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Poultry waste management: An approach for sustainable development

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Abstract
Indian poultry sector has shown spectacular growth since the late seventies. South and West Indian states have been the leading states in this regard. As per 19th Livestock Census, 2012, poultry population in India is 729.2millions, which is remarkable considering a population of 73.5 million in 1951, and an annual growth rate of 21% in broiler sector alone. Poultry provide globally important sources of animal protein and are amongst the most intensively reared of all livestock species. Despite their immense socio-economic benefits in terms of production of eggs, meat and employment generations often constitute some environmental risks to both human and animal lives through water/soil and air pollution. These waste products are produced in form of hatchery wastes, birds' excrement, litters and on-farm mortalities, among others**.** If these wastes are not used in an adequate form, they provoke enormous pollution problems. Poultry feathers being rich sources of keratin proteins and amino acids, can be converted into valuable products such as feather meal, bio diesel, biodegradable plastic and fertilizer. Poultry manure is also useful as fertilizer, methane and to produce electricity. This review explore detail about the scope for adoption of various poultry wastes. Poultry waste generation is enormous. However, cost effective technologies are yet to be identified to recycle the waste to useful products.

Keywords: waste, poultry, environment, biofuel

1. Introduction

Worldwide, the poultry industry is growing rapidly and contributes towards addressing key national development goals, as well as, in improving the standard of living of people through poverty alleviation and creating employment opportunities contended that the problem coming along with the poultry production is the manure that needs to be taken care of, as a non-appropriate treatment or disposal can become risky for environment and humans. For instance, manure can support the spread of diseases and may pollute soil and groundwater resources if not properly handled. Waste is defined as anything that is no longer useful and needs to be disposed of. Furthermore, waste may be defined by the type and place in which it is produced, such as agricultural, household, industrial and mining. The poultry industry produces large amounts of waste that include solid waste and wastewater. The solid waste consists of bedding material, excreta (manure), feed, feathers, hatchery waste (empty shells, infertile eggs, dead embryos and late hatchlings), shells, sludge, abattoir waste (offals, blood, feathers and condemned carcasses) and mortality.

2. Classification of poultry waste

It is mandatory to concentrate on the following poultry farm waste products which are mainly responsible for the environmental pollution:

1. Poultry feather
2. Poultry offal
3. Poultry litter/manure

3. Poultry Feather

3.1 Composition

Chicken feathers contain nutrients approximately 91% protein (keratin), 1% lipids, and 8% water. The amino acid sequence of a chicken feather is exactly same as that of other feathers and also has a great deal in common with reptilian keratins from claws. The amino acid sequence is mainly composed of cystine, glutamine, proline and serine. However almost histidine, lysine, tryptophan, glutamic acid and glycine are absent. Serine (16%) is the most abundant amino acid in chicken feathers. [1] Keratins are insoluble proteins present in feathers, wool, hooves, scales, hair, nails (hard keratins) and also in stratum corneum (soft keratins). These specific proteins which belong to the scleroprotein groups are compounds that are highly resistant to physical, chemical and biological actions. Mechanical stability and high resistance to proteolytic degradation of keratin is due to the presence of disulfide bonds, hydrogen bonds, salt linkages and cross linkages. Chicken feather fiber basically consists of α- helical and some β- sheet conformations. Its outer quill is almost entirely made up of β- sheet conformations and few α- helical conformations. Hard β- sheet keratins have higher cystine content than soft α- helix keratins and thus a much greater presence of disulphide (S-S) bonds that link adjacent keratin proteins. The presence of strong covalent bonds stabilize the three-dimensional protein structure and are very difficult to break [1].

3.2 Utilization

3.2.1 Feather meal

Feathers are also converted to feather meal with usage as animal feed, organic fertilizers and feed supplements, as it is made up of >90% protein and are rich in hydrophobic amino acids like cystine, arginine and threonine. One of the most common methods of feather meal production is hydrothermal process where feathers are digested under high pressure at high temperature. However, hydrothermal treatment leads to destruction of essential amino acids like methionine, lysine, tyrosine, tryptophan that accounts to poor digestibility and low nutritional value [2].

3.2.2 Chemical hydrolysis

Chicken feather keratin when treated with lime (calcium hydroxide) to get a liquid product rich in amino acids and polypeptides, can be used as an animal feed supplement. At high temperatures (150°C), 80% of feather keratin is solubilised within 25 min. However a relatively longer reaction time (300 min) is needed at moderate temperatures (100°C). After 3 h of hydrolysis at 150°C, 95% of feather keratin is digested. Under the recommended conditions (100°C, 300 min, and 0.1 g $Ca(OH)_2$/g dry feather), after lime treatment, about 54% of calcium can be recovered by carbonating. In rumen fluid, ammonia production from soluble keratin similar to that of soybean and cottonseed meals and is greatly less than that of urea, showing that ammonia toxicity will not result from cattle being fed with soluble keratin [3].

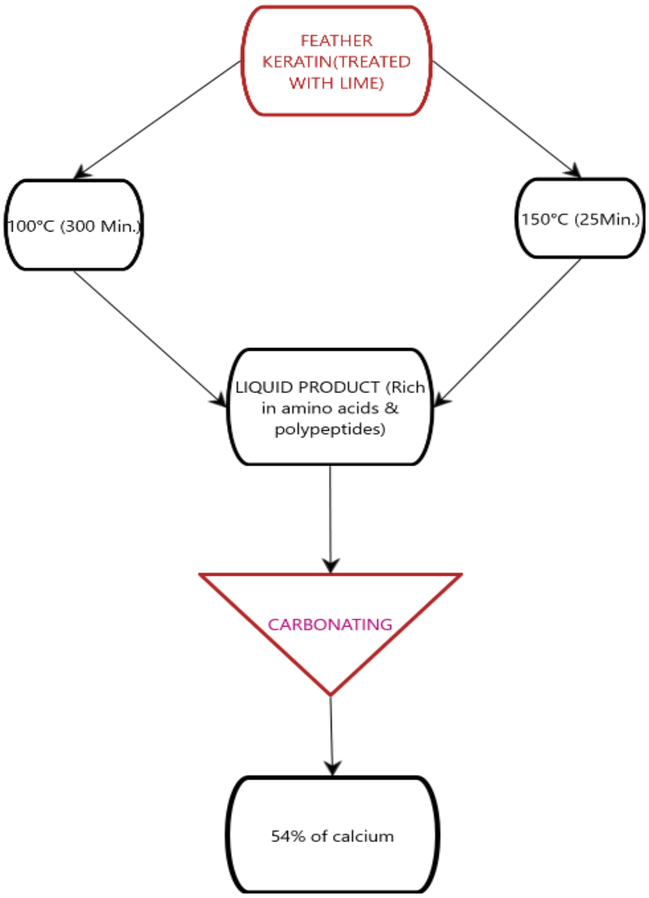

Fig 1: Chemical Hydrolysis of Feather Keratin

3.3 Feather bioconversion

Feather wastes are utilized on a limited basis only as a dietary protein supplement (as feather meal). Initially, the feather wastes can be cooked either with steam or chemically to make it more digestible, but such treatments are expensive. Meanwhile, microorganisms play an alternative role to increase the biovalue of feather wastes. It has already been reported that the feather-lysate produced by Bacillus licheniformis PWD-1 has nutritional features for feed similar to soybean protein. Even though bacterial keratinolytic proteases showed a potential for feather bioconversion, improvement of enzyme activities and higher yields are required to make these suitable for industrial applications. [4]

Table 1: Feather Degrading Bacteria and Properties

Bacteria Name	Production Of Keratinolytic Activities (IN Units)	Optimum Temprature (Degree Celcius)	Optimum PH
Bacillus subtilis	142	40	5-9
Bacillus pumilus	96	40	5-6
Bacillus cereus	109	30	7

Feather-degrading bacteria are now isolated from poultry waste. Among those isolates, three strains of *Bacillus subtilis*, *Bacillus pumilus* and *Bacillus cereus* have the potential to degrade feathers with a production of 142, 96 and 109 units of keratinolytic activities, respectively. The production of keratinolytic protease by *B. pumilus* and *B. cereus* are possible with feathers, but not with *B. subtilis* since it produces the enzyme constitutively in the presence of various proteins such as casein, feather and BSA. The maximum keratinolytic activities of *B. subtilis* and *B. pumilus* are 161 and 149units/ml after 84 and 72 h of cultivation, respectively.

3.4 Bio diesel

Slaughter house wastes like feathers, blood, and innards are being processed and utilized as high-protein animal feed sources or as fertilizer due to its high nitrogen content. It is estimated that these wastes contain up to 12 per cent fat. Scientists from the University of Nevada isolated the animal fat and successfully produced biodiesel comparable to biodiesel from other feed stock. Environmental friendly processes are developed for the production of biodiesel from feather meal. In biodiesel production, primarily fat is extracted from feather meal in boiling water (70°C) and subsequently trans- esterified into biodiesel using potassium, nitrogen and methane; 7-11% biodiesel (on a dry basis) is produced in this process. ASTM analysis confirmed that biodiesel from feather meal is of good quality when compared to other biodiesel made from other common feed stocks.

3.5 Technical textiles

The nonwoven is prepared by using low cost chicken feathers. The advantage of application of chicken feathers in textile field are wide. The nonwoven textile materials prepared by chicken feathers are very versatile and have a wide application in the field of technical textiles. [5]

3.6 Biodegradable plastic

Poultry feathers are also converted into biodegradable plastics by a process called polymerization. In this process, feathers which contain keratin protein are pulverized into fine dust. Chemicals that make keratin molecules to join together are used to form long chains (polymerization). It is further moulded into various shapes when heated at 170°C. These thermoplastics can be popularised to manufacture all kinds of products, from plastic cups and plates to furniture.

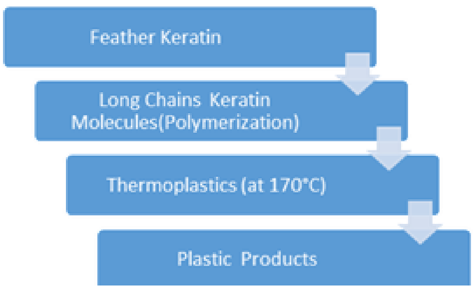

Fig 2: Formation of Biodegradable Plastic

3.7 Fertilizer
A slow release nitrogen fertilizer is developed from poultry feathers. In this attempt, the structure of keratin fibres are modified by steam hydrolysis for 12 weeks to break disulphide bonds, enzymatic hydrolysis by Bacillus licheniformis to break polypeptide bonds and steam hydrolysis (autoclaving) to improve mineralisation followed by cross linking of protein by formaldehyde reaction to minimize excess mineralisation.[6].

4. Poultry Offal
Organic solid by-products and wastes produced in broiler farming and slaughtering are blood, feet, head, bone, trimmings and organs. Offal consists of 5.3% of total Kjeldahl nitrogen, 32% proteins, 54% lipids and 0.6 to 0.9 % methane production potential [7].

4.1 Micro flora
Poultry by-products and wastes contain several 100 different species of micro-organisms in contaminated feather, feet, intestinal contents, and processing equipments, including harmful pathogens such as Salmonella sp., Staphylococcus sp., and Clostridium sp. Finnish meat products contain considerably lower pathogen levels (Ministry of Agriculture and Forestry, 2000). For example, in 1997, positive Salmonella samples in broiler and turkey meat in slaughtered flock and meat from cutting plants rated between 0.6% and 3.1%, respectively [8]. In comparison, in the US, about 30% of chicken products were contaminated with live Salmonella, and 60–80% of chickens were contaminated with Campylobacter, many strains of which are resistant to common antibiotics.

4.2 Residues
Birds also accumulate various heavy metals, drugs, and other chemicals added in their feed for nutritional and pharmaceutical purposes. Veterinary drugs and other chemical contaminants are also present in poultry in different concentrations; e.g., zinc and copper concentrations in poultry feeds in England and Wales range from 28–4030 to 5–234 mg/kg TS, respectively. However zinc and copper concentrations in poultry manure are ca. 400 and ca. 80 mg/kg TS, respectively [9]. Poultry litter in Israel showed to contain varying levels of testosterone (up to 700 ng/g) and oestrogen (up to 500 ng/g), which can interfere with reproductive function [10].

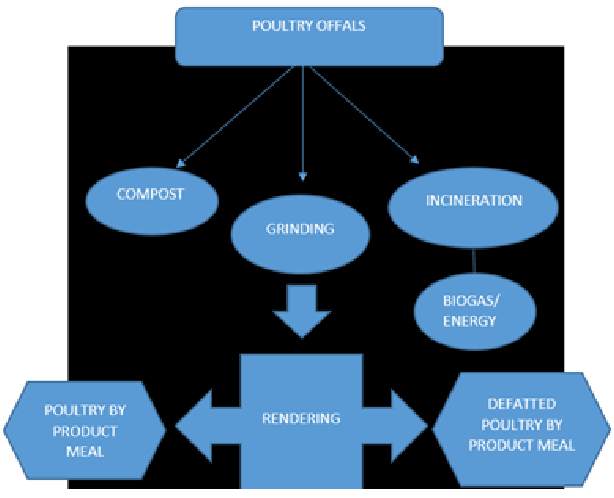

Fig 3: Poultry Offals Utilization

4.3 Incineration
Incineration refers to technologies of thermal destruction, apparently among the most effective methods for destroying potentially infectious agents [11]. Air-dried poultry litter is an established combustible solid fuel with a gross calorific value of about 13.5 GJ per tonne, about half that of coal. But materials having a high moisture content have little or no energy value. In incineration, the air emission, process conditions, and the disposal of solid and liquid residues need to be strictly controlled.

4.4 Burial and controlled landfilling
Burial of dead birds on the farm has to be strictly monitored to avoid groundwater contamination. As the operation, monitoring, and control of land filling also became more tightly regulated under Directive 1999/31/EC. [12] In Europe landfills must prevent as much as possible, its adverse effects on the local environment, particularly the pollution of surface water, groundwater, soil and air. All these measures may increase the costs of land filling.

4.5 Rendering
Rendering refers to different heating applications to remove fat from meat. Rendering at 133°C for a minimum of 20 min at 3 bars or an alternative heat treatment is required for high-risk materials used for animal feed or as an intermediate product for the manufacture of organic fertiliser or other derived products. Rendering produces meat-bone-meal, which can be used in animal feed or as fertiliser or further processed via anaerobic digestion or composting. In addition, rendering produces fat, which may be used for animal feed, in chemical industry products, or burned as fuel. Slaughterhouse by-products are preserved with formic acid as it has good source of proteins and vitamins and are used as animal feed [13]. As one among the biggest fur animal producers in the world, Finland uses an annual 370 million kg of fur animal feed, more than half of which are by-products from the meat and fish industry. Legislation, however, has become stringent about the use of slaughter by-products for animal feed to reduce the risk of disease transmission via the feed and the food chain.

4.6 Composting
Composting is an aerobic biological process to degrade organic material. It is a common method to treat poultry slaughterhouse wastes, grease trap residues, manure, litter, and sometimes also feather. Composting reduces pathogens, and the resulting compost can be used as soil conditioner or fertiliser. However, wastes having high moisture with low fibre content need higher amounts of moisture-sorbing and structural support to compost well [14].

4.7 Anaerobic digestion
Anaerobic digestion is a biological process in which organic matter is degraded to methane. Methane can be used as a source of bio-energy to replace fossil fuels thereby reducing carbon dioxide emissions. Anaerobic digestion reduces pathogens and odours and requires little land space for treatment, and can treat wet and pasty wastes [15]. In addition, any releases to air, water, and land from the process can be well controlled. Most of the nutrients also remain in the treated material and can be recovered for agriculture or feed use.

4.8 Methane production
The biological methane production rate and yield of different

poultry slaughtering residues differ from each other. Poultry offal, blood, and bone meal which were rich in proteins and lipids, showed high methane yields at different concentrations of volatile solids. Blood and bone meal produced methane rapidly. The methane production of offal need more time probably due to longchain fatty acid inhibition. The length of time depends on the source and various concentrations of inoculum and incubation temperature. Sewage sludge at 35ºC, have the shortest delay of a few days, while granular sludge did not produce methane within 64 days of incubation. Feather showed somewhat lower methane yield of 0.21 m3 kg -1 when volatile solids were added (50 m3 ton -1 wet weight). Combined thermal (120ºC, 5 min) and enzymatic (commercial alkaline endopeptidase, 210 g 1 -1) pre-treatments resulted in increased methane yield by 37 to 51%. Thermal (70-120ºC, 5-60 min), chemical (NaOH 2-10 g 1-1, 2-24 h), and enzymatic pre-treatments are less effective, with methane yield increasing only by 5 to 32%. Anaerobic digestion of the poultry slaughter residues appears a promising possibility because of the high methane yield and nitrogen content of these residues (8 to 14% N of total solids).

5. Poultry Litter Management

Poultry litter consists of bedding material mixed with manure, feathers, spilled water and waste feed accumulated during the production cycle. The bedding material, primarily have high carbon content biomass and this contributes to the energy content of litter [16]. Materials used include straw, sawdust, wood shavings, shredded paper and peanut or rice hulls [17]. Because of its high plant nutrient levels, it is a valuable organic fertilizer providing plant nutrients such as nitrogen (N), phosphorus (P) and potassium (K). Applying poultry litter residues to crop soil will increase organic matter and as a result the soil's water-holding capacity and improve soil tilth. However, one of the main risks related to agricultural field is the imbalance of N and P in poultry manure. These two nutrients in poultry litter are not in the same proportion as needed by crops. A soil analysis is important to determine the appropriate balance of N-P-K and Ca for the desired crop and although poultry litter contains many of the valuable macronutrients found in expensive commercial fertilizers, the NPK ratios may not be ideally suited to the soil nutrient needs [16]. There are many different waste management options for litter including land application of litter as an organic fertiliser.

5.1 Utilization

5.1.1 Litter re-use

One solution to dealing with used or spent litter, widely adopted in the United States of America, is to re-use it for subsequent batches of broilers. While there are cost-saving benefits from not entirely replacing spent litter with new bedding material for each batch, there is also a bonus in that the eventual multi-batch litter makes for an improved compost due to its higher proportion of nutrients from greater proportion of chicken excreta to bedding material in the litter. If there are concerns about carryover of disease organisms in re-used litter, methods to reduce pathogen load developed under Poultry CRC project Methods to quantify and inactivate viruses in poultry litter can be accessed via the following links. These include standard procedures for in-shed pasteurisation of litter between batches and the LitterHeatMap model to predict and optimise temperatures in litter being pasteurised by heaping.

5.1.2 Poultry waste in livestock feeding

Poultry litter has been used in diets for poultry, swine, lambs, ewes, lactating cows, wintering cattle and brood cows. Poultry litter and/or manure are used as livestock feed in most countries [18]. Including Israel and some states in the US. Poultry waste used for animal feeding is obtained primarily from laying hens (caged and not caged) as well as broiler operations. Poultry litter is also used to feed livestock. Cage layer waste can be used by ruminants as a source of supplemental protein. Chaudhry *et al*. (1997) stated that amino acid nitrogen of cage layer waste ranges from 37 to 40% of total nitrogen and that about 40 to 60% of total nitrogen in poultry excreta is present in the form of non-protein nitrogen (NPN). Uric acid, the major NPN source in poultry is degraded to ammonia by rumen microbes. According to National Research Council (NRC) (1984), the maximum inclusion rate for poultry waste in ruminant feeds is 20%. Crickenberger and Goode (1996) suggested that adding broiler litter to beef cattle rations at a level of 20% or higher (as fed basis) generally meets the animal's needs for crude protein, calcium and phosphorus. The investigators reported beneficial effects of feeding corn silage to which poultry litter has been added at a level of 30%. Furthermore, Muller (1980) observed that poultry waste fed at levels above 35% usually covers almost the total protein requirement of sheep, and contributes substantially to the energy of the total ration. The investigator noted that the only problem encountered in feeding processed poultry waste to sheep is the toxicity derived from the high copper level in poultry diets. Jordon *et al*. (2002) measured body conditions of sheep fed dried poultry waste, soybean or urea as winter supplements and concluded that feeding a supplement containing dried poultry waste resulted in performance similar to that of conventional supplements containing soya bean meal. In Nigeria, Owen *et al*. (2008) investigated the nutrient quality of heat treated poultry litter and obtained dry matter (DM), crude protein, energy, crude fibre, ether extract and ash values of 87%, 20%, 621.41 kcal/kg, 10.40%, 2.2% and 18.50%, respectively. In addition, phosphorus, calcium, sodium, potassium and magnesium values in the litter were 4.50%, 2.00%, 0.10%, 2.05 and 0.48%, respectively. The investigators concluded that poultry litter could be incorporated into animal feeds.

5.1.3 Closed-loop systems

An important concept for a waste manager is a closed-loop system where outputs from one industry become inputs for another. Therefore, pollution could be defined as a resource or raw product that has an adverse effect on the environment which has not been transformed into another useful product. Land application satisfies this requirement as litter is transformed into plants while soil structure is improved by increasing soil organic matter. Composting litter before applying to land can enhance both plant growth and soil structure.

5.1.4 Composting

Composting is a natural, biological process by which organic material is broken down and decomposed. It is also the manipulation of the natural aerobic process of biological decomposition of organic materials to increase the decomposition rate. This process is carried out by successive microbial populations which function under increasing temperatures to break down organic materials into carbon dioxide, water, minerals, and stabilized organic matter. Composting of waste is viewed as a viable means of reducing litter needs by recycling and reusing litter. Additionally, composting results in a product that is much more environmentally acceptable than raw litter for land application. It is a biological process in which organic wastes are stabilized and converted into a product to be used as a soil conditioner and organic fertilizer. According to Anon (2002), composting provides an inexpensive alternative for disposal of animal-based wastes and other biological residuals. Properly composted material is environmentally safe and a valuable soil amendment for growing certain crops. The basic objective in composting is to maximize microbial activity at the expense of the waste material. To achieve this, maximum metabolic heat output by thermophilic bacteria must be attained. According to Malone (2005), microorganisms will rapidly compost carcasses in the presence of oxygen (>5%), moisture (4060%), and a proper carbon to nitrogen ratio (20:1 to 35:1). This process produces carbon dioxide, water vapour, heat and compost. Under proper conditions, thermophilic organisms will cause the compost to heat to temperatures ranging from 57 to 63 oC. Evanylo *et al*. (2009) stated that mesophilic bacteria thrive at temperatures of 25° to 42 °C, but they can survive at higher temperatures. Mesophilic bacteria feed on the most readily available carbohydrates and proteins. Their metabolic activity raises the temperature of the windrow sufficiently to allow the takeover by thermophilic bacteria which perform best at temperatures ranging from 50° to 60 °C. If the temperature rises much above 66 °C, the majority of the bacterial population and many other living organisms will die. Anon (2002) stated that it takes 2 to 6 months for the animal to decompose.

5.1.5 Biogas production

The anaerobic digestion of organic wastes leads in the generation of biogas, which contains of approximately 60% CH_4 and 38% carbon dioxide (CO_2). The remaining 2% is water vapor, NH_3 and hydrogen sulfide. CH_4 has a range of possible uses as an energy source, but it has primarily been used by direct burning for heat or as fuel for internal combustion engines (Hashimoto *et al*., 1980). Possible uses for the digester effluent include fertilizer and feed supplement for animals, although the nutritive value of the effluent is dependent on the digestion system and operation method as well as the method of collection. Studies of biogas generation by anaerobic digestion of a number of animal wastes, including poultry waste, points that several variables influence biogas generation. A number of researchers have described the method of digestion systems for poultry manure. Most of these systems were designed to operate in the mesophilic range (approximately 35°C), as recommended by Smith (1980) for on-farm systems.Net energy produced during digestion has been reported to range from approximately 60% to 75% (Morrison *et al*., 1980) of gross output. While the theory of biogas generation is well established, there have been several reports of operational difficulties accompanying anaerobic digestion of poultry manure, which must be diluted for hydraulic transport. The major problems include mechanical aspects such as mixing, screening, pumping and plumbing, formation of scum, grit accumulation and others. In addition, the equipment is not simple and the digesters must often be operated without skilled technicians. These problems may influence the economic feasibility of biogas generation. Barth and Hegg (1979) state that biogas production is economically justifiable when the digestion systems operate at design capacity, but found that none of eight plants they visited was operating at capacity. The primary reason cited was operators' lack of familiarity with the technology; when confronted with a problem, the digestion system was simply shut down.

5.1.6 Mass burn combustion

Chicken litter is one of the wastes comes from the Chicken poultry farms [19] that constitute a complex source of organic nutritive ingredients with environmental effects.These wastes can be used to make the energy generation. Percentage of heat energy of produced by the Laying hen and Broilers are more than other farm cattles.The most effective and successful conversion of poultry litter to energy involves the use of mass burn combustion and, in particular, step-grate combustion systems [17]. The wastes can be burnt in purpose-built incinerators. The heat can then be used to produce electricity, or to provide heating for the buildings. Advanced technologies can be employed to ensure that the waste gases emitted from these facilities will reduce the environmental risk.

5.1.7 Fluidised bed combustion

In fluidized bed combustion is devise contains three main types of fluidised beds, bubbling, turbulent or circulating bed types. All designs consist of a bed of sand in a refractory-lined chamber through which primary combustion air is blown from below. Adjusting the airflow fluidises the sand particles. Cyclones are placed within the freeboard to re-circulate the sand to the bed. The fluidised bed reactor facilitates the dispersion of incoming fuel, where it is quickly heated to ignition temperature and provides sufficient residence time in the reactor for complete combustion. Fluidised beds are compact and have high heat-storage and heat transfer rates and thus allow faster ignition of low combustible waste to recover the heat. Using poultry litter as an energy resource (combined heat and power), combustion studies of poultry litter on its own or mixed 1:1 with peat were carried out in an atmospheric bubbling fluidised bed [20]. The high moisture content of chicken litter provided uncertainty as to whether combustion could be sustained on 100% chicken litter therefore, a mixture with peat was considered to help improve combustion.

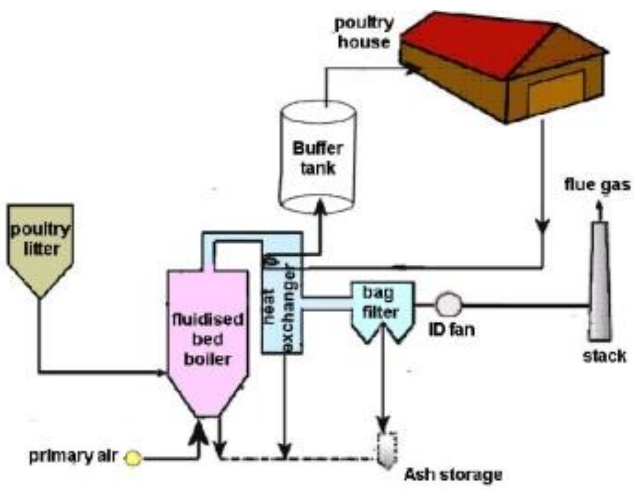

Fig 4: Fluidised bed combustion [21]

The study found that as long as the moisture content of chicken litter is kept below 25%, the combustion will not need the addition of peat. Leachability tests were carried out with the ashes collected to verify whether or not they could safely be used in agricultural lands. The results showed little tendency to leach. These studies illustrate that fluidised bed technology can be used for the direct combustion of poultry litter. The minimization of moisture content at low cost is obviously desirable and worthy of investigation for all combustion techniques. The manipulation of diet to lower the moisture content of poultry litter may be an approach worth considering. High moisture barley, which is sometimes included in the feed given to broiler chickens in Norway, was stored under different conditions to study the effect on the digestive tract and, consequently, the moisture content of the poultry manure. The barley was preserved anaerobically by ensiling using different additives, aerobically with propionic acid, or by drying [17].

5.1.8 Direct combustion

Direct combustion and incineration are recognised as efficient options for generating renewable energy and fertiliser grade ash from litter and could potentially close the nutrient loop for the poultry industry. There are currently successful large scale off-site electricity utilities operating in the UK that primarily use litter as a fuel. For on-site electricity and heat generation, smaller direct combustion systems are being researched and developed, and if commercialized, could supply Australian broiler growers with both environmentally sustainable waste disposal and energy.

5.1.9 Vermiculture

The use of specially selected earthworm species to degrade waste is known as vermiculture. This technique has been widely adopted by home gardeners to utilize green wastes and vegetable scraps. Vermiculture has the potential to produce both humic rich vermi-compost (vermicast) and meat meal (vermimeal) from litter. Traditionally, the vermiculture process has primarily been adopted to produce vermicast, a recognised valuable organic fertiliser.

6. Conclusion

Poultry waste is one of the major pollutants if not properly disposed. Poultry feathers can be treated chemically or biologically with microbes to improve the nutritive value of feather wastes which can be used as animal feed. They can also be biologically converted into feed supplements, biodiesel, and biodegradable plastic and organic fertilizer. The offals are utilized by various methods like rendering, incineration, burial, controlled land filling, composting and anaerobic digestion. Rendering produces meat-bone meal which may be used as animal feed or fertilizer. Composting reduces pathogens. The compost is used as soil conditioner or fertilizer. Poultry litter contains carbon, nitrogen, phosphorous, chlorine, calcium, magnesium, and sodium, manganese, ferrous, copper and arsenic. It is used as a very good source of fertilizer. Methane gas produced from poultry litter is converted into electricity using a patented technology. Altogether, poultry wastes can be effectively utilized if properly treated to reduce the ill effects and a range of value added products like fertilizer, biodiesel, animal feed, electricity, bone meal and biodegradable plastic can be produced.

7. References

1. Kannapan Saravanan, Bharathi Dhurai. Exploration on amino acid content and morphological structure in chicken feather fiber, JTATM, 2012, 7:3.
2. Ekta Tiwary, Rani Gupta. Rapid conversion of chicken feather to feather meal using dimeric keratinase from Bacillus licheniformis ER-15, J Bioprocess Biotechniq. 2012; 2:4.
3. Guillermo Coward-Kelly, Vincent S. Chang, Frank K. Lime treatment of keratinous materials for the generation of highly digestible animal feed: 1. Chicken feathers, Bioresource Technol. 2006; 97(11):1337-43.
4. Kim JM, Lim WJ, Suh HJ. Feather-degrading Bacillus species from poultry waste, Process Biochemistry. 2001; 37:287-291.
5. Chinta SK, Landage SM, Yadav Krati. Application of Chicken Feathers in Technical Textiles, IJIRSET. 2013; 2:4.
6. Jong-Myung Choi, Paul Nelson V. Developing a Slow-release Nitrogen Fertilizer from Organic Sources: II. Using Poultry Feathers, J. Amer. Soc. Hort. Sci. 1996; 121(4):634-638.
7. Salminen E, Rintala J. Anaerobic digestion of organic solid poultry slaughterhouse waste – a review, Bioresource Technology. 2002; 83:13-26.
8. Ministry of Agriculture and Forestry. Control of foodstuffs of animal origin. Veterinary and food department, 2000.
9. Nicholson FA, Chambers BJ, Williams JR, Unwin RJ. Heavy metal contents of livestock feeds and animal manures in England and Wales. Bioresour. Technol. 1999; 70:23-31.
10. Shore LS, Harel-Markowitz E, Gurevich M, Shemesh M. Factors affecting the concentration of testosterone in poultry litter. J. Environ. Sci. Health A. 1993; 28(8):1737-1749.
11. Ritter WF, Chinside AEM. Impact of dead bird disposal pits on groundwater quality on the Delmarva Peninsula. Bioresour. Technol. 1995; 53:105-111.
12. Commission of the European Communities, Council Directive 1999/31/EC. Official Journal. 1999; 182:1-9.
13. Pulsa A. Turkistarhat tarvitsevat laadukasta teurasj€atett€a. Lihalehti. 1996; 3:38-41. in Finnish
14. Tritt WP, Schuchardt F. Materials flow and possibilities of treating liquid and solid wastes from slaughterhouses in Germany. A review. Bioresour. Technol. 1992; 41:235-245.
15. Braber K. Anaerobic digestion of municipal solid waste: a modern waste disposal option on the verge of breakthrough. Biomass Bioenergy. 1995; 9:365-376.
16. Reardon T, Berdegue J, Escobar G. Rural nonfarm employment and incomes in Latin America: Overview and policy implications. World Development. 2001; 29:395-409.
17. Kelleher BP, Leahy JJ, Henihan AM, O’Dwyer TF, Sutton D, Leahy MJ. Advances in poultry litter disposal technology, Bioresource technology. 2002; 83:27-36.
18. Smith LW, Wheeler WE. Nutritional and economic value of animal excreta. Journal of Animal Science. 1979; 48:144-156.
19. Zaigham NA, Nayyer ZA. In Proceedings of Renewable Energy Technologies & Sustainable Development, 2005, 65p.

20. Abelha P, Gulyurtlu I, Boavida JS, Cabrita I, Leahy JJ, Kelleher B, Leahy M. Combustion of chicken litter in a fluidised bed combustor. In: The Second International Mediterranean Combustion Symposium, Sharm El-Sheikh, Egypt, 2002, 6-11.
21. Bowen B, Lynch D, Lynch D, Henihan AM, Leahy JJ, McDonnell K. Biosecurity on Poultry Farms from On-Farm Fluidized Bed Combustion and Energy Recovery from Poultry Litter. Sustainability. 2010; 2:2135-2143.