

Composting Poultry Manure: An Effective Strategy to Reduce Environmental Pollution

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Poultry is a common term of those bird species which are reared by man and give economic benefit to him and can reproduce freely under intensive rearing. There are about 10,000 species of birds in the world, and only 12-13 species are belongs to poultry; such as chicken, duck, pigeon, guinea fowl, turkey, goose, quail, ostrich, pea fowl, pheasant, bush fowl and grouse. Presently poultry, mainly chicken (broiler and layer) industry is a rapid rising and prospective sector in Bangladesh.

There are about 1, 50,000 commercial poultry farms (broiler and layer farms) and near about 130 Parent stock farms in Bangladesh (ICDDR, 2008). Besides the supplementation of protein (meat from broiler and eggs from layer chicken) to the people, a great unemployment problem is solved by this industry. Besides farm management, a large number of manpower also involved in the sister industry e.g., feed mill, broiler processing plant, transportation and marketing of feed, broiler and eggs. There are about 4 million people are directly involved in this industry and helps the country by employment, income generation, and supplying protein source for maintaining proper health (ICDDR, 2008). Government of Bangladesh has encouraged this private poultry sector through financial deliberation, and also about 150 NGOs extend support to this prospective industry, helping rural people to come out of extreme poverty cycle.

Although poultry industry plays a key role in developing our socio-economic and health sector, it might also be a great threat to our environment. About 3079 metric ton poultry manure produces daily from a total of 42 million chickens in Bangladesh (Waste concern, 2005). A large amount of poultry manure and litters (feces with bedding materials) can become hazardous to the environment as well as being detrimental to the health and safety of both humans and animals.

Characteristics of poultry manure:

Poultry manure is a valuable resource and it contains a significant amount of nitrogen, phosphorus, potassium, calcium, sulphur and many other macro and micro minerals. On the basis of the poultry rearing system there are 2 types of poultry manures: i) broiler litter; normally broilers are reared in the floor of a house with sufficient bedding materials (saw dust, rice husk or wood shavings, etc). After selling the broiler the excreta with bedding materials are removed from the house and termed as litter. It contains less water and easy to handle. ii) layer manure; normally layers are reared in the cage housing system, the excreta is called manure. Layer manure is a semi solid mass and falls directly on the concrete floor and needs to be cleaned daily. There is a heavy accumulation of flies and insects and also produces bad odor if not cleaned or raked daily. Comparatively layer manure produces more odor than broiler litter.

Present status of poultry waste disposal in Bangladesh:

Manure treatment facility is very poor in Bangladesh that might be the principal cause of obnoxious environmental condition. Only a few modern poultry houses has their own treatment facility of litters among 1,50,000 poultry farms. Although properly planned and managed, manure management systems can still out of control of the hands of poultry farmers. Becoming aware of the potential hazards and problems associated with poultry manure management can greatly help in the understanding and developing of sound poultry management practices. Due to lack of proper management technology we deprived from the valuable resource, moreover, we facing a lot of environmental problems with this large amount of manures.

In most cases poultry farmers are dumping their manures at the low land, fallow land or road side at the nearby area of the farm. Small and medium farmers tend to dump their waste into other people's land adjacent to the farm. The nearby dwellings of the dumping poultry manure are severely affected by offensive smell, dust and surface water pollution. In the rainy season, leaching from dumped poultry manure pollute the surface water which is hazardous for aquatic life. Dumping is not a scientific disposal of poultry manure, because there is an anaerobic condition inside and a cause of continuous production of bad odor. The greatest public complaint about most poultry production areas is about the obnoxious smell from dumped manure.

Fish farmers are used a large amount of raw poultry manure in their pond as fish feed which is also a wrong practice. Fresh poultry manure release a large amount of nitrogen and phosphorus to the water body which may cause eutrophication which is also hazardous to the environment. Finish product of the poultry manure can be used as fertilizer for plankton growth in the water body that is a good food for fish. Utilization of fresh or dumped poultry manure in the water body is a cause of water pollution by increasing NH₄-N, orthophosphate, TOC and BOD content. Presence of these chemicals in the water body is toxic for fish as well as human also.

Many people adjacent to the poultry farm area used raw poultry manures or litter to their agricultural field as fertilizer. Although there are a lot of nutrients in the manure, but these are not in available forms for the plant uptake. Moreover, there are lots of insects, larvae, weed seeds, pathogens in the raw manures and also a cause of odor problem. This is also a wrong practice in the utilization of poultry manure. Some small broiler farmers used their wasted litter materials as fuel for everyday cooking after drying them in the sun, but this practice only a fewer cases. Also, an offensive smell is produced during burning this litter.

Recently some enthusiastic poultry farmers are using their manure for biogas production in anaerobic digester. It is an effective utilization of poultry waste that produces methane gas for cooking. It needs initial high cost involvement to establish biogas plant. It might be a good source of energy and can be used as an alternative to Titas gas. Skilled personnel, high technology and sufficient equipment might be reduced the demand of electricity by producing electric current from available poultry manure in the near future.

After manure has been excreted by the poultry, it quickly begins to undergo some type of microbial decomposition. The complex molecules in the poultry manure are broken down into simpler compounds by the decomposition. Poultry waste/manure must be decomposed properly before further application for better environmental security. The decomposition process of the poultry manure can take place in two ways. If oxygen supply is sufficient then the decomposition is said to be aerobic. The aerobic decomposition of poultry manure is basically an odorless process which produces stabilized organic matter, some carbon dioxide and water by microorganisms. On the other hand, most of the poultry farmers of Bangladesh practices anaerobic decomposition by piling or dumping of their poultry manure. During anaerobic decomposition of poultry manure, an abundant amount of carbon dioxide, ammonia, hydrogen sulfide and methane gases are produced which is hazardous to both man and livestock also. In some cases methyl mercaptan (CH₃SH) gas also produced in anaerobic decomposition which is poisonous to animals and humans. The detrimental effects of these gases are shown in Table 1.

Table 1. Properties of the gases produced from poultry manures and their physiological responses on adult human (source: CAMMG, 1979)

Effects of poultry manure gas on human life:

Ammonia is highly soluble in water and can easily explosive at higher concentrations. It has a clear, pungent odor and acts as an irritant to most tissues at relatively low concentrations. Severe eye irritation, respiratory spasm, rapid asphyxia, and/or fatal state occurred at higher ammonia concentration. It is released from fresh manure and during the process of anaerobic decomposition.

Carbon dioxide is highly soluble in water and is released from manure decomposition and animal respiration. Carbon dioxide is not a serious problem in a well ventilated facility. Problems can occur if failure of the ventilation system occurs. Death due to carbon dioxide asphyxiation occurs very rarely. Often in a poorly ventilated facility or a facility with a malfunctioning ventilation system, any death might be occurred due to the result of heat stress and oxygen deficiency.

Of all of the manure gases, hydrogen sulfide is the most toxic and is potentially the most dangerous. It can be identified by its characteristics smells of rotten eggs. Hydrogen sulfide is produced during the anaerobic decomposition of manure. High concentrations can be released by agitation and pumping of liquid wastes (LWFH, 1985). Some empty tanks and pits contain higher concentrations of H₂S that is greatly hazardous and lethal to animal life.

Methane is a highly flammable gas that produced from the anaerobic decomposition of manure. At low concentrations, it burns with a blue flame but at higher concentrations there is a real danger of explosions. The majority of methane gas is the result of the decomposition of animal manure. Since methane is lighter than air, it has a tendency to rise and pool at the top of stagnant corners or in tightly enclosed manure storage pits.

A pulmonary irritant that can cause pulmonary edema after inhalation of high concentrations and liver injury has been documented after occupational exposure of methyl mercaptan. It can cause coma and death at high concentrations, acting as a chemical asphyxiant similar to hydrogen sulfide. Methemoglobinemia has been reported after occupational exposure of methyl mercaptan gas.

Carbon monoxide is also a very harmful gas of about the same density as air. This gas is not produced directly from poultry manure but can be the result of poultry manure operations. It is exhausted from gas engines, gas, oil and coal heaters. The best way of preventing a toxic build up of carbon monoxide is to ensure that all engines are vented to the outside of the facility. If this is not possible, then sufficient ventilation to prevent gas buildup should be provided. Entering poultry manure storage areas and pits at any time are extremely dangerous, especially during or following emptying of the storage.

Besides these gases, several types of amides, peptides, organic and volatile fatty acids, free fatty acids, are decomposed and create an obnoxious environment (interaction of putrefactive, rancid and fermentative odor) during anaerobic decomposition of poultry manures. These are intermediates of protein, lipid and carbohydrate metabolism and accumulate in anaerobic decomposition systems. The odors are the result of the biological breakdown of the poultry manure under anaerobic conditions within storages, piles, lagoons, or indoor pits. Public complaint also results when the manure is being spread as a fertilizer on an agricultural field without proper treatment.

What is composting?

Composting is a controlled, microbial process that converts biodegradable, organic materials into a stable, humus like product called compost. The activity of these micro-organisms is influenced by the carbon to nitrogen (C:N) ratio, oxygen supply, moisture content, temperature, and pH of the compost pile. Properly managed composting increases the rate of natural decomposition and generates sufficient heat to destroy weed seeds, pathogens, and fly larvae.

Composting process:

The composting process is occurred by the participation of large number of aerobic micro-organisms (mainly mesophilic and thermophilic bacteria, protozoa, fungi, rotifer) that decompose organic material in order to maintain their proper growth and reproduction. Aerobic decomposition converts biodegradable organic matter (OM) in manure to oxidize end products, primarily carbon dioxide and water. Moisture and carbon-nitrogen ratio (C/N ratio) of the composting materials are also very important factor for the composting process. Moisture must be maintained within 55-65% in the composting pile. If the manure contains more moisture, it must be corrected by adding saw dust or other available bulking agents (chopped rice/wheat straw, dry leaves, rice husk, etc). In this case, broiler litter is very suitable for composting and no need to add any bulking materials with it, because normally it contains 60% moisture. Bulking material is necessary for layer manure to maintain about 60% moisture and proper C/N ratio. An air (O₂) source must be needed at the bottom of the composting pile for the optimum growth and development of the aerobic microorganisms.

The decomposition of OM by microorganisms increases the temperature in the compost pile and it is the most important indicator of the efficiency of composting. Initially mesophilic organisms are responsible for the break down of the readily available OM and start to increase the temperature of the compost pile and reaches up to 40-45 °C temperature within 2-3 days. The initial low temperature period is called lag period, and this lag period is necessary for the development of the microbial population. As the microbial population begins to degrade the most readily degradable material and increase the population, the temperature of the compost pile begins to rise rapidly. Thermophilic organisms are active when the pile temperature reaches at 40-45 °C and then the temperature reaches up to 60-70 °C within a short period. High temperature period is called active composting period and maximum biodegradation is occurred at this period.

As the pile temperatures increase into the thermophilic stage, the pile becomes inhabited by a diverse population of micro-organisms operating at peak growth and efficiency. This microbial activity sustains the vigorous heating that is necessary for the complete destruction of pathogens, fly larvae, and weed seeds. The diversity of the microbial population also allows the decomposition of a wide range of material from simple, easily degradable material to more complex, decay resistant matter, such as cellulose. All odors are removed from the composting pile during active composting period. If the temperature becomes too high, the enzymes of the micro-organisms are denatured and they cannot get the nutrition to survive. As a result, microbial population and their activity are starts to decrease. As microbial activity decreases, more heat is lost from the pile than is generated, and the compost pile begins to cool. Thermophilic stage ranges between 1 to 2 weeks depending on the nature of composting materials. Compost pile needs to turn over after every 3-4 days for proper aeration and mixing.

Curing stage is started after active composting and is characterized by a lower level of microbial activity. When curing has reached its final stage, the compost is said to be stabilized. Curing is marked by a lower level of microbial activity and is responsible for stabilizing the products resulting from active composting period. Stabilization includes further decomposition of organic acids and decay resistant compounds, the formation of humic compounds, and the formation of nitrate-nitrogen. Another benefit of curing is that certain fungi begin to inhabit the pile and contribute to the disease suppressant qualities of the compost. Because microbial activity has decreased and is operating at a lower level, little heat is generated and the pile temperature continues to decrease or remains at a low level. Proper management of moisture and oxygen is still required during the curing period to maintain microbial activity. The length of the curing period varies with the type of operation, the length of the active composting period, and the intended end use of the compost. Short, active composting periods require extended curing periods to allow for sufficient decomposition and stabilization. Larger particle size also converted into smaller parts during curing period. Curing is generally considered as complete when the pile temperature reaches to the ambient temperature.

Benefits of composting:

Composting might be an effective way to treat livestock wastes which provides an environment-friendly crop production system by utilizing solid organic wastes. Compost improves the physical properties of soil by serving as a soil conditioner through the addition of humus and organic matter to the soil. Manure compost has the advantage of improving soil structure, increasing soil organic matter, suppressing soil-borne plant pathogens, and enhancing plant growth, but raw manure or immature compost may cause phytotoxicity to plants and adversely affect the environment when applied to soil. The addition of humus and organic matter increases the water and nutrient holding capacity of the soil, decreases the soil bulk density, and improves the soil aeration and pore structure. These improvements result from the direct effects of the compost material itself and the indirect effects brought about through the promotion of soil microbial activity and earthworms.

Most plant nutrients in compost are in an organic form. Although compost is not high in nitrogen, phosphorous, or potassium, (it contains approximately 2% of each) these nutrients are released slowly over a long period of time. This results in a more efficient utilization of nitrogen and a decreased potential for nitrogen leaching. Nutrients become available to plant roots at a slower rate from compost compared to inorganic fertilizers. Recently it was investigated from an experiment that a slow releasing crystal fertilizer named struvite or MAP ($Mg NH_4 PO_4 \cdot 6H_2O$) was formed during manure composting if $MgCl_2$ was added during composting process (Lee et al., 2009). As poultry manure contains a large amount of nitrogen and phosphorus, addition of Mg salt helps to make magnesium ammonium phosphate (MAP) crystal in the compost. MAP crystal increases the fertilizer value of manure compost.

Bangladesh could be self-sufficient in fertilizer, and also can export fertilizer after fulfill the national demand if all poultry manures that are produces from 1,50,000 poultry farm (3079 metric ton/day) are used for compost production. It reduces the obnoxious gas production and water pollution and thus ensures the pollution free, eco-friendly environment. Besides these, it can help to increase total agricultural production by increasing soil fertility. Finally, it can be says that "composting poultry manure: An effective strategy to reduce environmental pollution and better crop production".

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