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Usage of Poultry Waste for Welfare of Mankind- *A Review*

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Abstract: ***In India poultry industry is the fastest growing agro-based industry. There is large amount of accumulation of poultry related wastes in terms of litter, manure etc. and the extent of waste production is more when there is intensive poultry production. Due to intensive poultry production there is every chance of major environmental problems as poultry waste is a major source of pollution, pathogens and odour. Besides all these problems, poultry litter contains lot of energy and fertilizer sources which can be utilized for the betterment of agriculture. The fertilizer obtained from poultry wastes, becomes organic fertilizer which enhances the soil fertility, sustainability which provides prospect for the agricultural sector to reduce their dependence on chemical fertilizers. For sustainability in agriculture, use of chemical fertilizers should be avoided and instead of this new waste management systems should be implemented which will be economically feasible and eco-friendly. For best utilization of poultry waste options like compost preparation should be adopted. Although poultry litter is a good source of nitrogen, phosphorus and trace elements for crop production but its direct application to the fields become counter-productive. Therefore, the best way to utilize poultry litter is to use it in the form of compost. Compost made out of poultry wastes becomes very effective in improving the physical, chemical and biological fertility of soil. Since poultry litter has got lot of nitrogen and phosphorus, so to neutralize the deleterious effect of the toxicity arose out of high concentration of nitrogen and phosphorus, brown materials like dry or woody plant material may be used. A perfect mixture of poultry litter and brown material forms the compost pile may heat up and take less time to break down into useable compost and will not smell bad. The brown material also helps the litter to allow air to pass through the compost which will result in better quality of fertilizer in the form of compost. It can, therefore, be concluded that the poultry litter can be mixed with supplements like rice hulls and straw in proper ratio of carbon and nitrogen for compost preparation for the safe application in the field. Wastes including mortalities, hair, feathers and processing wastes can be converted to products which are useful for mankind. The poultry farm waste products such as poultry feather, offal and litter/manure are mainly responsible for the environmental pollution. Renewable sources can be used to develop by products which can be used efficiently. It also decreases environmental pollution. Poultry litter can be used for different purposes: As fertilizer in agriculture, for compost formation, pelletization, electric power generation, and cogeneration of steam and electric power. Poultry litter produced annually can be estimated by multiplying the average amount of litter generated per bird times the number of birds produced annually (Carr, 2002). Consumption of clean energy and increasing agricultural productivity is the prime agenda of the developing countries, in order to feed the increasing population and continue to keep our surrounding environment as clean as possible.***

1.Poultry Manure and Its Utility in Agriculture

Rearing of chickens is labor intensive and good management skills are required. Management of different variables in production houses must be maintained for the optimum growth of birds and at the same time health of the poultry should be maintained. Poultry litter contains 13 plant nutrients including: nitrogen, phosphorous, potassium, calcium, magnesium, sulfur, manganese, copper, zinc, chlorine, boron, iron, and molybdenum (John et al., Bolan et al., 2004). Litter contains approximately 25% of moisture content. It can be dry also. When combusted can cause increase in temperature of approximately 2000 degrees Fahrenheit. It can be used as a potential energy source (Darren et al., 2006). Poultry manure or chicken manure consists of mainly faeces and urine of chickens. Poultry litter contains mixture of manure with left over feed, feathers and bedding materials like wood shavings or sawdust. It is an organic manure enriched with elements like N, P, K and trace elements like Zn, Cu, As etc. The composition and quality of poultry litter varies with the types of poultry, types of litter used, diet and dietary supplements, and way of collection and storage of the litter (Shamim Reza, 2016).

At present, the most common use of poultry litter in agriculture is it's application to crops as fertilizer. Abroad Regulations have been devised by Management Programs for the proper use of poultry litter. With increase in storage time, nutritional value of the litter deteriorates rapidly. Depending on the processing conditions also, the nutritive value of poultry manure varies. Poultry manure contains nitrogen, phosphorous and potassium at 1-3% range and also other micro-nutrients at considerable amount (Amanullah et al., 2010; Bolan et al., 2010). Besides absorption of moisture, manure has readily available nitrogen, if care is not taken it can cause burning problem. Application of poultry manure for crop production improves soil moisture retention and greater uptake of nutrients by plants. Deep litter manure is produced by layers. The litter consists of rice husk or wood shavings when mixed with the faecal matter of chickens, aerobic fermentation occurs (Simpson, 1986). Application of poultry manure increases the phosphorus content of the soil. The amount of poultry litter that can be applied as fertilizer depends on the phosphorus content of the soil in the field, further this has to be verified by conducting tests. Phosphorus Fertility Index Value (FIV) and its Phosphorus Site Index (PSI) are calculated. It is observed that poultry litter cannot be legally applied to the fields where soils with a FIV greater than 150 and a PSI greater than 100 are recorded (Litchen berg et al., 2002, http://www.arec.umd.edu/Policycenter/). The value of poultry litter in land application as fertilizer depends on several factors, including the value of the nutrients provided, application costs and transportation costs. Under nitrogen-based nutrient management plans, less of the phosphorus and potassium contained in the litter applied, are taken up by crops than under phosphorus-based management plans. The average nutrient value per ton of litter is lower under the nitrogen based nutrient management system than the latter (Sharpley and Moyer, 2000; Tiquia and Tam, 2002).

Composting of poultry manure can be done with paddy straw or sorghum straw. The blending of litter with straw increases carbon, nitrogen and phosphorus content of the compost (Amanullah et al., 2007). Composting is done prior to usage of litter as fertilizer. Composting is the controlled biological process of the decomposition of organic materials into a humus rich product that can be used as a fertilizer for agricultural purposes. Composting of litter is by aerobic transformation process, while an anaerobic process results in digestate.

There are basically four general methods of producing compost: static pile, standard windrow, improved windrow, and in-vessel and agitation. Static pile is the simplest. It involves mixing of the poultry litter with a carbon source (most often sawdust) and stacking it into a pile that is aerated from below. Windrow methods involve laying out the poultry litter/sawdust mixture in long piles that form tall rows. The rows are turned periodically to increase aeration and thus speed the composting process. Improved windrow is similar to standard windrow but involves greater usage of equipment and facilities that increase production efficiencies (Karanja et al., 2005). Input costs for producing composts include the costs of sawdust as a carbon source, and the costs incurred on cleaning out poultry houses for providing the litter (Musa et al., 2012). The poultry industry is one of the largest and fastest growing industries. It is a source of cheap animal protein but at the same time is also producing lot of waste matter whose proper utilization can be economic and reduce environmental pollution. During handling of manure, and from storage areas greenhouse gases, such as carbon dioxide, methane and nitrous oxide are released from manure which cause ozone depletion and global warming. Improved manure handling and storage methods are needed to reduce the emission of these gases (Aneja et al., 2006). If used inappropriately causes many economic and environmental hazards. Some special techniques are needed to produce quality litter compost and at the same time reduce pollution.

Composting should be done on a suitable base to prevent mixing with ground water.

- Compost must be protected from rain and wind in order to prevent water or moisture absorption and protect it from getting contaminated.
- When the pile is too dry, or too wet it creates problems of production of dust, or an excessive odour is emitted. Moisture content around 45-50% should be maintained.

Fresh poultry litter usage is not safe, as it contains many pathogenic organisms, harmful chemicals, and weed seeds; therefore, composting is necessary to use them as fertilizer. To compost, fresh chicken manure should be mixed with different ratios of Carbon source. The Carbon source is also needed to be a bulking agent that facilitates the aeration of the compost pile. The pile temperature should be maintained between 55 and 65°C for minimum 2 weeks (Rader, 2013).For obtaining sustainable production and clean environment, monitoring environmental factors is an important aspect of poultry litter management practice. Regular analysis of manure samples, soil and drainage water should be analysed for contaminants. All farm activities should be recorded for proper environmental monitoring and subsequent use of poultry manure (Eklind and Kirchmann, 2000). An inoculum of specially selected aerobic bacteria is recommended in order to speed the process and improve humus quality. Mesophilic and thermophilic microorganisms are involved and are important in managing the composting process (Van der Wurff et al., 2016). Composting procedure kills pathogens, converts ammonia to stable organic forms and improves the nature of the waste. During composting, solid waste should be aerated regularly by inverting or mixing the material (Gajalakshmi and Abbasi, 2008).When poultry litter is used as a mulching material, it conserves soil moisture and saves the surface feeding roots from drying out in the summer heat and maintains the soil temperature. Poultry manure is capable of improving the biological fertility of mine tailings. Poultry litter is increasingly being used in the rehabilitation of disturbed land resulting from mining and other industrial activities (Franzluebbers and Doraiswamy, 2007).

As Livestock Feed

Poultry manure or litter can be used as feed for cattle and fish. To use the litter as feed the other materials present in it like plastic, feathers, glass pieces etc. must be removed. Poultry litter with ash content more than 28% is not safe to be used as feed, so low ash content must be maintained. Unprocessed poultry litter contains pathogenic microorganisms like Clostridium, Salmonella and Enterobacter spp.; and feed additives, which are added in poultry diet and can be present in the litter as waste by-products, such as antibiotics, coccidiostats, and arsenicals (Smith and Fries, 1973). Therefore to use as feed, proper processing is a must to eliminate these substances from the litter. Properly processed poultry manure and litter are enriched with protein, minerals and fibre and are mixed with cattle feed for these nutrients. In U.S. they have been used as a useful feed ingredient for around 40 years (Espino et al., 2008).

As a Good Fuel Source

Rising cost of fuel in urban areas leads to development of alternative cheap and renewable sources. Chicken wastes in India are largely used as organic manure for agricultural purposes. Rules are there to minimise spreading of litter on land, and the rising cost of labor for clearance of litter, more attention is being paid to extracting more value from litter (and other by-products from the chicken meat industry, and processing waste) in the form of energy. Methane can be captured from the decomposing manure and converted to electricity or heat, or the waste can be used to produce liquid fuel (Mcanulty et al., 2017). Biogas is a well-established fuel that can supplement or even replace wood as an energy source. In the rural areas of developing countries, biogas units provide fuel for domestic purposes (Nazir, 1991). Biogas production from organic materials not only produces energy, but preserves the nutrients, which can be recycled back to the land in the form of a slurry. Biogas generally comprises of 55-65 % methane, 35-45 %carbon dioxide, 0.5-1.0 % hydrogen sulphide and traces of water vapour. The organic content also acts as a soil conditioner by contributing humus (Integrated Resource Recovery, UNDP Project Management, and Report Number 5). Three basic designs of biogas plants--fixed dome, floating cover , and bag have been used in a number of countries. For domestic

purpose biogas is used for cooking and lighting. Poultry litter can be used as a great source of fuel. Poultry litter with moisture content less than 15% can be burnt directly as fuel to generate heat energy. Biogas, a very useful combustible gas with around 60% methane, can also be produced by anaerobic digestion of poultry waste. It is through use of microorganisms which in turn produce biogas, liquid fuel and nutrient-rich solids. In the second case i e by thermo chemical method, heat or chemicals are used to carry out pyrolysis for production of biogas **(**Elasri and El amin Afilal, 2016**)**. Biogas, produced by poultry litter, can be used for various purposes including fuel for engines, to produce electricity, to produce heat by simply burning and so on. Biogas production in a way contributes for mitigating climate change by reducing greenhouse gases emission and sequestrating carbon. In Nepal it is used as a technology for meeting household energy requirements than its other utilities (Singh et al., 2008). The temperature variable in the poultry sheds can be maintained by usage of heaters, fans, air movers etc. For these operations energy in the form of electricity is required. Poultry farms and industries are growing and innovative technologies are to be used. With the advent of new technologies poultry waste like litter, can be used for the generation of power energy which can be used for electrical operations (Huang et al., 2015). Research should be in a way so that there will be cost reductions for the generation of power from litter. Electricity is utilized to light the poultry houses, and also in the usage of automated systems (Crawford, 2013, Thesis). Many states in U.S. are producing a huge amount of turkey and broiler waste to use those as renewable green resources and to produce electricity. Benefits and costs of a biogas plant vary depending upon the use of inputs and outputs by the particular user. Studies have shown the applicability of locally made biodigesters in the production of biogas (Rajeni , et al., 2016). The remaining slurry after production of biogas was found to be enriched compost in the bio-digester after biogas production which was suggested to be used for improvement of agricultural soil nutrient and productivity. Using poultry litter to create bioenergy has many benefits, some of which are

- Reducing the amount of waste by recovering the energy from waste
- Not allowing harmful bacteria, flies and weed seeds near manure , i.e. by utilising it efficiently.
- Converting organic nitrogen into usable forms which can be used by plants.

The nutrient composition of the litter and how much energy could be produced from the available chicken litter should be determined. Some of these benefits are described in the 2008 US Government paper Livestock waste-to-bioenergy generation opportunities[page 7941–2].

Darling Downs Fresh Eggs is the first Australian egg producer, and one of only a few in the world, to use renewable energy as electricity, generated from poultry manure by anaerobic digestion. The company in turn reduced its grid electricity usage . The principle is that an anaerobic digester converts the chicken manure to biogas, and a generator converts the biogas to electricity. The re-use of poultry litter resulted in an increase in biogas production, there are also reports that the use of fermentation in the microbiological treatment of poultry litter seems to have negatively influence on production of biogas (Dornelas et al., 2017). In India from broiler and layer hatcheries 9486 million tons of poultry waste is being produced. From the bird litter, produced per day 1.69 million m3 of biogas can be produced. A 2 Kw electricity can be generated from 1m3 of biogas (Ezhilvalavan et al., 2016).

2.Different Uses of Poultry Feathers

To decrease reliance on petroleum resources, industries find a better way to produce biodiesel by utilising the usage of feathers obtained from poultry industries. Chicken feathers can be used for the production of biodiesel, as the feathers contain fat. It is low cost and environmentally friendly. The study concluded that rooster feathers are superior in comparison to broiler feathers as it has important properties of biodiesel (Purandardas et al., 2018). Feathers contain high value keratin which can be utilised for making by products. These products are inexpensive and easily renewable. For meat purpose, consumption of chicken is large and feathers are obtained during production of clean meat. They are disposed off by burning, land filling etc. (Gurav and Jadhav, 2013). The by products should be free of microbial toxins. Feathers are primarily a waste product, which should be processed before use. The product is usually a supplement which is given to pigs or livestock (Park et al., 2000). Feathers are being utilised for decoration purpose. Selection is based upon size, shape and colour. Feathers of peacocks have been used for medicinal purpose for bareness and snake bites (Murari et al., 2005). Feathers are also used as dusters and bedding material. They are warm, soft and lightweight. Feather meal is rich in arginine, threonine and cysteine (El Boushy et al., 1990).The barbs of the feather have the durable properties of being utilised in textile industries. These can be blended with other fibres before synthesizing as yarns. Filamentous polymers can be made out of dimers, tetramers of keratin proteins, which are utilised for the manufacture of fabrics, plastics etc. The protein obtained from feathers can be used as binding agent in textile industries and textile printing (Reddy et al., 2014). Because of warmth, fire resistance, fluffiness nature they can be used with materials used in production of winter season fabrics. Grafting using acrylic monomers can make the feathers to be used as films. Keratin based proteins give more strength. Chicken feathers can be used as a raw material for replacement of petroleum based products used in packaging material such as bioplastics (Ramakrishnan et al., 2018). In the cartons chicken fibres can be used as an interlining material, which will prevent the damage to the delicate materials. The feathers can be used for thermal or sound insulation, in the ceiling or roof tops (Tesfaye et al., 2017). Keratin in feathers, provide protection against insects and pests. Chicken feathers composite boards used in construction industry can replace wood and plastic boards which are combustible (Aranberri et al., 2017). Chicken feather cholesterol can be used in the production of Vitamin D3. Cholesterol can be used for the synthesis of steroid pharmaceuticals (Moore, 1989).

If the by-products are not utilised properly or less utilised then it leads to loss of potential revenues. It also adds to the increasing cost towards, disposal of these products. Non-

utilization of animal by-products in a proper way may create major health problems. Meat, poultry and fish processing wastes have a potential for recycling raw materials or for conversion into useful products of higher value (Jayathilakan et al., 2012). Waste products from the poultry processing and egg production industries must be efficiently dealt with as the growth of these industries depends largely on waste management. Product specific waste is from slaughter house waste from meat production. The waste from meat processing or industry is subjected to quick changes due to protein break down, auto oxidation and changes in enzymatic activity. Such waste includes bones, tendons, skin, the contents of the gastro-intestinal tract, blood and internal organs. These vary with each type of animal (Sielaff, 1996; Grosse,1984). More than half the animal by-products are not suitable for normal consumption, because of their unusual physical and chemical characteristics. As a result, a valuable source of potential revenue is lost, and the cost of disposing of these products is increasing.

In India, the slaughter house waste management system is very poor and several measures are being taken for the effective management of wastes generated from slaughter houses. Effective management of liquid waste/effluent by proper treatments, as per the guidelines should be followed (Manual of Sewage treatment published by the Ministry of Urban development). The blood available from the slaughter houses should be collected and make use of its full potential in pharmaceutical industry. Provisions should be made for improved method of dressing, evisceration, safe disposal of waste products, control of odours, curbing activities of illegal slaughtering of animals, provisions of dry rendering plants and modernization of slaughter houses. (http://urbanindia.nic.in).

Uses of Blood, Blood and Chicken Meal

Edible meat by-products contain many essential nutrients. Some are used as medicines because they contain special nutrients such as amino acids, hormones, minerals, vitamins and fatty acids. Not only blood, but several other meat by-products, has a higher level of moisture than meat. Some examples are lung, kidney, brain, spleen, and tripe. Some organ meat, including liver and kidney, contains a higher level of carbohydrate than other meat materials (Devatkal et al. 2004). Blood is used in food as an emulsifier, a stabilizer, a clarifier, a color additive, and as a nutritional component (Silva and Silvestre, 2003). Blood is approximately 2 percent of the live bird weight, and a source of highly concentrated protein when filtered and dried to produce blood meal.

Most blood used in livestock feed is in the form of blood meal. It is used as a protein supplement, as a milk substitute, as a lysine or as a vitamin supplement and is an excellent source of most of the trace minerals. Many blood components such as fibrinogen, fibrinolysin, serotonin, kalikreninsa, immunoglobulins and plasminogen are isolated for chemical or medical uses (Young and Lawrie, 2007).

The marrow inside some of the bones can also be used as food. The marrow may be 4.0–6.0% of the carcass weight (West and Shaw 1975). For centuries, bones have been used to make soup and gelatine. Animal organs and glands offer a wide variety of flavours and textures, and often have a high nutritional value. Brain, nervous system and spinal cord are a source of cholesterol which is the raw material for the synthesis of vitamin D3. Cholesterol is also used as an emulsifier in cosmetics (Ejike and Emmanuel 2009). Other materials can be isolated from the hypothalamus of the brain for the same purpose.

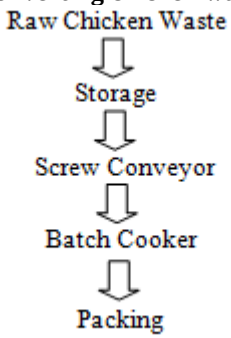
The World Bank Group (2007) provided detailed and useful environmental health and safety guidelines for all steps of poultry processing, from the reception of live birds, through slaughter and evisceration, to simple waste processing. This infor-mation note focuses on the utilization of organic solids, of which an estimated 1 million tonnes are generated every year world-wide (Charles Michael Williams).

For very small or backyard flock operations, slaughter is likely to generate very small quantities of solid wastes, and management of these wastes should focus more on proper disposal and recycling (burial or composting) re-garding biosecurity and human health issues.

Chicken meal has high nutritive value for the poultry feed and have major market for the same. Major benefits of using the chicken meal are as poultry feed ingredients. The chicken meal contains moderate to high levels of amino acids like lysine, methionine and threonine.

If processed properly the amino acids are highly available**.** The chicken meal is rich source of digestible protein and minerals (Meeker and Hamilton, 2006). The chicken rendering will help sustain animal agriculture by transforming waste animal tissues in to valuable chicken meal.

Steps for converting chicken waste to chicken meal



High Value Chicken Meal for Feed Ingredient

*(Source: https://3.imimg.com/data3/*EW*/LC/MY-2685969/chicken-rendering-plant.pdf)*

In India rendering plants are available in Coimbatore, Kerala etc. To have the rendering plants in the State to address the issue of poultry wastes often thrown by poultry stalls on road sides and rivers. The rendering plant converts the waste into sterilized meat meal and manure (The HINDU, INDIA, March 2017).

Poultry industry by-products include offal, bone, blood, viscera, feet and feathers but in certain regions these may be considered mainstream products (e.g., chicken feet/paws). Twenty to thirty years ago, meat that remained after

automated or manual deboning was not harvested. Today, this is accomplished by mechanical deboners and the resulting meat is used as a major ingredient in emulsion-type meat products (e.g., bologna, frankfurters) and as a minor ingredient in ground meat products (e.g., sausages). Meat/poultry by-products and wastes may contain different species of microorganisms even when the feathers, feet, and intestinal contents are removed. These microorganisms include potential pathogens such as Salmonella sp., Staphylococcus sp., and Clostridium sp. (Salminen and Rintala, 2002).

The meat industry generates a lot of waste water. Measuring its organic matter content is the first step in determining treatment(s) and estimating costs. There are several ways to measure and express the organic matter load: BOD5(biological oxygen demand); COD (chemical oxygen demand); total dissolved solids; suspended solids (SS); fats, oils and greases (FOG; these terms will be further explained below). Overall, meat processing effluents are high in nitrogen, phosphorus, solids, and BOD5 levels and can potentially lead to eutrophication (Benka-Coker and Ojior, 1995; Arvanitoyannis and Ladas, 2008).

Biological oxygen demand (BOD) is a semi-quantitative measure of organic content in waste water. Chemical oxygen demand (COD) measures pollution by using a strong oxidizing compound, orange dichromate, while maintaining the reaction at a high temperature.

Total oxygen demand (TOD) measures the amount of oxygen required for combustion of all the material in a water sample at 900°C.

In order to reduce waste water surcharges, most medium and large meat processing plants have their own waste water treatment operation. Smaller plants, at the very least, have a primary means of filtering out some of the large materials (feathers, offal) and small meat pieces that contribute to high BOD values.

Good management practices for safe and beneficial utilisation of poultry manure for sustainable production and for other alternatives should be explored, and which will have negligible effect on environment should be developed. Knowledge is also required for the effective planning and operation of a waste management system that is appropriate for a particular environment.

3.Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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