# Intensive broiler farming in the EU: impact on the environment, human health and animal welfare

## Final report

Report carried out for

Eurogroup for Animals


Submitted by

Agra CEAS Consulting Ltd

Telephone: +32 (0) 2 736 00 88

Fax: +32 (0) 2 732 1361

E-mail: info@ceasc.com

www.ceasc.com

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# 1. Executive Summary

Intensive broiler farming is typically characterised by high stocking densities, fast growth rates leading to a young slaughter age, very large holdings, and indoor rearing without access to enrichments. Although poultry farms with more than 100,000 heads account for less than 1% of total poultry holdings in the EU, Eurostat data shows that these holdings account for 38% of total poultry numbers.

While there are slight differences in intensive broiler farming practices across the EU, these are subtle; production in the main producing countries tends to adhere to stocking densities of 33kg/$m^2$ or higher, and a slaughter age in the range of 35-45 days. Intensive broiler production accounts for the vast majority (90%+) of broiler production in the EU. Nonetheless, some alternative, higher animal welfare standards for intensive rearing (with or without access to verandas or outdoor runs) have emerged and there is some free-range and organic production.

The intensification of broiler production results in environmental concerns and poses hazards to human and animal health. Chief among these concerns are the use of antibiotics and the impacts stemming from litter and manure waste streams. Intensive broiler rearing systems typically still require a substantial use of antibiotic treatments, primarily due to issues with faster growing breeds, high stocking densities and high ammonia concentrations. This high usage can impact the environment in several ways, including through the degradation of organic matter. Furthermore, it also contributes to the problem of antimicrobial resistance, ultimately with potential impacts on human health.

Litter and manure waste streams – a combination of different substances, including faeces, feathers, and wasted feed - contain nutrients and substances that pollute the environment. The intensity and scale of intensive production can accentuate both the concentration and impact of these substances. Nitrogen compounds (including ammonia), which can contaminate the air and affect soil and water quality, are among the nutrients that are contained in litter and waste streams. Phosphorous compounds, which can impact environmental balance, are also present; as may be heavy metals (which can cause contamination), antimicrobial residues and pathogens.

In addition to the impacts stemming from antibiotic usage and litter/manure waste streams in intensive broiler rearing systems, other by-products of this industry can impact the environment and human health. Dust can have a greater impact on broiler and human health in intensive production systems due to the typically large scale of production. The carcasses of birds that die on farm require disposal and can act as pollutants; and faster growing breeds – which tend to be used for intensive production – tend to have higher weekly mortality rates. Energy usage depends more on the design of the broiler house than the method of rearing; and the environmental impacts of feed under different systems depend on a variety of factors.

In view of the negative environmental, animal welfare and human health consequences stemming from intensive broiler farming practices, the adoption of alternative broiler production methods should be considered as a means to tackle these issues.

# 2. Intensive broiler farming practices in the EU: an overview

## 2.1. Intensive farming systems: an overview

Over recent decades the broiler industry (i.e. the industry of chickens that are reared for meat production) has been growing to supply consumers with inexpensive poultry meat (CIWF, 2013). Broilers can be raised in extensive or intensive systems. Intensive production systems are the most common in broiler rearing and are generally used by larger companies, as they are associated with large-scale meat production (FAO, 2004). Data on broilers in the EU by method of rearing is limited; however, an estimated 90% are raised in intensive indoors systems, with up to 5% in free range systems and around 5% in alternative indoor systems that are less intensive than those mandated by legislation or industry standards (CIWF, 2013a). 1% of broilers are reared in organic systems (European Commission, 2016).

As reported by CIWF (2018), in the EU, standard intensively farmed broilers are usually:

- Reared under high stocking densities (max. 33 kg/$m^2$, with possible derogations) without outdoor access.
- Bred for very fast growth, gaining over 50g per day and hence reaching market weight (around 2.2kg) in less than 6 weeks.
- Inactive especially in the last weeks of life, when broilers spend 15% of their time active.
- Reared in barren environments: broiler sheds are generally bare except for feeding and drinking points and litter (on the floor).

These practices have been highlighted by various pieces of literature as having a negative impact on animal welfare. Fast growth rates in particular have been identified as a factor that have a negative impact on various welfare aspects (EFSA, 2010).

As reported by FAO (2004), broiler intensive rearing systems can be either based on deep litter or slatted floors. In both cases, birds are confined in the poultry house, without access to outdoor areas:

- **Deep litter system**. The floor is covered with a deep litter made of different substances, including maize or rice, straw, and absorbent (but non-toxic) material. In a deep-litter system birds can move around the poultry house freely. This is the system which is most commonly used in the EU;
- **Slatted floor system**: In this case birds have reduced contact with faeces, which collect underneath the elevated slats. However, birds are allowed less freedom of movement within the poultry house. This system can allow stocking rates to be increased by five birds/$m^2$ of floor space.

## 2.2. Intensive broilers farming practices in selected EU Member States

The largest EU producers of poultry meat are (in order) Poland, UK, Germany, France, Spain, Italy and the Netherlands. These seven countries account for around three quarters of the total European production[1]. Council Directive 2007/43/CE[2] lays down minimum rules for the protection of chickens kept for meat production at the EU level, as reported in **Box 1**.

***Box 1: Key requirements under Directive 2007/43/CE***

- Poultry houses must allow all broilers adequate access to drinkers, feed, and dry and friable litter.
- Buildings must have adequate lighting during the lighting periods and sufficient ventilation.
- All chickens must be inspected at least twice a day.
- Chickens that are seriously injured or in poor health must be treated or immediately culled.
- Surgical procedures performed for purposes other than medical treatment are generally prohibited. Beak trimming and castration are allowed only in some cases.
- The maximum stocking density allowed is 33 kg/m$^2$. A stocking density of a maximum of 39 kg/m$^2$ is permitted if the owner complies with certain environment parameters. The stocking density may rise to a maximum of 42 kg/m$^2$ in exceptional cases.
- High-density poultry houses must be equipped with ventilation, heating and cooling systems to ensure appropriate temperature, humidity levels, and $CO_2$ and $NH_3$ concentrations.

**Table 1** illustrates the main similarities and differences in the implementation of the Directive in Poland, UK, Germany, France, and Netherlands. When transposing the EU Directive, these five countries adopted different rules in terms of:

- **Stocking density**: this largely varies from 33kg/m$^2$ in Poland to 42 kg/m$^2$ in the Netherlands.
- **Ventilation**: this varies based on house characteristics and temperature.
- **Temperature**: this varies depending on rearing stage and climatic conditions.
- **Production cycle**: each cycle can last between 35 and 45 days, with one or two weeks of empty period after depopulation.
- **Caponisation** (castration of cockerels) is allowed only in France, but its use is relatively limited.
- **Beak trimming**: where allowed (UK, France, Netherlands) is usually not practiced.

[1] According to data from DG Agri: https://ec.europa.eu/agriculture/sites/agriculture/files/dashboards/poultry-meat-dashboard_en.pdf

[2] Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0043&from=EN

**Table 1: Broiler farming practices in the EU**

| | PL | UK | DE | FR | NL |
|---|---|---|---|---|---|
| **Farm characteristics** | | | | | |
| Stocking density (majority) | 33 kg/m$^2$ | 38 kg/m$^{2*}$ | 39 kg/m$^2$ | 39-42 kg/m$^2$ | 42 kg/m$^2$ |
| Ventilation | Min. 1 m$^3$ of air per 1 kg of chicken/h | Largely varies depending on location, type and age of housing, as well as temperature. | Mechanical ventilation, with a minimum air replacement rate of 4.5 m3/h for each kg of liveweight. | - Older farms with cheaper ventilation systems are predominant.<br>- Newer farms have ventilation systems with changing air flows depending on the local temperature. | Largely varies depending on the age of the farm and on the farm income. |
| Luminosity | Max. 20 lux at bird eye level | Max. 20 lux at bird eye level | Max. 20 lux at bird eye level | Max. 20 lux at bird eye level | Max. 20 lux at bird eye level |
| Temperature | 30°C diminishing to 20°C with the aging of birds | Pre-heating (around 25°C); temperature increased to 34°C at placement, at 23°C by day 25 and then lowered to 18°C. | Does not exceed the outside temperature by +3°C when the outside temperature >30°C. | Does not exceed the outside temperature by +3°C when the outside temperature >30°C. | Usually 21-34°C |
| **Air quality** | | | | | |
| Concentration of $NH_3$ | Max. 20 ppm | Max. 20 ppm | Max. 20 cm$^3$/m$^3$ | Max. 20 ppm | Max. 20 ppm |
| Concentration of $CO_2$ | Max. 3000 ppm | Max. 3000 ppm | Max. 3000 cm$^3$/m$^3$ | Max. 3000 ppm | Max. 3000 ppm |
| **Animal welfare** | | | | | |

| | PL | UK | DE | FR | NL |
|---|---|---|---|---|---|
| Caponisation | Not allowed | Not allowed | *N.A.* | Allowed but limited | Not allowed |
| Beak trimming | Not allowed | Legally allowed but rare* | *N.A.* | Allowed but rare | Allowed but rare |
| **Production cycle and inspections** | | | | | |
| Production cycle (days) | 35-45 | 35-45 | 38-41 | 35 | 42 |
| Empty period after depopulation (days) | 10-14 | 7-10 | 8 | 14 | 7 |
| Inspections (times per day) | *N.A.* | *N.A.* | 2-4 | 2-3 | *N.A.* |

*Source: Agra CEAS Consulting (Food Chain Evaluation Consortium), 2017*

** The Red Tractor scheme, which covers the majority (90%+) of poultry meat produced in the UK, limits the stocking density at 38kg/m$^2$ and does not permit beak trimming, though UK legislation limits the stocking density to 39kg/m$^2$.*

## 2.3. Summary of key difference under higher animal welfare standards

Higher animal welfare standards for broilers have also emerged. **Table 2** presents an overview of the main standards and illustrates significant differences in comparison to the standard intensive farming methods required by the implementation of the EU Broiler Directive.

**Table 2: Key selected differences under higher welfare standards**

| | RSPCA Assured | Beter leven (1 star) | Tierschutzbund (premium) |
|---|---|---|---|
| Stocking density (majority) | 21-30 kg/m$^2$ depending on system of production | Max. 25 kg/m$^2$ | Max. 21 kg / m$^2$ |
| Luminosity | - Max. 20 lux at bird eye level<br>- 8 hours continuous light per day | - Mix. 20 lux (natural daylight)<br>- Min. 8h dark per day | - Mix. 20 lux (natural daylight)<br>- Min. 8h dark per day |
| Humidity | Max. 70% when outside temperature is < 10°C | *N.A.* | 50-70% (recommended) |
| Concentration of $NH_3$ | Max. 20 ppm | *N.A.* | Max. 15 ppm |
| Concentration of $CO_2$ | Max. 3,000 ppm | *N.A.* | Max. 3,000 ppm |
| Concentration of CO | Max. 50 ppm per 8 hours | *N.A.* | *N.A.* |
| Inhalable dust | 10mg/m$^3$ per 8 hours | *N.A.* | *N.A.* |
| Bird breed / slaughter age | Restrictions on breeds only breeds tested and approved by the RSPCA. No slaughter age specified. Growth rate: max **60g/day** for indoor use; **52g/day** for free range | Minimum slaughter age 56 days | Breeds that do not gain more than 45g per day. |

*Sources: RSPCA, 2017; Tierschutzlabel, 2017; Beter Leven, 2016.*

**Summary**

- Intensive broiler farming is typically characterised by high stocking densities, fast growth, large holdings and an indoor environment lacking in enrichment.

- There are slight differences in intensive broiler farming practices across the EU

- Some higher welfare standards for indoor rearing (with or without access to outdoor runs) have emerged.

- Taken together, alternative indoors, free-range, and organic broiler production systems still represent a small proportion of the total (around 10%)

# 3. The direct impact of intensive broiler farming practices on environment and human health

Intensification of production often results in environmental concerns and poses hazards to human and animal health. This section therefore focuses on the direct impact of intensive broiler farming practices on the environment (air, land, water, resources) and human health.

## 3.1. The use of antibiotics in the broiler industry

### 3.1.1. EU regulatory framework

The use of antibiotics other than *coccidiostats* and *histomonostats* as feed additives for broiler chickens has been forbidden in the EU since January 1st 2006 (Regulation 1831/ 2003)[3]. Antimicrobial agents are therefore administered to broilers for therapeutic purposes only, namely for treating bacterial infections (Landoni and Albarellos, 2015). Furthermore, the EU applies maximum residue limits (MRL) for antimicrobials in poultry products (within the limits imposed by Council Directive 96/23/EC[4] on the antibiotic residues in food and animal products (meat and eggs).

In other parts of the world lower doses of antimicrobial compounds can be used as feed additives to improve feed efficiency (Reinhardt, 2018).

### 3.1.2. The use of antibiotics in intensive broiler rearing systems

Intensive broiler rearing systems are associated with a considerable use of antibiotics for therapeutic purposes due to three major reasons:

- **Fast growing birds**. In intensive production systems, broilers are genetically selected for fast growth and typically slaughtered at 35-45 days of age. The fast growth rate of intensively raised broilers is associated with health and welfare problems also leading to high mortality rates, which means that these birds have a greater need for antibiotics for therapeutic purposes (ASOA, 2017, EFSA 2012). Antibiotic usage in poultry in the UK, for example, is 44 mg per kg of population correction unit (ASOA, 2016)[5].
- **High stocking density**. High stocking densities primarily cause thermal stress, which can compromise immunological function and is associated with intestinal injury (ASOA, 2017; EMA and EFSA, 2017). Furthermore, high stock densities increase the risk of transmission of diseases within flocks and in some cases, for example Salmonella, to humans (Djeffal et al, 2018).

[3] Regulation (EC) No 1831/2003 of the European Parliament and of the Council of 22 September 2003 on additives for use in animal nutrition, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003R1831&from=en

[4] Council Directive 96/23/EC of 29 April 1996 on measures to monitor certain substances and residues thereof in live animals and animal products and repealing Directives 85/358/EEC and 86/469/EEC and Decisions 89/187/EEC and 91/664/EEC, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31996L0023&from=en

[5] While this covers production under all systems in the UK, around 95% of broilers in the UK are reared under indoor systems in which birds are generally slaughtered between 35 and 40 days of age (https://www.britishpoultry.org.uk/identity-cms/wp-content/uploads/2017/02/BPC-Infographics-What-Is-Free-Range-and-Organic-Chicken-Meat.jpg)

- **High ammonia concentrations**. High levels of ammonia can also damage the birds' immune system, hence increasing the birds' vulnerability to bacterial diseases, especially *Escherichia coli* infections. Vulnerability to respiratory diseases is also increased by high ammonia concentrations. Infections are a major reason for the use of antibiotics in the poultry production chain (ASOA, 2017).

In the subsequent sections, the impact of antibiotics on the environment and human health is examined. The impact of drug residues in faeces will be further investigated in section 3.2.2.

### *3.1.3. Impact on the environment and human health*

The sections below focus on the impact on the environment and human health of the use of antibiotics in intensive broiler production. Beyond these impacts, intensive production as such has an impact on the environment and human health through management practices that negatively affect environmental indicators and contribute to higher prevalence of zoonoses.

**Impact on the environment:**

FAO (2008) reported that, irrespective of dose, an estimated 75% of antimicrobial agents administered to intensively reared broilers may be excreted into the environment; and other and more recent literature reiterates this estimate (Wongsuvan et al, 2018; Kummerer, 2009). As they are generally resist to biodegradation, antibiotics have been classified as emerging pseudo-persistent organic pollutants; and evidence suggests that antibiotics might have a toxic effect in the soil and aquatic environment.

- In waters, drugs residues can negatively influence the aquatic life and behaviour, hence leading to a **degradation of organic matter** (Kummerer, 2009), especially when combined with other antibiotics (Carvalho and Santos, 2016). Kummerer (2009) indicates that exposure to antibiotics in the environment may have adverse reproductive effects in the early life stages of different organisms, which may dramatically affect populations. Examples are the significantly depressed hatching rate for *Artemia sp. cysts* and the high mortality rate recorded for *nauplii*, as well as the toxic effects on reproduction of *Daphnia magna*. Since other aquatic animals feed on these organisms, their disappearance is likely to affect other organisms as well. Furthermore, antibiotics in the environment can also affect the behaviour of aquatic organisms, as is the case for Daphnia magna's directional movement (phototaxis).
- In the soil, antibiotics may cause different effects according to their physicochemical properties, soil characteristics, and climate conditions. Research demonstrated that acid rains accelerate the accumulation of antibiotics in animal manure and soil surface, while heavy rains enhance antibiotics' accumulation in deeper parts of the soil (Pan and Chu, 2017).
- Tests have shown that the presence of antibiotics in soil may lead to the development of resistant genes in bacteria in soils. The magnitude of longer-term impacts resulting from this risk are unknown (Danish Mund et al, 2016).

**Impact on human health:**

Both EU and international institutions strongly argue for the prudent use of antibiotics in both food producing animals and humans. This is based on well-accepted scientific principles to minimise bacteria resistance behaviour, which are endorsed by the international scientific community, including the FAO, the European food safety agency (EFSA), the World Animal Health Organization (OIE), the European Centre for Disease Control (ECDC), the European Medicines Agency (EMA-CVMP) and the World Health Organization (WHO). The four types of bacteria most commonly associated with antimicrobial resistance (AMR) in humans are Salmonella spp., Campylobacter spp., Escherichia coli and Enterococcus spp. Experts agree that these four types of bacteria are likely to be transmitted frequently from animals to humans, in particular through food[6]. Salmonella and Campylobacter are the two most reported zoonotic infections in Europe. However, over the last decade certain other bacteria (e.g., E. coli) have become a major and rapidly increasing problem. Furthermore, emerging evidence in the EU has shown that Staphylococcus aureus (including methicillin-resistant *Staphylococcus aureus* - MRSA) also occurs in food animals and can later be found in food products and environments shared with humans[7].

As the Alliance to Save Our Antibiotics (2016) reported, the administration of antibiotics to broilers has contributed to growing human resistance to antibiotics administered for infections like *Campylobacter* and Salmonella (bacterial infections), as well as *Escherichia coli* and *Enterococcus* (Nunan and Young, 2013). Given that there are no new classes of antibiotics in the pipeline, there is concern for the availability of effective critically important antibiotic solutions beyond the next 10 years to treat infections caused by resistant bacteria (EMA-CMVP).

The latest joint report by EFSA and the ECDC[8] (2016) shows both persisting prevalence of the main zoonoses affecting broilers and poultry meat in humans through food (Salmonella, Campylobacter, Escherichia coli) and persisting antimicrobial resistance to certain antibiotics commonly used to treat these infections in humans. The monitoring of some infections in food-producing animals focuses particularly on intensive production methods, and may extend beyond transmission through food to transmission to workers at farm level and beyond. For instance, studies monitoring MRSA both in intensive poultry and in humans show the occurrence of MRSA in farmers and those repeatedly exposed to livestock[9].

**Summary**

- Antimicrobial agents are administered to broilers in the EU for therapeutic purposes only.

- Intensive broiler rearing systems are associated with a greater use of antibiotics for therapeutic purposes due to high stocking densities, stressful conditions and fast growth rates.

[6] As concluded in the Report of the 1st Meeting of the WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance (WHO – AGISAR, 2009): *"[a] large number of studies have shown that the use of antimicrobial agents in food animals favours antimicrobial resistance among non-typhoid Salmonella and Campylobacter; later, these can transmit to and cause infections in people. This can then result in failure of antimicrobial treatment in people with resistant infections. … The main route of transmission between food animals and people is via contaminated food products."*

[7] WHO-AGISAR reports; ECDC/EFSA findings

[8] ECDC/EFSA (2018): The European Union summary report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2016.

[9] For example, Köck et al. (2017) state that LA-MRSA persistently colonises between 9–37% of poultry farmers, as well as 24% and 86% of pig farmers, 37% of cattle farmers, and a proportion of slaughterhouse workers (3–6%) and veterinarians (3–45%).

- This higher usage can impact the environment in several ways, including through the degradation of organic matter.

- It also contributes to the problem of antimicrobial resistance, ultimately with potential impacts on human health.

## 3.2. Management of litter and manure waste streams

### 3.2.1. Broiler nutrition and litter management

Broilers' litter is a combination of different substances, including faeces, feathers, and wasted feed. The tens to hundreds of thousands of animals reared in a single, intensive confinement production system produce an enormous amount of waste; for example, in the EU, broiler farms holding over 5,000 birds account for almost 94% of production (European Commission, 2016). According to Eurostat data, the 1,550 EU poultry holdings with more than 100,000 head have an average of 219,665 head each. A Broiler produces about 0.036 kg dry matter per day, of which around 70% is manure, and the remainder is the litter base (Celignis Analytical, 2014). Therefore, broiler litter must be properly managed in intensive production systems, to prevent the contamination of air, soil and water, as well as negative consequences for human health (Thyagarajan et al, 2014).

### 3.2.2. Impact on the environment and human health

Broiler litter is rich nitrogen, phosphorus, potassium, and other nutrients which play a vital role in crops growth. For this reason, broiler manure is largely used as a fertiliser in agriculture.
However, as reported in **Table 3**, poor litter management may pose some environmental challenges and risks for human health, which are mainly related to:

- nonpoint pollution of surface waters with nitrogen and phosphorous;
- ammonia emissions through litter production, storage, handling, and land application;
- builds up in soils of heavy metals, such as arsenic, copper and zinc, which can also pose a risk to human health;
- spread of parasites to water supplies;
- antimicrobial residues contamination of groundwater.

### Table 3: Litter substances and their potential impact on the environment

| Nutrient/ Substance present in manure | Potential environmental impact | | Risks posed to human health |
|---|---|---|---|
| | Gas emissions | Soil, resources, and water contamination | |
| **Nitrogen** | Ammonia, Dinitrogen, Nitroux oxide, and Nitrate emissions | Nonpoint pollution of surface water | |
| **Phosphorus** | Phosphate emissions | - Builds up in soil<br>- Nonpoint pollution of surface water<br>- Limits biological activity in waters | |
| **Arsenic**<br>**Copper**<br>**Zinc** | | - Toxic to plants<br>- Contamination of water through surface run-off and leaching<br>- Potential re-entry into the food chain through feedstuff contamination | Accumulated heavy meal exposure in the feed chain |
| **Antimicrobial agents** | | Contamination of water and groundwater resources | Development of antimicrobial-resistant bacterial strains |
| **Pathogens** | | Pathogenic agents may spread to water supply | |

*Source: Agra CEAS based on FAO (2008)*

Some of these challenges might be greater in intensive systems, as further investigated below.

### Nutrients

*Nitrogen (N)*

According to FAO (2008), broilers raised in intensive production systems consume a great amount of protein and other substances containing nitrogen. Most of this nitrogen (approximately 50-80%, as estimated by FAO) is then excreted. As a result, nitrogenous compounds are released as gases into the atmosphere. A 2013 European Commission report indicates that nitrogen compounds, i.e. ammonia, nitrogen oxides, and nitrous oxide gases contribute to **contamination of the air**. Similarly, reactive nitrogen (i.e. nitrites, nitrates, and ammonium) pollutes air when it is part of aerosol particles (see section 3.3), **affecting soil and water quality** through surface run-offs and leaching into surface and ground waters.

In terms of human health, research suggests that the inhalation of huge amount of nitrogen dioxide can harm the human respiratory tract and increase human vulnerability to respiratory infections and asthma (Queensland Government, 2016).

**Box 2: *Ammonia emissions***

Ammonia ($NH_3$) emissions in intensive broiler rearing systems can be particularly high, given that higher stocking densities promote thermal stress in the birds which is associated with the release of ammonia gases (ASOA, 2017).

$NH_3$ has been recognised as a **major air pollutant** due to its harmful effects when absorbed by land, water, and vegetation. The ammonia deposition is associated with: soil and water acidification, eutrophication and subsequent loss in biodiversity, as well as increases in greenhouse gases (GHG) emissions. Furthermore, **high concentrations of ammonia in poultry housing** can reduce feed intake, impede bird growth and increase bird susceptibility to certain diseases (FAO, 2008; Broucek et al, 2015).

*Phosphorus (P)*

Phosphorus is the second most abundant element in broilers' body after calcium, as it is present in most poultry feed (IFP – CEFIC, 2018; Landoni and Albarellos, 2015). Excessive phosphorus in a local area can cause environmental imbalance; it may stimulate excessive algae growth in rivers, limiting wider biological activity in water resources; and can also build up in soil. Furthermore, it is responsible for **phosphate emissions** (FAO, 2008). In order to prevent the excessive production of phosphate emissions it is recommended to reduce the phosphorus in broilers' diet from organic sources, which cannot be easily digested by birds due to a lack of the enzyme needed for the assimilation, i.e. the phytase (Humer et al, 2014). Nevertheless, this is not likely to happen in intensive broiler production, where feedstuff tends to contain high amounts of phytic acid, i.e. organic phosphorus (Bolan et al, 2010).

**Box 3: *Nutrient pollution of surface waters***

Runoffs from poultry farms contribute to the contamination of water sources particularly with phosphorus and nitrogen. These nutrients are called 'nonpoint' because they involve widely dispersed activities. As indicated above, phosphorous and nitrogen may be present in larger quantities in the manure of broilers reared in intensive systems. High levels of these substances in water sources cause the **loss of aquatic biodiversity** (Shortle and Horan, 2016).

## Heavy metals

Minerals such as arsenic (As)[10], copper (Cu) and zinc (Zn) are largely used as feed additives and veterinary medicines, to facilitate weight increase and prevent the spread of diseases among intensively-raised broilers (Okeke, 2015). Nonetheless, the excretion of these elements may pose some risks for the environment and human health (FAO, 2008). Heavy metal toxicity is the foremost challenge, due to its bioaccumulation through the food chain, which may ultimately pose risks for

[10] Arsenic is considered an "undesirable substance" in the EU. In accordance with EU Directive 2002/32/EC, the use of arsenic as a feed additive is limited because of its potential danger to animal or human health, the environment, as well as the livestock production.

human health through heavy metal poisoning (Musa et al, 2013). Large amounts of heavy minerals in broilers litter might indeed be responsible for:

- High **level of toxicity in plants**;
- Risks of heavy metal poisoning for the animals that feed on these plants;
- **Contamination of water sources** through surface run-off and leaching;
- **Contamination of feedstuff** and subsequent negative impact on animal health (FA0, 2008).

**Antimicrobial residues**

As already indicated in section 3.1, evidence suggests that intensive broiler rearing systems still make substantial use of antibiotics[11], mainly due to high stocking density and faster growing birds (ASOA, 2017). Antimicrobial agents[12], which are mostly administered to broilers for therapeutic effects, may be excreted into the environment, leading to the development of **antimicrobial-resistant bacterial strains** in humans (see section 3.1.3). Furthermore, evidence indicate that antimicrobial residues in manure might also be responsible for the **contamination of soil, surface water and groundwater** resources close to farms involved in intensive broilers rearing activities (FAO, 2008).

**Pathogens**

In case of poorly managed litters, pathogens in manure may easier **spread in soil and water resources**. Evidence suggests that parasites such as *Cryptosporidium* and *Giardia spp* can easily spread from manure to water supplies and can remain viable in the environment for long periods of time (Vermeulen n et al, 2017); hence increasing the risk of animal and human infectious diseases being caused by these pathogens.

**Summary**

- Litter and manure waste streams contain nutrients and substances which pollute the environment; and the intensity and scale of intensive production can accentuate the impact of these substances.

- Nitrogen compounds (including ammonia), which can contaminate the air and affect soil and water quality, are among these.

- Phosphorous compounds, which can impact environmental balance; heavy metals, which can cause contamination; antimicrobial residues and pathogens can also be found in litter and manure waste streams.

## 3.3. Other impacts

[11] It is important here to clarify that all antibiotics are antimicrobials, but not all antimicrobials are antibiotics. Therefore, antimicrobial residues in the text shall be understood as 'antibiotics residues'.

[12] An antimicrobial agent kills or inhibits the growth of microorganisms like bacteria, fungi, parasites, virus etc. (Journal of Antimicrobial Agents, https://www.omicsonline.org/antimicrobial-agents.php)

### 3.3.1. Management of dust

#### Broiler dust

Broiler dust consists of substances such as feather fragments, faeces, skin debris or dander, feed particles, and bacteria (Jerez et al, 2014). High densities and broilers' confinement in enclosed buildings causes a higher concentration of airborne dust and microorganisms in the form of bioaerosols (HSE, 2016); and the higher number of animals increases the scale of the overall issue. These so-called fine particles, or $PM_{2.5}$ (i.e. with a size range of 2.5 micrometres), are small enough to reach the lungs when inhaled by humans (Viegas et al, 2013).

There are several activities in intensive broiler farming that create airborne poultry dust, including:

- Laying down bedding;
- Populating poultry houses with young birds;
- Cleaning the poultry house;
- Depopulation of the poultry house and final clean;
- Litter/manure management (HSE, 2016).

The presence of broiler dust can ultimately cause respiratory diseases in birds kept in intensive systems.

#### Dust inhalation impact on human health

Evidence suggests that occasional or chronic inhalation of poultry dust might cause respiratory diseases in humans, on the basis of the length of the exposure, as set out below:

- Toxic pneumonitis, or organic dust syndrome, i.e. an acute inflammatory reaction in the airways and fever (Malmberg and Larson, 1993);
- Increased phlegm production and pulmonary inflammation 4 to 10 hours after an occasional exposure; and
- Bronchitis and asthma following a chronic exposure to dust (Cole et al, 2000). People working on intensive broiler farms are therefore at risk. Given the negative impact dust may have human health, EU Directive 2008/50/EU[13] has introduced limits on particulate matter, including dust, as set out below:
- 40 $\mu g/m^3$ yearly limit, or 50 $\mu g/m^3$ daily limit on coarse particles ($PM_{10}$)[14], with maximum 35 permitted exceedances each year, and 25 $\mu g/m^3$ yearly for fine particles.

### 3.3.2. Management of on-farm carcasses

*This section focuses on risks from on-farm carcasses (i.e. carcasses of broilers that died on the farm; for example, of natural causes) may pose to the environmental and human health. The impact of carcasses*

[13] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0050&from=EN
[14] Particulate matters with a diameter of 10 micrometers (μm).

*resulting from the slaughtering of broilers is therefore not taken into account, as this relates to the slaughter stage of the broiler production chain and therefore is primarily determined by slaughterhouse practice.*

On farm mortality rates can be impacted by a number of factors, including notably[15]:

- ***Breeds***: faster growing breeds (which are generally used in intensive production) typically suffer higher weekly mortality rates compared to slower growing or higher welfare breeds.
- ***Physical condition of the bird***: weaker birds are more susceptible to pathogens and ultimately death.
- ***Suitability of housing***: high levels of mortality often occur during periods of extreme environmental temperature; unsuitable housing in extreme climates can therefore play a role.

## The disposal of carcasses in the EU

Birds that die prematurely of disease or other factors can attract rats, flies, and other animals that can act as external vectors of infection. For this reason, Regulation 1069/2009[16] imposes strict requirements for the disposal of poultry carcasses from broilers that died other than by being slaughtered. A number of possible disposal methods are set out for these carcasses, including incineration.

## Impact on the environment and human health

As a starting point, the environmental impact of on-farm carcasses is affected by: the number carcasses / mortality rate; method of disposal; and composition of the carcasses (which is affected by cause of death, diet, antibiotic usage, breed, etc).

Improper management of broilers carcasses can pose serious environmental and human health risks. In particular, the US EPA (2017) indicates two possible threats for the environment from improper disposal, as set out below:

- Water contamination in areas prone to flooding or where there is a shallow water table.
- Release of nutrients, pathogens and other components of the decomposed body (see also section 3.2.2) into the environment.

As is the case with poultry litter, broilers carcasses also transmit pathogens with zoonotic potential, such as Avian Influenza (some strains), fungi, bacteria, parasites and mites (see also section 3.2.2). On the occasion of recent outbreaks, i.e. avian influenza (HPAI), it was observed that large volumes of carcasses could generate **large amounts of leachate and other pollutants**, hence increasing the risk of air, water and soil contamination (US EPA, 2017).

[15] Under Directive 2007/43/EC, on farm mortality rates for stocking densities above 33kg/m2 must be recorded.

[16] 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, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:300:0001:0033:EN:PDF

### *3.3.3. Resource use associated with intensive broiler farming practices*

*This section is about the on-farm consumption of resources (e.g. the energy consumption at poultry houses) and their impact on the environment and human health. The impact of feed production is presented in section 3.6.2. Resource use associated with other stages of the production chain (e.g. slaughtering, transport, international trade) fall outside the area of intensive farm production and hence are not covered.*

Intensive broiler farming practices involve large use of energy for heating, ventilation and air conditioning systems, which result in carbon dioxide emissions. However, quantification of the energy consumption of intensive poultry farms is challenging as poultry houses are not all the same. **Table 4** indicates a range of energy use values in broiler production, which vary with the technologies applied, the production characteristics of the farms, as well as climatic conditions (FAO, 2008).

**Table 4: Ranges of energy use values in broiler production**

| | kWh/m$^2$ year | Wh/kg meat | kWh/bird place/year (basic housing system) |
|---|---|---|---|
| **Heating** | 86-137 | 380-758 | 4.5 |
| **Ventilation** | 4-11 | 21-46 | 0.73 |
| **Lighting** | N. A. | N. A. | 0.33 |
| **Total electrical energy** | 7-16 | 48-81 | |
| **Total thermal energy** | 86-137 | 380-758 | |
| **Total energy consumption** | | | 5.84 |

Source: Costantino et al (2016); JRC (2017).

In summary, available evidence suggests that energy use depends more on the design of the poultry house itself than the nature of the system (intensive or otherwise).

In terms of land use, production systems where broilers are reared more intensively (i.e. more animals per area) are considered to use less land than extensive or alternative systems. Nonetheless, this conclusion ignores the broader socio-economic framework. For example, according to a Food Climate Research Network, intensive systems, "*with their lower employment- per-output rates, and higher profitability, have undermined small scale farming, so forcing small holders to expand onto more marginal areas simply to survive*" (Garnett, 2010). Nonetheless, Garnett underlined that the complex socio-economic framework behind intensive broiler production systems has not been researched in sufficient depth to provide robust conclusions.

### *3.3.4. The impact of feed production for intensive broiler farming practices on the environment*

#### Feed consumption in intensive systems

Broiler feed includes cereal grains, protein meals, fats and oils, minerals, feed additives, and various raw materials, such as roots and tubers. Cereals are the major source of feed for broilers – accounting for approximately 60% of their diet, according to FAO. In the EU, wheat is the main cereal used in the broiler production (Poultry Hub, 2018; FAO, 2008). Nonetheless, soy is an important component of broiler feed. According to figures from Rabobank (2017), soy comprises around 15% of animal feed as a whole, with the percentage slightly higher in the case of broiler feed. According to Eurostat data, some 95% of soy used in the EU is imported from third countries.

Feed consumption by production system is difficult to estimate, as this depends on several factors, such as temperature and the characteristics of the poultry farm, including managerial ability, the precise composition of the feed and the method of production and source of the crops used in the feed.

Intensive broiler production systems are likely to use imported soy in feed, partly because conventional production can use GM soy, which constitutes the majority of soy imports. This has knock-on effects stemming from intensive feed production (see below) and GHG emissions arising from the long-distance transport of soy. However, there are alternative and sustainable potential feed sources. For example, WUR (2011) suggested the use of seaweed and algae, human garbage, other waste products, worms or grass. WUR also indicated that local production in greenhouses can be a sustainable alternative to prevent high GHG emissions.

## Environmental impacts related to feed production

One consequence of the increasing demand for broiler feed is that feed production has been more and more intensified. Intensive feed production involves the use of artificial fertilisers and pesticides and has therefore an environmental footprint (CIWF, 2003). As reported by FAO (2008), feed production – especially when intensive – major impact on the environment concerns especially:

- **Pollution of land and water resources**, mainly due to the intensive use of mineral fertiliser, pesticides and herbicides in crops production.
- **Air pollution**, due to the application of nitrogen fertiliser to cropland, which causes the volatilisation of ammonia.
- **Land-use and land-use change**, due to the expansion of cropland for feed production, as a result of an increasing demand for feed in intensive systems. In most cases forests are converted into cultivable lands, hence contributing to **deforestation**. Deforestation has in turn an impact on water cycles and runoffs, hence contributing to **soil erosion**. Changes in land use can also boost **GHG emissions** and thus contribute to climate change, as indicated in **Box 5**. Land use and land-use change are also responsible for the **modification of natural ecosystems and habitats**, which contributes to biodiversity loss.

Intensive broiler production systems may use feed from intensive production sources that use fertilisers and pesticides, with the resulting environmental impacts set out above. On the other hand, restrictions on feed sourcing imposed by production systems such as organic means that the impact arising from these factors will be limited *vis-à-vis* intensive systems.

***Box 4: Feed production and GHG emissions***

The intensification of feed production is responsible for emissions of GHG gases, as set out below:

- **Carbon dioxide** ($CO_2$) is produced by the burning of fossil fuels during the manufacture of fertiliser.
- Intensive broiler production is indirectly associated with **Nitrous oxide** ($N_2O$) emissions, because of the sector's high concentrate-feed requirements and the related emissions from arable land due to the use of nitrogen fertiliser (FAO, 2008).

Overall, FAO (2008) estimated that **intensive poultry production** (indirectly and directly) **contributes to approximately 2% of the global GHG emissions** from the livestock sector. This estimate though does not include emissions from land use and land-use change associated with feed production or emissions related to transport of feed.

**Summary**

Other impacts include:

- Dust, which can impact broiler and human health. While present in all broiler production systems, the scale of intensive production can accentuate the issue.

- On farm carcasses, which require disposal. Faster growing breeds – which tend to be used for intensive production – tend to have higher weekly mortality rates.

- Energy usage, which tends to depend more on the design of the broiler house; and feed, the impacts of which depend on a variety of factors.

# 4. Conclusions

Intensive broiler farming methods across the EU vary but are generally characterised by high stocking densities (>38kg / $m^2$), short production cycles (around or under 40 days) and large flocks with 38% of birds in the EU held on farms with at least 100 000 head of poultry. All this typically leads to a high environmental concentration in a small spatial area.

A major sustainability concern arising from intensive broiler farming practices is the continuing high reliance on antibiotics to counteract the negative health effects arising from high stocking densities and fast growth rate of the chickens; and the resulting impacts of this antibiotic usage on the environment, animal welfare, as well as human health and antimicrobial resistance more broadly. The latter is a particularly concerning long-term risk; while there are already clear indications of, and impacts from, increasing antimicrobial resistance, it is generally recognised that more substantial impacts can be expected in the long-term if action is not taken.

Further significant concerns can arise from litter and manure waste streams in intensive broiler production systems. Local pollution issues may arise from the high concentration of certain nutrients and heavy metals in manure; and the spread of antimicrobial agents and pathogens, with resulting impacts on antimicrobial resistance and the potential for the spread of diseases.

Finally, the high concentration of dust present in intensive broiler farms may lead to air pollution within the broiler house, with resulting impacts on the respiratory functions of both birds and broiler house workers.

As a result of these various issues in intensive chicken production, the adoption of other broiler production methods should be considered. While antimicrobial resistance continues to be a key issue of concern across the EU, the impact of intensive chicken production on the environment and on animal welfare also provides an imperative to consider alternative broiler production methods.

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