fertilisers.

Grain Production 100 ha	Requirement as average in rotation		Maximum allowed import from organic animal products	Maximum allowed import from conventional animal products					kg N other fertilisers from Annex II (plant based)	Total import
				Confirmed No fur/no lifelong cages/crates		Unspecified origin		Animal by-products		
				processed	unprocessed	processed	unprocessed			
	kg N/ha	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm
Value	150	15000	17000	17000	12500	12500	10000	12500		
Maximum available in region			0	10000	unlimited	unlimited	unlimited	unlimited	unlimited	
Import based on fertilisation plan			0	10000	5000	0	0	0	0	15000

Vegetable Production 10 ha	Requirement as average in rotation		Maximum allowed import from organic animal products	Maximum allowed import from conventional animal products					kg N other fertilisers from Annex II (plant based)	Total import
				Confirmed No fur/no lifelong cages/crates		Unspecified origin		Animal by-products		
				processed	unprocessed	processed	unprocessed			
	kg N/ha	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm	kg N/farm
Value	200	2000	17000	1700	1250	1250	1000	1250		
Maximum available in region			500	unlimited	unlimited	unlimited	unlimited	unlimited	unlimited	
Import based on fertilisation plan			500	1200		0	0	0	300	2000