Chapter 16
Biofertiliser from Animal Wastes

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Abstract The increase in demand for animal products is a major and growing source of pollution and diseases globally. Due to constrained disposal places and firmer regulations on burning, animal waste is a worldwide problem. Handling animal waste has certain significant dangers that are connected to the condition of the land, water, and air. As a regenerative and sustainable supply of plant nutrients, biofertilisers based on animal waste are an advantageous tool in the agricultural sector. In order to promote and encourage their usage as well as develop the supply chain, it is necessary for different stakeholders and governments to strengthen animal waste-based biofertilisers. Animal waste-based biofertilisers will mitigate hazards from global population food needs and production and will slow down/stop the widespread chemicalization in agroecosystems.

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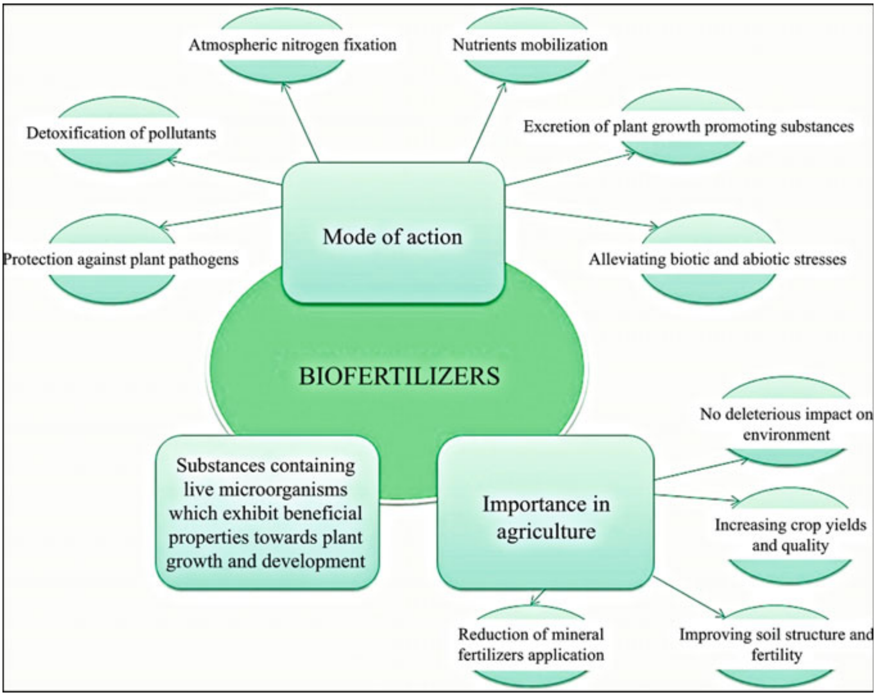
Graphical Abstract



Keywords Agroecosystems · Environment · Industrialisation · Livestock · Chemical fertilisers · UN sustainable development goals

16.1 Introduction

The farming of animals in agriculture has a substantial role in both social and economic well-being of a nation by helping to supply the nation with food, create jobs, increase household income, generate revenue, pay taxes, preserve assets, use animals for traction, diversify agriculture, improve soil fertility, and provide transportation (Malomo et al. 2018). The term "animal wastes" refer to the solid, semisolid, and liquid by-products (faeces, urine, bedding materials including straw, sawdust, and rice hulls) produced by animals. Typically, the animals are raised to provide food for human use, such as meat, milk, and eggs (Sims and Maguire 2018). The faeces of cows, pigs, and chickens are the most common types of animal waste. Given their potential to pollute both surface and groundwater, animal wastes are a source of growing concern. (Gerba and Pepper 2009). Pathogens in animal faeces may contaminate food or water, or they can enter the body directly via inhalation, skin sores, and other paths that are open to pathogen entrance, which contributes to the spread of many zoonotic illnesses (Cavin and Butler 2016). Various approaches have been investigated in recent years for the reduction of organic waste materials as well as recycling and reusing these resources for the manufacturing of goods with additional value. Converting organic waste into biofertilisers is one of the newest strategies (Du et al. 2020).

Organic fertilisers known as “biofertilisers” also have microorganisms that have qualities that are advantageous for plant growth and development. These fertilisers also promote nutrient absorption, soil fertility, and crop yields (Mącik et al. 2020). Due to their sustainability and environmental friendliness, biofertilisers are seen to be an effective substitute for synthetic chemical fertilisers (SCF), which are expensive and harmful to the food and soil health (Jaffri et al. 2021). For intensive agriculture to provide large yields, several synthetic fertilisers are used. Synthetic fertilisers are expensive and dangerous for the nutrition and health of the soil (Singh et al. 2021). The eutrophication of water bodies, the greenhouse effect, and the heavy metals accumulation such as arsenic, cadmium, and plumbum are all strongly related to the excessive use of synthetic fertilisers (Mącik et al. 2020). Additionally, intensive chemical fertiliser usage reduces soil fertility and biodiversity (Singh et al. 2021). One of the finest alternatives to chemical fertilisers is biofertilisers derived from animal manure. Biofertilisers made from animal waste assist in restoring normal soil fertility and enhance the structure and functionality of the soil (Singh et al. 2021). Use of biofertiliser is primarily intended to support plant development without having a negative impact on the environment and to increase agricultural yields (Mishra et al. 2013). The yearly production of manure by domesticated cattle, pigs, and poultry, excluding animals on pasture, is around 120 million tonnes. (Loyon 2018). By 2023, the biofertiliser market is anticipated to grow at a CAGR of over 14%. The size of the worldwide biofertiliser market was USD 1106.4 million in 2016, and by the end of 2024, it is expected to have increased by USD 3124.5 million at a pace of 14.2% (Joshi and Gauraha 2022).

According to projections, the world’s population will reach 9.7 billion by 2050, and the globe currently faces a climate emergency as a result of rapid urbanisation, industrialisation, and agricultural production using synthetic chemicals (Joshi and Gauraha 2022). Animal waste-based biofertilisers are amongst alternatives to the established farming system and help to decrease dependency on artificial plant protection inputs in crop production. This also helps to keep the environment clean, reduces population, and helps to protect the environment.

16.2 Biofertiliser from Animal Wastes

The quickest and best approach to make use of organic wastes is as substitute fertilisers and soil additives. Potentially safe to use as a broad-acre biofertiliser is the acquired low-cost biodegradable end product of organic waste. The development of an affordable technology for the treatment of industrial animal wastes is made possible by several methods for using animal wastes (Fig. 16.1). The European rendering market gathered and processed 15 million tonnes of animal waste in 2002 (Hall and Sullivan 2001). Utilisation of animal remains by different methods which is a special field of waste management. Some of these are following.

Fig. 16.1 Animal waste produced in a local dairy farm in Peshawar, Pakistan

16.2.1 Vermicompost

Vermicompost is a term used to describe how earthworms break down organic waste into a uniform mixture that resembles humus. The faecal by-products of bacteria and earthworms are combined to form vermicompost, a complex material. As voracious eaters, earthworms change the makeup of organic materials and progressively transform it into more nutritious elements. The nutrient content of vermicompost is greater than the traditional compost, hence converting it into valuable fertilisers. Earthworm increases the surface area of materials, making them more favourable for microbial activity. These have the ability to consume different types of excreta from livestock and cattle dung (Pandit et al. 2012).

16.2.2 Digestate Biofertiliser

Anaerobic digestion is a low-cost method of producing digestive biofertiliser. The technique makes use of a variety of raw materials, including commercial, agricultural, and household trash. The generation of food waste has significantly increased as a result of the growing world population (Curry and Pillay 2012). According to Johansen et al. (2013), digestate biofertiliser increases the diversity of soil microbes. The biofertiliser quality of digestate produced by the digestion of chicken droppings and cow dung was evaluated by Alfa et al. in 2014. Garfi et al. (2011) investigated the characteristics of digestate made from guinea pig dung. The soil's fertility may be increased by applying digestate biofertiliser, which is produced by the anaerobic digestion of human excreta. The digestate may be used as an effective biofertiliser for crop growth and yield due to the presence of organisms that fix nitrogen and solubilise phosphate (Owamah et al. 2014).

16.2.3 Poultry Waste-Based Biofertiliser

Animal waste is defined as bones or animal parts that are not primarily intended for human consumption and are regarded as high-risk items. Composting and anaerobic digestion are ecologically friendly methods for disposing of this garbage and treating it to get rid of any potential microbes. It reduces pollutants, stabilises sludge, and generates biogas, making it a potential option for poultry slaughterhouses processing organic waste. The hydrolysis of organic matter, which occurs as part of digestion, is the rate-limiting stage since the organics in chicken slaughterhouse wastes degrade slowly (Park et al. 2017). Poultry slaughterhouse wastes are combined with agricultural wastes, sewage sludge, wood dust, and activated compost over a 90-day composting cycle. The creation of mature and stable compost was made possible by the study of microbiological and physicochemical factors throughout the composting process (Asses et al. 2019).

16.3 Manure Management

A critical component of the agricultural waste management system is the treatment of animal manure (Malomo et al. 2018). Manure has long been valued as a soil amendment for growing crops. Manure management, taken in its broadest meaning, refers to the effective use of animal waste in accordance with each farm's capabilities and objectives in order to improve the soil's quality, the nutrition of the crops, and farm profitability. Manure management is described as a process of making decisions that aims to maximise agricultural productivity whilst minimising nutrient loss from manure, both now and in the future (Karmakar et al. 2007). Due to the growth of the livestock business, the increase in the number of livestock animals, and the adoption of environmental legislation and standards, appropriate manure management systems (MMS) are becoming more and more crucial. Management planning now has to take into account more decision factors as a result of growing environmental and sustainability concerns (Li et al. 1994). Environmental laws that aim to avoid pollution of the air, water, and land have a greater impact on the choice of manure management and treatment alternatives. Examples include how housing management, manure storage and treatment, and land application methods may be impacted by controlled decreases in ammonia emissions (Westerman and Bicudo 2005).

Enacted in 1997 and adopted in 2005, the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) is a global agreement (Boehm 2005). For the first commitment period (from 2008 to 2012), parties of this protocol agreed on a legally enforceable greenhouse gas (GHG) emission reduction target. These objectives were created to lower GHG emissions worldwide by around 5% from 1990 levels. A potential avenue for reducing GHG emissions is manure management in livestock husbandry. At every step of managing manure, including collection, handling/storage, treatment, and application to the ground, greenhouse gases are produced. Utilizing the right decision support system (DSS) might help livestock owners discover MMS or other elements that contribute to the decrease of GHG emissions (Karmakar et al. 2007).

16.4 Importance of Livestock Waste Management

Animal waste is most often a source of concern since it may produce a lot of CO_2 and ammonia, which can cause acid rain and the greenhouse effect. It may contaminate water supplies and aid in the spread of infectious illnesses. The discharge of smells and the contamination of water sources might lead to societal unrest if sufficient planning is not made. The following factors show the necessity, benefits, and significance of proper management of animal waste (Font-Palma 2019):

1. In soils deficient in organic matter, livestock dung aids in maintaining soil fertility. The physical state of the soil is improved by adding manure, which also improves soil structure and improves the soil's ability to store water.
2. Additionally, animal manure contributes to the improvement of the soil's microclimate for fauna and flora.
3. Manure is also used as fuel.
4. Manure waste and other organic wastes from animal ranches have the potential to be a significant source of energy.
5. Utilizing animal manure might help with resource management, crop and livestock production, and post-harvest loss reduction.
6. As a sustainable energy resource, bio-energy sources are becoming more and more popular which might help address issues like the growing cost of fuel and the demand for energy by serving as an alternative to pricey fossil fuels.
7. Sustainable agriculture is supported by biogas produced from animal waste and by-products, which is renewable and ecologically benign. Additionally, the digesters provide superior-quality organic waste.
8. Lower the risk of infection for both the animal and human populations.
9. Until it is decomposed and changed into a soluble form, the nitrogen in manure remains bound up in its organic state (ammonium nitrate). Ammonium nitrate is added to soil to increase fertility.
10. Decreases prohibited waste discharge which might endanger the quality of the water and soil.

16.4.1 Traditional Method of Livestock Waste Management

Dung cake: In less developed nations, cow dung is physically collected and spread out on the proper racks to sundry before being used as fuel for heating and cooking (Font-Palma 2019).

Dumping into heaps or pits: It is the most common and traditional waste management method, in which all garbage is dumped into a pit on a farm or field (Font-Palma 2019).

Composting: The first stage in the composting of organic waste is the thermophilic stage (45–65 °C), in which microorganisms, mostly bacteria, fungus, and actinomycetes create heat, carbon dioxide, and water. By combining or aerating the varied organic material, a uniform and stable humus-like product is produced. Composting is the process of aerobically breaking down biodegradable organic waste. The biodegradation process is rather quick, requiring just 4–6 weeks to stabilise the material. Compostable material may be utilised as organic fertiliser since it is odourless, fine-textured, and low in moisture. It is furnished with a fork, a brush, and a tiny cart with four wheels. The brush is rotated by a gear motor with a belt drive and pulley system (Font-Palma 2019).

16.4.2 Advance Methods of Livestock Waste Management

16.4.2.1 Biogas Production

Animal waste, household garbage, and agricultural waste may all be used to produce biogas, a clean, environmentally friendly fuel that is readily accessible in rural areas. Under anaerobic circumstances, bacteria convert organic materials to gases to produce biogas. Methane makes up 55–65% of biogas, along with carbon dioxide (35–45%), hydrogen sulphide (0.5–1.0%), and water vapour in very small amounts. Biogas has an average calorific value of 20 MJ/m^3 (4713 kcal/m^3) (Font-Palma 2019).

16.4.2.2 Vermicomposting

The earthworm consumes the organic material and excretes "vermicompost," which is a small, pelleted substance. Important plant nutrients like N, P, K, and Ca that are contained in organic waste are released during vermicomposting and changed into forms that are more soluble and useful to plants. Additionally, vermicompost has physiologically active ingredients like plant growth regulators. In addition, the worms themselves serve as a source of protein for animal feed. Composting period is shortened to 60–75 days, whilst N, P, and K content are increased by three to four times (Font-Palma 2019).

16.4.2.3 Pyrolysis

The process of pyrolysis involves heating condensed organic molecules in a reactor, often without oxygen, and causing chemical degradation. Straw, twigs, sawdust, and other agricultural and forestry waste are some of the main raw materials utilised in pyrolysis. These raw materials are converted into a variety of products under high pressure and temperature. Manure may be pyrolyzed by heating it to between 480 and 830°F whilst maintaining a low oxygen level in the air. In a closed system at temperatures between 400 to 1472°F, waste is chemically broken down by a thermochemical process. Gases, oil, and ash are the by-products. H_2, H_2S, CH_3, CO, and ethylene are amongst the gases. When compared to other animal manures, dairy faeces produced the most gas per unit of dry solids, followed by chicken, beef, and swine faeces (Brugger and Windisch 2015).

16.4.2.4 Soldier Fly Breeding

The larvae or “grubs” of black soldier flies (BSF) are well adapted to handle animal manure. The BSF larvae may survive for many weeks, whereas the adults only have a short lifespan, and during that period, they can absorb enormous amounts of food waste or manure. This process yields two beneficial by-products: the castings or waste, which may be used to enhance the soil, and the larvae, which are a fantastic source of food for a variety of creatures, including fish, birds, reptiles, and amphibians (Font-Palma 2019).

16.4.2.5 Litter Management

The excreta, bedding, leftover feed, and feathers all make up poultry litter. Wood shavings, sawdust, straw, peanut hulls, and other fibrous materials may be used as bedding. The majority of the chicken litter comes from the broiler industry. The litter may have accumulated across numerous bird harvests or may have come from a single crop of broilers. 20–25% of the moisture in the litter is typical. Mostly, beef cows and stocker cattle are fed poultry litter. On a dry matter basis, broiler litter includes 25–50% crude protein and 55–60% TDN and is a good source of important minerals. The nutritional content is thus on par with or better than that of high-quality legume hay. Instead of being an issue with waste, poultry litter can and should be a source of nutrition and energy (Schlegel et al. 2015).

16.4.2.6 Ammonia Recycling

Using a gas permeable membrane to recycle ammonia from animal wastewater is a conventional technique (Maglinao et al. 2015). This membrane is impermeable to water and only permits the passage of gases. Gaseous ammonia is captured and concentrated in a stripping solution with the use of a microporous hydrophobic membrane. Organic acid and mineral acid of 1 normalcy make up the stripping solution. Polypropylene and polyurethane are membranes that are used for filtration. Manure pH affects ammonia recovery, increasing it by 1.2% per hour at pH 8.3 and 13% per hour at pH 10, and the average removal rate is 45–153 mg of ammonia litre/day (Parihar et al. 2019).

16.4.2.7 Enzymatic Fermentation into Ethanol

Due to its relatively high (up to 50%) fibre content, manure comes within this group. Fibre makes up the majority of manure’s resource component, therefore converting it to biochemical using a sugar platform offers a method for this higher degree of manure use. This procedure comprises the hydrolysis of the cellulose and hemicellulose found in fibre into simple sugars, which may then be processed chemically or biologically to produce ethanol for use as a fuel or other compounds (Chen et al. 2005). With total sugar conversions nearing 79%, diluted sulphuric acid pre-treatment and enzyme hydrolysis are a preferable method. The feasibility of turning feedlot cow dung into ethanol (70% efficiency) was confirmed by fermentation tests using the resulting C6 hydrolysates. This procedure might provide higher yields with advancements (such as the fermentation of C5 sugars), thus enhancing its viability as a feedstock for biofuels (Vancov et al. 2015).

16.5 Value-Added Products from Animal Waste

External components including beddings, urine, wash water, spilt feed, and water are also included in manure made from animal waste. Animal dung was essential for improving soil fertility before organic fertilisers were developed (Malomo et al. 2018). Through technology, several items from animal excrement are produced (and bio-waste). Processing of animal manure often includes digestion, which frequently occurs concurrently with the digestion of other bio-wastes. The majority of methods are also useful for digestates and the separation products they produce (Ehlert and Schoumans, 2015). According to Malomo et al. (2018), major animal waste component includes nutrients (manure, fertiliser, biomass conversion; animal feed, soil alterations, compost; etc.), organic matter (soil amendments/structuring), solids (bedding), energy (biogas, bio-oil, and syngas), and fibre (peat substitute, paper, and building materials).

A range of value-added products is produced via processing methods. Ammonium sulphate solutions in water (lightly acidic), ash (PK fertiliser, liming material), biochar, compost (organic fertiliser or organic soil amendment), and digestate are the primary products, and their potential for recycle and reuse (organic fertiliser or organic soil amendment) and mineral concentrations of potassium and nitrogen organo-mineral fertilisers, which are NPK fertilisers embedded in organic matter and have relatively high nutrient contents, are organic fertilisers with relatively low nutrient contents (Table 16.1). Precipitated salts include magnesium ammonium phosphate (Mg-struvite), potassium ammonium phosphate (K-struvite), magnesium phosphates, and calcium phosphates (Ehlert and Schoumans, 2015).

16.6 Application of Biofertilisers in Agriculture Practices

The world's population is growing, and it is predicted that by 2050, there will be 9.7 billion people on the planet (Ehrlich and Harte 2015). Industrialisation, urbanisation, and agricultural productivity are all intimately related to the growing world population (Gizaki et al. 2015; Mahanty et al. 2017; Santos et al. 2012). The nutritional needs of mankind cannot be satisfied by traditional agriculture. For plant nutrition and disease management, traditional farming practices employ a tonne of synthetic

Table 16.1 Categorisation of different types of livestock manure (Wen et al. 2007)

Parameters	Dairy	Beef	Feedlot
Solid content (% of fresh manure)			
Total solids (dry matter)	13.39	12.56	26.61
Total volatile solids	11.21	9.97	22.78
Elements (% of dry matter)			
Carbon	45.37	43.81	43.56
Nitrogen	3.03	1.94	2.72
Phosphorus	0.48	0.42	0.81
Potassium	2.86	1.44	0.92
Calcium	1.2	1.06	0.69
Magnesium	0.55	0.3	0.34
Sodium	0.47	0.25	0.12
Copper	0.003	0.0002	0.0018
Zinc	0.032	0.0042	0.0087
Iron	0.03	0.059	0.055
Sulphur	0.31	0.25	0.21
Aluminium	0.014	0.017	0.021
Cobalt	0.0009	0.0002	0.0002
Chromium	0.0002	0.0002	0.0001
Manganese	0.051	0.06	0.012
Molybdenum	0.0003	0.0002	0.0008
Nickel	0.001	0.001	–
Vanadium	0.0005	0.0006	–

fertilisers and pesticides, which has increased crop growth, productivity, and quality as well as farmers' revenue. On the other hand, by polluting water, air, and soil reservoirs, the rising use of artificial assistance has seriously harmed the natural environment (Rahman and Zhang 2018). These agrochemicals have accumulated belowground as a result of their improper application and inability to biodegrade. These build up underground, changing the soil's properties negatively in terms of structure, fertility, and water-holding capacity resulting in the greenhouse effect and eutrophication of water basins. An alternative to traditional agriculture, organic farming promotes crop development whilst preserving the soil's high quality and biodiversity. Biofertilisers contribute to the preservation of a soil environment rich in micronutrients as well as macronutrients via nitrogen fixation, phosphate and potassium solubilisation and mineralisation, the release of plant growth-regulating compounds, and the synthesis of antibiotics. Farmers have utilised legumes to improve soil fertility since prehistoric times. Whilst Nobbe and Hiltner developed "Nitragin," a Rhizobia laboratory culture, in 1895, it was followed by the discovery of Azotobacter and blue-green algae, which marked the beginning of the industry's usage of biofertilisers (Ramesh 2008).

16.7 Animal Waste-Based Biofertilisers in Aquaculture

What occurred in the past, current trends, and potential future developments are three key issues that are discussed in relation to the development of ecologically sustainable aquaculture. Traditional aquaculture mostly benefits the environment since it feeds farmed aquatic animals with trash and by-products from the farm and the neighbourhood, such as leftover food from open water bodies, animal or human excrement, or agricultural leftovers (Zajdband 2011).

Traditional and contemporary aquaculture production methods are compared, with a focus on the kind of nutrient inputs, in natural ecosystems and man-made agroecosystems. Natural ecosystems and man-made agroecosystems are studied in relation to terrestrial and aquatic, coastal/offshore, land- and waterscapes, and aquaculture. The failure of traditional integrated aquaculture, along with increased environmental sustainability concerns, has resulted in a substantial change. The two-way impacts of aquaculture on the environment are explored, and environmental issues are shown via case studies of genuine traditional and modern inland and coastal aquaculture techniques in temperate and tropical settings (Zajdband 2011).

Due of its widespread availability on farms, animal dung is the most widely used organic fertiliser. In reality, one significant element that accounts for the sharp rise in Chinese inland aquaculture productivity over the last several decades is the increasing availability of organic fertilisers as a consequence of increased chicken and pig production (Weimin 2010). The only method for the majority of small farmers to increase pond production is to employ animal dung, even though wealthy farmers often use artificial fertilisers (Ahmed et al. 2010). But combining mineral and organic fertilisers is another strategy (Zajdband 2011). Feed that has been spilled, bedding material, and farm animal excrement are all considered to be manure. Organic fertilisers also include green manures with high nitrogen concentration and fresh or composted agricultural by-products such as pressmud and a by-product of sugarcane (Keshavanath et al. 2006). Fish ponds have been fertilised using a wide range of animal manures. Its composition, which may change over time, determines the effectiveness of the manure as fertiliser. For effective use, the manure must be applied to the pond in a certain order (Zajdband 2011).

16.7.1 Pond Water for Irrigation

Aquaculture effluents can also be utilised to water land-based crops. In reality, rather than being used for fish farming, pond building on farms may be primarily for irrigation reasons (Fernando and Halwart 2000; Nhan et al. 2007). Because it includes both dissolved and suspended inorganic and organic components from fish culture (such as feeds and fertilisers, as well as other external nutrients, including materials produced via soil erosion, run-off, and leaching), pond-outlet water is often nutrient-rich. However, pesticide or antibiotic chemical residues may be present in the aquaculture wastes. Commonly, the composition of pond effluent changes with the season, being richer in the summer when fertilisation and feeding rates are greater (Zajdband 2011).

16.8 Factors Affecting the Quantity and Quality of Animal Manure

Animal dung varies in terms of both volume and nutritional content and depends on a wide range of factors that can be categorised into four groups: (1) animal-specific factors; (2) factors relating to animal feed and feeding; (3) factors relating to housing, bedding materials, and waste collection; and (4) factors relating to the transportation, processing, and storage of waste. Manure is considered to be of good quality if it contains enough amounts of the nutrients, such as nitrogen and phosphorus that are often to be responsible for limiting pond primary production (Zajdband 2011).

16.9 Environment and Economic Significance of Animal-Based Biofertilisers

According to Malomo et al. (2018), some of the major associated benefits of comprehensive manure management through animal-derived biofertilisers include as follows:

- Prevents the environmental impacts on air, water, soil, wildlife, and the marine ecosystem.
- Reduces the risks associated with animal waste and protects human health by preventing and spread of diseases.
- Increases productivity, lowers medical expenses, improves environmental quality, and maintains ecosystem services. It also contributes to economic stability by reducing costs via environmental and human health benefits.
- Contributes to economic stability by creating appealing and amusing human settlements, and employment, including low, medium, and high-skilled jobs.

16.10 Animal-Based Biofertilisers and Sustainable Development Goals

Due to population expansion and intense pressure to raise agricultural output to meet the needs of the expanding population, the world's need for food has grown. For the last several decades, chemical fertilisers have been the easy fix, but their excessive and careless use has resulted in food contamination, weed resistance, new illnesses, severe environmental effects, and a major negative impact on human health (Sansinenea 2021).

Animal waste has increased turbidness through the movement of soil particles into streams, rivers, and lakes (Gerba and Pepper 2009). The possibility to generate and utilise animal waste-based biofertilisers as an alternative to chemical fertilisers in agriculture has been made possible by rising demands for sustainable agricultural objectives, declining reliance on agrochemicals, and producing more nutritious and organic foods (Joshi and Gauraha 2022). Sustainable handling of animal waste may benefit both farmers and the broader population in a number of ways (Malomo et al. 2018). The use of animal wastes as biofertilisers will help and contribute significantly towards achieving UN sustainable development goals (SDGs). The waste of animals poses significant problems and risks to the public's health, but with the right management, it may become a useful resource.

Certain significant barriers to biofertiliser use include farmer unawareness, performance benefits over chemical counterparts, and supply chain, which will lead to stable and sustained growth for biofertilisers in the future (Joshi and Gauraha 2022). The application of biofertilisers is helpful, especially in increasing sustainable agricultural practices along with enhancing the yield, protecting the plants from various biotic and abiotic stresses, and improving the content of pharmaceutically vital secondary metabolites (Tripathi and Singh 2021). Strict policies and legal frameworks are needed for sustainable animal waste management through the production of biofertilisers (Malomo et al. 2018). Such practices will contribute to reducing the detrimental impacts of animal waste and increase organic agricultural practice and global strive for zero emissions.

16.11 Conclusions

The significance of sustainable animal waste management through the production of biofertilisers cannot be over-emphasised. Although some local and international practices of biofertiliser production from animal waste are gaining popularity, still more comprehensive policies and practices are needed for better management of animal waste to produce biofertilisers. Pressure from global policymakers, international environmental organisations, scientist, climate activists, and movements is needed to increase and encourage appropriate activities and actions to promote animal waste-based biofertilisers.

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