Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2022; 10(5): 321-326

Received: 01-08-2022
Accepted: 04-09-2022

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Livestock waste management practices to strengthen the farm profitability

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DOI: https://doi.org/10.22271/j.ento.2022.v10.i5d.9075

Abstract
“Livestock waste” means livestock manure, unconsumed feed and associated bedding materials or litter and animal carcasses from normal mortalities of livestock on a farm. Waste management includes the activities and actions required to manage waste from its inception to its final disposal. Livestock wastes if not manage properly it may lead to fecal contamination of waters receiving agricultural runoff. The danger to humans lies in the possibility of these fecal organisms entering water and food supplies. Groundwater and surface waters may harbor pathogens originating from animal fecal deposits. Animal waste contains many beneficial constituents that if recycled effectively, can be used as fertilizer for crops, fodder for animals and to produce energy. There are a number of methods of livestock waste management to enhance farm profitability. Which are composting, biogas production, rotator drum composting, vermicomposting, biodynamic fertilizer etc. Composting is an accelerated bio-oxidation of organic matter passing through a thermophilic stage, where microorganisms liberate heat, carbon dioxide and water. Biogas is clean environment friendly fuel that can be obtained by anaerobic digestion of animal residues and domestic and farm wastes, abundantly available in the countryside. Biogas is bacterial conversion of organic matter in to gases under anaerobic conditions. The earthworm eats the organic matter and excretes little pelleted material called “vermicompost”. During vermicomposting, the important plant nutrients, such as N, P, K, and Ca present in the organic waste are released and converted into forms that are more soluble and available to the plants. Among all advance methods biogas production and vermicomposting are most common in India. Livestock waste contains significant amounts of micro-organisms which make it a source of major risk to the public. Risks of nutrients, organic material and pathogens containing water bodies and food products are common with increased livestock waste spread.

Keywords: Livestock waste, composting, biogas, vermicompost, Gomutra, Panchgavya

Introduction
The livestock waste is major source of noxious gases, harmful pathogens and odor. Hence, it has public health and environmental concern. Hence, livestock waste is to be managed properly to mitigate production of these pollutants in order to protect environment. “There are few things certain in life- one is death, second is change and the other is waste.” No one can stop these things to take place in our lives. But with better management we can prepare ourselves. Each of us has a right to clean air, water and food. This right can be fulfilled by maintaining a clear and healthy environment. Generally, waste is defined as at the end of the product life cycle and is disposed of in landfills. In a common man’s eye anything that is unwanted or not useful is garbage or waste. However scientifically speaking there is no waste as such in the world. Almost all the components of solid waste have some potential if it is converted or treated in a scientific manner. Hence we can define solid waste as “Organic or inorganic waste materials produced out of household or commercial activities, that have lost their value in the eyes of the first owner but which may be of great value to somebody else” (Robinson, 1986) [1].
During last decade, the livestock keeping practices were changed from mixed farming systems to specialized dairy farming with zero grazing under confinement. This system of livestock keeping is termed as confined animal feeding operations, which are specialized and intensive livestock farming.

These trends of livestock keeping adapted to improve profitability have resulted in the pollution of air, water and soil (Gerber *et al.,* 2005) [2]. Livestock waste is major source of green house gas, pollution, pathogens and odor. 40% of global methane is produced by agriculture and livestock by-products followed by 18% from waste disposal globally. It is a rich source of energy and fertilizer elements which can be recovered for betterment of agriculture (EPA, 1998) [3].

Traditionally the dung cakes are utilized for cooking the food in rural areas particularly in developing countries. The increasing use of petroleum products forced us to utilize the ability of livestock waste for various possible energy products; among them biogas is most popular product in majority of countries of the world. Good quality organic fertilizer from animal waste provides an opportunity for the agricultural sector to reduce their reliance on chemical fertilizer which improves the soil fertility and sustainability. The use of animal waste as input for bio-energy conversion processes can allow farmers to take advantage of new markets for waste products. Proper utilization of cow dung and cow urine into manure, pesticides, medicines and other daily products can generate millions of employment opportunities in rural areas as well it can protect soil from chemicals and fertilizers and improve soil fertility (Vijay, 2011) [4]. Hence, there is a need for new waste management systems that make animal operations economically feasible and eco-friendly which ensures higher profit to livestock owners, recycling and sustainable use of nutrients with mitigation of environmental impacts (Barth, 2006) [5]

Importance of livestock waste management

Animal waste contains many beneficial constituents that if recycled effectively, can be used as fertilizer for crops, fodder for animals and to produce energy. Animal manure is rich in nitrogen, phosphorus and potassium. In addition to providing supplemental nutrients for crop growth, manure has several beneficial effects on soil properties. Application of organic waste decreases the bulk density of the soil by increasing both the organic fraction of the soil and the stability of aggregates. Organic wastes also improves water filtration rate, water holding capacity and the hydraulic conductivity of the soil. All these properties of animal waste will be available only if they are carefully managed. If not they might cause detrimental effects on the environment.

Some of the important benefit of livestock waste as follows: [a] Livestock manure helps to maintain soil fertility in soils lacking organic content. [b] Adding manure to the soil increases the nutrient retention capacity, improves the soil's physical condition by increasing its water holding capacity, and improves soil structure. [c] Animal manure also helps to create a better climate for micro flora and fauna in soils. [d] Waste manure and other organic materials from livestock farms could be an important source of energy production. [e] Livestock waste can be used in resource management, in crop and livestock production and in the reduction of post-harvest losses. [f] Livestock waste management plays an important role in the livelihoods of many rural dwellers in India. [g] Bio-energy sources are increasingly gaining attention as a sustainable energy resource that may help to cope with challenges like, increasing demand for energy, rising fuel prices by providing substitutions for expensive fossil fuels. [h] Biogas from livestock waste and residues provides a renewable and environmentally friendly source that supports sustainable agriculture. Additionally, the byproducts of the 'digesters' provide organic waste of superior quality. [i] Reduce source of infection for animal and human population. [j] Dung is also used as fuel. [k] Reduce source of methane emission. [l] Reduce Cause of bad odor in surroundings. [m] Reducing fly nuisance. [n] Helps in proper nutrient management practices (reduce loss of organic matters). [o] Helps in controlling vectors and fomits. [p] Reduce environment pollution. [q]. Reduces illegal discharge of waste which can pose a direct threat to the quality of soil and water system **(**Arthur and Baidoo, 2011) [6].

Common livestock waste

Dung, urine, placenta, still births, post mortem debris, bedding, feed wastage, milk-house wastes or wash, dead animals and birds, slaughter house waste, hair, hoof and horns etc (Sastry and Thomas, 2015) [7].

a. Solid types of livestock farm waste: Dung, Wasted feed, Bedding, Carcass Dead animal Bedding material/poultry litter material
b. Liquid types of livestock farm waste: Urine, Water of washing
c. Gaseous types of livestock farm waste: Methane, Carbon dioxide, Ammonia

Methods of livestock waste management

I. Methods of solid and liquid waste management

i. Traditional methods of solid and liquid waste management

Dung Cake: The only use for manure other than fertilizer is in underdeveloped countries, where cow manure is gathered by hand and placed on suitable racks to sun-dry for use as fuel for cooking and heating. In north Indian States-Cow-Dung Cake is major fuels for cooking (Ramlal and Saha, 2012) [8].

Dumping into Heaps or Pits: It is most common and old method of waste management, in this method all waste material dumped in to a pit at farm or field.

Composting: Composting is an accelerated bio-oxidation of organic matter passing through a thermophilic stage (45 to 65 ºC) where microorganisms (mainly bacteria, fungi and actinomycetes) liberate heat, carbon dioxide and water. The heterogeneous organic material is transformed into a homogeneous and stabilized humus like product through turning or aeration. Composting is the aerobic degradation of biodegradable organic waste. It is a relatively fast biodegradation process, taking typically 4-6 weeks to reach a stabilized material. The composted material is odorless and fine textured with low moisture content and can be used as an organic fertilizer. Composting biological waste with poultry manure can be an effective means of conserving the nitrogen in the manure, which not only improves the fertilizer value, but also reduces the potential for NH3 to contribute the environmental pollution (Mahimairaja *et al*., 1994) [9].

Some of the important benefit of compost as follows

[a] Compost adds organic matter, improves soil structure, reduces fertilizer requirements and reduces the potential for soil erosion. [b] Composting reduces the weight and moisture content and increases stability of manure. [c] Compost is easier to handle than manure and stores well without odors or fly problems, thus lowering the risk of pollution and nuisance

complaints. [d] Composted manure is less susceptible to leaching and further ammonia losses. [e] Composting high-carbon manure/bedding mixtures lowers the carbon/nitrogen ratio to acceptable levels for land application. [f] Proper temperatures within the compost pile will reduce pathogens.

ii. Advance methods of solid and liquid waste management

Biogas production: Biogas is clean environment friendly fuel that can be obtained by anaerobic digestion of animal residues and domestic and farm wastes, abundantly available in the countryside. Biogas is bacterial conversion of organic matter in to gases under anaerobic conditions. Biogas generally comprise of 55-65% methane, 35-45% carbondioxide, 0.5-1.0% hydrogen sulfide and traces of water vapor. Average calorific value of biogas is 4713kcal/m^3. (Jiang *et al.,* 2011) [10].

Various advantages of bio gas production as follows: [a] Biogas provides an environmentally friendly process that supports sustainable agriculture. [b] It is one of the simplest sources of renewable energy and can be derived from sewage; liquid manure from hens, cattle and pigs; and organic waste from agriculture or food processing. [c] The by-products of the 'digesters' provide organic waste of superior quality. [d] Biogas is particularly well suited to household energy needs as it, improves both soil conditions and household sanitation. [e] Manure-based biogas digester systems are considered ecological since the technology captures and utilizes methane directly, thereby limiting total greenhouse gas emissions from livestock. [f] By using bio-energy resources and non-polluting technology, biogas generation serves a triple function: waste removal, environmental management and energy production. [g] Biogas is now widely integrated with animal husbandry and can become a major means of manure treatment in the agricultural sector and environmental protection. [h] Biogas can be used in a specially designed burner for cooking purpose. A biogas plant of 2 cubic meters capacity is sufficient for providing cooking fuel needs of a family of about five person (Lantz *et al.,* 2007) [11]. [i] Biogas is used in silk mantle lamps for lighting purpose. The requirement of gas for powering a100 candle lamp (60W) is 0.13 cubic meter per hour. [j] Biogas can be used to operate a dual fuel engine to replace up to 80% of diesel-oil. Diesel engines have been modified to run 100 percent on biogas. Petrol and CNG engines can also be modified easily to use biogas. [k] Biogas can be used as compressed bio-gas (CBG). Gas compressed up to 200 bar pressure using a three-stage gas compressor. Stored in high pressure steel cylinders (Vijay *et al*., 2011) [12]. It can be used to power motor vehicles, fuel for cooking and lighting of houses. [l] Biogas can be used as electricity and rotary drum composter (Khandelwal and Mahdi, 1986) [13].

Vermicomposting: The earthworm eats the organic matter and excrete little pelleted material called "Vermicompost". During vermicomposting, the important plant nutrients, such as N, P, K, and Ca present in the organic waste are released and converted into forms that are more soluble and available to the plants. Vermicompost also contain biologically active substances such as plant growth regulators. Moreover, the worms themselves provide a protein source for animal feed. It Increase N, P, K content 3 to 4 times and composting time is reduced to 60-75 days.

There are different species of earthworms Viz. *Eisenia foetida* (Red earthworms), *Eudrilus eugeniae* (night crawler), *Perionyx excavates* etc. Red earthworm is preferred because of its high multiplication rate and thereby converts the organic matter into vermicompost within 45-50 days. Since it is a surface feeder it converts organic materials into vermicompost from top. Its conversion rate is 2 quintal/1500worms/2months.

When raw material is completely decomposed it appear black. Watering should be stopped as compost gets ready. The compost should be kept over a heap of partially decompost cow dung from compost. After two days compost can be separated and sieved for use. Optimum moisture level 30-40% should be maintained and 18-25 ºC temperature. C/N ratio of vermicompost should be 11.88, total nitrogen should be 1, 02%, Total Phosphorus should be 0.30%, Total potassium should be 0.24% and calcium and Magnesium should be 0.17% and 0.06% respectively. The doses for field crops should be 4.5-5 t. per hectare, for fruit crops 3-5Kg per plant.

Pyrolysis: Pyrolysis is a thermochemical process, in which waste is chemically decomposed in a closed system at 400 to 1472° F. Pyrolysis is the chemical decomposition of condensed organic materials by heating in a reactor, largely in the absence of oxygen. The pyrolysis mainly uses straw, branches, sawdust and other agricultural and forestry waste as raw material, through high temperature and pressure, forms the raw materials into a variety of products. Manure may be pyrolyzed by subjecting it to a temperature of 480-1830°F in an oxygen-deficient atmosphere. The products are gases, oil, and ash. The gases include H2, H2S, CH3, CO, and ethylene. Various livestock manures and found that dairy feces produced the most gas per unit of dry solids, followed by chicken, beef, and swine feces (White and Taiganides, 1971) [14].

Soldier fly breeding: Black soldier fly (BSF) larvae or "grubs" are uniquely suited to treat livestock waste. While the BSF adults only live for a few days their larvae can live for several weeks, and during that time they can consume huge quantities of food waste or manure. There are two useful byproducts of this process; the residue or castings which can be used as a soil enrichment, and the larvae themselves which represent an excellent source of food for many types of animals including fish, birds, reptiles, amphibians and more (Nyakeri *et al*., 2017) [15].

Litter management: Poultry litter includes excreta, bedding, wasted feed and feathers. Bedding may consist of wood shavings, sawdust, straw, peanut hulls or other fibrous materials. Most of the poultry litter is from broiler production. The litter may be from one crop of broilers or accumulated over several crops of birds. The litter usually contains 20 to 25% moisture. Poultry litter is fed mainly to beef cows and stocker cattle. Broiler litter contains 25 to 50% crude protein and 55 to 60% TDN, dry matter basis, and is rich in essential minerals. Thus, the nutritional value is similar to or higher than good quality legume hay**.** Poultry litter instead of being a problem of waste can and should be a source of energy and nutrients. The poultry farms in India exist as clusters and the quantity of litter available cannot be so high to encourage the investors to go for power generation using combustion route. Therefore, gasification (thermal degradation) appears to be the economically viable solution for the effective disposal of waste with revenue generation (Kirubakaran *et al*., 2006) [16].

Cow dung as mosquito repellant: The ingredients of cow dung and phytochemical compounds of plant extract are responsible for mosquito repellence. The mosquito coils available in market creates heavy smoke that can generate respiratory problems especially for patients of Asthma, COPD and other respiratory diseases. The cow dung provides an herbal repellent with long lasting protection, safe for human life, human and domestic animal skin with no side effect and no feedback of environmental ill effect, as an alternative to synthetic chemical repellents. The formulation was safe, eco-friendly, cheap, easy to use and has maximum repellence against mosquitoes. Production of these natural repellents with cow dung may help common man in earning more money (Sharma *et al*., 2017) [17].

Gomutra in therapy: Gomutra is important part of Indian tradition. It is not only holy but also has various important medicinal uses. Classical treatises in Ayurved i.e. Charaka, Sushruta and Vagbhata Samhita have described Ashta mutra (eight types of urine) along with their properties, indication and formulations. Cow urine is one of them. In this modern era, the diseases related to life style like cancer, autoimmune diseases, diabetes, AIDS etc. are increasing day by day. Irrational use of antibiotics is also responsible for increase in antibiotic resistant infectious diseases. Gomutra (Cow urine) is scientifically proven to act as an immunomodulator along with its bacteriostatic action. Cow urine can be used as a therapy in several disorders like diabetes, cancer, tuberculosis, disease of ears, teeth, skin, kidney, liver, biopsy, jaundice and plague. Urine contains volatile salts it is useful in acidity, paralysis, pain in kidney and intestine **(**Harshad, 2017) [18].

Panchgavya in therapy: Panchgavya is a term used to describe five major substances, obtained from cow, which include cow's urine, milk, ghee, curd and dung. All the five products possess medicinal properties against many disorders and are used for the medicinal purpose singly or in combination with some other herbs. This kind of treatment is called Panchgavya therapy or cowpathy. The ancient ayurvedic literature (Vir Charak Samhita, Sushrut, Gad Nigrah) suggests a number of pharmacological applications of the substances obtained from Panchgavya. These substances are abundantly used in Ayurveda for treatment of several disorders such as leucoderma, hyperlipidemia, arthritis, renal disorders, dietary disorders, gastrointestinal track disorders, acidity, asthma etc. These remedies seem to be potent anticancer and anti HIV agents. Recently the cow urine has been granted U.S. Patents (No. 6410059 and 6896907) for its medicinal properties, particularly for its use along with antibiotics for the control of bacterial infection and fight against cancers. The panchgavya products also show many other applications viz. excellent agricultural applications in the form of bio-fertilizers, vermicompost and biopesticides, which improves soil fertility and provide food grains free from the health hazards of using chemical fertilizers/pesticides (Dhama, 2005) [19].

Cow dung as pots/gamla: Dung Pots/Gamla is an innovative product and most environmentally friendly container. Dung Pots transplanting pots are made from odor-free, 100% composted cow manure. Fully decomposable Dung Pots feature natural soil-conditioning fertilizers and can be planted directly into the soil to grow sturdier, healthier plants without adding plastic containers to your local landfill. It is easy to handle and absolutely odor-free and non-toxic.

II. Method of carcass management

i. Traditional method of carcass disposal

Burial: The most common method of carcass disposal. For burial a pit of about 8-9 feet depth dug and the width and length depends upon the size of carcass. The carcass is laid on its back with feet upward in the pit. Bedding used for the dead animal, its excreta, feed left over and the top 5c.m. soil from the place where dead animal was lying, should also be buried along with the carcass. The carcass is covered with a thick layer of quick lime and the pit is then filled with dirt or soil. The pit can be fenced if required. The area surrounding the burial pit can also be sprayed with suitable disinfectant Select burial sites with care to avoid ground water contamination.

Burning: It is the method of burning the carcass at high temperature of fire. In this method 7 feet long trenches crossing each other are dug. The trenches are made 15" wide and 18" deep in the centre and made shallow towards ends. The trench is first filled with wood, branches of tree, straws, etc. before placing the carcass. Sufficient quantity of kerosene is sprinkled over the entire material and then the straw is ignited by firing the wood the carcass and all the infectious materials will be completely burnt.

Electric incinerators: In this method carcass is burnt in electric incinerator. This is economical and safe method for cremating large number of carcass from a single trained operator in lesser time without risk of infection.

ii. Advance method of carcass management

Composting of carcass: Composting is a controlled biological decomposition process that converts organic matter into a stable, humus-like product. Composting bovine mortalities is a relatively inexpensive, biosecure, and environmentally sound approach to addressing the issue of carcass disposal when properly managed. Composting animal carcasses is characterized by microbial breakdown of a large centralized nitrogen source (Epstein, 1997) [20].

Challenges associated with livestock waste handling

Livestock waste operations have been shown to cause significant environmental and public health problems (Table 1), including nutrient enrichment of surface and ground waters, contamination of drinking water supplies, fish kills, and odors. Livestock waste, if not properly managed, can be transported by water over the surface of agricultural land to nearby lakes and streams. There, the nutrients in livestock waste can reduce the oxygen content of the water, leading to algae blooms, fish kills, and threats to other wildlife. Solids deposited in water bodies can accelerate eutrophication by releasing nutrients over extended periods. Leaching from manure storage lagoons and percolation through the soil of fields when livestock waste is applied has resulted in nutrient contamination of groundwater resources, and also can contribute to surface water pollution through subsurface groundwater recharge of lakes and streams.

Livestock waste is not the only source of pathogens in surface waters, it has been responsible for shellfish contamination in some coastal waters. Closure of shellfish beds and recreational beaches can be necessitated by high fecal coliform counts, both from animal waste runoff and discharge of improperly treated sewage. Some animal diseases also can be transmitted to humans through contact with animal feces. Concern about the health effects of growing antibiotic resistance, fostered in part by widespread use of drugs in animal agriculture, is starting to attract more attention. Atmospheric deposition of nitrogen from animal operations is also an environmental concern. This occurs when nitrogen in liquid waste is volatilized as ammonia nitrogen from anaerobic (oxygen-deprived) lagoons, causing ammonia to evaporate. Volatilization also occurs after land application. Once in the atmosphere, it is converted to forms which are redeposit within 50-100 miles on land or in surface waters. These forms of nitrogen are water-soluble, meaning the nitrogen can adversely affect water quality much like nitrogen fertilizer if it enters a stream as direct surface runoff.

Therefore, livestock waste can be a contaminant for food, soil and water. It may also a cause of offensive odor. The public health and economic costs in form of disease outbreaks, rejects of products, products recalls and regulatory fines and so on that could be associated with improper disposal of livestock waste or animal manure contaminated foods and food products may far exceed whatever cost-savings are being targeted by the producers who adopt unsustainable livestock waste management practices. Therefore, manure management systems must integrate appropriate measures for odor control. Reducing the frequency, intensity, duration and offensiveness of the odor is the main goal of effective odor control (Smith *et al*., 2001) [21].

Table 1: Livestock waste, potential pathogens and illnesses caused in humans

Type of organism	Illness caused in humans	Route of infection
Escherichia coli (Bacteria)	Bloody diarrhea, severe anemia, kidney failure or even death	Direct contact with feces and through water contaminated with feces
Campylobacter (Bacteria)	Diarrhea and systemic illness	Fecal contaminated water
Salmonella (Bacteria)	Diarrhea, fever, and abdominal cramp	Through fecal contaminated water or food
Leptospira (Bacteria)	Leptospirosis with symptoms such as high fever, kidney or liver failure, meningitis, or even death	Directly through animal urine or soil containing animal urine contacting breaks in the eyes, skin, mouth or nose
Listeria (Bacteria)	Listeriosis characterized by fever, chills, headache, upset stomach and vomiting, most likely to affect pregnant women and unborn babies	Manure contaminated food
Shigella (Bacteria)	Bloody diarrhea	Direct contact with feces
Cryptosporidium (Parasite)	Watery diarrhea, may be life-threatening to peoples with poor immune system	Soil, water, food, or surfaces contaminated with feces of infected animal
Hepatitis A (Virus)	Viral liver disease causing mild to severe illness, flu-like symptom, diarrhea, fever, discomfort, decreased appetite, tiredness	Fecal, or by indirect contact through contaminated food and water
Rotavirus (Virus)	Gastroenteritis. Symptoms include severe diarrhea, vomiting, fever, and dehydration	Contamination of hands, objects, food or water with infected feces
Nipah virus (Virus)	Conjunctivitis, fever, cough, sore throat, muscle aches, pneumonia	Contact with contaminated droppings

Conclusion

Livestock production systems produce a large quantity of animal manure. The management of manure as a resource can offer benefits to livestock producers. Livestock waste management helps to maintain soil fertility in soils lacking organic content. However, livestock waste contains significant amounts of microorganisms which make it a source of major risk to the public. Efficient management of livestock waste helps to increase socio- economic status of developing country, and also reduce chances of spreading disease from waste.

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