In: Contaminants in Agriculture and Environment: Health Risks and Remediation
DOI: 10.26832/AESA-2019-CAE-0164-03

Chapter 3

Organic wastes in agriculture: Risks and remedies for sustainable agriculture production

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Chapter contents

Abstract

Agricultural and non-agricultural wastes are the valuable sources of plant nutrients which is useful to maintain soil health. The potential of their handling, storage and disposal have broad implications for the environment beyond the farm. Effective organic waste management and good agricultural practice can be done through valuing the organic waste nutrient content, reduce losses of organic wastes from storage and timely applications of organic wastes which significant influence on nutrient loss.

Keywords: Agricultural risks, Environmental pollution, Organic wastes, Sustainable agriculture, Waste minimization

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Introduction

Organic waste in agriculture is defined as "contaminants from the cultivation and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy and crops." These comprise the non-product turn outs of agricultural production and processing that may include stuff beneficial to man but whose commercial worth is less than the expense of gathering, conveyance, and processing for favorable use. In this chapter, two different forms of organic waste that which are responsible for agricultural pollution have been discussed.

In the first place are those which are generated by agricultural activities. These primarily include excreta (urine and fecal matter) of farm animals but may also comprise additional substances such as silage effluent and unclean water from milk parlors. In the second place, are the residues like sewerage, slurry, paper-pulp and food processing residues. These wastes are generally produced off-farm (i.e. largely from households and industries) and are often brought onto agricultural lands and applied or recycled there. These agricultural and non-agricultural organic wastes include a variety of substances, such as carbohydrates, fats, proteins, nitrates, phosphates and ammonia, and possibly being subjected to contamination by pesticides, oils, veterinary products, trace metals and pathogens (Smith *et al.*, 2001). The present chapter will focus on:

- agricultural organic wastes and their production.
- the pollution risks associated with organic farm wastes and remedies to limit these risks.

Pollution from agricultural organic wastes

The utilization of organic wastes, particularly manure from cattle and other farm animals to agricultural land has conventionally been significant for preservation of soil fertility. Nutrient status as well as organic matter levels in the soil have been maintained by organic wastes since historical era. This scenario of utilization of agricultural wastes has changed significantly with an increase in specialization and upsurge of animal farming. Several significant trends have appeared in the production and use of these wastes. First and foremost, the quantity of manure and slurry produced is very high compared to the portion put to use. The unutilized wastes are generally disposed off without treatment. Secondly, upsurge inside the livestock sector has led to great number of animals being concentrated in comparatively limited areas, so in consequence the production of huge quantity of waste at an individual location.

Despite being a precious substitute to synthetic inorganic fertilizers, a number of farmers have somewhat limited notion of their nutritive value and as a result might manage them ineffectively and unproductively (MAFF, 2000). This results in inadequate utilization of their nutritive content. The farmers may continue extensive use of chemical fertilizers even after the application of animal manure. Application of organic farm wastes could have resulted in substantial saving in chemical fertilizer expenditures without compromising with the crop yield (Smith *et al.*, 2001). Another important consequence of underestimating the nutritive value of organic wastes is that a huge quantity of these is applied in a small area of agricultural land. The excesses are washed due to rain and runoff causing nutrient leaching and environmental pollution.

A wide and extensive attitude needs to be adopted while controlling the pollution caused by the organic wastes. This is because the pollution caused by these wastes can take place in numerous ways. The waterways, particularly lakes, rivers, ponds and ditches, adjoining the areas producing, storing or using organic wastes are potentially susceptible to point-source pollution. Another risk associated with these wastes is the diffuse pollution caused by microbial break-down of manure which leads to nitrate leaching. Organic wastes not only pose a serious environmental threat but are problematic for crops as well as farm animals, various problems caused because of organic wastes to crops and farm animals are listed in Table 3.1.

Classification of farm wastes

Farm wastes can be grouped into four major classes:

Slurry

Slurry is defined as ' excreta produced by livestock in a yard or building or a mixture consisting entirely or primarily of such excreta, bedding, rainwater and washing from a building or yard used by livestock or any combination thereof ; a consistency that allows it to be pumped or discharged by gravity at any stage in the process of handling” (HMSO, 1991). Thus, a mixture of fecal matter, urine and water with dry matter not more than 10% is considered to be slurry (Shepherd and Gibbs, 2001).

Manure

Waste materials like straw from deep litter or conventionally covered yards having a high solid content such that it can be piled is called manure. The dry matter content is generally more than

Table 3.1. *Problems caused through organic waste application for crops and livestock.*

Problem	Reason
Winter kill	Application of organic wastes to crop during the winter may smother small seedlings, as well as promote growth during mild weather thereby increasing the risk of winter kill.
Scorch	Damage can be caused by direct contact slurry and the crop.
Fouling	Livestock may not feed on grassland tainted with organic waste
Disease	Diseases (parasites, bacteria etc.) may be passed onto livestock.
Staggers	Heavy application can cause nutrient in herbage and subsequently on grazing livestock (e.g. magnesium/potassium imbalance, known as hypomagnesaemia).
Flies	Excessive application can cause environmental nuisance.

10% and has a very low density when stacked afresh. Manure which has been piled for a long duration say a couple of months, tend to become darker in color, easily crumbled and of greater density than freshly stacked manure.

Dirty water

Water used for washing yards, milk-parlors, farmsteads, barns etc. contributes towards waste water from farms. Rainwater which has been contaminated by farm wastes, manure, crop residues is also included in waste water from farms (MAFF, 1993). This water has very low dry matter content of less than 3% and needs to be disposed off safely.

Silage effluent

This comprises the discharge from a variety of fodder crops, chiefly grass, when confined in a pit, silo or large bale during the course of making silage.

Pollution risks from farm wastes

Oxygen dissolved in water is continuously used up by the organisms living in water bodies. This oxygen is generally restored naturally due to processes like re-aeration and photosynthesis. Other processes also contribute in the replenishment of dissolved oxygen in water bodies. Temperature drop in water bodies reduce the microbial activities and cause a rise in the oxygen saturation potential of the water. Sometimes water rich in dissolved oxygen discharges in the water bodies increasing the concentration of dissolved oxygen (Nemerow, 1991). This equilibrium can be seriously disturbed organic pollutants enters a waterway. These serve as food material for the microbes as well as small invertebrates living in the water bodies. In case the concentration of organic wastes is high, this leads to rapid increase in the population of these organisms which deplete the dissolved oxygen at a rate much higher than the rate of replenishment (Mason, 1996). Thus, the levels of oxygen in the water bodies may fall to an extremely low level and cause serious damage to 'clean-water organisms.' The tolerance in fish to depleting oxygen levels is comparatively very low (Table 3.2).

Table 3.2. *Relative tolerance to oxygen depletion by some river organisms.*

Common name	Spices	Tolerance
Salmon	*Salmo solar*	Low
Brown trout	*Salmo trutta*	Low
Shrimp	*Gammarus pulex*	Medium
Water hog-louse	*Asellus aquaticus*	Medium
Chironomid midge	*Chironomus riparius*	High
Blood-worm	*Tubifex tubifex*	High

Thus, their population levels are affected drastically due to pollution from organic wastes. One of the most frequently applied measures for estimating the 'relative pollution potential' of an organic pollutant is in terms of oxygen required by microbes to break-down the material. It is referred to as the Biochemical Oxygen Demand (BOD). Higher values of BOD specify the presence of a potentially serious contaminant, as such its release into the waterway must be stopped. Each of the organic farm wastes belong to this category (Table 3.3). the poor management and disposal of slurries and silage effluents into water bodies can cause serious pollution hazards. Thus, even low quantities of these wastes should not be discharged into water bodies.

The contamination issues accompanying the silage wastewater are furthermore aggravated by two factors; firstly, the effluent is extremely corrosive (Table 3.4) and can leak through the floor of the silos, collection lines or storage reservoirs that may be damaged, rusty, fractured or permeable (Richardson *et al*., 1999). Secondly, the water content in the silage determines its volume, which can be very large is the water content is high. Thus, the volume of effluent produced during silage making can be very large. The prediction of influence of an organic contaminant flowing into a waterway is somewhat complicated. This is due to the reason that these effects are governed by a number of factors; viz. temperature, dilution rates and the type of watercourse. The time or season of the year is also significant. Farm wastes produced in early summer is generally more problematic than winter produced materials (O'Donnell *et al.*, 1997). However, the process of self-purification enables the waterways to to recuperate from organic over time, where the decomposition of organic material and replenishment of oxygen levels by natural processes takes place (Mason, 1996).

Table 3.3. *The Biochemical Oxygen Demand (BOD, mg l^{-1}) of farm wastes in comparison with other organic materials (NRA, 1992).*

Organic material	Typical BOD
Clean river water	<5
Untreated human sewage	350
Yard washings	2000
Animal slurry	30000
Silage effluent	60000

Table 3.4. *Selected characteristics of silage effluent, collected from unwilled grass silage (O'Donnell et al., 1995).*

Characteristic	Value
pH	3.8
Titratable acidity (mmd $NaOH^{-1}$)	177
Lactic acid (g kg^{-1})	24
Acetic acid (g kg^{-1})	3.3
Volatile fatty acids (acetic, propionic and butyric acid) (g kg^{-1})	3.5

Ammonia toxicity in waterways

Ammonia naturally occurs in two different forms- ammonium ions (NH_4^+) and unionized ammonia, NH_3, (Francis-Floyd 2009). Ammonia is formed naturally from the decomposition of organic matter as well as excreted by fish as a nitrogenous waste product. It is also a derivative of protein metabolism and is chiefly excreted through the gill membranes. A very little quantity is also excreted in the urine. Bacterial convert this ammonia into nitrite and nitrate (Figure 3.1). The quantities produced naturally are generally small and considered harmless for fish and other aquatic organisms (Francis-Floyd, 2009). The toxic nature of aquatic ammonia is primarily due to its unionized form, NH_3 (Arthur *et al*. 1987). With the increase in pH, the toxic nature of ammonia increases due to the increase in comparative quantity of unionized ammonia. This is shown in Figure 3.2 (Brinkman *et al*. 2009; Delos and Erickson, 1999).

Despite the fact that ammonia is an essential and life-sustaining nutrient, surplus amount of this compound may collect in the bodies of organisms and cause changes in metabolic system of aquatic biota or raise their body pH. Fish might experience a loss of equilibrium, hyper-excitability, increase in respiration and oxygen intake, and increase in heart-rate. The presence of significantly high levels of ammonia in organic farm wastes is an additional pollution hazard for fish and other freshwater invertebrates. The pollution caused by ammonia is not only limited to surface water bodies but affects groundwater also (DETR, 2001). A rise in the level of free ammonia in waterways can inhibit the process of nitrification in sediments, thus causing the potentially toxic accumulation of nitrite in the water body (Kim *et al*., 2008).

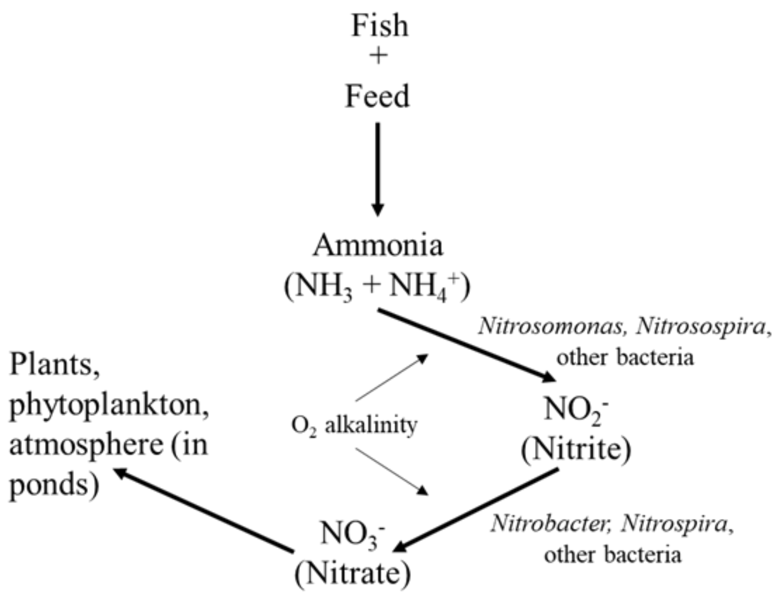

Figure 3.1. *Conversion of fish-generated ammonia in the environment.*

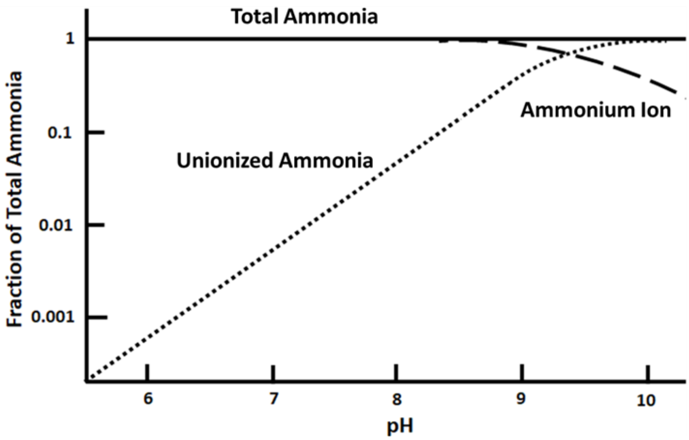

***Figure* 3.2.** *Chemical speciation of ammonia over a range of pH values (EPA, 1999).*

Furthermore, it was the production of manures and slurries, and washing of yards and milking parlors that was causing a measurable deterioration in the quality of watercourses (Epstein, 2011). Reductions in water quality during the study were also related to rainfall. Periods of heavy rainfall caused the increased run-off of slurry from yards as well as from fields that had recently received slurry applications (Tepe and Boyd, 2003).

Pathogens from farm wastes

Cattle and other farm animals are potential transporters of a number of disease-causing bacteria, viruses and parasites. These are carried to human beings if the application of these wastes to soil results in contamination of crops or water bodies. Increasing the awareness about various pathogenic microbes of animal origin (zoonoses) has been identified as a major community-health concern, particularly due to the outbreak of water-borne diseases, seemingly triggered by fecal contamination of organic wastes. Many pathogenic bacteria, viruses, and protozoa are present in even healthy animals, but can cause serious ailments or even death when transmitted to human beings. Some of the major pathways which transmit pathogens to humans are shown in Figure 3.3. The wastes from farm animals, like feces, respiratory secretions, urine, and sloughed feathers, fur or skin) usually comprise excessive concentrations of human and animal pathogens (Strauch and Ballarini, 1994). The concentration of certain pathogens in fecal matter of farm animals ranges from millions to billions per gram of wet weight or millions per milliliter of urine (Mustafa and Anjum, 2009). Moreover, the tendency of production establishments to raise a large number of animals in fairly modest spaces leads to the production of extremely large quantities of concentrated waste materials that needs to be efficiently taken care of in order to reduce environmental and community health hazards.

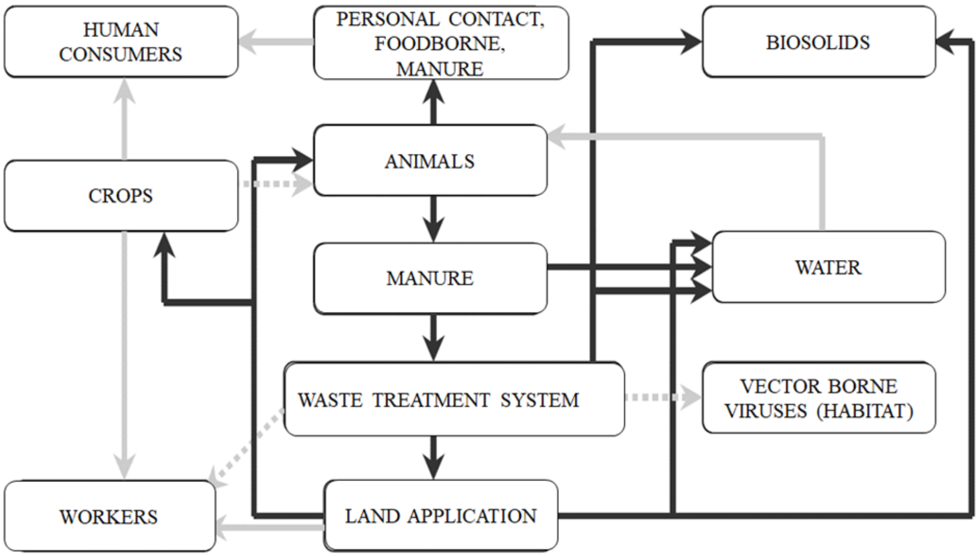

Figure 3.3. *Sources and transmission pathways of pathogens to humans from animal agriculture (Sobsey et al., 2006).*

Animal pathogens that pose potential risks to animal and possibly human health include a variety of viruses (Table 3.5), such as swine hepatitis E virus, bacteria (Table 3.6), *Salmonella species*, and parasites (Table 3.7) such as *Cryptosporidium parvum*. Several pathogenic organisms similar to those referred are prevalent in cattle and other farm animals and their eradication from livestock as well as their production centers is a challenging task. Since the pathogens are highly wide-spread in livestock, these are generally present in fresh animal manure and other animal wastes. Thus, these farm wastes need to be adequately treated and contained in order to prevent the health hazards they pose to animal as well as human health (Graczyk *et al*., 2000).

Sewage application to agricultural land

Sewage applied to agricultural lands is not only obtained from domestic sewage and waste-water, it may also collect impurities from industrial wastes and runoff from roads. Thus, it comprises various metal impurities including cadmium (Cd), copper (Cu), chromium (Cr), nickel (Ni), lead (Pb) and zinc (Zn), as well as organic micro-pollutants such as Polynuclear Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs) (Smith, 1995). However, due to implementation of different regulations, the contamination of sewage with metallic and other industrial products has significantly declined (Environment Agency, 2001). Despite various regulations, substantial quantity of chemicals may find their way to sewage sludge.

Table 3.5. *Some important animal viruses potentially present in animal manure (Sobsey et al., 2006).*

Virus or virus group	Taxonomic group	Animal hosts	Disease in animals	Human infection/ disease	Transmission routes	Presence in manure
Enteroviruses	Picornaviridae	Bovine, porcine, avian	Yes, in some	No, but needs study	Fecal-oral and respiratory	Yes
Caliciviruses	Caliciviridae	Bovine, porcine, avian	Yes, in some	No, but needs study	Fecal-oral and respiratory	Yes
Reoviruses	Reoviridae	Wide host range for some	Yes, in some	Yes/No	Fecal-oral and respiratory	Yes
Rotaviruses	Reoviridae	Found in many animals	Yes, in some	No, but needs study	Fecal-oral and respiratory	Yes
Adenoviruses	Adenoviridae	In many animals	Yes, in some	No, but needs study	Fecal-oral and respiratory	Yes
Herpes viruses	Herpesviridae	In many animals	Yes, some	No, but needs study	Respiratory	Yes
Myxoviruses	Myxoviridae	In many animals	Yes, in some	Yes, some; no, others	Respiratory	Yes
Pestiviruses	Pestiviridae	In many animals	Yes, in some	No	Fecal-oral and respiratory	Maybe
Corona-viruses	Coronaviridae	In many animals	Yes, in some	No	Respiratory	Yes
Hepatitis E virus	Uncertain	Swine, rat, chicken, maybe others	Yes, but mild effects	Maybe	Respiratory and enteric	Yes
Vesicular stomatitis virus	Rhabdovirus	Cattle, horses, swine; others	Yes	Yes, occupationally	Contact with infected animals	Maybe

These include:

- dichlorobenzene from toilet cleaner and alkyl benzenes from detergents.
- Cu and Zn from domestic products such as shampoos, skin creams, toilet cleaners and mouthwash.
- Cu and Zn from plumbing fittings, water pipes and storage tanks;
- Hg from dental surgeries.

These metals are an essential component of the natural environment and are extremely important for the growth and development of both plants and animals, but at the same time their overdose is highly toxic. Many elements like Cd, Cu and Zn may also accumulate within the soil profile over the years and prove extremely detrimental to soil microbes, soil animals, crop plants and possibly enter the human food-chain (Renner, 2000). Another important concern associated with the application of sewage sludge to agricultural lands is the Nitrogen (N) and Phosphorous (P) pollution. Large scale applications of sewage and wastewater to agricultural lands might result in the leaching of these two nutrients into the waterways, thus contaminating them. Application of raw sewage slurries may also emit foul odor which is a serious environmental problem. Further-

Table 3.6. *Some important bacteria potentially present in animals and their wastes (Sobsey et al., 2006).*

Genus and species	**Animal hosts**	**Disease in animal hosts**	**Human infection and disease**	**Transmission routes**	**Presence in manure?**	**Non-fecal sources?**
Aeromonas hydrophila	Many	Usually no	Yes, but only virulent strains	Water, wounds, food	Yes	Yes
Arcobacter butzleria	Many	Yes, often	Yes	Direct contact, maybe food and water	Yes	No
Bacillus anthracis	Goats; others	Yes	Yes	Aerosols, skin (wounds), ingestion	Yes	Yes
Brucella abortus	Cattle	Yes	Yes	Direct contact, food, air, water	Yes, rare	No
Campylobacter jejuni	Poultry, other fowl	No	Yes	Food and water	Yes	Maybe
Chlamydia psittaci	Parrots; other fowl	-	Yes	Direct contact; airborne	Unlikely	No
Clostridium perfringens	Many	Sometimes	Yes	Food, wounds	Yes	Yes, soil and sediments
Clostridium botulinum	Many	Sometimes	Yes	Food	Maybe	Yes, soil and sediments
Escherichia coli	All mammals	No	Yes, pathogenic strains	Food and water	Yes	No, but natural occurrence in tropics
Erysipelothrix rhusiopathiae	Swine, other animals, fish and shellfish	Yes, sometimes	Yes, rare	Direct contact, skin abrasions	Yes	Yes, infected animals
Francisella tularensis	Ovines, other animals, ticks, deerflies	No	Yes	Direct contact, fomites	Yes	Animal tissue
Leptospira interrogans and other species	Many animals	No	Yes	Direct contact	Yes	Urine
Listeria monocytogenes	Many animals	No	Yes	Food, water, fomites	-	Soil, vegetation
Mycobacterium tuberculosis	Rare; some animals	-	Yes	Respiratory exposure	Yes	No
Mycobacterium paratuberculosis	Some animals	-	Yes	Respiratory	Yes	No
Salmonella species	Many animals	No	Yes	Food, water, fomites	Yes	No
Yersinia pestis	Rats, squirrels, other animals	No	Yes	Flea bite, direct contact	Yes	Animal tissue
Yersinia enterocolitica	Swine, other animals	No	Yes	Direct contact, food, water	Yes	Possibly environmental sources

Table 3.7. *Some important parasites potentially present in animals and their wastes (Sobsey et al., 2006).*

Parasite	Taxonomic group	Animal hosts	Disease in animals?	Human infection/ disease	Transmission routes	In manure?
Ascaris suum	Helminth, nematode	Swine	Yes	Yes	Ingestion of water, food, soil	Yes
Balantidium coli	Protozoan, ciliate	Swine, other animals	No	Yes	Contact, ingestion of water and soil	Yes
Cryptosporidi um parvum	Protozoan, coccidian	Many animals	Yes	Yes	Ingestion of water	Yes
Giardia lamblia	Protozoan, flagellate	Many animals	Yes	Yes	Ingestion of water	Yes
Microsporidia	Protozoans, microsporidia	Many animals	No	Yes, immuno-compromized	Ingestion, possibly water	Yes
*Pneumocystis carinii**	Fungus; similar to protozoans	Environment and many animals	Yes	Yes, immuno-compromized	Inhalation	Yes
Toxoplasma gondii	Protozoan, coccidian	Felines	Yes	Yes	Ingestion of feces, food, water	Yes, if an infected host

**Previously considered a protozoan parasite, but now known to be a mycotic agent.*

Table 3.8. *Required minimum separation distance between manure storage and watercourses, wetlands, and wells*

Storage type	Distance to	
	Watercourse or wetland, m (ft)	*Source of domestic water, m (ft)*
On-farm storage facility	90 (300)	90 (300) *
Field storage	90 (300)	90 (300) *
Composting	90 (300)	90 (300) *

** Public water supply 300 m (984 ft).*

Figure 3.4. *In barn storage - manure pack.*

Figure 3.5. *Solid manure storage - curbed concrete slab with ramp.*

Figure 3.6. *Solid or semi-solid manure storage - concrete slab with sidewalls and drive-in ramp.*

Figure 3.7. *Liquid manure storage - circular concrete tank.*

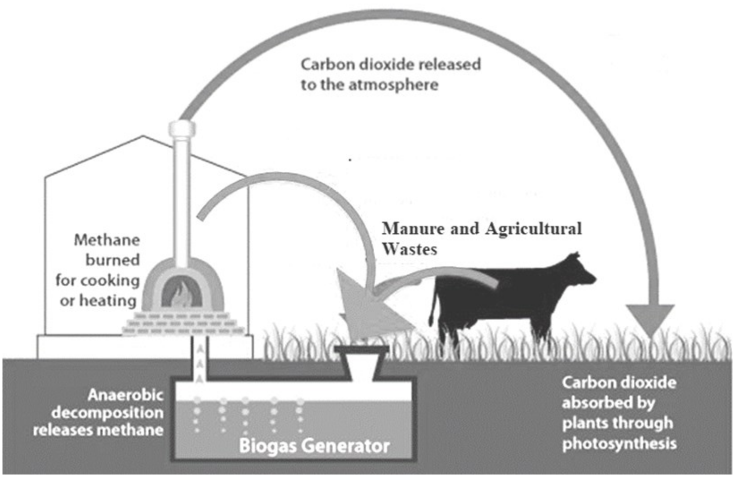

Figure 3.8. *Biogas production (Source: Sobsey et al., 2006).*

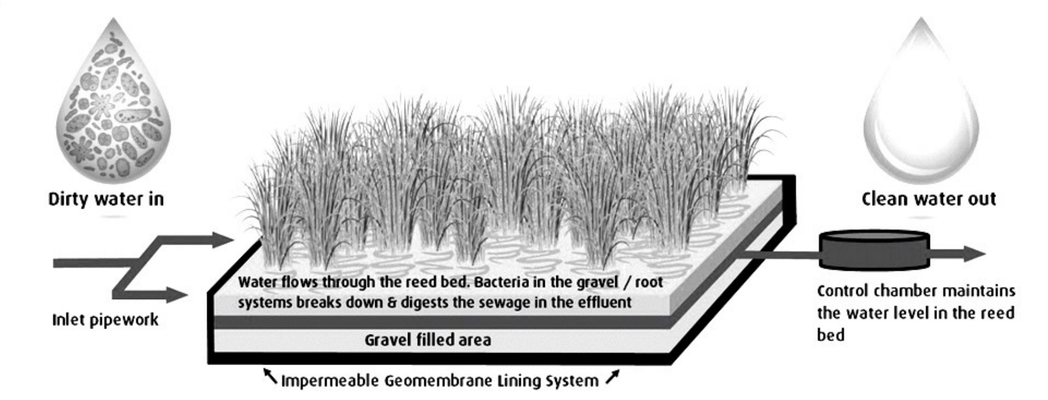

Figure 3.9. *Reed bed treatment (Source: Sobsey et al., 2006).*

more, the sewage sludges can also cause pathogen contamination similar to that of the livestock wastes. Some important pathogens present in the sewage include bacteria such as *Salmonella* (especially *Salmonella typhimurium* DT104), human viruses such as Hepatitis A, parasitic nematodes and worms, and parasitic protozoa such as *Cryptosporidium*.

Practical solutions

Poor management of organic wastes from farms is the primary cause of pollution resulting from the organic wastes. Poor management results in:

- spillages;
- run-off due to over-application in the field;
- run-off from yards;
- inadequate storage capacity, structure and management;
- leaking/unknown drainage systems;
- application of slurries when land is frozen or waterlogged.

Most pollution issues related to farm wastes can be evaded using good manure management practices, proper storage facilities, and adequate separation distances between non-compatible land uses. The management practices include collecting, storing, transporting and applying manure to land. The purpose of managing farm wastes must be to maximize the soil amending value of manure and to reduce the risk of environment pollution.

Handling and collection

The collection and storage of organic wastes depends on the moisture content of the waste. The storage facility is selected depending on whether the manure is solid, semi-solid or liquid. Solid wastes (<80% moisture content) can either be stacked and can be collected using equipment that moves bulk materials. Semi-solid wastes have lower moisture content (80-95%) and does not flow. Thus, it can be collected and piled like solid wastes. Liquid wastes (>95% moisture content) flow under the influence of gravity and can be pumped for storage.

Storage

The storage facility for wastes should be sufficiently large to store wastes for a sufficiently long time and allow precipitation of solids and application to lands. Solid wastes can be stored in three different ways- in barns as solid manure packs (Figure 3.4); on curbed concrete pads which can contain runoff (Figure 3.5); and on curbed control slab with roof. Field storage of wastes should be avoided especially where the soil is highly permeable, is in proximity of a watercourse or has a shallow groundwater table. Semi-solid wastes can be stored on curbed concrete slabs with earthen beds. The floor should be sloping to allow access to tractors (Figure 3.6).

The earthen beds need to be designed and constructed carefully to prevent seepage. For soils having low clay content, semi-solid wastes may be stored in roofed structure with reinforced concrete walls. The storage structures should also be well-ventilated. Liquid wastes must be stored in impermeable enclosures such as concrete tanks, above ground glass-lined steel tanks and earthen ponds (Figure 3.7).

Setback considerations

Suitable distance between livestock facilities and neighbors is one means of recompensing for foul odor production and reduction in the potential for nuisance conflicts. Establishing farmyards in the vicinity of developing areas can assure for growth of the venture in future. Greater distance from settlements offers more time for odors to become diluted due to mixing with air.

The recommended Minimum Separation Distance (MSD) between a livestock operation and a single residence or residential and recreational areas varies with the following factors:

- size of the agricultural operation measured in animal units
- degree of expansion from existing operation
- type of manure storage
- type of housing
- type of livestock

With the increase in the size of livestock establishments, the distance from the residential areas should also increase. However, the criteria may change from area to area as well as recommendations of local municipalities. The municipality should be necessarily contacted before establishment of any new facility.

The location wells and watercourses the proximity of animal farms and manure storages should be planned in detail. This is more vital in earthen storage structures and areas with a shallow bedrock and water table. Required MSD between manure storage and watercourses, wetlands, and wells are given in Table 3.8.

Wells should be located uphill from storages and constructed in a manner that will reduce the risk of pollutants entering the well. Grouting the annular space outside the casing with cement or bentonite grout must be carried out.

Alternative technologies for farm waste treatment

Biogas production and reed bed treatment (RBT) have been identified as two of the most practical solutions to problems associated with organic agricultural wastes.

Biogas production

An alternative to applying slurry and manure to land is to anaerobically digest the organic materials with micro-organisms to produce biogas; a mixture of methane (55–65%) and carbon dioxide (35–45%). An anaerobic digester will partly convert manure to energy in the form of biogas which contains methane. Biogas is used as a renewable fuel and the byproducts of digestion can be used as a manure in the fields (Figure 3.8).

Reed bed treatment

An alternative way of treating dirty water, such as dairy washings and yard run-off, is to use an RBT system. This is an artificially constructed wetland usually planted with Common Reed *(Phragmites australis)* through which the dirty water slowly trickles (Figure 3.9). The reeds not only absorb nutrients such as nitrogen and phosphorus, but also have the ability to transfer oxygen down through their stems and out via their root system into the surrounding rhizosphere. This increases the capacity of the system for the aerobic bacterial decomposition of organic pollutants (e.g. milk, urine and faeces), as well as encouraging the proliferation of a wide range of aquatic organisms, some of which directly utilise additional pollutants (Shepherd and Gibbs, 2001).There are numerous designs of RBT system for treating sewage, industrial effluents and highways run-off, as well as agricultural wastes. Their main benefits, compared to the conventional treatment of dirty water in tanks and lagoons, are claimed to be low capital cost, very effective water treatment, minimal (if not enhanced) visual impact, and little smell.

Conclusion

It is clear from the above discussion that agricultural and non-agricultural wastes may be valuable sources of plant nutrients and soil conditioner/improver. Yet, potential problems associated with their handling, storage and disposal may have broad implications for the environment beyond the farm. Effective organic waste management and good agricultural practice may entail: knowing and valuing the organic waste nutrient content; using this information to balance nutrient inputs and removals, such as crop offtake; reduce losses of organic wastes from storage and anima housing; apply the wastes evenly and incorporate into soil rapidly; timely applications of organic wastes have a significant influence on nutrient loss, i.e. avoid late summer or early autumn applications.

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Cite this chapter as: Parvaze, S. and Kumar, R. (2019). Organic wastes in agriculture: Risks and remedies for sustainable agriculture production. In: Kumar, V., Kumar, R., Singh, J. and Kumar, P. (eds) Contaminants in Agriculture and Environment: Health Risks and Remediation, Volume 1, Agro Environ Media, Haridwar, India, pp. 21-37, https://doi.org/10.26832/AESA-2019-CAE-0164-03