More Nutrients and More Hazards When Using Poultry Litter in Plant and/or Animal Nutrition

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Abstract

Poultry litter is an organic mixture of feces, wasted feeds, bedding materials and some feathers. So, it’s still valuable fertilizer resource needed in many agricultural areas. An alternative uses for almost 50% of the litter generated in concentrated production farms are directed to feed small and large ruminants. Undoubtedly, poultry litter had high nutritive value to both plant and animal, while it simultaneously contains wide range of both biological and chemical hazards. Clear understanding of the hazard(s) cycle and pathway in environment are essential requirements for establishing effective control strategies to prevent or reduce the adverse effects on agriculture, environment, food safety and public health.

Introduction

Lacking of organic substances, especially in new reclaimed sandy soil and the high nutritive value of poultry litter leads to recommend the usage of such waste as fertilizer of choice. Average nutritive value of poultry litter as fertilizer, calculated as N, P, and K is 3.1, 0.5 and 2.8%, respectively. As well, the poultry ashes contain the 4 main requirements of Cu, Fe, Mn and Zn at concentrations of 332, 195, 277 and 252ppm, respectively [1]. Poultry litter is commonly recycled into the soil to enhance both structure and fertility of agricultural land, especially the new reclaimed sandy soil. Poultry litter contains significant amounts of nitrogen due to the presence of high levels of bio available protein and amino acids [2].

Poultry Litter as Plant Fertilizer and Enhancer (Table 1)

Recently, there have been some food safety and human health issues associated with the usage of poultry litter. Poultry litter as an important source of nutrients for many edible crops, may also contain some biological hazards that can threaten human health [4]. Poultry litter could be a source of human pathogens such as Salmonella, Campylobacter and Listeria that can potentially contaminate both edible crops and environment, which consequently leads to food-borne diseases [5,6]. Poultry litter contains wide and diverse counts of microorganism including both of gram positive and negative bacteria. Surveillance data from USA and Canada showed that the hazards of Salmonella, E.coli, Campylobacter and Listeria are the most responsible pathogens due to usage of poultry litter [7]. Poultry wastes are commonly composting prior to application in order to control the biological hazards in the end recycled product. Many studies showed that some pathogenic cells remained persisting the finished compost [8]. As well, during composting there is a high significant possibility for some pathogens re-growth including the survived small population of pathogen and the transferred ones from the environment? A wide range of biological hazards were reported in poultry litter and wastes including Actinobacillus, Bordetella, Campylobacter, Clostridium, Corynebacterium, Escherichia coli, Globicatella, Listeria, Mycobacterium, Salmonella, Staphylococcus and Streptococcus [1,9-11].

Table 1: Some poultry litter wastes and nutrients content. National Resource, Agriculture and Engineering Service [3]

| %Component | Broiler Litter | Broiler Cake | Roasted lit. | Breeder Lit. |
|------------|---------------|--------------|--------------|--------------|
| Moisture   | 21.5          | 40           | 22.5         | 33.5         |
| Total solids | 87.5         | 60           | 77.5         | 66.5         |
| Total-N(Lb/T) | 72           | 46           | 71           | 34           |
| P2O5       | 69            | 53           | 72           | 56           |
| K2O        | 46            | 36           | 46           | 33           |
| Ca         | 44            | 34           | 42           | 89           |
| Mg         | 8             | 7            | 9            | 7            |
| Zn-Cu-Mn   | (0.2 0.7)     |              |              |              |

It’s worthy to mention that both quality and quantity of biological hazards are affected by many variables including,
not limiting to, the pathogen specie and serotype, poultry specie and age, season and farm management practices [12]. As an example, fecal samples of 10 week old layers had a significant prevalence of Salmonella (55%), the decreased by aging to reach (41%) at 25-28 weeks, then (5.5%) at 66-74 weeks old. Also, the prevalence of Salmonella in floor litter of broilers was significantly related to age of the flock and the geographical region in which the flocks were housed [7]. Recently, it’s well known that Salmonella sp. is the most common biological hazard in poultry litter [13]. Survey studies extended for 10 years on food-borne disease outbreaks caused by Salmonella showed that, Salmonella are commonly associated with 24 - 30% of poultry meat products and eggs, respectively [14]. Chicken egg could be salmonella-contaminated horizontally or vertically. Horizontal transmission occurred as a result to fecal contact, while vertical one is due to infected ovaries or eggs [15].

In poultry industry, especially in farms of broilers and table eggs the management systems are mainly depending upon prophylaxis management practices. So, the flocks are routinely exposed to different kinds of antibiotics. Consequently, the great amounts of chicken litter and the widespread usage might accompany by widespread antibiotic-resistant bacteria contaminating the environment [4]. Antibiotic-resistant bacteria could be transferred either vertically or horizontally. The routine use of antibiotics as prophylaxis and/or growth promoter enhances the selectivity of antibiotic-resistant bacteria inside the gastrointestinal tract which excreted and applied to the agricultural lands [16]. The increased and repeated usage of antibiotics in poultry industry introduces more selective pressure resulting the development of multi-resistance characteristics in certain bacterial populations. It’s important to identify and characterize different isolated antibiotic-resistant bacteria of poultry litter to predict their pathogenicity and their persistence in environment [17].

Poultry Litter as Feed Component for Farm Ruminants

Also, poultry litter is used in many countries as feed ingredient for farm ruminants, as low cost feed ingredient (Table 2)

Table 2: Proximate analysis and nutritive value of poultry wastes. Roothaert et al. [18]

| Poultry Waste          | % DM | % CP | % CF | % Ash |
|------------------------|------|------|------|-------|
| Poultry litter          | 84.7 | 31.3 | 16.8 | 15    |
| Broiler litter "Rhodes"| 86.5 | 19.5 | 14.4 | 13.1  |
| Broiler litter "sawdust"| 87.5 | 25.5 | 17.7 | 15.6  |
| Layer manure dried      | 89.7 | 28   | 12.7 | 28    |

Ruminants as biological system modifiers had the capability to digest and utilize in proper feed stuffs and wastes which are not permitted or allowed to other livestock species [19]. Salmonellosis was reported in cattle fed in proper treated and composted broiler litter [20]. So, the specifications of the national authorities of the countries permitting the usage of poultry litter as animal feedstuff should mandate defined processing techniques to guarantee that the treated poultry litter is completely free of human and animal pathogens. Also, an association of both antibiotic-resistant bacteria and antibiotic residues could threaten water quality when poultry housing facilities or improper poultry waste were in contact to running water [21]. Contaminated water could transfer resistant pathogens and antibiotic residues to other water resources commonly used in irrigation, drinking, washing or any other uses of water [21].

The usage of poultry litter, improperly treated, could lead to unexpected harmful effects, considering the following cycles and pathways:

- Transferring both of biological and chemical hazards to soil and agriculture environment,
- Mobilization of hazards in soil and environment of agriculture,
- Transferring and uptake of hazards from soil and environment to accumulate in edible plant tissues,
- Exposure of farm animals to both biological and chemical hazards potentiated in poultry litter,
- Exposure of human to contaminated edible plants or ingesting food of animal origin that previously exposed to poultry litter.

Transfer of Biological and Chemical Hazards to Agriculture Environment

Commonly, and before applying to agriculture, poultry litter was exposed to certain treatments with different practical effective impacts. Composting is the most common practices in farms. Such treatment(s) had the capability to inactivate large populations of biological hazards [22,23]. Many studies agreed that some pathogenic populations could survive after composting processes [9,23,24]. The retained little pathogenic cells could re-grow in the finished treated product. The alternatives of physical, chemical and biological treatments could not eliminate the biological hazards, especially the food borne pathogens [9,22]. As a result of composting or the other alternative treatment, some microbial strains could gain stress-adaptation. Thus, more
Mobilization of Hazards in Agriculture Environment

Poultry litter as a natural nutritive resource is intentionally applied to arable agriculture lands to improve both structure and fertility of the soil. Poultry litter which is composting improperly might carry some food-borne hazards which have the potentiality to survive and/or re-grow to high level of populations under certain environmental conditions [28]. As well, some microbial strains could be acclimatized and adapted to environment during composting processes [12,13,29]. Poultry litter as a mixture of different media involving feces, bedding materials, wasted feeds and feathers, represent favorable media for wide range of biological and chemical hazards. Such biological hazards include many food-borne pathogens like Salmonella, Campylobacter, Listeria, Actinomycets, Escherichia coli and Clostridium at high concentrations could reach up to \(10^{10}\)CFU/gram of poultry litter [1,10,30]. The remaining high levels of populations might display different metabolic pathways and interfered with the environmental micro flora. It’s worthy to mention that the most potent biological hazards are the antibiotic-resistant bacteria and stress adapted pathogens which previously exposed to low doses of antibiotics and/or unfavorable processing treatments [15,28]. The vertical and horizontal mobilization of such resistant microbes could threaten human, animal and public health, especially when those fatal hazards had the capability to break through food chain. As well, bacterial antibiotic resistance may be induced in animal guts that previously exposed to poultry litter either when they ingest feeds containing poultry litter or when they were grazed on contaminated arable lands [31-33].

Transformation of Antibiotic Residues to Edible Plant Tissues

Antibiotics are commonly administered to poultry feed, besides the great amounts used in the prophylaxis management systems. Most of the oral applied antibiotics are poorly absorbed in the poultry gut, and then consequently those large amounts of antibiotics were excreted in feces and urine "manure". Approximately 90% of the applied antibiotics might be excreted as the parent compound(s) [34]. The most common antibiotics present in poultry litter are bacitracin, chlorotetracycline, monensin, tylosin, penicillin, chloramphenicol and virginiamycin [5,35]. Quantitatively, antibiotic residues in poultry litter showed varied range between negligible traces up to 216mg/kg of the dried poultry litter [5].

Undoubtedly, there is an expected risk when using poultry litter in either plant or animal nutrition due to the mechanisms of uptake and accumulation of certain hazards in edible tissues of exposed plants and animals. The most common observed chemical hazards were antibiotic residues [4]. In general, the uptake of pharmaceuticals is depending upon the physical and chemical properties of the parent drug or its degraded products. So, it’s very important to define whether a chemical is neutral or ionized at the natural environmental media pH values. Thu, there are separate models exist to predict uptake of chemicals in different forms. For neutral chemicals, hydrophobicity is proposed to be the most incorporated factor affecting the uptake of chemicals from soil to plant edible tissues [36]. Regarding the usage of poultry litter as feed component for ruminants, the risk assessment of antibiotic residues should be determined considering many factors including, not limited to, the nature and stability of the chemical, the pattern and metabolic pathways inside the ruminant’s body, the targeted organs and the excreted, secreted and accumulated pattern [33,37,38].

Recently, the World Health Organization (WHO, 2014) issued a list of important antibiotics to human medicine contains 32 drug classes with 260 individual drug. Out of the listed 260 drugs, 39 are recommended and commonly prescribed for use in farm animals. The 39 antibiotics used in veterinary medicine are distributed between prophylaxes, curatives and feed additives. It’s not easy to determine which veterinary antibiotics have undesired significant effects on human health. It’s worthy to mention that the antibiotics available for use in animal agriculture are varied from one country to another. So, the available data concerning some developed countries are not necessarily representing other countries. For accurate evaluation or to determine the effective agriculture antibiotics having impact clinical outcomes, there is a need for true data about; pathogen’s ecology as well as data dealing the prioritized list of bacteria posing antibiotic resistance [13][39]. However, accurate disinfection strategies should be carefully established to avoid biological and chemical contamination during poultry litter composting. Multi-step treatment in combination with composting, as first step, is preferred to get rid of large population of pathogens [19]. Treatment techniques should include certain parameters including indicator microbes and certain chemicals to evaluate the efficacy and validity of the applied techniques [27,40,41,42].

Conclusion

Expansion in poultry industry resulted an increased yield of poultry litter wastes which might threaten public health. Recycling of such wastes is recommended and applied
in many countries due to the potential nutrients which are required for plant and animal nutrition. In both developed and developing countries the usage of poultry wastes is allowed to enhance structure and fertility of arable soils. Moreover, many countries including Egypt approved the usage of poultry litter as feed component which could be admitted to farm ruminants. Recycling of poultry litter had many environmental, economic and nutritional advantages. In most countries permitted the usage of poultry litter in agriculture, there are rigid rules and specifications should be followed before application. The adopted criteria aiming to ensure that the recycled product is free from biological hazards especially the pathogens. Actually, most of the potential biological hazards could be controlled when applying efficient composting physical, chemical and biological systems. Meanwhile, there is still a problem due to the contamination of the treated wastes with antibiotic-resistant bacteria and stress-adapted pathogens. Moreover the chemical hazard of high concentrations of antibiotic residues could potentiate dramatic effects, especially when introduced to food chain. So, accurate and efficient strategies are urgently needed to control either biological or chemical hazards, especially that of stress-adapted pathogens and antibiotic residues.

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