Dairy Farm Waste Management and Value Addition of Waste to Farm Profitability

Kapadiya R. I.[1], Trivedi, P. G.[2], Thakkar, N. K.[3], Lunagariya, P. M.[4], Modi, R. J.[5], and Wadhwani, K. N.[6]

[1]Technical Sales Lead (Dairy Feed), Cargill India Private Limited, Gujarat, India
[2]Junior Research Fellow, Livestock Research Station, Veterinary College, Kamdhenu University, Anand (Email: dr.pankaj1911@gmail.com)
[3]Assistant Professor, Department of Livestock Production & Management, Veterinary College, Kamdhenu University, Bhuj- Kutch
[4]Associate Professor & Head, Department of Livestock Farm Complex, Veterinary College, Kamdhenu University, Junagadh
[5]Associate Professor & Head, Department of Livestock Production Management, Veterinary College, Kamdhenu University, Bhuj-Kutch
[6]Research Scientist & Head, Livestock Research Station, Kamdhenu University, Navsari
Corresponding Author: Dr. P. G. Trivedi (Email: dr.pankaj1911@gmail.com)
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Abstract

Animal waste releases huge amounts of dangerous gases into the environment, which responsible for the acid rain and the greenhouse effect. This is the most prominent environmental concern with regard to animal waste. Additionally, it might contaminate water supplies and aid in the spread of infectious diseases. Large farms must effectively utilize wastes by disposing of them properly, adding nutrients back into the soil, and preventing the spread of disease and pathogens. Collection, transportation, treatment, and disposal of garbage along with monitoring and regulation are all included in waste management. Disposal of dairy farm waste may be direct or indirect. Both traditional & advanced methods like composting, biogas production, vermicompost, fish pond feeding, algae, azolla and mushroom cultivation etc. are in practiced. The effective use of agricultural and its byproduct waste, such as from crop farming and animal husbandry waste by any of the above-mentioned techniques and to making some ecofriendly items, can provide additional income to the farmers, precisely doubling their income and ultimately the wealth of the nation. Cow urine and dung having medicinal value and dung is also used for making some ornamental/decorative/cosmetic items, mosquitos' coil, paper pulp, paint, etc.

Keywords: Farm Waste, Biogas, Vermicompost, Panchagavyas

Introduction:

Dairy farming having important role in the Indian economy. It contributes to food supply supplementation, job creation, and nutritional improvement. Cattle manure is a major source of toxic gases, germs, and odour, it poses a public health and environmental risk. As a result, livestock manure must be appropriately managed in order to reduce the creation of harmful pollutants and safeguard the environment. Proper use of livestock waste in the production of biogas, compost, and vermicompost can significantly boost crop output and sustainability. There are various significant, cost-effective, and efficient methods of disposing of manure and farm waste. In attention to effective waste management results in not only massive pollution but also nutritional loss. The efficiency of farm operations will undoubtedly increase with a better understanding of these techniques, and there may be opportunities to profit from what has traditionally been considered waste. The growing of algae from animal waste can be used to make bio-oil and other important items. Integrating fish farming with livestock or using trash has good potential to make money (Sorathiya *et al.,* 2014).

The agricultural sector has the chance to use high-quality organic fertilizer made from animal manure to lessen its dependency on chemical fertilizers, which increases the soil's fertility and sustainability. Farmers may be able to benefit from new markets for waste products by using animal waste as an input for bioenergy conversion processes. In addition to creating millions of jobs in rural areas, the proper use of cow dung and cow urine can improve soil fertility, protect soil from chemicals and fertilizers, and be turned into pesticides, medications, and other daily items (Vijay, 2011). Organic waste application reduces soil bulk density by increasing both the organic percentage of the soil and aggregate stability. Organic waste also improves the soil's water filtration rate, water retention capacity, and hydraulic conductivity. All these animal waste qualities will be available only if they are correctly managed. According to Ayurveda, it can also work as a cleanser for all wastes in nature (Randhwa and Khullar, 2011). Therefore, In India, Cow (*B. indicus*) is not only just milk-producing animal but also truly considered as Gomata (mother of all) and Kamdhenu (Dhama *et al.,* 2005).

Table. 1: Average amounts of dung produced by different livestock species

Animal	Quantity of dung (kg/day)	
	Range	Average
Cattle	18-30	24
Buffaloes	25-40	32.5
Horse	9-18	13.50
Sheep & Goat	1-2.5	1.75
(Singh *et al.,* 2018)		

- **Types of livestock farm waste:**
  - Solid: Dung, Feed, Bedding materials
  - Liquid: Urine, Washing water
- **Aims of dairy farm waste management**
  - To remove the threat of sickness
  - To convert garbage into commercially useful commodities like bioenergy
  - For lowering greenhouse gas emission
  - To prevent subsurface water pollution
  - For annihilating pathogenic organisms and weed seeds
  - To solve the problem of fly and mosquito breeding

Ruminant manure is a valuable resource as a soil fertilizer, providing both macro and micronutrients required for plant growth, and is a low-cost alternative to mineral fertilizer (Lazcano *et al.,* 2008). Manure is rich in nutrients, including trace elements necessary for crop growth. Approximately 70-80% of nitrogen (N), 60-85% of phosphorus (P), and 80-90% of potassium (K) found in feeds is excreted in the manure (Anonymous, 2021). These nutrients can replace the fertilizer needed for pasture or crop growth, eliminating the need to purchase fertilizers. Utilization of these nutrients by proper technique is highly desirable for efficient utilization of the animal wastes.

Farm waste is managed using a variety of methods, including composting, biogas production (anaerobic fermentation), aerobic oxidation in ditches, lakes, and lagoons, direct field application, used as fish food in fish ponds, to grow algae, to produce azolla, and to grow mushrooms out of water waste.

Composting:

Composting and vermicomposting are two of the best-known processes for the biological stabilization of solid waste (Lazcano *et al.,* 2008).

A variety of organic materials, including livestock manure, can be stabilized through the natural aerobic process of composting. A properly composted manure smells like humus. Well-managed composting eliminates pathogens and weed seeds due to the heat produced during the composting process. Composting is a useful method for properly recycling the deceased animals, but it can also leave behind feathers, teeth, and bone fragments that can be removed mechanically if necessary. By composting dead birds using a unique process, the poultry sector in the United States was able to solve its problem with dead bird disposal (Morrow and Ferket, 1993).

Solid waste is gathered in a composting pile in a pit 1.5 m deep and 3×4 metre dimensions or larger as required (3 cubic metre/adult animal unit) according to one design (Allnutt design described by R.G. Linton). This design has two pits with walls on all three sides and a temporary roof on top to avoid desiccation, as well as different filling and emptying methods. The front side should have a gutter filled with cresol and water to control fly breeding, as well as a vertical sliding shutter to prevent trash from falling into the gutter. The manure should be dumped and well-packed in each compartment separately. While one is filled and packed, fermentation and decomposition occur in the other, which was filled earlier. The manure should be turned periodically to ensure uniform decomposition; this also enhances the destruction of larvae of parasites that are normally present in the dung. During composting, frequent mixing of waste is required. The manure from other livestock farms like sheep, goat, pig, and poultry can be decomposed in a similar manner. After piling within 24 hours temperature rises to 50°C, and within 3-8 days it reaches to 70°C. Thereafter, it falls to 50°C. C: N ratio and moisture are important in this process.

Animal dead bodies can be buried in a compost pile within 24 h of death and covered with a thick layer of solid manure or soil. Composting is done in such a way that it will control odors, flies, rodents, and other vermin (Morrow, 2001). Dead animals with a history of neurological disease, anthrax, or other diseases and conditions kept under quarantine should not be composted (Belay *et al.,* 2002).

Vermicomposting:

Vermicompost is organic manure produced from the cast of earth worms, especially Eisenia, Eudrillus, Perionyx, and Dolvin species from agricultural and livestock waste. The earthworms eat 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 contains biologically active substances such as plant growth regulators (Sorathiya et al., 2014). Vermicompost is a rich source of nitrogen, phosphorus, and Potassium. Palaniappan and Annadurai, (2010) reported that the farm yard manure contained 0.80 % N, 0.41 % P2O5, and 0.74 % K2O.

Vermicompost helps to improve soil texture, water retention capacity, aeration, and erosion control. As a result, nutritious, non-toxic, and delicious food can be grown in the soil without endangering the health of people or animals. The process of preparation is quite straightforward and economical, and rural farmers can readily adopt it for their own profit. Vermicomposting is a technology that can also handle a large volume of waste from animal and agricultural sources. By supplying a healthy, prosperous, and deserving environment, this will unquestionably increase the prosperity of rural residents.

Table. 2: Comparative nutritive profile of vermicompost and farm yard manure

Nutrient	Vermicompost	Farm Yard Manure
N (%)	1.6	0.5
PO (%)	0.7	0.2
KO (%)	0.8	0.5
Ca (%)	0.5	0.9
Mg (%)	0.2	0.2
Fe (ppm)	175.0	146.5
Mn (ppm)	96.5	69.0
Zn (ppm)	24.5	14.5
Cu (ppm)	5.0	2.8
C:N ratio	15.5	31.3

(Singh *et al.,* 2018)

Biogas production:

Anaerobic biomass digestion is a well-known method for producing gas. Worldwide, there are currently billions of biogas installations. In order to preserve energy in rural areas, particularly in developing nations in Asia and Africa, biogas can be utilized as a substitute for other nonrenewable fuels. Biogas is a clean, effective, and renewable source of energy. The two leading Asian nations utilizing biogas technology are India and China. In most developing nations in Asia and Africa, the biogas produced is mostly used for residential applications.

Biogas production is an environmentally benign method of producing energy from biomass, and the waste can be utilized as a soil conditioner. The anaerobic biological breakdown of organic materials produces biogas. It is mostly made up of methane and carbon dioxide. The predominant component of biomass (50%-85%) is flammable methane, which serves as the primary energy source (Sindhu *et al.,* 2019). Biogas helps to reduce the negative externalities associated with organic waste, such as groundwater and soil contamination, the emission of local air pollutants such as dioxins and furans, and methane, a potent greenhouse gas (Kumar and Sharma, 2014).

Several support schemes like, the New National Biogas and Organic Manure Programme (NNBOMP) has been implemented by the government for biogas development in India to provide clean cooking fuel for kitchens, lighting and meeting other thermal and small power needs of farmers/dairy farmers /users including individual households and to improve organic manure system based on bio slurry from biogas plants in rural and semi urban areas by setting up of small size biogas plants of 1 to 25 Cubic meter capacity and to provide biogas plant produced slurry (liquid / semi-solid or dried) as an organic enriched bio- manure to help reduce use of chemical fertilizers such as urea, linking biogas slurry with enrichment units such as vermicomposting, Phosphate Rich Organic Manure (PROM) plants and other organic enrichment facilities as a source of value addition to bio gas plant slurry (MNRE, 2022).

Aerobic Oxidation:

An oxygen-rich environment is necessary for the microbial process of aerobic digestion to take place. Under aerobic circumstances, organic material is oxidized, resulting in the production of substances like nitrate, phosphate, and carbon dioxide. In aerobic digesters, microbial growth is often high, which results in shorter retention durations while producing biogas (Ohimain and Izah, 2017). Keep slurry in shallow ditches, lagoons, and lakes for disposal. For optimal oxidation, the BOD (Biological oxygen demand) per acre is typically 20. Large regions are needed, and solid sludge removal is occasionally necessary. After combining with fresh water or by itself, upper water is utilized for irrigation.

Direct Application of Waste in the Farm Land:

Direct application of solid waste by spreading or slurry by sprawling is possible on large farm land that is not in productive use, but this method is inefficient due to nutrient loss, pathogen problems, and sometimes toxicities to the plants grown on this type of land. Manure application can have a significant impact on the chemical, physical and biological properties of soil. Most of these effects are due to an increasing in soil organic matter resulting from manure application. The ability of manure to promote formation of water stable aggregates in the soil has a profound effect on soil structure and physical characteristics. Water stable aggregates increase infiltration, porosity and water holding capacity and decrease soil compaction and erosion (Haynes and Naidu, 1998).

Use as fish feed in fish ponds:

The greatest way to recycle organic wastes is to combine fish and cattle production. India has made substantial use of cattle dung as a source of manure for carp polyculture. Fish and cattle can be raised together profitably. Although the bovine dung and urine are not as rich in nutrients as the waste from pigs and poultry, cattle producers can nevertheless utilize them to maintain a fish pond. You can build a shed next to your pond if you have livestock. The floor of the shed should be lined with brick and have sufficient drainage. A preferable option is to fully combine the dung and pee, dilute with water, and then evenly spread the mixture into your fish pond. For a fish pond to remain fertile, it requires 10 to 15 tons of cow dung and urine annually. Cow dung and urine dosages for new ponds must be increased. In general, the 1-hectare pond can be maintained with just 2 cows' worth of dung and pee. Cow manure that has been converted into biogas slurry is considerably superior. One hectare of the pond can generate between 2,500 and 3,000 kg of fish annually (Kanika, 2021).

Livestock Research Station, Navsari (Gujarat) is utilizing the wallowing pond made for buffaloes for fresh water aquaculture with fish yield of 5 t ha-1 without any supplementary feeding (Anonymous, 1998). The said pond was manured by dung and urine of buffaloes excreted during wallowing in summer months where as in winter months the slurry produced during washing of livestock sheds was directly drained into the said pond. This is very useful recommendation made available to farmers during 1998 from the said university. The pond water is periodically pumped to irrigate the fodder farm with good result (Anonymous, 1998).

For cultivation of algae:

Algae is also being used as a third-generation feedstock for biofuels and other value-added goods such as bioelectricity and antibiotics (Ghangrekar and Das, 2022). When cattle dung is digested anaerobically and thermochemically, gases are created that can be used to make algal biomass. Algae use carbon dioxide 10 times more efficiently than terrestrial plants and can produce algal biomass and intracellular oil (Miao and Wu, 2006).

Algae culture, which has the advantage of rapid nutrient uptake in effluent streams, is one of the finest procedures for removing excess nutrients. In the meantime, algae have been shown to be one of the most promising non-food crop-based feedstock for biofuels production (Chen *et al.,* 2012). Alga farming also has several advantages, including rapid biomass harvesting rates of up to 50 metric tons acre-1 year-1 (Demirbas, 2001), massive amounts of fatty acids and hydrocarbons, and the ability to contribute to waste treatment. These algal products can be used to make a variety of value-added products, including bio-oil. As a result, it is an extremely promising non-crop raw material to produce biofuels.

Production of Azolla and Cultivation of Mushrooms:

Waste water from agricultural institutions such as fodder fields, dairy or other livestock farms, and milking parlours can be utilized to cultivate and produce Azolla feed additives for livestock, as well as mushroom cultivation for human use. Azolla is a high-protein supplement that can be used to complement the concentrate diet of cattle. Azolla fodder supplementation has been found in multiple studies to increase milk output in dairy cows. Mushrooms are fungi that grow in agricultural wastewater and give a dietary rich source of protein that humans and livestock can consume. It can be offered for a higher price due to its high nutritional content. When practices like mushroom growing and the use of agricultural waste for Azolla feed are combined, farmers may be able to earn more money (Wankhade *et al.,* 2020).

Value addition of waste to farm profitability:

Value addition refers to the act of adding value(s) to a product to create form, place, and time utility which increase the value offered by a product or service. It is a practice that enhances or improves the quality and shelf life of an existing product or introduces new products for uses. (Kaur *et al.,* 2021). It can be applicable to every raw material irrespective of food and non-food markets which should be of superior quality with ease of use providing consumer convenience and economic profit to the producer.

The Government of India has envisaged a journey of doubling farmers' income till 2022-2023 and envisioned many policy reforms for the same. Farmers in India rely on major farm produce and do not utilize the by-products or wastes emerging from their farms for monetary benefits. The agricultural sector generates approximately 1300 million tons of waste annually, where up to 50% comprising of raw material are discarded without treatment (Amran *et al.,* 2021). Current strategies to recover value from wastes and low-value co-products from livestock industries yield limited value; hence, new technologies are required to upgrade wastes and co-products, and generate high-value products that can feed into the livestock value chain (Ramirez *et al.,* 2021).

The efficient conversion of livestock waste into biogas, compost, and vermicompost can help to boost crop productivity and sustainability. In certain developed and developing nations, work has been done on animal waste management and value addition. If used for biogas bottling, the 60 m3 biogas plant may save $147 per day. The combined process of composting and vermicomposting is superior to either composting or vermicomposting because it takes less time to complete the cycle and produces substrates with better physical and chemical qualities that can support crops. Sustainable agricultural, household, and livestock waste utilization has the potential to significantly increase farmers' income, (Singh *et al.,* 2021), through vermicomposting, biogas production, and traditional composting. Vermicomposting, composting, and biogas production have all been subjected to comparative economic analysis in terms of various expenses. Vermicomposting (INR 2224.72, USD 29.42) yielded the highest net returns per metric ton of dung, followed by biogas production and composting. Some broad-spectrum botanical pesticides like, “Neemastra” and “Bramhastra” also made from the livestock waste. Whereas, the separation of liquid slurry from the solid dung and it is used as biofertilizer for the soil and the left solid dung material used as bedding material for the poultry.

For the effective utilization of the agricultural waste and its byproducts by following methods can be efficient to increase wealth of farmer (Wankhade *et al.,* 2020)

- ✓ Landfills and as a Fertilizer like Farmyard Manure (FYM)

- ✓ Biogas Production through Anaerobic Decomposition
- ✓ Composting and Vermicomposting
- ✓ Integrated Farming System (Livestock-fish, Poultry-fish-rice)
- ✓ Production of Azolla and Cultivation of Mushrooms
- ✓ Utilization through the Preparation of Panchgavya and Certain Value-added Products
- ✓ Bio-fuels and Biomass Gasification
- ✓ Timber and Paper Industry

Panchagavya can also be made from agricultural waste, notably livestock waste such as cattle dung and urine. It signifies milk, urine, dung, ghee, and curd obtained from cows and is vital in Ayurveda and ancient Indian clinical practices. Panchgavya therapy is known as 'Cowpathy' in Ayurveda. In India, the cow is venerated as a divinity named 'Gaumata,' which refers to its nurturing qualities as a mother. Panchagavya is recommended by Ayurveda to cure disorders of numerous systems, including severe ones, with little to no side effects. It can contribute to the development of a healthy population, alternative energy sources, the fulfilment of nutritional needs, the abolition of poverty, a pollution-free environment, organic farming, and so on. Panchgavya can also give back to mother nature by promoting soil fertility, earthworm production, protecting crops from bacterial and fungal infections, etc. Scientific efforts shall be taken to build evidence for the clinical application of Cowpathy (Bajaj *et al.,* 2022).

The other value-added products from cattle waste are Ghana and Drava Jeevamrit, a traditional organic fertilizer that works as a cool drink for plants which boosts the plant growth and gives a good yield. The preparation and selling of these products in the market can be a better income source along with utilization of waste materials to the farmer. According to recent research, algae growing from cattle waste can be transformed into bio-oil and a variety of other useful goods. There is a lot of potential in waste-fed or livestock-integrated fish farming (Sorathiya *et al.,* 2014).

Agricultural and its byproduct waste like sugarcane bagasse, straws, etc. can be used for producing ethanol as a fuel source and a burning material for the generation of power. Bio-ethanol is one of the most important alternative renewable energy sources that substitute fossil fuels. Biomass generally refers to any plant or animal matter. The term agricultural waste biomass refers to those organic materials in the form of residual stalks from crops, leaves, roots, seeds, and seed shells, etc. These techniques are used for generation of energy by utilization of agricultural waste through gasification methods like briquetting, charring, gasification-thermal mode, and gasification-electrical mode. The importance of biofuels (biodiesel and ethanol) is rapidly growing in response to rising concerns about crude oil supplies and rapid climate change. Biodiesel is a clean and safe fuel. Bio diesel is a green fuel made from edible and inedible vegetable oils or animal fats. We can use it today in our DIESEL engine with no modifications. We can even mix it with the remaining petroleum diesel. Biodiesel is cool since it reduces greenhouse gas emissions by 78% (Raman, 2019). Because their qualitative ingredients match diesel and petrol, biodiesel and bioethanol have emerged as the most viable sustainable alternatives to fossil fuel. Furthermore, they emit less pollution than their fossil-fuel counterparts.

Cow dung is very useful as a fertilizer. It is a growth stimulant. Foreigners have well understood the importance of cow dung. The result of this is that many countries have started using organic manure made from cow dung in abundance. Due to not having enough cow dung available with them, they have started importing organic manure (Vermicompost) made from cow dung from India. Recently, National President Organic Farmer Producer Association of India, Dr. Atul Gupta told that in news, they have received an order of 192 metric tons of cow dung from Kuwait. Export of animal products is an important contributor to the Indian agricultural sector.

Dung brick preparation and porous bricks also making from the crop residue, it made by mixing crop residues such as paddy straw, wheat straw and sawdust in brick earth to get higher water absorption, surface evaporation and lower dry weight than those of the conventional bricks. Cow dung has been referred to as a “gold mine” owing to its vast applications in the arena of agriculture, energy resource, environmental protection, and therapeutic applications (Randhawa and Kullar, 2011), as well as its also use in the field of agriculture, energy resource, environmental protection, and therapeutic applications. It is also used as a co-product in agriculture, such as manure, bio-fertilizer, bio-pesticides and pest-repellent. Several Products has been launched by the manufacturing companies such as soap, toothpaste, floor cleaners, hair oil, incense, shaving cream, and face wash from the cow dung to earn money. The soap contains dried and pulverized cow dung, orange peel, lavender powder, and gooseberries, the company says. The toothpaste is made of dung, ghee, and urine. It is now readying a line of cosmetic products and medicines as well (Singh, 2020). Now a day, the god statue and repellent (puja-agarbati) also making from the caw dung, and it is wide demand in market.

There are many farmers accepted the concept of the farm waste management and value addition and makes ornamental products out of agricultural waste and cow dung like; Hand belt (Rakhi), Mobile stand, Wall watch, Bhakti mala, God statue, Flower pot, Bird nest pot, dung made cap and other many ornaments. It is the most effective way to increase agricultural profitability by adding value to farm waste.

Cow dung alone or in combinations with those obtained from other mosquito repellent plant species, could be potentially used for the preparation of mosquito repellent products. The ingredients of cow dung and phytochemical compounds of plant extract are responsible for mosquito repellence. Cow dung containing Vedic paint for coloring the house is also available in market and it helpful to maintain the house temperature in high environmental temperature. The waste like crop residues like straws, peals and residual fodder from livestock feeding can be used for the preparation of pulp for paper, cardboard, and plywood production. The cow dung paper pulp is produced through the steps of washing material, dewatering, steaming, and pulping. The cow dung paper pulp is suitable for producing industrial packing paper or common paper. The present invention provides new pulp source, and has waste utilization, environment friendship and low cost.

Conclusion:

The animal wastes are affecting the atmospheric air with offensive odors, release of large quantities of CO_2 and ammonia which might contribute to acid rain and the greenhouse effect. It could also pollute water sources and be instrumental in spreading infectious diseases. If the disposal of water is not properly planned it might create social tension owing to the release of odors and contamination of water sources. Proper disposal and returning of nutrients back in the soil without pollution and spreading of diseases/pathogens, is required for efficient utilization of wastes on large farms. Waste management includes collection, transport, treatment and disposal of waste together with monitoring and regulation. Disposal of dairy farm waste may be direct or indirect. Both traditional & advanced methods like composting, biogas production, vermicompost, fish pond feeding, algae, azolla and mushroom cultivation etc. are in practiced. Cow urine and dung having medicinal value and dung is also used for making some ornamental/decorative/cosmetic items, mosquitos coil, paper pulp, paint etc., as well as the efficient utilization of agricultural and its byproduct waste like from crop farming, animal husbandry waste by any of the above-mentioned techniques and to making some ecofreindly items, can provide additional income to the farmers, precisely doubling their income and ultimately the wealth of the nation.

References:

Amran, M. A.; Palaniveloo, K.; Fauzi, R.; Mohd Satar, N.; Mohidin, T. B. M.; Mohan, G.; Razak, S. A.; Arunasalam, M.; Nagappan, T. and Jaya Seelan, S. S. (2021). Value-Added Metabolites from Agricultural Waste and Application of Green Extraction Techniques. *Sustainability*. Available at https://doi.org/10.3390/ su132011432.

Anonymous, (1998). AGRESCO report of livestock research station. Gujarat Agricultural University, Navsari.

Anonymous, (2021). Manure as a Nutrient Resource. UMass Extension Crops, Dairy, Livestock & Equine Program. Available at https://ag.umass.edu/crops-dairy-livestock-equine/fact-sheets/manure-nutrient-resource.

Bajaj, K. K.; Chavhan, V.; Raut, N. A.; and Gurav, S. (2022). *Panchgavya*: A precious gift to humankind. *J Ayurveda Integr Med.* 13(2): 1-9.

Belay, A.; Claassens, A. S.; Wehner, F. C. (2002). Effect of direct nitrogen and potassium and residual phosphorous fertilizers on soil chemical properties, microbial components and maize yield under long term crop rotation. *Biology and Fertility of Soil*, 35: 420-427.

Chen, R.; Li, R.; Deitz, L.; Liu, Y.; Janstevenson, R. and Liao, W. (2012). Freshwater algal cultivation with animal waste for nutrient removal and biomass production. *Biomass and Bioenergy*. 39: 128-138.

Demirbas, A. (2001). Biomass resource facilities and biomass conversion processing for fuels and chemicals. *Energy Conversion and Management*, 42:1357-1378.

Dhama, K.; Chauhan, R. S. and Singhal, L. (2005). Anti-cancer activity of cow urine: current status and future directions. *International Journal of Cow Science*, 1: 1-25.

Ghangrekar, M. M. and Das, S. (2022). Integration of wastewater treatment with algal cultivation for the production of biofuel and bioenergy. *An integration of phycoremediation processes in waste water treatment*. *pp*. 289-312.

Haynes, R. J. and Naidu, R. (1998). Influence of line, fertilizer and manure application on soil organic matter content and soil physical condition. *A Review: Nutrient Cycling in Agroecosystem*, 51: 123-137.

Kanika, M. (2021). Fish Farming: Advantages of Using Cow Dung & Urine as Fertilizer in Fish Farm. Available at https://krishijagran.com/animal-husbandry/fish-farming-advantages-of-using-cow-dung-urine-as-fertilizer-in-fish-farm/.

Kaur, H.; Kaur, I.; Singh, V. P. and Wakchaure, N. S. (2021). Level of value addition of milk at farm and its relationship with socio-economic characteristics of dairy farmers in Punjab State. *International Journal of Current Microbiology and Applied Sciences*, 10(1):337-346.

Kumar, A. and Sharma, M. P. (2014). GHG emission and carbon sequestration potential from MSW of Indian metro cities. *Urban Climate*, 8: 30-41.

Lazcano, C.; Gómez-Brandón, M. and Domínguez, J. (2008). Comparison of the effectiveness of composting and vermicomposting for the biological stabilization of cattle manure. *Chemosphere*, 72(7): 1013-1019.

Miao, X. and Wu, Q. (2006). Biodiesel production from heterotrophic microalgal oil. *Bioresearch Technology*. 97: 841-846.

MNRE, (2022). Bio-energy Schemes: New National Biogas and Organic Manure Programme (NNBOMP). Available at https://mnre.gov.in/bio-energy/schemes.

Morrow, M. (2001). Alternative methods for the disposal of swine carcasses, extension swine husbandry. Department of Animal Science, Department of Poultry Science, North Carolina State University, Raleigh.

Morrow, W. M. and Ferket, P. R. (1993). The disposal of dead pigs: a review. *Swine Health Production*, 1: 13-37.

Ohimain, E. I. and Izah, S. C. (2017). A review of biogas production from palm oil mill effluents using different configurations of bioreactors. *Renewable and Sustainable Energy Reviews, Elsevier,* 70: 242-253.

Palaniappan, S. P. and Annadurai, K. (2010). Organic farming: theory and practices. Scientific publishers, (India), Jodhpur, *pp*. 97.

Raman (2019). Biofuels as an Alternative Energy Source for Sustainability. *Adv Biotechnol Microbiol.* 14(4): 123-127.

Ramirez, J; McCabeC, B.; Jensen, P. D.; Speight, R.; Harrison, M.; Berg, L. V. D. and O'Hara, I. (2021). Wastes to profit: a circular economy approach to value-addition in livestock industries. *Animal Production Science*, 61: 541-550.

Randhawa, G. K. and Kullar, J. S. (2011). Bioremediation of pharmaceuticals, pesticides, and petrochemicals with gomeya/cow dung. *ISRN Pharmacology.* Availablr at doi:10.5402/20s11/362459s.

Sheldrick, W.; Syers, J. K. and Lingard, J. (2003). Contribution of livestock excreta to nutrient balances. *Nutrient Cycling in Agroecosystems*, 66(2): 119-131.

Sindhu, R.; Binod, P.; Pandey, A.; Ankaram, S.; Duan, A. and Awasthi, M. K. (2019). Biofuel production from Biomass: Toward Sustainable development. *Current* *developments in biotechnology and bioengineering*, *pp.* 79-92.

Singh, A. K.; Roy, S. and Tripti, K. (2018). Advanced methods of dairy farm waste disposal. Available at https://en.engormix.com/dairy-cattle/articles/advanced-methods-dairy-farm-t43033.htm.

Singh, A.; Tiwari, R.; Chandrahas. And Dutt T. (2021). Augmentation of farmers' income in India through sustainable waste management techniques. *Waste Management Research,* 39(6): 849-859.

Singh, R. (2020). How to increase the income of livestock farmer's in India. Available at https://www.pashudhanpraharee.com/how-to-increase-the-income-of-livestock farmers-in-india/.

Sorathiya, L. M.; Fulsoundar, A. B.; Tyagi, K. K.; Patel, M. D. and Singh, R. R. (2014). Eco-friendly and modern methods of livestock waste recycling for enhancing farm profitability. *The International Journal of Recycling of Organic Waste in Agriculture,* 3(50): 1-7.

Vijay, V. K. (2011). Biogas enrichment and bottling technology for vehicular use. *Biogas forum,* 1(1): 12-15.

Wankhade, P. R.; Talokar, A. J.; Gourkhede, D. P.; Sakhare, D. T. and Verma, D. (2020). Utilization of livestock waste to enhance farmers' wealth. *Indian Dairy Man. pp.* 84-86.