

Livestock Waste Management in Kenya: A Futuristic Perspective

Rachuonyo, H. A.
University of Eldoret; P.O. Box
1125-30100, Eldoret
rachuonyo@yahoo.com

E. J. Mukhwana
Sacred Training Institute, P.O.
Box 8771-00200, Nairobi,
Kenya
director@sti.co.ke

J. K. Kitilit
k2kitilit@yahoo.com

D. K. Kios
University of Eldoret; P.O. Box
1125-30100, Eldoret
kiosdk@yahoo.com

M. N. Ongubo
University of Eldoret; P.O. Box
1125-30100, Eldoret
ongubomary@yahoo.com

G. N. Mabonga
University of Eldoret; P.O. Box
1125-30100, Eldoret
gnakokonya@yahoo.com

G. O. Oliech
University of Eldoret; P.O. Box
1125-30100, Eldoret
profoduliech@yahoo.com

Abstract

Livestock waste management remains a major global concern because of nitrogen and phosphorus pollution, environmental safety and quality of crop and animal products. Livestock production is the largest source of atmospheric ammonia, accounting for over 40 % of the global inventory. Sources of wastes are production farms and slaughter/processing/packing plants. Objective of livestock waste management is to make best use of nutrients in manure while protecting natural resources from pollution for improved environmental quality and sustainability. When managed properly, manure can be a valuable resource for farmers especially in rural areas; providing nutrients for crops, generating income, improving nutrient use efficiency, among other benefits. However, if land is insufficient to use generated manure or if mismanaged, then pollution risks to water supplies and other ecosystem resources could result. Unmanaged waste could be breeding grounds for disease causing pathogens and vectors, generate odour, ruin aesthetic values, increase production costs and reduce farm product quality, among other dangers. Best management practices to reduce negative impacts include feed manipulation & feeding strategies, breeding for improved feed intake, as well as diligent management and use of improved technologies on handling, processing and disposal. Three main forms of manure are solid, liquid and slurry, each of which has its way of handling, management and disposal. Options for managing waste include composting, processing for sale, aerobic & anaerobic lagoon treatment, vegetative waterways, soakaway ponds, biogas production or direct land application. All these methods are practised with varying degrees of success in Kenya. Considering rapid population increase and subsequent land fragmentation, many farmers are constrained when it comes to available options. Determinant factors on choice include financial constraints, production systems in place, size of farm operations, compliance with local and international laws/regulations and standards, land availability, awareness of existing technologies, among others. This paper review and shares best practices and global trends for manure management in general, with Kenya's future in mind, to ensure improved environmental quality and economical usage. This will have both short and long term economic and environmental impact that benefits production system in the country and beyond.

Keywords: *Environmental Pollution, Environmental Conservation, Manure Treatment, Nutrient Cycling, Sustainable Development, Waste Management*

Introduction

With high population densities in Kenya, in some areas more than 800 persons/km², there is high demand for the limited resources, especially food and land. Soils are now subject to continuous and intensive cultivation and fertility status is on the decline in a number of areas, thus presenting a serious threat to food security (Lekasi *et al.*, 2001b). Ownership of livestock is widespread amongst households in most parts of the country, especially within the high potential areas ranging between 77 and 85% of households keeping dairy cattle (EPZA, 2005). Decreasing land size holdings has led to a shift from extensive to more intensive mixed crop/livestock farming systems including acquisition of external inputs to feed livestock and replenish soil nutrients. Key areas of concern across the world include the underlying public concern with manure management and its potential pollution risks associated with air, water, habitat and soil resources; large quantities of manure generation and application to limited land area, often without considering potential hazards; and most emphasis appears to be on water pollution (Rachuonyo, 2002; Safley, 1994). Challenges associated with manure management are similar in many

locations; only practices to deal with these challenges may be varied. Review of legislation, regulation and policy elsewhere should be considered valuable as the various governmental approaches to livestock waste management are extremely dynamic at this time, especially in Europe and USA (Agriculture Canada, 1994). While we cannot extrapolate from experiences of other jurisdiction directly, combinations of such are helpful in providing various policy approaches that may be successful for sustainable environmental quality and improvement on general livelihoods. In summary, nutrient management plans should be required for not only concentrated animal operations but also any sizable livestock production farm (Rachuonyo *et al.*, 2002). The broad objectives of this paper were to evaluate the production, challenges, management, use and policy guidelines of livestock waste from various nations and utilize this information in projecting future strategies and direction for improving manure nutrient management in Kenya; consistent with vision 2030.

Manure Production and Concerns

Livestock farming has undergone a significant transformation in the past few decades. Production has shifted from smaller, family -owned farms to large farms that often have corporate contracts. Most meat and dairy products now are produced on large farms with single species buildings or open-air pens, resulting in large quantities of waste (MacDonald & McBride, 2009). —Livestock wastel means livestock excreta and associated losses, animal remains, slaughterhouse refuse, bedding, wash waters, sprinkling waters from livestock cooling, precipitation polluted by falling on or flowing onto an animal feeding operation, and other materials polluted by livestock (Illinois Administrative Code 506). People often believe that animal manure is harmless, but in truth it can be quite hazardous. Factory livestock facilities pollute the air and release over 400 separate gasses, mostly due to the large amounts of manure they produce. The principal gases released are hydrogen sulfide, methane, ammonia, and carbon dioxide. Gasses can be dangerous air pollutants that threaten both the environment and human health. Nitric oxides are also released in large quantities from farms through manure application, and are among the leading causes of acid rain

Main Concerns with Manure

No matter what part of United States, Europe, Canada or elsewhere in the world that one might choose to examine, the underlying public concern associated with manure and manure management is pollution and potential pollution. Recent patterns of concentrated intensive livestock operations, profitability of large scale livestock production and agricultural policies have all contributed to the increased production of manures. As a result, large quantities of manure have been applied to a limited land area often without considering the potential hazards, especially in developed countries (Rachuonyo, 2013). The threat of pollution in all its forms, effects and potential effects is prevalent where these large quantities of livestock waste are produced. Estimates indicate that the amount of livestock waste is 13 times greater than the amount of human sanitary waste generated in the United States (EPA, 2001). Livestock and poultry waste can be introduced to the environment through direct discharges, through land application of manure, and from open feedlots, barns and housing, and pastures. Concerns with potential pollution of air, water, habitat and soil resources resulting from livestock manure management are key public policy concerns in many countries, Kenya among them. Most emphasis appears to be on water pollution and a focus of concern is on the decreasing quality of drinking water. In agriculture, concerns with manure are centred on improving nutrient use efficiency in crop and animal production as well as increasing the fertilizer equivalence value of animal manure (Sutton *et al.*, 2013).

Pollution

Pollution can be defined as an unwelcome concentration of substances that are beyond the environment's capacity to handle. Animal waste from farms and related practices can severely impact an ecosystem, especially water quality, if not managed properly. Livestock waste has the potential to contribute excess nutrients, pathogens, organic matter, solids and odorous compounds to the environment. These substances can cause eutrophication of surface waters, degradation of ground waters and be detrimental to people and other living things.

Nutrient Loss

Nutrient loss is a basic focal point being given consideration in all jurisdictions, especially in the agricultural sector. That is, nitrate (NO₃) and phosphorus (P) leaching along with surface runoff are seen to be the primary factors in potential water and soil pollution. Timing of application of manure is an important issue in preventing leaching and surface runoff. Ideally, applications should be made when crop

uptake is at its maximum and weather conditions are optimal. When livestock manures are applied to correspond with the needs of the crop, the potential of damage to the environment is lowered. If manure is applied in excess of crop needs or when the crop is not growing then there is a potential of polluting soil, water, habitat and air (Watson *et al.*, 1994). In a study by Lekasi *et al.*, (2001a) steers fed a basal diet of napier grass and dairy meal concentrate resulted in significantly higher N, both in faeces and urine, than the low concentrate levels. Urinary N can be conserved when wheat straw is applied at relatively high amount of 1.8 kg liveweight/yr, about 720 kg/400 kg cow liveweight/yr. On average, 28 and 18% of the N input as feed was recovered in faeces and urine, respectively. Of the total N excreted, faecal N contributed between 47 and 76% (mean 61%) while urinary N ranged between 24 and 53% (mean 39%). Greatest loss of N during the accumulation phase was observed in heaps with high moisture contents from the addition of urine. During the composting phase, manures with maize stover refusals manually added had the greatest N losses. Overall, N losses ranged between 34 and 63%.

Water Pollution

Disposal of excess manure from intensive livestock production is seen to be one of the sources of pollution to groundwater and in some cases drinking water supplies (Sutton, 1990). Water pollution, whether it is surface or groundwater, is the most obvious concern related to livestock waste management and the initial reason many governments have been forced to deal with livestock waste policy development (SWMR, 2013). Over the last decade, levels of groundwater contamination by nitrogen have become apparent (Kerns & Broomhall, 1992; Weinberg, 1994). When people perceive that their drinking water may be polluted with livestock wastes, they become intensely concerned. Almost every country has some type of water protection legislation which is often the basis for starting to deal with manure management as a problem. In several countries, public health or other like bodies has certain powers where safety or public health is at risk (Watson *et al.*, 1994).

Air Pollution

Livestock wastes produce ammonia, methane, fine particulate and volatile organic compounds (CDMMG, 1989). Livestock production is the largest source of atmospheric ammonia, accounting for over 50 % and 40 % of the national and global inventories, respectively (Moore *et al.*, 1995). Air pollution begins from the time manure leaves the animal. The smell of manure gases gets the public's attention. The complaints regarding smell against operations are an added pressure on farmers in dealing with manure management. Minimizing ammonia losses to the atmosphere has become a major policy target. Air pollution is also controlled through manure storage and application policies. For example, in the Netherlands all storage structures must have covers and manure must be incorporated into the soil within 24 hours after spreading. Sweden manure must be incorporated within 4-12 hours after spreading depending on location (Abler & Shortle, 1992; Bertrand, 1988). Thus, it is not surprising that live stock ammonia is an area of growing public concern and regulatory debate.

Soil Pollution

Very few countries appear to have legislation that specifically relates to soil contamination. The Netherlands have a Soil Protection Act (1987) which covers a number of the problems related to pollution from manure by indirectly enforcing N, P, and NH₃ standards as well as reducing the acidifying effects of ammonia on the soil (Francis, 1992). The Law of Soil Protection in the Netherlands restricts application of manure, regulates spreading of manure and suggests working the manure into the soil (Brussard & Grossman, 1990).

Habitat Degradation

Water pollution is not just limited to the human use issues, but plays a major role as it impacts on habitat for fish and wildlife. Aquatic habitat contamination and oxygen depletion is a major consideration as well as toxicity of ammonia and nitrite from manure sources. In Canada, the Federal Fisheries Act pertains to the unauthorized discharge of any substance harmful to fish (Pattin, 1994). The European Communities 1991 Directive concerning the protection of waters against pollution caused by nitrate from agricultural sources states that members must designate areas where the total nitrogen concentration in water exceeds 50mg/L or where eutrophication occurs (Milne, 2005). Denmark has also developed an action plan for the aquatic environment to control pollution of aquatic habitats (Sunderland, 1991). In France, the Civil Code may require ecological damage to be 'made good', that is, restoration to its original condition (Rolf, 1993). A unique program in the U.S.A. resulted from a conglomerate of several states

(Maryland, Pennsylvania, Delaware & Virginia) developing the Chesapeake Bay Agreement to improve water quality and habitat by reducing nutrients entering the bay (Perkinson, 1994).

Management and Practice Problems

Pollution caused or perceived to be caused by spreading manure in excess has given rise to specific problems related to manure management. Individual countries, states, provinces, counties and so on are being forced to deal with what appears to be inadequate manure storage, inappropriate manure application, increased livestock densities and a lack of efficient manure disposal methods. Each jurisdiction handles these direct and often diverse manure management problems in a variety of ways and will be discussed.

Manure Storage

Concentration and intensification in livestock production has resulted in a need for storage of solid manure and slurry. Because the application of manure in many countries has been limited to certain times of the year related to crop and soil condition, storage during low demand periods is necessary (i.e., fall/winter). Manure storage capacities are often based on livestock units. Adequate storage capacity is related to the size of facility, livestock units, length of storage and consideration of high rainfall and flood conditions. Many jurisdictions require storage capacity for a certain length of time (i.e. 5 months) and enough to withstand a 24 hour 10 to 25 year rainfall. Permanent manure storage permits are required in the Netherlands (Bertrand, 1988). Specific design details such as cover and ventilation are a large part of current manure storage requirements set out within government regulations. Besides the design of storage facilities, location and type (earthen, concrete) of facility poses yet another dilemma. Distances from waterways, wells, farmhouses are all factors of consideration when determining where to locate manure storage structures. Designing, constructing and maintaining manure storage facilities is a large expense to the farmer. Many jurisdictions offer funding and cost-share programs to help off-set the farmer's monetary output. In Kenya, it was observed that most farmers preferred to store their manure in a heap or pit (67%) rather than by deep littering (33%), and 90% did not cover the manure. Forty-six percent of farmers kept the manure under some sort of shade (Lekasi *et al.*, 2001a).

Manure Application

The details of the application requirements for manure appear in many of the regulations and policies (Abler & Shortle, 1992; Batie & Diebel, 1990; Conrad & Teherani-Kronner, 1989). In several countries, manure application has strict technical limits imposed with respect to timing, soil nutrient requirement, rate of application and water protection. Timing is dependent on season, soil condition (frozen, unfrozen), soil moisture, cover crop and so on. Placing restrictions on when manure can be applied helps to prevent excessive runoff. The method and equipment used to apply manure is sometimes restricted as well. Many countries require manure to be injected directly into the soil or spread and integrated within a short period of time (i.e. 6-24 hours). In Denmark, specific timing and application regulations exist under the Environmental Protection Act (Kofoed *et al.*, 1986). Quantity and rate of manure application is often limited to the type of crop being grown and its nutrient requirements. Several European countries totally restrict any manure application in designated areas called water protection zones (Beier *et al.*, 1994; Swedish Board of Agriculture, 1994). Along similar lines, manure application is usually only permitted within a certain distance of a stream, open ditch or other water body.

Livestock Density

Livestock density is yet another issue related to quantity of manure and pollution extent and risk. Restricting livestock numbers based on calculations of area of land associated with a farm unit has been used in some instances and is being considered in others. This poses an economic problem for the farmer who, with improved technology, has intensified activities on a relatively small area to remain a viable business. Existing operations must either maintain/reduce their livestock numbers or find more land to spread manure. New livestock operations may only be permitted to start with a certain number of animals, which cannot be expanded upon. For example, in Sweden, animal density requirements apply to the whole country (Swedish Board of Agriculture, 1994). These regulations apply to all farms with at least 10 animal units. A balance must exist between the number of animals on the farm and the amount of land available for spreading livestock waste. Under the Law of Management, the maximum number of animals has been accurately calculated with consideration given to the amount of phosphorus in manure and a crop's normal requirements of phosphorus. Dairy cows cannot be more than 1.6 animals per

hectare, fattening pigs 10.5 animals per hectare, laying hens 100 birds per hectare (Brussard & Grossman, 1990; Colorado Department of Public Health and Environment, 2013).

Waste Disposal

Disposal of manure remains the number one dilemma for both the individual farmer and the industry as a whole. In many cases, using manures has become less related to fertilizing and more accurately labelled waste disposal. As we move from farm-scale to industrial-scale production, disposing of manure in a safe, economical, efficient and non-polluting manner has been a leading research agenda item in many countries (Hanley, 1991; Safley, 1994). Some countries have evolved strict and specific policy and practices while others approach the issue through education and voluntary actions. To quote from an article indicative of how severe the problem of manure surpluses can become, "For the time being, the Dutch may have won their constant battle against water, now they are in imminent danger of drowning in manure" (Brussard & Grossman, 1990). Excess manure production is prevalent in countries that have increased intensive livestock production as population and thus demands have increased. Disposal of manure involves many factors including availability of land associated with the farm unit, manure contracts with other land owners, and maximum quantities of manure allowed for a farm unit per hectare (Safley, 1994). The Netherlands has specific legislation related to disposal known as the Fertilizer Act of 1984, which regulates trade in fertilizing products, removal of surplus manure and its financing as well as the production of animal manure (Francis, 1992). The Act restricts the transfer of manure production to another business or to another location and establishes regulations regarding surplus manure. The Manure Law of 1987 took over many of the Fertilizer Act regulations and created the Manure Bank which is unique to the Netherlands and was formed to aid in efficient transfer of excess manure. Membership is not mandatory and it is run as a non-profit operation. Some of the banks funding relies upon a levy paid on manure surpluses and is used to create facilities for efficient transport, supervision and processing of surpluses. Contractual agreements for surplus manure to be applied elsewhere also exist in Switzerland (Swedish Board of Agriculture, 1994). These supply contracts for surplus manure must be entered into by owners with inadequate land base. Nutrient Management Plans, Best Management Practices and Codes of Practice have been adopted as general requirements by many jurisdictions (Madison *et al.*, 1986; Watson *et al.*, 1994). In some cases, they are part of detailed legislation and regulation, in others they are strictly voluntary. These plans cover a variety of purposes including reducing pollution, guidelines for use and management of manure, storage, application, water protection and standards for new livestock facilities. Financial assistance is often offered to encourage adoption of these plans and practices.

Legislation, Regulation and Policy

One of the most important outputs of the Earth Summit (United Nations Conference on Environment and Development) in 1992 was Agenda 21: an action plan for the 1990s and well into the twenty-first century, elaborating strategies and integrated programme measures to halt and reverse the effects of environmental degradation and to promote environmentally sound and sustainable development in all countries (UNCED, 1992). This shows how important environmental conservation and protection as well as the sustainable use of resources is recognized. The legislative, regulatory and policy frameworks with respect to livestock waste management are extremely dynamic at this time in Europe and in the U.S.A and is becoming the trend in many parts of the world (Beegle & Lanyon, 1994). Extrapolation of these from elsewhere may not be directly; however, the combination of experiences may be helpful in that they provide various policy approaches with varying degrees of success. The general idea is to incorporate livestock waste within wider scope of environmental protection. For example, the European Community legislation based on 1980 Drinking Water Directive which requires all members to observe standards established within a five year period (Batie & Diebel, 1990). The nitrate standard established was a maximum of 50mg NO₃ per litre of drinking water with a recommendation for 25mg/L. Denmark's 1987 Environmental Protection Act sets a strictly regulated national framework for manure storage, application, designation of environmentally sensitive areas, and livestock density control through a production unit geographic location and size regulation (Brussard & Grossman, 1990). Netherlands' legislation includes the 1987 Soil Protection Act and Manure Law which provide national standards for manure application, timing, storage, local enforcement, animal density, levies on manure surpluses and creation of a national manure bank (Abler & Shortle, 1992). The Nuisance Act provides opportunity for the development of ammonia emissions standards related to manure storage. Sweden's 1988 Law of Management and Environmental Protection Law provide for regulations regarding animal density requirements, manure application, storage, cover cropping and mechanisms to avoid ammonia loss.

(Swedish Board of Agriculture, 1994). The United States federal legislation that has implications for livestock waste management includes the Clean Water Act, Safe Drinking Water Act, Food Security Act, Environmental Protection Act and Water Quality Act (Rolfe, 1993). Within a federal legislation framework, more specific legislation/ordinances associated with livestock waste management activities are regulated and include liquid manure directives, animal density, timing of manure application, length of storage and relationship with urban and rural land use planning and public health. Requirements are in place for all commercial operations to have nutrient management plans that follow best management practices. In the United States, The Water Quality Act 1987 requires each state to develop programs to control nonpoint sources of pollution of both surface and ground waters (Perkinson, 1994). In most of the States including Colorado, Delaware, Illinois, Indiana, Maryland, among others, the Confined Animal Feeding Operations Control Law is designed to protect waters of the state from potential impact due to confined animal feeding operations; and includes development of manure management plans and permit process, provisions for conditions of manure storage, application rates, flood plain locations, discharge permit system and submission of manure and process waste water management plans to the State Department of Health; livestock waste quantity application criteria with focus on water and odour pollution concerns (EPA, 2009; Spellman & Whiting, 2007).

Regulations and Enforcement

Livestock waste management regulation and enforcement for the jurisdictions reviewed are a complex mixture of activity at various levels of government. In some instances a specific level of government is responsible, but more often a shared responsibility of two or three levels of government is utilized for integrated approaches. The direct involvement of livestock producers or their organizations in regulation and enforcement appears to be becoming more common.

Key regulations which are described as being strictly enforced include (Abler & Shortle, 1992; Patni, 1994; Sunderland, 1991):

1. All farmers must develop and submit annual manure application plans
2. Properties with greater than 31 livestock units must have not less than 9 months manure storage capacity
3. Manure application rates are determined, for example, by the quantity of manure from cow rearing which must not exceed 2.3 livestock units/hectare/year
4. Manure must be incorporated into bare soil less than 12 hours after application
5. Location of livestock production facilities and manure storage facilities is regulated
6. Establishment of manure storage capacities based on livestock units is required
7. Environmentally sensitive areas are designated (4% of arable land)
8. Livestock number control
9. Timing of manure application
10. Length of storage prior to spreading
11. In some states a liquid manure directive restricts manure application quantities and time periods.
12. National standards for quantity of manure, timing and method of application
13. Detailed commodity specific manure storage regulations
14. Manure storage permits required
15. Restrictions on emissions of ammonia
16. Efficient transport and transfer of surplus manure
17. Indirectly enforce N, P, and NH₃ standards (reviewed every 2 - 5 years)
18. Slurry application by land injection methods
19. Restrict farm practices in designated water protection zones
20. Prohibition of expansion and starting new livestock enterprises
21. Detailed winter spreading, snow and frozen soils specifications
22. Manure must be incorporated within 24 hours
23. Limitations of chemical fertilizer usage
24. Obligated to keep farm records of slurry and manure production

Enforcement involves a peer group review by local livestock producer co-ops and in cases of non-compliance, legal action is taken through the Ministry of Environment. Penalties include fines for infringement and detention or imprisonment up to 1 year for acts of gross negligence.

Policy

Policy is generally linked and integrated with the legislation, regulations and enforcement provisions. In European Community, all member countries must impose general pollution and nuisance control with limits to nitrate as per the Drinking Water Directive (Agriculture Canada, 1994). Farmers must develop annual manure application plans to control pollution of the aquatic environment with N and P. Civil and rural codes apply which may require rehabilitation and restoration of ecological damage to original conditions. Water protection zones may be designated with restrictions on farming practices to reduce the leaching of nitrates. Farmers are compensated by annual payments per hectare affected (Rolfe, 1993). New enterprises must seek approval from land use planning authorities. A nitrate reduction scheme establishes nitrate sensitive areas with compensation for extra costs incurred in restricting agricultural practices (Patni, 1994). Codes of good agriculture practice are the focus of livestock waste management policy. Policy emphasis is on education, awareness and financial incentive, rather than legislation and regulation. Most federal and state policies are based on extension education, guidelines, best management and nutrient management plans associated with financial incentives for livestock waste management (Safley, 1994).

Applied Livestock waste Management Practices

Three key components in waste management consideration include livestock facility site selection, waste storage and land application. Facility site selection emphasizes natural land characteristics (slopes, surficial geology, soils, vegetation and surface drainage), and includes visual impact, microclimate, health and safety considerations. Generally, accepted agricultural and management practices for manure management and utilization provides livestock facility runoff control, wastewater management and odour management (reduction of frequency, intensity, duration and offensiveness of odour) specifications (Safley, 1994). All European Community countries require building permits for new sites. The permit is only issued if it can be determined that the operation will not cause pollution. Dairy housing mainly pasture during spring/summer/fall and barn during winter months; ventilation required for scrubbing of ammonia emissions from barns (Smith & Chambers, 1993).

On-Farm Storage Facilities

The need for storage facilities to match application rates and timing to crop demand is almost universally recognized and most have developed relevant regulations and financial incentives (Abler & Shortle, 1992; Bertrand, 1988; Weinberg, 1994). For beef operations, storage of manure is needed for a minimum of 4-6 months. Slurry is held in concrete lined lagoons while solid waste is confined to concrete slabs. Dairy slurry is washed from parlour into concrete lined lagoons for 5-6 months storage. Swine operations use concrete walled tanks, steel tanks and plastic lined lagoons. Specific rules with regard to installations include siting at least 100 m. from third-party dwellings, camping and sports facilities and premises of professional use, 35 m. away from watercourses, 200 m. away from bathing resorts and beaches and 500 m. from fish farms. Poultry slurry must be stored 500 m. from any dwelling. In the Netherlands, reception pits from swine manure must be covered due to odour and NH_3 (Bertrand, 1988). Delaware's manure storage guidelines suggest the following essential features for on-farm storage facilities: sufficient capacity to store manure until proper disposal application on cropland; proper location to avoid runoff to surface water or percolation to groundwater; and measures that ensure effective odour and fly control (CDMMG, 1989).

Land Application of Livestock Waste

European Community manure and slurry application is limited to 210 kg N/ha with reductions by the year 2000 to 170 kg N/ha (Bertrand, 1988). Danish farmers are required to develop application plans at the beginning of each year for their manure disposal. These plans are reviewed and enforced by the local co-op. Punishment for not managing manure disposal effectively could be a reduction in stocking level. Applying slurry during the growing season makes it necessary for special machinery to be used in order to directly incorporate manure in the soil between the row crops or dribble it through flexible pipes at the foot of broadly sown plants in close rows. In Denmark, it has been stated by farmers that new methods and machinery for more accurate application of livestock manures are expensive and demand high investment (Sunderland, 1991). French farmers in Brittany are restricted by rules for slurry spreading. For pig slurry a distance of 200 m. is required from dwellings and business premises, unless slurry has been deodorized, then 50 m is accepted (Kofoed *et al.*, 1986). Animal density for all of Sweden is regulated so that the supply of phosphorus by manure corresponds to the needs of the crop (approx. 20

kg/ha/yr). Farms wishing to expand or change their animal units must show that they have enough associated land for spreading (Francis, 1992).

General guidelines of industry framework for land applications of manure include (CDMMG, 1989; Hanley, 1991; Madison et al., 1986):

1. Manures should be uniformly applied to soils. The amount of manure applied per acre (gallon/acre or tons/acre) should be known, so manure nutrients can be effectively managed
2. Manures should not be applied to soils within 150 feet of surface waters or to areas subject to flooding unless:
3. Manure is injected or surface-applied with immediate incorporation (i.e. within 48 hours after application) and/or conservation practices are used to protect against runoff and erosion losses to surface waters
4. Liquid manures should be applied in a manner that will not result in ponding or runoff to adjacent property, drainage ditches, or surface water
5. As land slopes increase from zero percent, the risk of runoff and erosion also increases, particularly for liquid manure. Adequate soil and water conservation practices should be used which will control runoff and erosion for a particular site, taking into consideration such factors as type of manure, surface residue or vegetative conditions, soil type, slope, etc.
6. Whenever possible, manure should be injected or surface -spread and incorporated within 72 hours of application
7. Not more than 25 tons per acre (63,000 kg./ha.) of solid dairy manure (or its equivalent on a P-content basis) should be applied annually unless it is incorporated
8. Where incorporation is not possible, limit applications to 25 tons per acre (63,000 kg./ha.) of solid dairy manure (or its equivalent on P-content basis) over a five-year period
9. Manure may be applied up to the rate that will provide the N needs of the crops to be grown. This will often result in over-application of P and/or K
10. When soil-test P levels reach 150 pounds per acre (168 kg./ha.), plant P-demanding crops such as alfalfa. Reduce manure application rates
11. If soil-test P levels reach 300 pounds per acre (336 kg./ha.), discontinue manure application until soil P levels drop
12. Do not apply manure to frozen soils within 200 feet (61 m) of lakes and streams. Never apply it in grassed waterways, terrace channels, open surface drains or other areas where water flow may concentrate
13. Do not apply manure within the 10 year floodplain or within 200 feet (61 m) of lakes and streams unless it is incorporated within 72 hours.
14. Manure can be safely applied to frozen soils on slopes of 6 percent or less. Protect these areas from upslope runoff
15. If you apply manure to frozen soils on slopes between 6 and 12 percent, contour strip s, terraces or other conservation measures must be in place
16. Do not apply manure to frozen soils on slopes greater than 12 percent
17. Do not apply manure where there is less than 10 inches (25 cm) of soil over bedrock
18. Where the soil cover is 10 inches to 20 inches thick, incorporate manure within 72 hours. Do not apply manure to these soils when they are frozen
19. On coarse-textured soils, such as sands or loamy sands, limit fall manure applications to areas where crops are growing, or delay applications until soil temperatures are less than 50 degrees F (10°C).

Composting

Composting is not a new waste treatment technology. It has been widely practiced by gardeners and farmers all over the world as a sustainable means of returning nutrients to the soil. The process of composting transforms organic waste such as livestock waste into useful soil conditioner or fertilizer. As compost is stable and readily assimilated by soil, it can enhance soil structure, texture, water -holding capacity and infiltration, colour, biodiversity and help prevent soil erosion, among other benefits. Composting also enables production of a more consistent quality product, reduced use of bulking agent, better odour control as potentially odorous air from the process can be easily collected for treatment.

Peters (1998) assessed the success of composting projects by several community groups in Nairobi's low-income areas as means of improving community environmental conditions and generating income through the sale of the compost. A complementary purpose of the study was to add to the limited amount of research on waste in East Africa. The study found that composting can be an effective strategy

for alleviating the problems of unmanaged waste in Nairobi's informal settlements. Composting managed to achieve a number of beneficial environmental effects such as improved health, improved physical environment, and initiation of urban agriculture, among others. However, the biggest constraint faced by most composting groups in generating income is finding a market for the compost. The expense of transportation prevents the groups from bringing the compost to an accessible point of sale. Most of the groups have nowhere to store the compost, so it deteriorates rapidly in harsh sunlight (UNCHS, 1989).

Manure Processing

Many systems of manure processing have been researched, only few are used on any larger scale. Manure processing aims at converting surplus manure in products of higher value and/or products which are easier to transport. As well, it helps to reduce local manure surpluses. Feasibility of large scale manure processing depends on the local circumstances (local legislation, fertilizer prices) and processing cost. The techniques available include livestock manure excrement solid-liquid separator, screw press swine manure separating machine and cow dung dewater processing equipment. The liquid mixture (manure, urine and water with a dry matter content of 5 – 12 %) can be used for biogas production. This will not essentially change the composition of the manure from the environmental point of view. It is an energy production process. The dry matter content of the manure is increased a little bit, the smell is reduced but all the minerals (N,P and K are still in the manure mixture. Without or after biogas fermentation this mixture could be directly applied as fertilizer to agriculture land (crop land or pasture).

Further drying of the solid fraction is an expensive process, very often requiring fossil fuel. However, the dried manure could be pelletized and used as fertilizer for special crops or in the hobby gardening, normally only a small marketing niche for this type of product. The dried fraction could also be used for burning. This is frequently not cost efficient, the drying will require more energy than the effective energy gained from burning the product. Manure from broilers could be an exception because the original product is mixed with wood shavings and has a high DM content. The residual ash of the burning process contains P and K and can be used in the fertilizer industry. Again the fertilizer industry will only be interested in this product if it is available in large quantities of a confirmed constant quality. The residual ash could contain residues of heavy metals which make it unsuitable for further processing by the fertilizer industry. Benefits of processing include reduced volume of manure and the emissions to the environment, production of biogas reduces the need for fossil fuel, composted manure has a higher value as organic fertilizer and the transport cost are reduced to bring manure from surplus areas to deficit areas. However; most processes require large quantities of manure and are generally not techniques suitable for farm implementation. Some of the end-products have to be produced in very large quantities and of a very reliable quality before acceptance by the industry. Most processes are expensive and cost between US\$ 10 to 20 per ton of liquid manure. These techniques are applicable to the industrial livestock production systems and to the mixed cut and carry system and external feed resources, where manure is stored in the form of a liquid mixture and cannot be directly applied to the land.

Kenya's Future Livestock Waste Management Options

Historically, manure generated by livestock has been returned to soil for benefits mentioned above. Land application is the best method of utilizing manure; however, recent trends in livestock production and processing raise concerns over environmental degradation and water quality impairment. Like any developing country, Kenya has its own shares of challenges in several areas, waste management being one of them. Some of these challenges include political interference, corruption, shortage of enforcement resources, complacency/complaisance, limited awareness, contempt for authority, poor collaboration/co-ordination of stakeholders, cultural attitude/perception, ambivalent commitment by administration, poverty/ignorance, poor governance, discriminative application of the law and limited infrastructural support. Waste management choices mentioned above are used in various places, especially composting, lagoons and direct land application. National Environmental Management Authority is requiring nutrient management plans, imposing tougher regulations and demanding more accountability in waste handling. However, voluntary control measures are less costly and more productive than government control and regulations. Growing concern about waste handling coincides with the public concern about environmental quality. Following best management practices can improve the environment and reduce liability to farmers.

Conclusions and Recommendations

Governments, agencies and farmers are struggling with manure management issues, but with so many areas of concern and such a complicated system, absolute solutions remain to be found. Approaches

to livestock waste management practices, legislation, regulation and policy are extremely dynamic at the present time. In areas of intensive livestock production in Europe, U.S.A. and Canada waste management and associated environmental considerations are becoming increasingly key public policy issues and this needs to be promoted locally since production standards already determine access to international markets. Actions taken to date haven't necessarily remedied the problems, but have rather attempted to abate the problems while searching for solutions. Recommendations therefore include:

1. *Regulation and accountability.* Factory farms are industrial facilities and should be regulated accordingly. They must obtain permits, monitor water quality and pay for cleaning up and disposing their wastes
2. *Increased transparency.* The public should know where CAFOs are located, how CAFOs in their neighbourhoods dispose of their waste, and what water-bodies or drinking water sources may be at risk. There is not currently a comprehensive database of this critical information, which should be collected and made publicly available.
3. *Public awareness and participation .* Local governments and residents must have a say in whether to allow factory farms in their communities. The public is also entitled to review and comment on the contents of pollution reduction plans and to enforce the terms, where a factory farm is in violation.
4. *New technology.* Factory-farm technology standards must be strengthened. The National Environmental Management Authority must consider recent technology advances that significantly reduce pathogens.
5. *Alternative farming practices.* National and county governments should promote methods of raising livestock that reduce the concentration of animals and use manure safely. Many alternative methods exist; they rely on keeping animal waste drier, which limits problems with spills, runoff and air pollution.
6. *Pollution-reduction programs for small feedlots.* Voluntary programs must be expanded to encourage smaller factory farms, which fall outside of the regulations for industrial facilities, to improve their management practices and take advantage of available technical assistance and other resources.
7. *Consumer pressure.* Individuals can help stop factory farm pollution by supporting livestock farms that use sustainable practices. In the grocery store, this means checking meat labels for "organic," "free range," "antibiotic-free," or similar wording, which indicates meat raised in a more sustainable manner. Many sustainable livestock farms also sell directly to consumers or through local farmers' markets

Changes result from new research findings, applied experience, industry economics and integration with other environmental and land use planning policy. There is no one model elsewhere that can be considered as a prototype for addressing livestock waste management issues; however, experience elsewhere can assist with developing a livestock waste management planning system. Priority must be given to educate the producer, government resource manager and the public.

References

- Abler, D.G. & Shortle, J.S. (1992). Potential for environmental and agricultural policy linkages and reforms in the European Community. *American Journal of Agricultural Economics* 74 , 3.
- Agriculture Canada. (1994). *A survey of environmental policy instruments for the agriculture sector in selected O. E.C.D. Countries.*
- Batie, S.S. & Diebel, P.L. (1990). Key policy choices in groundwater quality management . *Journal of Soil and Water Conservation.* 45(2), 194.
- Beegle, D.B. & Lanyon, L.E. (1994). Nutrient management legislation in Pennsylvania Supplement . *Journal of Soil and Water Conservation.* 49(2), 64.
- Beier, A., Dressing, S. & Shuyler, L. (1994). A new approach to run -off - State Coastal nonpoint pollution control programs. Supplement: *Journal of Soil and Water Conservation*, 49 (2), 72.
- Bertrand, R. (1988). *Manure management in Europe.* Soils Branch, BC Ministry of Agriculture and Fisheries. Abbotsford.
- Brussard, W.& Grossman, M.R.. (1990). Legislation to abate pollution from manure: the Dutch approach. *The North Carolina Journal of International Law and Commercial Regulation.* 15 (1), p.88.
- Colorado Department of Public Health and Environment. (2013). *Animal/livestock feeding operations frequently asked questions.* Retrieved from <http://www.colorado.gov/cs/Satellite/CDPHE-DEHS/CBON/1251588151450>.

- Committee for Delaware Manure Management Guidelines (CDMMG). (1989). *Manure management for environmental protection*. Department of Natural Resources & Environmental Control and University of Delaware.
- Conrad, J. & T eherani-Kronner, P. (1989). The politics of shit regulation of liquid manure application in North Rhine - Westphalia and Lower Saxony. *Policy and Politics*. 17(3), 241-254.
- Environmental Protection Agency (EPA). (2001). *Managing livestock, poultry, and horse waste to prevent contamination of drinking water*. Source Water Protection Practices Bulletin (EPA 916 -F-01-026). USA.
- Environmental Protection Agency. (2009). *Animal feeding operations*. Retrieved from http://cfpub.epa.gov/npdes/home.cfm?program_id=7 .
- Export Processing Zones Authority (EPZA). (2005). *Dairy industry in Kenya*: Retrieved from [http://www.epzakenya.com/UserFiles/files/DairyReport .pdf](http://www.epzakenya.com/UserFiles/files/DairyReport.pdf) .
- Francis, D.D. (1992). Control mechanisms to reduce fertilizer nitrogen movement into groundwater. *Journal of Soil and Water Conservation*, 47,6.
- Hanley, N. (1991). *Farming and the countryside: An economic Analysis of external costs and benefits*. United Kingdom: C.A.B. International
- Illinois Administrative Code 506. (2001).35: *Environmental protection; E: Agriculture Related Pollution. Chapter I: Pollution Control Board Part 506 Livestock Waste Regulations*.
- Kerns, W.R. & Broomhall, D. (1992). *Risk environmental priorities, and policy options in water quality*. Blacksburg, Virginia, USA: Virginia Polytechnic Institute and State University.
- Kofoed, A.D., Williams, J.H. & L'Hermite, P. (1986). *Efficient land use of sludge and manure*. England: Commission of the European Communities
- Lekasi, J.K., T anner, J.C., Kimani, S.K., & Harris, P.J.C.. (2001a). *Managing manure to sustain smallholder livelihoods in the East African Highlands*. UK: Garden Organic (formerly HDRA), Coventry, p 32.
- Lekasi, J.K., T anner, J.C., Kimani, S.K, & Harris, P .J.C. (2001b). *Manure management in the Kenya highlands: practices and potential* (2nd Ed.). HDRA Publications, Emmersons, Farmer Ward Road, Kenilworth, UK. Garden Organic (formerly HDRA), Coventry, UK. p 35.
- MacDonald, J.M. & McBride, W.D. (2009). *The transformation of U.S. livestock agriculture: Scale, efficiency, and risks*. United States: Department of Agriculture. Retrieved from <http://www.ers.usda.gov/Publications/EIB43/EIB43.pdf>.
- Madison, F., Kelling, K., Petersen, J., Daniel, T ., Jackson, G. & Massie, L. (1986). *Guidelines for applying manure to pasture and cropland in Wisconsin*. Winsconsin-Madison: Department of Agricultural Journalism, University of Wisconsin -Madison.
- Milne, J.A., (2005). Societal expectations of livestock farming in relation to environmental effects in Europe. *Livest. Prod Sci*. 96, 3-9.
- Moore, P. A., Daniel, T. C., Sharpley, A.N. & Wood, C.W. (1995). Poultry manure management: Environmentally sound options. *Journal of Soil and Water Conservation*, 50 (3), 321.
- Patni, N. K. (1994). *Regulatory aspects of animal manure utilization in Canada*. Ottawa, Canada: Agriculture and Agri-Food
- Perkinson, R. (1994). Evolution of nutrient management in the Chesapeake Bay Region. Supplement . *Journal of Soil and Water Conservation*. 49(2), 87.
- Peters, K. (1998). *Community-based waste management for environmental management and income generation in low-income areas: A Case Study of Nairobi, Kenya* . Retrieved from [http://www.cityfarmer.org/NairobiCompost .html](http://www.cityfarmer.org/NairobiCompost.html).
- Rachuonyo, H.A., Pond, W.G. and McGlone, J.J. (2002). Effects of stocking rate and crude protein intake during gestation on ground cover, soil-nitrate concentration, and sow and litter performance in an outdoor swine production system. *J Anim Sci* 80, 1451-1461.
- Rachuonyo, H.A., Curtis, S.E., Hoeft, R.G., Gonzini, L.C., & Ellis, M. (2013). Determination of nutrient digestibility, nitrogen retention and excretion and 15N dilution from labeled corn in swine diets. *African Journal of Education, Science and Technology*. 1(1), 21-38.
- Rolfe, C.J.B. (1993). *Using subsidies to promote environmental protection in agriculture: A Review of Programs in North America and Europe*. Vancouver: West Coast Environmental Law Association
- Safley, L.M. (1994). Best management practices for livestock pro duction. Supplement. *Journal of Soil and Water Conservation*, 49(2), 57.
- Smith, K.A. & Chambers, B.J. (1993). Utilizing the nitrogen content of organic manures on farms – problems and practical solutions. *Soil Use and Management*, 9 (3).
- Spellman, F.R. & Whiting, N.E. (2007). *Environmental management of concentrated animal feeding operations (CAFOs)*. Boca Raton, FL: CRC Press.
- Storm Water Manager's Resource Center (SWMR). *Pollution prevention fact sheet: Animal waste collection*. Retrieved from <http://www.stormwatercenter.net> .
- Sunderland, N. (1991). *Danish pollution laws bear down on farming*. Farmers Weekly.

- Sutton, A. L. (1990). *Animal agriculture's effect on water quality: pastures and feedlots*. Indiana: Department of Animal Science.
- Sutton, M.A., Howard, C.M., Bleeker, A., & Datta, A. (2013). The global nutrient challenge: From science to public engagement . *Environmental Development* . Elsevier 6, 80 – 85.
- Swedish Board of Agriculture. (1994). *Programme controlling nutrient Leakage from Agriculture*. Stig Karfsson - Swedish Institute of Agriculture Engineers.
- United Nations Centre for Human Settlements. (1989). *Improving income and housing: employment generation in low-income settlements*. Nairobi: UNCHS.
- United Nations Conference on Environment and Development . (1992). *Agenda 21: Program of Action for Sustainable Development*. New York: UNCED.
- Watson, J., Hassinger, E., Ref fruschinni, K., Sheedy, M. & Anthony, B. (1994). Best management practices meeting water quality goals. Supplement . *Journal of Soil and Water Conservation*. 49 (2), 39.
- Weinberg, A.C. (1994). Nutrient management measure to be implemented in the Coastal Zonel. Supplement. *Journal of Soil and Water Conservation*. 49(2), 71.