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Environmental impact in using poultry manure as organic fertilizer

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Abstract
This paper presents the environmental risk factors and the possible negative impacts on the environment from intensive farming of laying hens in storage conditions and valorization of poultry manure as natural fertilizer. The experiments and the analytical determinations were performed in the second phase of the project with the acronym VITAOU within PN II INNOVATION program, experimenting the first set of four innovative nutritional solutions for laying hens. The environmental risk factors are the existing pollutants in poultry manure: nitrogen and phosphorus compounds, heavy metals and pathogens. The obtained results show that the concentration of these elements in poultry manure is well below the limits imposed by environmental legislation. Therefore the poultry manure may become polluter only when failure to comply the good agricultural practices of fertilization. Comparing the concentration values of the four nutritional solutions with the concentration values obtained for the reference recipe was carried out a ranking of the nutritional solutions in terms of environmental impact in order to choose the best two nutritional solutions based on quality/cost environmental impact performance.

Keywords: pollution, risk factors, environmental impact, concentration, heavy metals, limit values

Introduction
The organic fertilizer as manure type are a cheap source of nutrients with a high value of fertilization per volume unit, considering that is rich in nutrients (nitrogen, phosphorus and trace elements).
These organic fertilizers cheaper than the chemicals fertilizers, are available for each farmer and in addition can be supplemented with chemical fertilizers to achieve the optimum of nutrients required by different cultures in case it is not insured. Besides the feritilizing effect, the poultry manure (most of all the solids ones) can also have highly positive effects on the biological activity of the soil, on the water retention capacity and on the resistance to drought, pests and diseases of crops, contributes to the soil structuring and regulates the aero-hydric regime, reduces the risk of degradation by different processes, improves and preserves the fertility status of the soil and increase its productivity (www.huro-cbc.eu).
Poultry manure can be processed and turned into a concentrated substance (drying, dehydration, composting, etc.) that can be sold as a valuable organic fertilizer, thus solving the problem of excess manure from the farm.
Their application in higher doses than those recommended, or in "closed" periods (especially in winter) can cause pollution phenomena of the soil, the surface water and the groundwater. Thus, in concentrations exceeding limits become pollutants.

Materials and Methods
The potential negative environmental impacts of the poultry industry always are correlate with the applied nutritional solutions. Nutritional solutions have the main purpose to ensure constant productivity and maintaining proper health of the birds. The variability of food composition and of the nutritional management applied leads to variability in the composition of manure and from here the variability of the types of negative environmental impacts that may occur.

The pollutants that can affect the environment at concentrations exceeding normal limits, are the compounds of nitrogen and phosphorus, heavy metals and pathogens. These pollutants can cause significant pollution of the environmental components soil, air, surface and groundwater.

Pollutants containing nitrogen:

In fresh manure nitrogen is found both in organic and anorganic form. The uric acid and its derivatives represents 60-70% of the total nitrogen excreted. The urea form is rapidly mineralized, in high humidity conditions, resulting soluble nitrates. The soluble nitrates are not retained by the soil adsorption complex and therefore are easy moved with surface runoff or infiltration water contributing to pollution of the surface and groundwater.

Pollutants containing phosphorus:

Phosphorus is also present in fresh manure excreted, both in organic and anorganic form. Anorganic component (70%) is represented by phosphates and poly-phosphates, while the organic component (30%) is mainly composed of phytate. As with the nitrogen, soluble compounds not retained in the soil contribute to pollution of surface and groundwater.

Heavy metals pollutants:

To achieve higher productivity performances to various parameters, the practiced diets for laying hens are often enriched in copper, zinc and other trace elements over their nutritional needs. The amounts excess are not absorbed and are found in manure. Manure can contain small amounts of hazardous metals such as cadmium, lead, nickel and chromium that can come either from the diet. The heavy metals accumulate in the arable soil layer because are not quickly levigated, especially if the soil is neutral or alkaline, and what plants accumulate is very little compared to the realized contribution. The increase of concentrations of heavy metals in soils may affect for long-term their fertility and agricultural productivity. Cadmium, lead and mercury in all cases manifest toxicity. The heavy metals are issued only if the soil is very acid, the acid soil pH will favor the loss of these metals with rainfall and irrigation water and there are the danger of reaching groundwater or surface water.

The pathogens:

In fresh manure the main group of micro-organisms is the bacteria to 10^7-10^9 CFU (Colony Forming Units) / g su In general, poultry intestinal microbiota is composed of at least 80% of Escherichia coli (http://grist.files.wordpress.com/2008/10/a84-3-1990e.pdf). Apart from Escherichia coli other Enterobacteriaceae are potential pathogen: Shigella sp., Salmonella sp., Klebsiella sp. and Intestinal Enterococci.

Types of impact of presented pollutants:

The reference document on Best Available Techniques (BREF) (eippcb.jrc.ec.europa.eu/ reference/ BREF / irpp_bref_0703.pdf) states that the activities related to intensive poultry in farms is potential bringer of environmental impact both positive and negative associated with large amounts of manure. The potential negative impacts on the environment caused by the emission of a large quantities of manure either by storage or by spreading as an organic fertilizer on the agricultural land are:

- Impact on soil environmental component (zonal or regional) - exceeding the nitrogen, phosphorus and heavy metals per hectare depending on soil type, annual or multi-annual adjacent crop needs, risk areas of pollution in the surrounding areas and climatic conditions. A number of heavy metal are toxic to some crops: Hg, Cr, As, Cd.
- Impact on air environment component (local / zonal atmosphere at farm) - the manure after excretion suffers a microbial decomposition by breaking complex molecules into more simple molecules. Often this process is accompanied by the elimination of gases. Aerobic decomposition produces stabilized organic matter, carbon dioxide and water. Anaerobic decomposition is accompanied by the production of dangerous gas to humans and animals (carbon dioxide, ammonia, hydrogen sulfide, methane, carbon mono-oxide) and local odors according to the management (temporary storage) of manure, in wet or dry system (http://grist.files.wordpress.com/ 2008/10/a84-3-1990e.pdf).

- Impact on groundwater environment component - nitrogen (increasing levels of nitrates), phosphorus and heavy metals pollution

- Impact on surface water environmental component - eutrophication (exceeding the nitrogen and phosphorus) and heavy metal pollution through the migration and diffuse spread as a result of regional rainfall.

The environmental impact assessment of the described pollutants is done comparing their concentration with the concentration limits set out in environmental legislation:

- OM 756/1997 to approve the regulation of environmental pollution assessment - establishes reference values for chemicals trace in soil depending on the type of land use
- O 344/2004 approving the technical norms on environmental protection especially soil, when sewage sludge is used in agriculture - sets the maximum permissible concentrations of heavy metals in sludge intended for use in agriculture
- OM 161/2006 on surface water quality classification - includes standards for chemical and physicochemical quality water according to water quality class
- HG 53/2009 for the approval of the National Plan for the protection of groundwater against pollution and deterioration and HG 449/2013 amending and supplementing the Annex to HG 53/2009 - establishes groundwater quality standards
- L 458/2002 on drinking water quality and L 311/2004 amending and supplementing L 458/2002 - sets drinking water quality parameters

National and European regulations on quality of manure used in agriculture or deposited on different surfaces do not require microbiological control.

To assess the pollutants whose concentrations in manure can exceed the admissible limits were analyzed a series of physico-chemical and micro-biological indicators ecologically relevant. Physico-chemical indicators considered are: total nitrogen, total phosphorus and heavy metals: Cu, Zn, Fe, Mg, Pb. Micro-biological indicators are total coliforms, Esherichia coli, enterococci and Salmonella.

The experiments and the analytical determinations were performed in the second phase of the project with the acronym VITAOU, project within PN II program INNOVATION, experimenting the first set of four innovative nutritional solutions using hybrid Lohmann Brown laying hens, aged 59-67 weeks.

The analytical determinations were performed in the laboratory Control Water, Soil, and Waste Pollution, and the laboratory Biotests-Bioanalysis. The analysis are included in the list of accredited testing by RENAR, the laboratories working in quality system according to the referential ISO 17025/2005.

The analytical determinations were performed on samples taken from the reference batch (M) fed on regular recipe unamended and the experimental batches (E1-E4) fed on regular recipe amended in four nutritional variants.

Results and discussion

Table 1 - Manure physico-chemical analysis- Average values of samples from experimental batches and the control batche

Indicator	Average samples E4 mg/kg dry weight	Average samples E3 mg/kg dry weight	Average samples E2 mg/kg dry weight	Average samples E1 mg/kg dry weight	Average samples M mg/kg dry weight	Indicators trend	Limit value of concentration mg/kg dry weight *	Limit value of concentration for annual quantyties kg/ha/year*
Total P	10979.00	8919.33	11394.00	11916.67	12927.33	Decreases		
Total N	26093.33	44936.00	45061.67	17639.67	17418.67	Increases	-	170
Cu	26.50	26.33	26.47	26.37	27.50	Decreases	500	12
Zn	391.66	395.33	294.67	327.67	283.00	Increases	2000	30
Fe	830.67	841.33	781.67	829.00	870.33	Decreases	-	-
Mn	362.00	370.67	341.67	486.33	417.67	Decreases	-	-
Pb	0.49	0.63	0.68	0.71	0.69	Decreases	300	15

*O 344/2004

Table 2 - Manure microbiological analysis- Average values of samples from experimental batches and the control batche

Indicator	Average samples E4	Average samples E3	Average samples E2	Average samples E1	Average samples M	Indicators trend	Max. adm. value
Total coliforms	29.40×10^{10} CFU	82.5×10^{9} CFU	15.6×10^{9} CFU	10.25×10^{9} CFU	18.5×10^{9} CFU	Increases/ Decreases	-
Esherichia coli	15.20×10^{10} CFU	10.3×10^{10} CFU	17.49×10^{9} CFU	12.60×10^{9} CFU	10.45×10^{9} CFU	Increases	-
Enterococci	17.95×10^{9}	12.45×10^{9}	12.5×10^{9}	49.7×10^{8}	64×10^{8}	Increases	-
Salmonella	Absent	Absent	Absent	Absent	Absent	Absent	

From the table 1 it results that the areas of concentration for heavy metals (Cu, Pb and Zn) is well below the maximum value allowed in order. Since the microbiological control is not imposed results that the poultry manure used as organic fertilizer have no impact on the environment. It could become polluter only when it accumulates a large quantities and not comply the good agricultural practices of fertilization.
Comparing the measured physico-chemical indicators for the four nutritional recipes with the reference batch indicators it finds that the total nitrogen and zinc increases to all nutritional solutions to compared reference batch. Except this two indicators, all new nutritional solutions improve the environmental state with a rate ranging between 50-70%.
Although the national and European regulations on biosolids quality used in agriculture or deposited on different surfaces do not require microbiological control, were performed determinations for microbiological indicators to establish the influence of the new nutritional recipes on the health of the birds.
From table 2 it results that the concentration of micro-organisms existing in the manure for the reference batch is normally: 10^{7}-10^{9} CFU / g of su (www.feropode.com), Salmonella is absent in all cases but the concentrations of total coliform, Esherichia coli and enterococci are higher in the experimental batches than in the reference batch, showing a slightly higher infectious potential.
Comparing the concentration corresponding to the four nutritional solutions with the obtained values for reference recipe it results the hierarchy for the nutritional solutions in terms of environmental impact: E4, E3, E2 and E1.

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