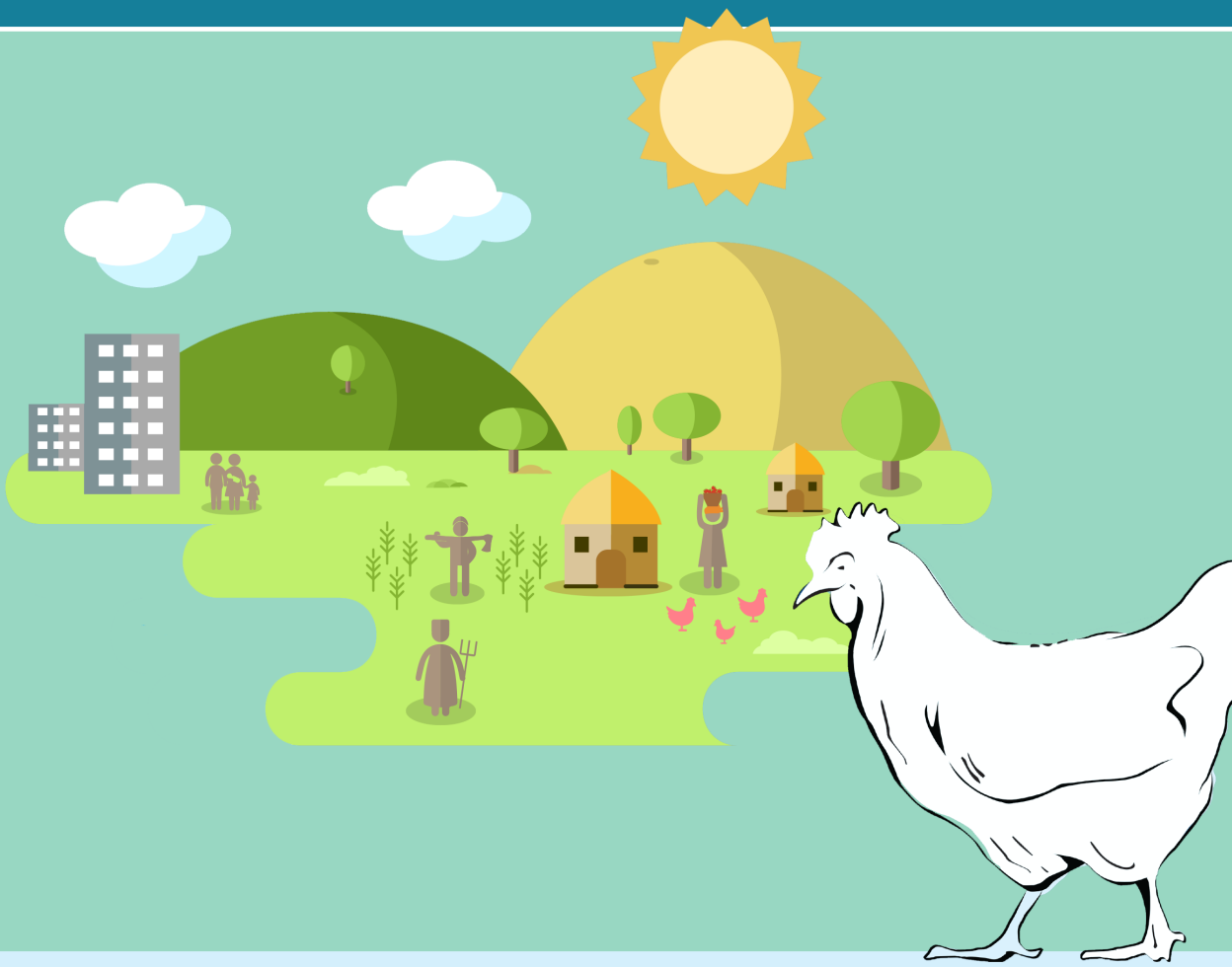
Food and Agriculture Organization of the United Nations

AFRICA SUSTAINABLE LIVESTOCK 2050

Pilot Intervention: Safe Disposal of Daily Poultry Mortality in Broiler Farms through Composting

EGYPT



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Executive summary

Unsafe methods of disposal of daily poultry mortalities in Egypt pose great environmental and public health threats. Twenty-one thousand Egyptian broiler farmers unsafely dispose of around 39 million poultry carcasses by throwing them along the roads, feeding them to stray dogs, or throwing them in water and drainage canals.

The African Sustainable Livestock 2050 project (ASL 2050) facilitated an innovative public–private co-creation process to identify sustainable and scalable solutions implementable with existing capacities and resources. The participatory dialogue started by identifying the priority practices in small and medium-scale broiler farms, which negatively affect the environment and public health. The priority practice selected by both sectors was the safe disposal of daily mortalities. An in-depth study was later performed to assess the best method of safe disposal of daily mortalities with respect to the feasibility, cost, and benefit of each one. Composting was the public and private sector's suggestion and was one of the most favored solutions. The reason for selecting this solution is based on evidence and could be summarized as follows:

- **Technically feasible:** as composting is doable by most broiler farmers using their current resource envelope.
- **Profit-enhancing:** as in most cases composting poultry carcasses increases the profit of the broiler farmers and, therefore, improves their livelihoods.
- **Self-sustainable:** farmers have incentives to maintain a profitable business model.
- **Institutionally implementable:** as frontline animal health officers are not expected to pay regular visits to poultry farmers to provide advice on poultry composting, but a few visits should suffice to support "a once-for-all" business change.
- Beneficial to **reduce public health and environmental risks**.

A pilot study was conducted in Menoufia and Qalyubia governorates in 25 farms for 36 production cycles to assess the on-ground effectiveness of composting as a disposal method. The main steps followed to implement the pilot are:

- Prepare technical guidelines on composting dead poultry.
- Conduct training of trainers (ToT), where an expert in composting trained the field veterinarians on how to compost dead birds.
- The field veterinarians train the farmers in the composting process.
- Purchase of soil thermometers to be used by field veterinarians for monitoring the compost temperature during the process.
- Mini wood composters are manufactured and given to the farmers participating in the pilot for free.
- Develop a data collection sheet to collect the required data about the farm and the pilot.
- The trained field veterinarians conducted weekly monitoring visits to the farms to follow up on the process, collect data on inputs and outputs, and identify the challenges encountered.
- 23 samples from the produced compost are sent to the Soil, Water, and Environment Research Institute (SWERI) for analysis with respect to the composition, presence of pathogens, plant pathogenic nematodes, and fungi.
- SWERI developed a brief on the benefit of using compost in agricultural land, and how to maximize the profit from composting by producing extracts such as humic acid and compost tea.

Key findings and results of the pilot

- Composting solved a key problem that the participating farms faced daily, which is the disposal of mortalities.
- The average recorded quantities of input and output from all farms show that adding 138 kg of dead birds to 73 kg of litter and 38 kg of sawdust (total of 251 kg) produced 127 kg of compost after an average maturation period of 24 days since adding the last layer.
- The results of testing the compost products for composition show that all samples have achieved the standard level of nitrogen, phosphorus, and potassium based on the Egyptian standard guideline for compost.

- ◊ **70 percent of the samples are free from pathogens.**
- ◊ **100 percent are free from nematodes pathogenic to plants and weed seeds.**
- ◊ **30 percent required more time for maturation.**

- The participating farms witnessed an average increase of 1 percent in their net profit margins during the cycle of the pilot compared to the previous cycle by selling the produced compost or using it in agricultural land.
- The pilot succeeded in changing the behavior of 47 percent of the participating farms. Almost half of the farmers sustained adopting composting as their preferred method of disposal of daily mortalities.

According to the results achieved, it is expected that scaling up the pilot would create a major impact on public health and environment, and on the profitability of farms represented in the following:

- Reduce the risk of dead birds thrown everywhere which increases the probability of the spread of pathogens and AMR transmission to soil and water and consequently to other animals and humans.
- Increase the amount of produced organic fertilizers, which can replace chemical fertilizers that have harmful effects on humans through residues in vegetables and fruits and burdens the government in subsidizing its price.
- Create a safe environment by avoiding water pollution from dead birds thrown in canals, as well as avoiding air and soil pollution, and the increase of insects from the decomposition of dead carcasses.
- It was proven from numerous studies that compost used in agricultural land assists in repairing the land composition to be more beneficial to plants and increases productivity. Therefore, the production of compost from animal origin on a larger scale will benefit the old and new agriculture land.

Context and background

Poultry production is the key source of protein in Egypt, where there are approximately 21 000 broiler farms. Large integrated companies have their own slaughterhouses and sell poultry meat either chilled or freeze to large supermarkets chain while the rest of farms sell their birds through traders to the live poultry shops in all governorates of Egypt and represent 71 percent of the poultry meat produced.

The consumption of poultry meat from live poultry vendors reached around 720 thousand tonnes in 2016, with a relative share of 64 percent followed by 327 thousand tonnes for frozen poultry representing 29 percent of the total consumption of poultry meat in 2016. As for chilled poultry and poultry meat products, their relative share has reached around 7 percent, with a total consumption of 78 thousand tonnes.[1]

The Emergency Centre for Transboundary Animal Diseases African Sustainable Livestock 2050 project (ASL2050) launched a public–private policy dialogue to assess the business model of broiler farms and their compliance with legislated biosecurity practices. While broiler farms are a profitable business, they often adopt rudimentary biosecurity practices, such as unsanitary waste management, unsafe disposal of dead birds, unsafe use of antibiotics and drugs, which negatively affect the environment and public health. ASL2050, therefore, further supported a co-creation process in Menoufia and Qaliobia governorates for stakeholders to identify actionable options to improve biosecurity, comply with the law, and minimize the risk of negative effects of poultry production on the environment and public health. In the Egyptian context, co-creation was a collaborative partnership where broiler farmers and animal health officers jointly designed a policy implementation mechanism that is a set of complementary public and private actions that facilitate the implementation of the existing policy and legal framework.

Broiler farmers and animal health officers agreed to start with one biosecurity practice, and that the unsafe disposal of daily mortalities, or dead birds, was one that created major environmental and public health threats and had to be changed. A survey conducted in Menoufia and Qalyubia governorates proved that the largest majority of small and medium broiler producers give bird carcasses to dogs or throw them along the roads or into drainage and water canals. In particular, available data indicates that broiler production in Menoufia and Qaliobia exceeds 68.1 million birds annually.[2] The average mortality rate is 7.5 percent, which makes the total number of mortalities per year in those governorates around 5.1 million birds. Data also indicates that 75 percent of farmers do not properly dispose of dead birds, with about 3.8 million birds unsafely disposed of each year in Menoufia and Qalyubia governorates. Extrapolating this figure to the country level means that, in entire Egypt, around 38.8 million poultry carcasses are unsafely disposed of every year. This has huge negative impacts on the environment and human health, such as water pollution and the spreading of pathogens.

The Egyptian government is fully committed to protecting the environment and public health, which is reflected in the Sustainable Agricultural Strategy towards 2030 as well as in the existing legislative framework that bans the unsafe disposal of poultry carcasses, dead animals and organic material in general.

1 FAO - 2017 . Broiler poultry industry: investment challenges and opportunities. https://greenbs.org/wp-content/uploads/2020/08/Egypt-Poultry-Sector-2017.pdf

2 CAPMAS 2020. Central Agency for Public Mobilization and Statistics. Annual Bulletin of Livestock Statistics 2018; Cairo, Egypt.

- The Sustainable Agricultural Development Strategy towards 2030 includes a variety of objectives including "*Improving environmental conditions and public health in rural areas*".
- Article 130 of Agriculture Law No. 53 / 1966 states that "*Dead animal bodies are forbidden to be thrown in any water canals, Nile or Nile branches, outer space or along roads and should be sanitarily buried in designated areas*"[3].
- The Waste Management Law 202 / 2020 states that: "*Dumping hazardous waste in Egypt's territorial waters is prohibited*", with hazardous waste defined as "*waste that contains organic or non-organic components or compounds that have a harmful effect on human health or the environment as a result of their physical, chemical or biological characteristics*". It also states that: "*the disposal of agricultural wastes in waterways is prohibited*." Penalties for violating the law range between EGP 1 000 (USD 65) and EGP 1 000 000 (USD 65 000) and violators can be also imprisoned for up to 5 years. Members of the Water Management Regulatory Authority are granted law enforcement authority[4].

Existing laws, however, are not fully enforced, which is likely due to two main reasons:

- Farmers perceive properly disposing of dead poultry as a net cost for their business and believe that it is cheaper to throw carcasses away than to incinerate/bury/compost them.
- Public officers are often few and over-committed and hence not in a position to regularly monitor the behavior of broiler farmers and issue a penalty when they throw dead birds along the roadside or into waterways.

Trial of composting the daily mortalities in broiler farms

Broiler farmers and animal health officers explored different options to properly dispose of dead poultry, from burying to incinerating, from selling them to cookers to composting them. In particular, they look at the technical feasibility, investment, recurrent costs and benefits of each of the methods. They concluded that composting was the most favored solution. Composting is:

- **Technically feasible,** composting is doable by most broiler farmers using their current resource envelope.
- **Profit enhancing,** as in most cases composting poultry carcasses increases the profit of the broiler farms and, therefore, improves their livelihoods.
- **Self-sustainable,** as farmers have incentives to maintain a profitable business model.

A layer of dead birds added to the compost pile.

Compost pile after the decomposition of birds and maturation.

3 Source: https://www.lexology.com/library/detail.aspx?g=cf552e4e-99f7-4f6d-b2b0-8130d2e6bd14
4 Source: http://www.lynxegypt.com/assets/pdfs/Waste-Management-Law.pdf

- **Institutionally implementable,** as frontline animal health officers are not expected to pay regular visits to poultry farmers to provide advice on poultry composting, but a few visits should suffice to support "a once-for-all" business change.
- Beneficial to **reduce public health and environmental risks**.
  - ◊ **It reduces public health risks and costs.** There is evidence of high load of pathogenic organisms in the Nile River and its branches - including bacteria, protozoa and viruses, which could translate into human diseases when water is used either for drinking or for irrigation[5].
  - ◊ **It minimizes the risks that poultry carcasses end up polluting soil and water. For example, foul odor, the spread of pathogens in the environment, as well as scavengers and insects that can spread diseases from the carcass to other animals or humans.** Pathogens from dead carcasses are also easily spread through water, which is used for both drinking and irrigation causing risk to human health, as well as the probability of transmission of antimicrobial resistance genes..

Once stakeholders agreed on composting as the best method to properly dispose of poultry carcasses, the issue became how to implement it in practice. Broiler farmers and government veterinary services officials agreed to start with a trial and developed a work plan that identified the requirements for implementing the trial, the steps to be taken and the roles and responsibilities of the various actors. Eventually, implementing the composting trial included a preparatory phase, an implementation phase and an evaluation.

Public and private sectors stakeholders' workshop to wrap up the field intervention, Cairo- Egypt.

Preparatory phase

The preparatory phase consisted of the following steps:

1. Contracting an expert in composting to develop guidelines on the composting process and train the veterinarians and farmers.
2. Selecting the districts where to implement the trial. We started with two governorates, two districts in each one, including Ashmoun and Quwesna in Menofia governorate and Banha and Kafr Shokr in Qaliobia governorate. These districts have small and medium-scale broiler farms with low to medium biosecurity level; the production is in an open house system either one house per farm or multiple vertical houses (several floors).
3. Selecting field veterinarians at district level to be assigned as the core field team to be.

5 Samy I. El-Kowrany, Enas A. El- Zamarany, Kholoud A. El-Nouby, Dalia A. El-Mehy, Ehab A. Abo Ali, Ahmad A. Othman, Wesam Salah, Ahmad A. El-Ebiary, Water pollution in the Middle Nile Delta, Egypt: An environmental study, Journal of Advanced Research, Volume 7, Issue 5, 2016. https://www.sciencedirect.com/science/article/pii/S2090123215001137

4. Identifying the farmers who will participate in the trial. An orientation meeting on poultry composting was organized for broiler farmers in the two districts after which farmers could themselves agree or not agree to participate in the trial. Self-selection by farmers, even though biased, definitely helped test the hypothesis that poultry composting is good for the business as the participating farmers were expected to be proactive. We can consider them as the early adopters of an innovation, those willing to assess innovative ideas that, if effective, will then be taken up by the majority of farmers.
5. Providing the technical specifications of mini-composters to be manufactured for use in some of the farms where the trial will be implemented.
6. Developing data collection sheet (Annex 1) on biosecurity, farm information and farm budget and organizing weekly data collection on the composting process.

One-off investments

1. Prepare guidelines on composting.
2. Training of field veterinarians.
3. Training of farmers.
4. Provide specifications of mini-composters to be manufactured for use in farms.
5. Develop advocacy material to demonstrate the process of composting.
6. Purchase of soil thermometers.

Implementation phase

The implementation phase consisted of the following steps:

1. We started with the organization of a TOT for field governmental veterinarians. Twenty were trained in (i) technical guidelines for composting dead poultry; (ii) the business dimension and profitability associated with composting dead birds; (iii) data collection for monitoring of the trial. We provided the field government veterinarians with soil thermometers to help monitor the appropriateness of the composting. These veterinarians represent a qualified team of public officers that fully understand the composting process and can act as an asset for scaling up in the near future.

Training of Trainers (ToT) of public field veterinarians on composting process, Cairo- Egypt.

2. Field veterinarians held training events for broiler farmers and poultry farm workers in each of the target districts – one training per district. The training included both theoretical and practical parts on how to compost dead birds and the business dimension of composting. A total of 48 participants were traine d in the representation of 21 broiler farms.

Training of the broiler farmers on composting the dead birds, Qualiubia and Menoufia Governorates- Egypt.

2. Each farm could start the trial at the beginning of the broiler production cycle. Accordingly, field veterinarians created a list of participating farms stating the farm name, location and start date of production. Implementation started consequently from day 1 of the production cycle in all farms with the field trial running from April to September 2022.
3. Farmers used two methods of composting: use of composting bins and piling. We provided composting bins to farms with the problem of stray dogs and no fence, and hence that could not simply pile dead birds and organic matter on the floor. The size of the composting bin was accurately based on flock size and expected mortality rate.

Table 1: Mini composter dimensions and capacity

Length	100 cm
Width	90 cm
Height	120 cm
Total volume	1.08 m3
Total mortality	Up to 280 kg

Table 1: calculation from Dr Sherif Moubarak, consultant on composting, Faculty of veterinary Medicine Cairo university

4. After starting the trial implementation, we realized that a reference guide detailing the various steps of composting could have facilitated the work at farm level. Accordingly, we developed a guide flyer on the composting process and distributed it to farmers.
5. Veterinary officers performed weekly field monitoring visits to follow up on the composting process at the farm level, collect data on inputs and outputs and identify challenges.
6. We organized a mid-time review in the two governorates to discuss and solve the identified challenges. A total of 43 stakeholders representing the participating farms and the field veterinary officers participated in the meetings. The meetings started with an overview of the composting process, from a technical and business perspective, followed by a discussion on problems in implementation and possible solutions. The discussion revealed a genuine interest of farmers in the composting process, even though some farmers were not explicitly implementing any composting but requested field veterinarians to do it.

A small survey on acceptance of the composting process among farmers revealed that in Menofia 75 percent of the farmers were totally convinced of the business value of composting and committed to continue doing it benefit while in Qalyubia only 30 percent were ready to proceed on their own.

8. We contracted the laboratory of "The Soil, Water, and Environment Research Institute" (SWERI) to analyse the compost produced in terms of its quality as fertilizer and pathogens content. In particular, a number of 23 samples from produced compost were sent to SWERI for analysis of the following:

- Composition (nitrogen, nitrate, phosphorus, potassium, and C/N ratio).
- Presence of pathogens (E-coli, Salmonella and Shigella).
- Presence of plant pathogenic nematodes.
- Presence of fungi.
- Presence of weed seeds.

Based on the Egyptian Standard Guidelines for compost, excellent quality compost should be free from pathogens, nematodes and fungi to ensure that there is no risk for animals, plants and humans. SWERI analysis showed that:

- All samples had good levels of nitrogen, phosphorus, and potassium based on the Egyptian standard guidelines for compost.
- 70 percent of the samples were free from pathogens.
- 100 percent of the sample were free from nematodes pathogenic to plants and weed seeds.
- 30 percent of the samples were not fully matured.

It is worth noting that most of the non-satisfactory results were recorded in samples of compost done at the start of the trial, suggesting that farmers have increasingly become more experienced over the course of time.

SWERI also developed a brief on the benefits of using compost for increasing crop productivity or farm profitability as well as how to maximize the profit by the production of extracts such as humic acid and compost tea. Finally, they conducted field visits to monitor and advise farmers on dead poultry composting and assisted them in practically producing a 'perfect' compost.

Results and analysis

Broiler farms

Field veterinary officers regularly gathered data from the 21 farms that composted dead birds for a total of 32 production cycles across the four target districts. Indeed, some farms repeated the trial for two or three production cycles, which shows commitment to improving their business model.

Table 2: Number of participating farms

Governorate	District	Number of farms	Number of cycles
Menoufia	Quwesna	7	15
	Ashmoun	6	9
Qaliobia	Banha	4	4
	Kafr Shokr	4	4
Total		21	32

Table 2: data collected from the field intervention

The majority (13) of participating farms were in Menoufia Governorate while 8 were in Qalyubia Governorate. Forty seven percent of the production cycles occurred in Quwesna and 28 percent in Ashmoun, while the rest were equally divided in Banha and Kafr Shokr districts (12.5 percent each) of Qaliobia Governorate. Participating farmers were small and medium commercial broiler farms, accordingly, half of them raise less than 5 000 birds; 28 percent raise 5 000–8 000 birds and 22 percent raise more than 8 000 birds. Most (88 percent) of the farms raise exotic breeds and 22 percent raise hybrid native breeds.

Figure 1: Location of farms

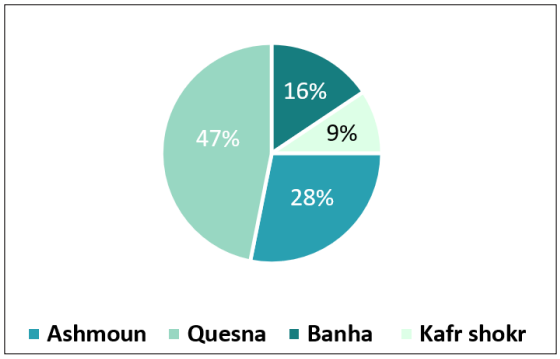

Figure 2: Capacity of farms

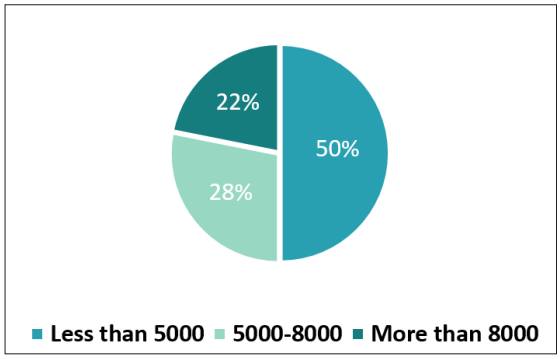

Figure 1 and 2: data collected from the field intervention

Biosecurity level

Figure 3: Former methods of disposal

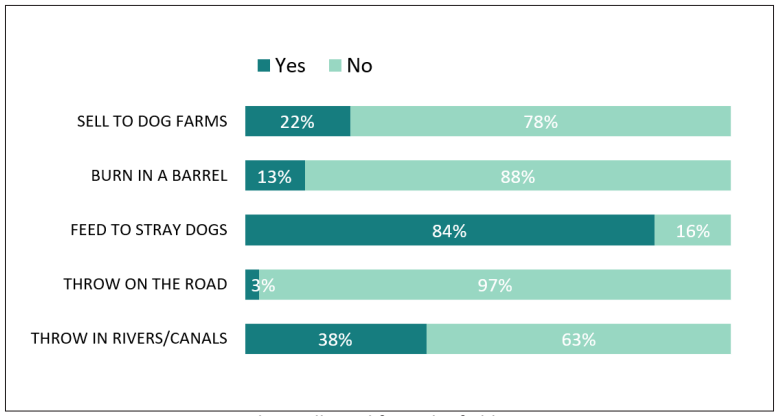

Figure 3: data collected from the field intervention

In addition, specific information on basic biosecurity measures in farms was collected through the designed questionnaire. Those measures included having a fence surrounding the farm, the presence of clothes changing room, a foot basin at the entrance of the poultry house, visitor control measures and providing workers with special clothes or shoes. The least followed measure is having a fence where 59 percent of farms lacked a fence that surrounds the farm followed by having a foot basin where 41 percent of farms do not have one. However, all farms reported having a changing room and providing the worker with special protective clothes and shoes.

The compliance level is also high regarding the visitor control measures either by not allowing any visitor to enter the farms or by providing visitors with protective or disposable clothes.

These results showed that the understanding of the farm owners to biosecurity is restricted to what is inside the farm such as the worker's clothes and preventing visitors. The outside of the farms does not concern them. More education on other daily practices of the workers on the farm and prevention of spread is required.

Figure 4: Compliance with selected biosecurity measures

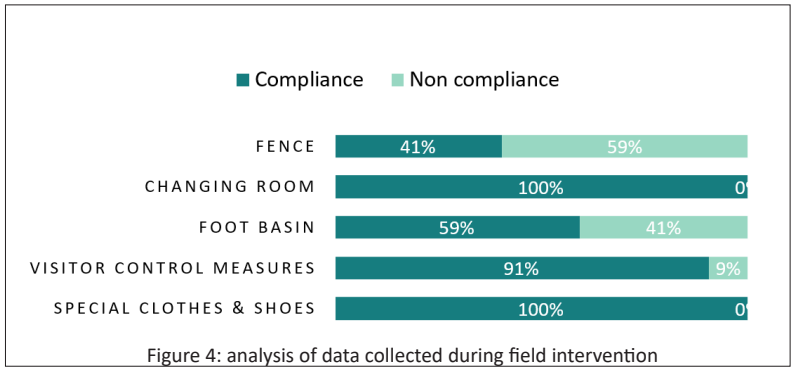

Figure 4: analysis of data collected during field intervention

To further investigate the relationship between compliance with good biosecurity measures and the number of mortalities, we compared the mortality rates of compliant farms to the non compliant farms with respect to having a fence, foot basin and visitor control measures. The results in Table 3 show that there is a negative correlation between compliance with good biosecurity measures and the mortality rate. The farms that have visitor control measures recorded a 5 percent lower mortality rate than non compliant ones, farms with a fence have a 3 percent lower mortality rate than those without a fence, and farms with a foot basin at their entrance have a 1 percent lower mortality rate than those with no foot basin.

Table 3: Relation between biosecurity measures and mortality rates

Variables	Mortality rate (percent)	
	Compliant farms	Non-compliant farms
Visitor control measures	4%	9%
Foot basin	4%	5%
Fence	2%	5%

Table 3: analysis of data collected during field intervention

Overall, there could be room for improvement in compliance with biosecurity measures for broiler farms in this sector. Composting would contribute to this improvement by solving the problem of the unsafe disposal of daily mortalities, which would reduce the risks of pathogens and disease transmission between the farms and hence lower the mortality rates.

Inputs vs outputs

The collected data from the participating farms during the pilot revealed the on ground quantities needed to convert the dead poultry to organic fertilizer. The average recorded quantities of input and output show that adding 138 kg of dead birds to 73 kg of litter and 38 kg of sawdust (a total of 251 kg) produced 127 kg of compost after an average maturation period of 24 days since adding the last layer. This means that the composted pile lost around half of its weight and size upon maturity, which is a 52 percent conversion rate.

Table 4: Average inputs and output by farm capacity

Farm capacity	Inputs (kgs)	Outputs (kgs)	Conversion rate
5 000	209	94	51%
5 000-8 000	232	118	51%
> 8 000	370	211	57%
Average	251	127	52%

Table 4: analysis of data collected during field intervention

Impact of compost on the profitability of farms

Composting does not only aim to mitigate the public health threats resulting from alternate unsafe methods of disposal, but it also further aims to increase the profitability of the farm as a key incentive that ensures the sustainability of implementing this method. A cost benefit analysis of composting is performed to compare the additional benefits of composting to the additional costs incurred to implement it.

- The **additional benefit** of composting lies in selling the produced compost or using it on agricultural land instead of buying extra amounts of fertilizers. The selling price of the produced compost is estimated at EGP 25 per kilo.
- The **additional costs** are mainly limited to the cost of sawdust or manure, a bin or mini composter, a thermometer to measure the temperature daily and testing the product to make sure that the batch is free from pathogens.
  - ◊ The cost of mini composters is around EGP 1 000 and can be durable for one year, which is EGP 200 per cycle (assuming five production cycles per year).
  - ◊ The cost of a thermometer is EGP 1 500 and can be durable for three years, which calculates to EGP 100 per cycle.
  - ◊ The cost of testing a sample in the lab is EGP 375; however, it is not mandatory to test every cycle. The farmer can store a few batches of the produced compost and only send a sample for lab testing twice a year. This would make the cost per cycle EGP 150.
  - ◊ The cost of additional manure needed for composting is EGP 200 per cycle.
- The **additional profit** that the farm yields from composting after deducting the costs is on average EGP 2500 which represents an 80 percent profit margin when comparing the additional profit to the additional revenues.

The cost–benefit analysis shows that investing in composting is rewarding because it requires minimal investments with the availability of most of the required components onsite and yields big returns.

Table 5: Cost-benefit analysis of composting

Compost variables	Average per cycle	Total annual (5 cycles)
Additional revenues	3 175	15 875
Quantity of compost (kgs)	127	635
Price per kilo	25	25
Additional costs	650	4 375
Cost of sample	150	750
Cost of bin	200	1 000
Cost of manure	200	1 000
Cost of thermometer	100	500
Net additional profit	2 525	12 625
Profitability (Profit/revenues)	80%	80%

*All prices are in Egyptian pounds (EGP).

Table 5: analysis of data collected during field intervention

We further compared the net profit margins of the participating farms before composting and after composting to quantify the impact of composting on the overall farm's profitability. To be able to do that, we gathered detailed data on the budgets of the participating farms including the fixed costs, variable costs and total revenues. Having the complete budgets of all farms for the cycle of the pilot, we managed to quantify the impact of composting on the net profit margins of the farms holding all other variables constant. The results in Table 5 show that the participating farms witnessed around 1 percent increase in their profit margins during the cycle of the pilot after deducting the costs of the composting process.

Table 6: Impact of composting on the profitability of farms

Farm variables	Pre composting	Post composting	Change
Total revenues	321 310	324 485	3 175
Total costs	319 862	320 512	650
Net profit	1 448	3 973	2 525
Net profit margin	0 %	1 %	1 %

*All prices and values are in Egyptian Pounds (EGP) and based on the data collected during the pilot in 2022.

Table 6: analysis of data collected during field intervention

The resulting increase in the profitability can be classified by the capacity of farms. Figure 5 shows that farms whose capacity less than 5 000 birds benefited more from compost with an increase of 1.8 percent in their profit margins compared to 0.6 percent for 8 000 plus farms even though they produced a lower amount of compost (94 kg) than bigger farms (211 kg). This is because bigger farms have bigger revenues, so the additional revenue generated from compost is not as impactful as in smaller farms. In addition to that, bigger farms have low mortality rates of 2 percent compared to 6 percent at smaller farms.

Figure 5: Profitability by farm capacity

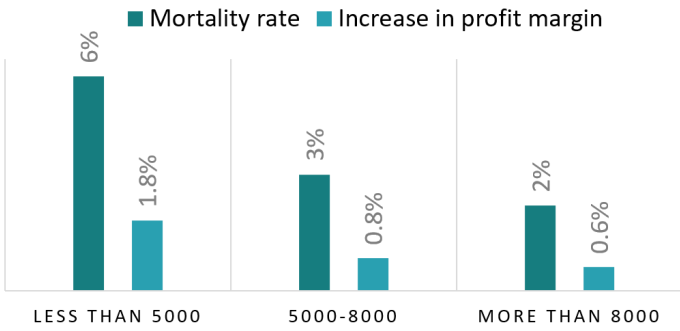

Figure 5: analysis of data collected during field intervention

Expected impact once scaling up the pilot

- **Direct impact**

  If the pilot is scaled up nationwide on the 21 000 broiler farms in Egypt, there might be an increased revenue for broiler farmers on the national level that could reach EGP 333.4 million annually. However, not all farms will establish composting as their method of disposal. So, if we suggest that only 20 percent of farms implement composting as a suitable method of disposal, this will still yield EGP 66.7 million of increased revenues per year.

- **Indirect impact**

  ◊ Reduce the risk of pathogens spreading and AMR transmission to soil and water and consequently to other animals and humans through dead birds thrown everywhere.
  ◊ Reduce the risk to human health and the environment by the production of organic fertilizers, which in fact can replace chemical fertilizers known to have harmful effects on humans represented by chemical residues in vegetables and fruits.
  ◊ Increase the amount of organic fertilizers in the market can reduce the burden cost of the government in making available chemical fertilizers at subsidized prices to farmers.
  ◊ Create a safe environment by avoiding water pollution from dead birds thrown in canals, as well as avoiding air and soil pollution, and the increase of insects from the decomposition of dead carcasses.
  ◊ It was proven from numerous studies that compost used in agricultural land assists in repairing the land composition to be more beneficial to plants and increases productivity. Therefore, the production of compost from animal origin on a larger scale will benefit the old and new a land.

Discussion

The benefit of carefully composting dead birds in poultry farms was to reduce public health and environmental risks emerging from throwing away the dead birds. It was also necessary to ensure that compost as a fertilizer as well as the composting process itself are environmentally friendly and with no risk to public health.

The nutrients necessary for plant growth are major elements such as nitrogen, phosphorus and potassium or minor elements such as iron, manganese, copper and zinc. The analysis of compost has proven the presence of all these nutrients, which can accelerate the growth and benefit the plants of all types. Organic fertilizers play an essential and pivotal role in preserving the environment from pollution by rationalizing the use of chemical fertilizers, which reduces the pollution of ground water with chemicals and the production of healthy and safe food free of chemical residues which consequently affects the human health.

The addition of organic fertilizers is also considered essential for most crops, not only because of its content of fertilizing elements, but rather because of its effect on improving the natural, chemical and vital properties of the soil. This leads to the consequent increase in the vital activity of soil microorganisms, which secrete growth regulators and stimulants that directly affect the cultivated crop without any damage that may appear as in the case of spraying plants with chemical materials.

According to the U.S. Environmental Protection Agency (USEPA, 2006), "On-site composting has been proven effective in deactivating avian influenza virus. On-site composting limits the risk of ground water contamination and air pollution, the potential of farm-to-farm disease transmission, transportation costs and tipping fees associated with off-site disposal. Also, there is the benefit of producing a usable product.[6]

Regarding reduction of the risk to public health, the produced compost, if perfectly done, is free from pathogens such as Salmonella, Shigella, E. coli and Enterococcus. These pathogens could be of a significant risk to human if released from dead birds to water used for drinking as well as in soil.

However, the most important and of greater probability is the risk of transmission of AMR genes. Antibiotics are used in the poultry sector for growth promotion, prophylaxis or therapeutic purposes.

However, their indiscriminate usage resulted in the emergence of multiple drug resistance strains causing public health risk to consumers. This has resulted in many recorded resistances in most of the pathogens normally inhabitant in poultry gut as well as endemic pathogens as Salmonella.[7] [8]

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6 Cornell University College of Agriculture and Life Sciences Department of Crop and Soil Sciences . 2008. Natural Rendering: Composting Poultry Mortality (umn.edu)

7 Gharieb, R.M., Tartor, Y.H. & Khedr, M.H.E. Non-Typhoidal Salmonella in poultry meat and diarrhoeic patients: prevalence, antibiogram, virulotyping, molecular detection and sequencing of class I integrons in multidrug resistant strains. Gut Pathog 7, 34 (2015). https://doi.org/10.1186/s13099-015-0081-1

8 Zagazig Veterinary Journal, Volume 45, Supplementary Issue (S1), p. 48-61, October 2017©Faculty of Veterinary Medicine, Zagazig University, 44511, Egypt. DOI: 10.5281/zenodo.1200240. https://www.academia.edu/36558381/Bacteriological_and_Molecular_Characterization_of_Salmonella_Species_Isolated_from_Humans_and_Chickens_in_Sharkia_Governorate_Egypt

Throwing dead poultry carcasses allows bacteria, including resistant ones, to filter into groundwater or onto produce. It also attracts insects such as houseflies and cockroaches, which are efficient carriers of multidrug-resistant bacteria.[9]

This emphasizes the necessity of safe disposal of poultry mortality and that composting is a sustainable way of reducing the risk to public health and the environment.

One of the main challenges encountered during the implementation of the pilot is the severe fluctuations in the prices of DOCs, feed and selling prices. There are global and domestic pressures that impacted the poultry industry in 2022 such as the war in Ukraine which affected the prices of feed globally and the devaluation of the Egyptian pound during 2022 which made the price of inputs skyrocket in a noticeably brief period. The selling price further witnessed the same fluctuations and instability where at some points the price was not high enough to cover the increasing prices of inputs, which caused major losses to many broiler farmers. Those factors drove many farmers to postpone starting a new production cycle until the prices stabilize and some of them even decided to shut down their business. These extraordinary circumstances affected the participation of the farmers in our pilot and reduced our targeted sample size.

Table 6 illustrates the big and rapid changes that happened to prices during the cycle of the pilot and the cycle before, especially in the selling price and the price of DOCs, which fluctuate very often.

Table 7: Fluctuations in prices during the pilot

	Previous cycle		Cycle of the pilot	
Variable	min	max	min	max
Selling price (exotic)	20	40	24	38
Selling price (hybrid native)	38	42	45	55
Price of DOCs (exotic)	5.75	13	4.75	12.75
Price of DOCs (hybrid native)	3	9	3	6
Price of feed	8 000	12 000	10 000	15 000
Net profit margin	-98%	20%	-71%	36%

All prices are in Egyptian pounds (EGP)

Regardless of the prices and their effect on the profitability of the farm, there are also other variables that could significantly affect the profitability of the farm such as the weight of the broiler, the amount of purchased feed, the mortality rate and the cost of medications and vaccines.

9 Ikhimiukor, O.O., Odih, E.E., Donado-Godoy, P. et al. A bottom-up view of antimicrobial resistance transmission in developing countries. Nat Microbiol 7, 757–765 (2022). https://doi.org/10.1038/s41564-022-01124-w

Conclusions and recommendations

- Composting is a success in broiler farms. It is easy to implement and solves the great problem of dead bird disposal.
- Composting is applicable at any mortality rate, in any farm size, in different production types and for different breeds. However, the method of composting will vary according to the size as well as the length of production. Larger farms and long production cycles as layers or breeders will require wider space and multiple composting bins.
- Composting is profitable; all farms witnessed an increase in their profit margins either by selling the produced compost or by using it in agricultural land.
- The benefit of composting in reducing risks to public health is well proven. Its use also promotes the efficiency of agricultural land. However, it is highly recommended to test the compost for presence of pathogens as a quality control measure to guarantee the safety of the production.

Annex 1

Monitoring Checklist for Composting Intervention in Egypt

General information

Name of farm: .....

District: .....

No. of chicken houses operating this cycle: .....

Capacity per chicken house: .....

Litter

Type of litter: *Saw dust* ☐ *Straw* ☐ *Hay* ☐

Quantity: ..... *Cost:* .....

Cleaning before cycle:

Type of detergent: ..... *Quantity (liter or kg):* ..... *Cost (liter or kg):* .....

Disinfectants before cycle

Type: ..... *Quantity (liter or kg):* ..... *Cost (liter or kg):* .....

DOCs

Number of DOCs bought for this cycle: ..... *Cost per DOC:* .....

Breed: ..... *Vaccinated:* *Yes* ☐ *No* ☐

For which diseases: .....

Workers

Number of workers: ..... *Wage per day/month/cycle:* .....

Date of start of the production cycle:

Biosecurity basics in the farm (check what is relevant):

☐ *Fence*

☐ *Foot basin*

☐ *Special clothes/shoes for workers*

☐ *Changing room*

☐ *Visitor control measures (disposable clothes, cover head, cover shoes, disinfectants)*

Former method of disposal of the daily mortalities:

☐ *Throw in river/ canals*

☐ *Throw along roads*

☐ *Feed to stray dogs*

☐ *Burning in barrel*

☐ *Burying*

☐ *Selling to dog farms* *Price/bird or weight:* .....

Selling to fish farms *Price/bird or weight:* .....

☐ *Other (specify)* .....

Methods of composting used:

☐ *Piling*

☐ *Box*

Information to be filled on weekly basis

Week #: from ……. /……/…… to ……. /……/……..

Average weight of the birds: ……

Addition for the compost

	Date	***Date***	***Date***	***Date***	***Date***	***Date***	***Date***
Number of dead birds							
Quantity of Sawdust/straw (unit?)							
Quantity of litter (unit?)							
Temperature							

Any signs of diseases during the week? *Yes* ☐ *No* ☐

Medicines administered *Type: ……* *Costs: ……*

Vaccines administered *Type: ……* *Costs: ……*

Status and problems faced in compost: explain in detail

……

……

Action/ solution done:

……

……

Any other problem in the farm you assist to solve *Yes* ☐ *No* ☐

Explain the problem and your action ……

……

……

Supervising vet: *……* ***Date of visit:*** *……*

Annex 2

	Cycle	Capacity	Number of mortalities	Mortality rate (%)	Weight (kg)	Mortalities (kg)	Sawdust (kg)	Litter (kg)	Inputs (kg)	Output (kg)	Conversion rate (%)
Farm 1	1	3000	61	2.0	1.2	77	29	62	168	100	60
	2	3000	74	2.5	1.4	97	29	74	200	100	50
Farm 2	3	3000	35	1.2	1.0	30	20	56	106	60	56
	4	3000	21	0.7	1.2	18	15	38	71	50	71
Farm 3	5	3000	83	2.8	1.0	99	51	84	234	150	64
	6	5000	97	2.0	1.3	88	31	64	183	130	71
	7	5000	64	1.3	1.4	69	26	67	162	80	49
Farm 4	8	2000	40	2.0	1.0	44	52	80	176	90	51
	9	2000	27	1.4	1.0	37	38	54	129	60	47
	10	2000	38	1.9	1.1	36	41	79	156	70	45
Farm 5	11	2000	35	1.8	1.1	34	42	71	147	70	47
Farm 6	12	5000	80	1.6	0.9	86	83	136	305	150	49
	13	5000	60	1.2	1.0	52	58	114	224	120	54
Farm 7	14	1000	37	3.7	1.2	39	33	86	158	60	38
	15	1000	20	2.0	1.3	22	27	40	89	50	56
Farm 8	16	9000	178	2.0	0.9	181	22	41	244	120	49
	17	9000	131	1.5	1.1	147	30	40	217	140	65
	18	9000	90	1.0	0.9	121	21	40	182	140	77
Farm 9	19	12600	309	2.5	1.1	500	39	70	609	270	44
Farm 10	20	5500	167	3.1	0.9	159	27	40	226	80	35
Farm 11	21	10000	432	4.4	1.5	616	51	77	743	500	67
Farm 12	22	2500	291	12.2	1.1	383	28	65	475	160	34
Farm 13	23	6000	327	5.6	1.0	359	38	140	536	260	49
	24	6000	55	0.9	1.0	37	13	36	86	25	29
Farm 14	25	4000	99	2.5	0.6	63	47	77	187	100	53
Farm 15	26	13000	261	2.0	0.2	44	15	146	205	70	34
Farm 16	27	9000	97	1.1	0.9	108	85	197	390	240	62
Farm 17	28	3000	723	26.8	0.8	665	26	48	739	200	27
Farm 18	29	5000	76	1.5	1.2	78	41	68	187	120	64
Farm 19	30	2000	26	1.3	0.6	16	27	33	76	30	40
Farm 20	31	5000	68	1.4	0.8	64	59	58	180	100	56
Farm 21	32	3000	81	2.7	0.8	53	69	67	189	160	85

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