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Research Article

Management of the Droppings of Laying Hens of the "Large Poultry Farm" of the AECAM Common Initiative Group (CIG) of Mendong and Proposal of a Treatment System

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Abstract

A Study on the management of the poultry manure at the “Large poultry farm” of the AECAM Common Initiative Group (CIG) of Mendong was carried out from June to December 2014, with the aim to propose a treatment system.

The methodology consisted of documentary research, interviews to collect information relative to the management of faeces from the poultry farm. The identification and characterization of the potential impacts of this management on the environment was done by using the Léopold’s matrix, Fecteau’s grid and direct observations. The analysis of the current situation helped to propose a treatment system which aims both at: mitigating the harmfulness of faeces by reducing the content of harmful substances and improving the valorization of these waste.

The results obtained show that the faeces produced are of two types namely; droppings and liquid manure, with a bi-weekly production quantities estimated at 52 140 ± 1 191 liters of droppings and 98 700 ± 3 371 liters of liquid manure. In addition to the lack of training and sensitization of the personnel in charge of these wastes, the collection and treatment tools are faulty. These leads to the disposal of dropping and poultry manure in neighboring water courses, bad odor spread and the loss of the esthetic view of the area. Meanwhile, 10% of the local populations and some members of the staff of the farm say that the management of the effluents is good, 52% find it bad. Regarding the potential impacts on the environment, the management of these wastes presents risks for the environment and the health due to the inadequacy identified in the field. These include; air pollution risks, deterioration of the quality of surface and underground water, soil pollution, fauna, flora and human intoxication. In general, the collection and transportation have less impact on environment as compared to storage and treatment of the droppings.

A drying system by “non-planted bed” was designed and proposed for the poultry farm. The cost for its implementation is estimated at 29,000,000 Fcfa (twenty-nine million Fcfa).

Keywords: Droppings; Poultry Manure; Management; Impacts; Pollution

Introduction

Animal production accounts for about 40% of the global value of agricultural production. It is growing faster than any other agricultural sub-sector. It supports the livelihood of some 1.3 billion people [1]. Animal production is an important economic activity, contributing 3, 10 and 16% of the gross domestic product of Cameroon, Central African Republic and Chad respectively. It is an extensive animal production of low-productivity, which is at the same time a source of income and a capital reserve for farmers [3]. Poultry farming plays an important nutritional, economic and socio-cultural role in the Central African region [6].

In Cameroon, poultry farming represents 16% of agricultural production and is a source of income for about 30% of the population [2]. In Algeria, poultry farming accounts for 30% of animal production and its products provide more than 50% of the average animal food intake [4].

The galloping population growth (of the order of 3% or more) in most sub-Saharan countries poses the problem of meeting animal protein needs, both in quantity and quality. To meet these needs, it is necessary to move towards intensification of animal production [2].

However, the intensification of livestock farming is not without negative effects on the society and the environment. The poultry sector generates large quantities of waste, including slurry, droppings, manure, blood, feathers, shells and poultry corpses. Due to their microbiological pollution load, effluents from poultry farms constitute a significant danger to public health. The management of disposal becomes difficult, especially in certain regions where intensive breeding is concentrated [10]. They are therefore discharged into receiving environments without specific treatment.

Cameroon has developed several legislative and regulatory texts relating to environmental management. Law 98/005 of 14 April 1998 on the water regime, in its article 4, prohibits the dumping, flowing, throwing, infiltration, burying, spreading, direct or indirect deposit in water of any solid, liquid or gaseous matter and in particular industrial, agricultural and atomic waste likely to alter the quality of surface or underground water, or sea water within the territorial limits, to harm public health as well as aquatic or underwater fauna and flora, to jeopardize the economic and tourist development of the regions. The Cameroonian Law makes of the person whose activity generates waste, whether hazardous or not, responsible for its disposal. Sanctions are provided for offenders. Therefore, it is important to regularly identify the different waste flows, the quantities produced, the processes that generate them and the costs involved, to carry out inventories of the disposal channels and the current storage methods. This monitoring and analysis of the quantities and costs of waste therefore makes it possible to highlight weaknesses and strengths in the management of the waste produced and to identify the possibilities for improving its disposal.

Several studies on the management of poultry manure have been carried out worldwide. We can cite the work of Paillat, Guérin, Medoc and Aubry, 2003. However, no study has focused on the management of waste from poultry effluent in Cameroon. After nearly a decade of operation, the promoters of the “Large Poultry Farm” need to assess the effectiveness and efficiency of the management system for the produced poultry droppings. In other words, are the collection, transport, treatment, storage and disposal systems for the poultry droppings produced within the “Large Poultry Farm” environmentally friendly? Hence the particular interest of this topic.

The general objective of this study is to evaluate the management of the droppings of laying hens at the AECAM CIG Mendong poultry farm and to propose an appropriate treatment system in case of identified failure.

More specifically, it aims to:

- Conduct an inventory of the management of laying hen droppings in the farm;
- Identify and characterize the impacts of managing laying hen droppings;
- Propose a system for treating laying hen droppings from the AECAM’s CIG “Large Poultry farm”.

Material and Methodology

The inventory of the management of laying hen droppings was done on one hand through direct observations, and on the other hand through a semi-structured interview and exchanges with the promoters as well as with farm agents and local residents.

During this research period, interviews were conducted with some of the farm's managers and employees. These interviews focused on wastewater management methods, water supply sources, sanitation infrastructures built by the structure, the state of sanitation of the farm, and the causes and harmful consequences of poultry droppings on the environment. In total, about fifty survey forms were administered within the farm and to the neighboring populations. To this end, the workers were monitored in their daily tasks for about four months in order to verify the relevance of the answers given in the interviews and surveys.

In order to obtain reliable data, the interviews were complemented by direct observation of the farm's droppings management system for laying hens. These observations provided a closer look at the actual hen's droppings management practices, and the images helped to illustrate the work. These observations served as a source of concrete information.

The identification and characterization of impacts related to the management of poultry droppings were respectively carried out using the Léopold's matrix and the Martin Fecteau's grid.

The impacts were identified using the Leopold matrix. This matrix correlates elements related to the management of the droppings with environmental components.

Impact characterization consists of determining the significance of the likely impact identified in the interrelationship matrix. On the basis of certain indicators, it makes it possible to determine the importance of risks or interactions on the environment. The significance of potential impacts identified on the management of poultry droppings on the "Large Poultry Farm" is determined using Fecteau's grid (1997), which integrates the parameters of duration, intensity, and extent of the impact. These three parameters are aggregated into a summary indicator to define the absolute significance of the impact. A fourth parameter (sensitivity of the environment) is added to the absolute importance to give the relative importance of the impact.

Dehydration techniques using drum kilns and paddle dryers are expensive for developing countries. The failure of this system in the AECAM CIG poultry farm in Mendong, therefore, suggests the need for less demanding and more manageable alternatives. Natural dehydration does not use fuel.

Non-planted drying beds could therefore contribute to the dehydration of the said droppings and allow for their better management, thus contributing to environmental protection. The drying bed thus offers more advantages than the previous methods. Here the drying is natural and fast, and outside the building, which reduces pungent odours due to the emission of ammonia into the building and the atmosphere [7].

The proposal for an efficient and sustainable treatment system for laying hen droppings from the "Large Poultry Farm" of the AECAM CIG in Mendong was carried out using a methodology that consisted of determining the designing parameters of the various system structures. However, preliminary work on the literature review led to the selection of non-planted drying beds that have demonstrated their performance in the dewatering of faecal sludge [8]. However, the designing of such a system necessarily requires taking into account parameters such as: quantification of the average volume of droppings produced as a function of time, the hydraulic load, the residence time, the available surface and the dry matter (DM) rate.

The quantity of chicken droppings produced on the farm was estimated three times a week for two weeks, on Mondays, Wednesdays and Saturdays. To do this, the height of the droppings in the bin was measured with a pigeonhole before the chicken coops were cleaned. After the slurry has been emptied into the storage tank, the height of the effluent is measured again, as well as its length and width. The initial volume and the volume after cleaning are then calculated.

The difference between the initial volume and the volume after cleaning is used to obtain the daily volume of slurry discharged. Since the dimensions of the truck bucket are known, the height occupied by the droppings after evacuation is measured and the volume calculated. The total volume of droppings produced in the two production units is calculated by summing the volume of dropping and the volume of slurry.

The theoretical surface area of the dehydration bed was calculated by dividing the daily volume of droppings produced by the hydraulic load. A residence time of the droppings on the bed was set. The available surface area within the poultry farm was measured. The total area required for the construction of the structure was calculated by multiplying the theoretical bed area by the residence time. The length, width, thicknesses of the filter layers and the freeboard were determined as well as the width of the gaps between the beds. This gap width includes the wall thicknesses. The actual surface area of a bed was calculated by multiplying the set length by the set width. The number of beds required was calculated by dividing the total available area by the actual area. The height of the walls was calculated by adding the thicknesses of the different filter layers, the hydraulic load and the freeboard. The construction cost of a bed was calculated according to three parameters: the duration of the construction site, the quantities of materials to be used and the quality of the personnel to be employed. Indeed, the quantities of materials (sand, gravel, cement, rebar, formwork, timber, nails, sheet metal, PVC pipes, breeze blocks, etc.) to be used were calculated. The unit price applied to these quantities gave the direct cost. A percentage allocated to the direct cost was used to obtain the total cost of the work.

The data from the various surveys were processed and analyzed using SPSS Statistics 20 and Microsoft Office Excel 2007. The mapping of the Yaounde VI District was done using Arc GIS 10 software.

Results

The droppings of the laying hens produced at the “Large Poultry Farm” of the AECAM CIG are essentially of two types: droppings and slurry (Table I). The quantities produced for each type vary according to the corresponding maintenance days. Overall, 52,140 ± 1191 liters of droppings and 98,700 ± 3371 liters of slurry are produced on average on the farm every two weeks. This corresponds to a total quantity of 150,840 ± 4290 liters for the same period. The weekly production is therefore around 75,420 ± 2,145 liters of droppings. However, the quantities of slurry produced are almost double the quantities of droppings collected.

At AECAM’s CIG “Large Poultry Farm” in Mendong, the staff responsible for managing the hens’ droppings use state-of-the-art, high-performance equipment. The equipment used inside the hen houses is automated. These include scrapers (Figure 1a) in the pits under the cage batteries, conveyor belts under each row of cages with a belt conveyor at the end of the roller. Outside the barn, eight shovels, two wheelbarrows and two trucks (Figure 1b) are used to collect and transport the droppings from the production area to the storage area inside the farm. In addition to this collection and transport equipment, there is also processing equipment consisting of three digesters, a paddle oven and a rotary cylinder dryer

Figure 1: Some material resources used (a- Scraper; b- Truck).

At the AECAM’s CIG “Large Poultry Farm”, the collection, storage and treatment of layer hen droppings are carried out by means of several advanced devices and tools (Figure 7). In fact, the evacuation of droppings from inside the rearing building to the outside is done by means of scrapers (Figure 7 a: scraper under cages) and by electrically operated evacuation belts in the building. At the end of the roller a belt conveyor transfers them out of the henhouse.

Once evacuated, the droppings follow a channel (Figure 7b: collection gutter) to a transitional collector (Figure 7c: watertight basin) that feeds the digesters. In order to ensure a rapid and gravity-fed evacuation of the droppings to the transitional tank, a large amount of water is added to the scraped droppings.

The droppings that are discharged with the belt conveyor are collected in dump trucks and transported to a storage area in a corner of the farm.

At the end of the digestion process, the residues from the bio-digester (digestate) are stored in compensation tanks which in turn empty their contents into a deep watertight pit (Figure 2).

The hen droppings and dehydrated slurry are transported using wheelbarrows (Figure 3a). These dried droppings are put into bags and then stored and covered with tarpaulins (Figure 3b).

Figure 2: Collection and treatment systems for the farm's hen droppings (a: Scraper under cages; b: Collection gutter; c: Digester feed tank; d: Digestate collection pit).

Figure 3: Transport and storage of dried droppings (a- Transport; b- Storage).

On the field, it was found that the drying devices are failing. The malfunctioning of the digester and the low capacity of the slurry storage tanks lead to the discharge of chicken droppings into the storm water collection gutters (Figure 4a and 4b), which discharge them directly into the aquatic environment (Figure 4c). The digester residues are removed from the pit and stored on non-concrete areas.

Figure 4: Direct discharge of slurry into nature (a- Nature; b- Gutters; c- Water; d- Bare Soil).

The survey conducted among residents, users and staff on the assessment of the state of hygiene in the "Large Poultry Farm" and its surroundings showed that opinions are diverse (Figure 5). 39.22% of the staff and users surveyed said that the farm was less dirty; 28.29% thought it was dirty; 19.80% thought it was very dirty; 5.31% thought it was clean and 7.38% had no opinion.

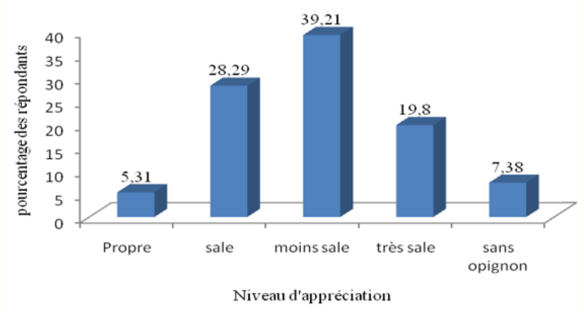

Figure 5: State of hygiene in the AECAM's CIG "Large Poultry Farm".

The results of surveys conducted among staff and the immediate neighborhood of the farm showed that 17% of respondents found this system of managing chicken droppings good. On the other hand, 27% find it fair and 56% find it bad (Figure 6).

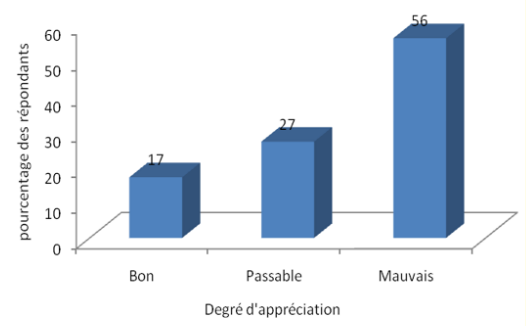

Figure 6: Assessment of the management system for chicken droppings at the "Large Poultry Farm".

In fact, most of the latter complain about water and air pollution problems.

The digesters are in a poor and malfunctioning state. The dropping dryers (Figure 7) in particular, the paddle kiln (Figure 7a) and the rotary cylinder dryer (Figure 7b), are rusty and therefore not functioning properly. The storage tanks can no longer

Figure 7: Defective drying equipment (a- Paddle oven; b- Rotary cylinder).

cope with the large quantities of droppings produced, resulting in overflows. The slurry is discharged into the rainwater drainage channels. These effluents are led into the neighboring watercourse with the resulting risks of contamination.

The potential impacts of managing laying hen droppings have been identified, and these impacts are associated with each stage of the management chain defined by the structure. This chain consists of collection, transport, treatment and finally storage (Table 1).

Impact-generating activities	Elements of the environment	Environmental impacts
Collection	Biophysical environment	Risk of soil pollution Risk of water pollution Risk of air pollution
	Socio-economic and human environment	Risk of disease Employment-generating activity
Transport	Biophysical environment	Risk of soil pollution Risk of water pollution Risk of air pollution
	Socio-economic and human environment	Risk of disease Employment-generating activity
Storage	Biophysical environment	Risk of soil pollution Risk of water pollution Risk of air pollution
	Socio-economic and human environment	Risk of disease Employment-generating activity
Treatment	Biophysical environment	Risk of soil pollution Risk of water pollution Risk of air pollution
	Socio-economic and human environment	Risk of disease Employment-generating activity

Table 1: Summary of the different impacts related to the management of chicken droppings.

The presence of faeces on the bare soil and in the surface water (Figure 8b) constitutes a risk of pollution of the water table by infiltration. This risk of pollution could be accentuated not only by the proximity of the aquifer, but also by the cracked soils in the area.

Figure 8: Discharge of chicken droppings (a: Heap of droppings eroded by rainfall; b: Point of discharge of droppings into surface water).

The dumping and piling up of chicken droppings in certain corners of the farm presents an unattractive appearance, leading to the ugliness of the environment (Figure 9a), and blocking rainwater and wastewater drains. Moreover, the piling up of droppings and slurry causes fermentation. This gives off foul odors. They attract flies and mosquitoes, vectors of multiple diseases (Figure 9b). This situation exposes workers and inhabitants of the neighborhood to many risks of disease.

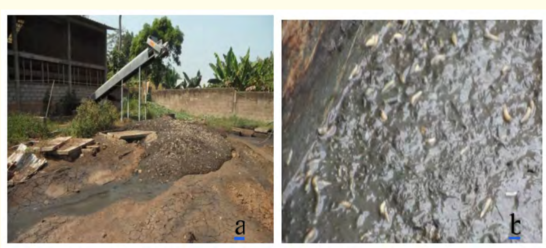

Figure 9: Damage to the aesthetic appearance of the farm (a: Pile of fresh droppings; b: Development of disease vectors at a point in the immediate environment of the farm).

The different impacts identified in the context of on-farm poultry droppings management can have positive or negative interactions with environmental components. It appears that droppings collection, transport, storage and treatment activities produce negative effects on the biophysical and socio-economic components of the environment.

The daily volume of faeces produced during the full-time operation of the “Large Poultry Farm” is 25m^3; The hydraulic load (thickness of the water layer in the beds) is 0.4m; The residence time of the effluents is fixed at 14 days; The theoretical surface area of a bed has been estimated at 83.3m^2; The total available surface area measured is 788m^2 for the construction of the works; The length, width and thickness of the two filtering layers of the bed have been fixed at 15m, 4m, 0.15m, and 0.15m respectively; The number of beds found after calculation is 12.

The beds operate in a rotating manner. After loading the first bed, it is closed to allow the second bed to be loaded. This exercise continues until the twelfth bed. The collection of dehydrated faeces begins with the first bed on the fifteenth day of stay and ends with the release of the twelfth bed. Released beds are reloaded as the collection process continues. The final moisture content after 12-15 days of drying should be approximately 60%. The yield of a bed is about 0.8.

The bed consists of four walls made of cement chipboard of 15 X 20 X 40 stuffed. The walls are stiffened by poles. The bottom of the bed is an ordinary concrete radiator poured into two slopes of 1% oriented both towards the axis of the bed (direction of width) and downstream (direction of length). The bottom of the drying bed is lined with perforated pipes that drain the leachate. Above the drains, there are two layers of gravel and a sheet of perforated sheet metal (Figure 10) that receive the droppings and allow the liquid to seep into the drain. The effluent collected in the drainage pipes is discharged into a gutter for proper treatment before being discharged into the wild.

Figure 10: Construction of the drying bed (a- Placement of the drain; b- Placement of the gravel pack; c- Bed ready to receive the slurry; d- Bed loaded with slurry.

The proposed system has been adopted within the facility for the treatment of chicken droppings. It has been implemented and is already being used for the purpose. Figure 10 below shows some parts of the work in progress.

Discussion

The results obtained in this study revealed that in the “Large Poultry Farm” two types of droppings are essentially produced and managed as slurry and droppings. These results corroborate those obtained by Boughaba [10-20], who showed that cage and slatted systems result in the management of droppings in the form of slurry and droppings.

The frequency of collection of droppings from laying hens in the “Large Poultry Farm” of the AECAM CIG in Mendong is irregular. In fact, collections are made on Mondays, Wednesdays and Saturdays: this corresponds to collection intervals of between 2 and 3 days. These results corroborate those obtained by Coorevits (2011), who showed the combined interests of rapid evacuation of animal excrement and its methanisation. According to Quideau and Lagadec [19-41], the rapid evacuation of animal dung coupled with its methanisation is a strategy that should make it possible to reduce greenhouse gas emissions while producing renewable energy.

However, these results differ from those obtained by Drabo [26-40] in cattle and sheep fattening farms in western Burkina Faso, which showed that daily collection was most common (60%) or weekly (33%) among the farmers surveyed in the city. This difference could be explained by the type of farming conducted. According to Drabo [33], weekly collection is said to take place in areas where livestock are kept in partial confinement but where the animals spend the day grazing and only return in the evening. However, the collection frequencies recorded in the present research work would be related to the type of farming that is done on an industrial scale, unlike family farming units where the low number of animals would be the cause of weekly collection.

A difference in quantity was noted between the types of droppings produced at the "Large Poultry Farm". These quantities also varied according to the collection periods. In effect, the quantities of slurry produced were almost twice as large as those of droppings collected. The difference between the types of droppings produced is linked to the water concentration of these different types of droppings, which gives them different aspects. Infact, the water content of slurry is very high, which gives it a liquid appearance, unlike droppings which are generally pasty or solid, due to the low water content [6-39].

As for the variability of the overall quantities of droppings between two collections, this could be justified by the difference in time intervals between the different collections. Thus, the quantities of droppings produced in two days are obviously lower than those produced in three days for the same number of laying hens.

The collection and treatment of chicken droppings on the farm is done using state-of-the-art equipment, including electrically operated scrapers and belts, drainage channels, trucks and digesters for treatment. Despite the presence of this equipment, the management of chicken droppings at the "Large Poultry Farm" remains problematic. Residents of the neighborhood as well as some workers deplored the emission of odors, the unsanitary conditions and the pollution of the environment. The same observation was made by Métras [37-41] who states that most of the time, poultry farms are known to be odorous.

All this is the result of an intensification of the activity and an under-designing of these units that no longer meet the functions assigned to them. According to Fall and Moustier [20-32], intensification of livestock farming in urban areas leads to a production of droppings that is not correlated with the installation of efficient sanitation structures, which often leads to a degradation of the urban environment.

It is therefore necessary to find alternative solutions for the sustainable management of these wastes and the protection of the environment and human health.

Potential impacts related to the management of chicken droppings on the "Large Poultry Farm" include degradation of air quality, degradation of groundwater and surface water quality, soil pollution, landscape alteration, poisoning of fauna and flora, and human exposure. These results are in line with those obtained by Moller., *et al*. [13-26] who found that pig droppings, collected as slurry, are rapidly subjected to aerobic and anaerobic decomposition processes resulting in the emission of methane to the atmosphere.

Spills from the transition basin, the digester and the drainage gutters have caused concern among residents of the neighborhood and even workers. These effects have been highlighted by various authors [1-41]. These authors have shown that the effects of air pollution are of two kinds: one toxic, the consequence of which is long term, and the other uncomfortable, which is immediate. Assuming that it is the toxic and uncomfortable aspects that these authors wanted to raise.

Furthermore, the open air storage of manure as practiced within the "Large Poultry Farm" constitutes a health risk for workers and neighboring populations. In effect, the storage of droppings plays a significant role in the spread and transmission of numerous diseases such as respiratory infections like chronic bronchitis, emphysema, head colds, etc. In addition, during the rainy season, animal dung is a breeding ground for mosquitoes [17].

Pollution of surface and ground water in the vicinity of the farm would emanate from the discharge of chicken droppings observed. These spills could lead to serious disturbances to the fauna and flora of this surface water. In effect, whether the water is surface, continental or coastal, the elements (N and P in particular) arrive there after the leaching of soluble compounds or particle runoff. When these flows exceed the purification capacities of ecosystems, surface waters undergo eutrophication, leading to a loss of biodiversity, excessive algal growth and nuisance to recreational activities [16-33]. Poultry droppings present a major ecological problem, as they cannot be incorporated into the soil in a fresh state because of the pathogens they contain and their nitrogen content [10-40].

Anaerobic fermentation processes in appropriate digesters (biomethanisation) would allow better management of poultry droppings, preservation of the environment and diversification of energy resources (alternative energy). These processes could produce energy at lower cost for cooking, heating and lighting, and fertilizers with high fertilizing potential (stabilized sludge) as soil improvers for agricultural land [11-26]. However, such systems require proper designing and regular maintenance.

The failure of this system in the " Large Poultry Farm " of the AECAM CIG of Mendong enables us to think of less demanding and easily manageable alternatives. Non-planted drying beds could thus contribute to the dehydration of poultry droppings produced at the " Large Poultry Farm" and thus allow for better management of these droppings and environmental protection. Dehydration technics using drum ovens and paddle dryers are expensive for developing countries. Natural dewatering does not use fuel. The drying bed has more advantages than the previous methods. In this case the drying is natural and rapid, and outside the building, which reduces pungent odors due to the emission of ammonia into the building and the atmosphere [41].

Conclusion

The general objective of this research work was to evaluate the management of droppings from laying hens at the "Large Poultry Farm" of AECAM's CIG in Mendong in order to propose a treatment system.

The farm produces large quantities of poultry droppings whose management is a concern for the promoter who is faced with defective treatment devices. The workers in charge of managing this type of waste say that they are more or less aware of the environmental impact of the droppings. The management of chicken droppings generates environmental impacts, including air, water and soil pollution. Collection and transport have less environmental impact than storage and treatment. Current droppings management poses a risk of air pollution, groundwater contamination, fauna, flora and humans. Surface waters in the vicinity of the farm receive continuous and uncontrolled discharges of droppings. Thus, the current management of laying hen droppings on the "Large Poultry Farm" is not environmentally sound. This management is not in line with the requirements of the law of 5 August 1996, which stipulates in article 42 that "waste must be managed in an ecologically rational manner in order to eliminate or reduce its harmful effects on human health, natural resources, fauna and flora, and on the quality of the environment in general. In effect, it is the cause of the ugliness of the landscape of the study area, the degradation of the quality of surface water, and the pollution of the soil and air.

The interaction matrix between the sources of impacts and the components of the environment shows that the gases emitted can act in the vicinity or on larger geographical scales. Air, soil and water pollution are however reversible.

The proposed system for the treatment of poultry droppings is an unplanted drying bed. Compared to other known systems, it has advantages in terms of design, construction and operation.

Conflict of Interest

The authors declare that they have no conflict of interest.

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