WASTE MANAGEMENT SYSTEM EVALUATION IN COMMERCIAL DAIRY FARMS

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Thesis submitted in partial fulfillment of the

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DECLARATION

I hereby declare that this thesis, entitled **"WASTE MANAGEMENT SYSTEM EVALUATION IN COMMERCIAL DAIRY FARMS"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

SANY THOMAS

Mannuthy,
31-10-2009.

CERTIFICATE

Certified that this thesis, entitled **"WASTE MANAGEMENT SYSTEM EVALUATION IN COMMERCIAL DAIRY FARMS"** is a record of research work done independently by **Sany Thomas**, under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Sany Thomas

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Dedicated to Palamattam

1. INTRODUCTION

Man has utilized livestock for many purposes like food and as a source of draught power throughout history. During the past twenty years, however, there has been a major change in livestock production practices due to specialization and intensification. As animals have been concentrated and the number increased in individual enterprises, the quantity of manure, requiring management, has increased. When animals are dispersed in woodland, pasture, or range areas, manure is distributed and the soil provides continuous assimilation. But in confined and intensified production systems, the manure disposal requires special techniques for handling and often proves staggering to confinement producers. In addition to the manure quantities produced by various livestock and poultry species, there are the additional volumes of bedding, waste water and wasted fodder which adds to the total bulk of waste produced which has to be managed. In this respect manure disposal problem became evident and there has emerged a need for development of livestock waste management technology.

India is basically an agrarian country. Livestock and crop production activities generate huge amount of biodegradable waste. Annually, India generates about 1677 million tonne animal waste, 500 million tonne agro waste, 4.5 million tonne food and fruit processing waste and 27.4 million tonne municipal solid waste. With increasing economic development resulting due to a rise in the population, there is increasing potential for livestock farming in India. Livestock sector in India has experienced remarkable growth during the last two decades due to

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1. INTRODUCTION

Man has utilized livestock for many purposes like food and as a source of draught power throughout history. During the past twenty years, however, there has been a major change in livestock production practices due to specialization and intensification. As animals have been concentrated and the number increased in individual enterprises, the quantity of manure, requiring management, has increased. When animals are dispersed in woodland, pasture, or range areas, manure is distributed and the soil provides continuous assimilation. But in confined and intensified production systems, the manure disposal requires special techniques for handling and often proves staggering to confinement producers. In addition to the manure quantities produced by various livestock and poultry species, there are the additional volumes of bedding, waste water and wasted fodder which adds to the total bulk of waste produced which has to be managed. In this respect manure disposal problem became evident and there has emerged a need for development of livestock waste management technology.

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increased demand for livestock based products. Increased livestock population can lead to the multiplication in production of livestock wastes. The safe disposal of huge quantity of biodegradable organic waste has become major problem in preserving environmental quality. This organic waste accumulates and causes pollution unless directed to biological pathways to return into active ecosystem. (Singh, 2008)

Waste can be defined as an unnecessary, unusable commodity at a given place, at a given time. The same substance becomes an usable commodity or a product, when properly managed and at a different place or different time So the term waste is a misnomer, because ultimately it is a usable commodity or livestock product which must be utilized carefully and productively. Livestock waste management is important for the economic survival of an enterprise. The large quantity of manure generated, if properly handled and utilized, is an asset.

Environmental issues relating to livestock farming are nowadays increasing and create a bottleneck in the establishment and running of animal farms. Since, livestock farming enterprises have a great potential in employment generation, food security and sustainable development, it is highly essential to formulate strategies for designing environment friendly livestock production system. Presently commercial dairy farms are not following a pattern of waste management system. The pollution caused by different farms varies due to their difference in the waste management system followed. So there is an emerging need for suggesting a cost efficient system for waste management in commercial dairy farms. Under these circumstances the present study was envisaged with the following objectives:

1 .To study the existing animal farm waste management in commercial dairy units

2. To study the effect of animal stocking on the quality of water, soil and air.

3. To suggest possible improvement in the existing waste management systems for dairy farms in Kerala

Review of Literature

2. REVIEW OF LITERATURE

2.1 WASTE GENERATED IN A DAIRY FARM

Bewick (1980) reported that the livestock waste include farm yard manure, which is the solid manure (where straw and other bedding is mixed with dung, urine and feed waste.) and the slurry and the liquid manure (which is the mixture of feces, urine and wash water from the animal houses).

Sastry and Thomas (2008) classified manure as (i) solid- (dung, feed wastes, soiled bedding) and (ii) liquid-(urine and wash water).

2.1.1 Quantity of waste generated

Tunney (1977) opinioned that the daily waste production by cattle was around 40-50Kg per day per livestock unit.

Bewick (1980) observed that the waste products from livestock could be enormous, on an average daily undiluted fresh manure production was equalent to five to eight per cent of animal live weight.

Sastry *et.al.* (1994) estimated that the livestock waste production in cattle farming was forty Kg per day per adult animal unit.

Sastry and Thomas (2008) reported the density of manure is as 700 to 1000 kg/m^3 and that of stored and decomposed manure as 1000 to 1300 kg/m^3 The size and number of manure pits required, depended on the production of manure on the farm, which was on an average 40 kg per day per adult unit or AU.

2.1.2 Composition of dairy solid waste

Dewi *et al.* (1994) observed that the nutrient content of farm yard manure and slurry was highly valuable. They reported average values of Nitrogen. Phosphorus, Potassium content of farm yard manure as 2, 0.4 and 1.7 per cent respectively.

Sastry and Thomas (2008) had found out that cattle dung has 77.5% water, 20.3% organic matter, 0.34%nitrogen, 0.16% phosphoric acid, 0.04% potash and 0.31% lime.

Senthilkumar *et al.* (2008) reported that undigested protein was also excreted in the faeces and the excess nitrogen from the digested protein was excreted in urine as urea. Potassium was absorbed during digestion, but most of it was excreted through urine. Calcium, manganese, iron and phosphorus were excreted mostly in faeces. The faeces of ruminants consisted mainly of undigested materials and it also contained residues from digestive fluids, waste mineral matter, worn out cells from gastrointestinal tract, bacteria and foreign matter.

2.1.3 Removal of manure from farm sheds

Linton (1952) observed that the collection of solid manure in animal habitations under ordinary management was usually carried out once or twice daily. Removal from the building was usually effected either by means of a wheelbarrow or similar vehicle, or often by simply throwing the manure through an open door on to a dump situated immediately outside the buildings.

Sastry and Thomas (2008) stated that under ideal managemental conditions solid manure was usually collected and removed from shed twice daily. Provisions were to be made to carry off and store liquid manure as and when the same accumulates.

2.1.4 Liquid manure

Kaneko *et.al.* (1997) stated that the most important livestock products were the cow dung and cow urine. Cow produces 17-45 ml of urine per Kg body weight per day. This means production of 6-15 liters of cow urine per animal per day.

2.1.4.1 Liquid manure removal

Sastry and Thomas (2008) stated that the liquid manure and wash water from the shed drained by a shallow 'U' shaped gutter located longitudinally to the long axis of the shed.

Sastry and Thomas (2008) stated that the mixed wash water could be directly led to fields of fodder grasses or could be fed as slurry to bio-gas plants. In Arey Milk Colony, Bombay, fodder grasses were being cultivated economically by irrigating them with wash water from cattle sheds.

Sastry and Thomas (2008) observed that the width of the drains might vary from thirty to forty cm. A slope of 1 in 40 should be provided to the drains towards storage tank so that liquid might flow down easily. Shallow 'U' shaped drains were preferable to drains with cut sides,

2.2 WASTE DISPOSAL METHODS IN A DAIRY FARM

Senthilkumar *et al.* (2008) observed that there were various methods for handling and treating animal waste in which the simplest and most effective method was to utilize them as a soil nutrient by recycling it back to the soil. Methods that were available for applying animal excreta into the soil included,. direct surface application followed by immediate ploughing, application after processing as Farm Yard Manure (FYM), conversion into compost, vermicomposting and biogas plants to produce gas and slurry manure.

2.2.1 Direct surface application

Sharma (2007) stated that the traditional method of utilization of livestock waste products was their direct application to their crop fields.

Senthilkumar *et al.* (2008) opinioned that both liquid and solid waste were directly spread on the open fields and subjected to sun drying under natural conditions. This was the oldest and cheapest method of recycling animal waste; the end products were carbon dioxide and water with an accumulation of nitrogen, sulphur, phosphorus and minerals in the soil. This method was environmentally undesirable. There was partial decomposing of organic matter with valuable losses of nitrogen and energy.

2.2.2. Spreading or drying of manure

Linton (1952) opinioned that, the spreading was a method which was suitable in hot, dry climates which consisted of spreading of manure within 24 hours of its being voided each day's output of manure in a thin layer. In certain circumstances, manure might be carted direct from the animal buildings to the land without any period of storage intervening. He also observed the common practice of depositing the manure in a dump immediately outside the buildings, and into which the drainage system empties, was most objectionable. A concrete pathway should connect the buildings and the manure pit and, where it was possible, accessibility to the latter from a hard road was an advantage when it comes to transferring the manure to the land.

Linton (1952) proposed that a proper system for hygienic disposal of animal excreta. As far as the livestock sanitation was concerned, the disposal of animal manure should be simple and as practicable as possible. So that they did not serve as a vehicle for the propagation of disease or become a source of public nuisance.

ICAR (2002) recommended that the application of animal manure to crops was considered as a method of disposing waste and of clearing storage system. Average daily amount of dung and feaces produced on a farm vary depending on the feed material and body weight of animal. The disposal of the manure might be done as solid, liquid or separated manure. Manure pits or slurry pits could be used for the manure disposal. Manure deposited could be scraped daily by tractor and blades, mechanical scraper, or flushed periodically with water for cleaning.

2.2.3 Manure pit

Sastry and Thomas (2008) stated that the manure pit should be placed as far from the buildings and they recommended that for reasons of hygiene, manure pits should be at a minimum distance of 10m from wells, rivers and tanks and from the boundary of the adjoining land property. Further, they must be impermeable to water.

2.2.4 Composting

Helton (2008) stated that livestock manure had been applied throughout recorded history as a soil amendment to improve soil properties and supply required nutrients for growth. Raw and composted manures generally acted as slow-release nutrient sources that could improve soil physical and chemical properties by increasing organic matter content while providing plant nutrients. Composting was a manure management strategy being evaluated because it produced a product that was more easily handled and stored than manure due to reduced weight and volume. Compost had less odour and temperatures developed during the composting process killed most pathogens and viable weed seeds.

Senthilkumar *et al.* (2008) stated that composting was a natural process in which organic matter was decomposed by micro-organisms forming humus like substance. This process was in practice for centuries by farmers who stock dung into piles or in pits. Composting was either aerobic or anaerobic. The advantages of aerobic decomposition were shorter stabilization time, absence of foul smell and destruction of weeds and pathogens.

2.2.5 Vermicomposting

Hamza (2004) stated that the all crops removed enormous quantity of nutrients through produce. In order to make the soil sustainable we must had to replenish the nutrient removed by the produce. Organic manures were essential to sustain crop production and preserves soil health and soil bio diversity.

Isaac and Nair (2004) stated that the decomposition was essentially a biological process that resulted in the breakdown of the organic material and release of nutrients entrapped in the tissues.

Sharma and Agarwal (2004) stated that the main goal and benefit of using earth worms for waste management was to convert organic waste into fertilizer. Vermicompost basically consisted of wormcasts in addition to some decayed organic matter. Earthworms actually consume the organic matter along with the microorganisms and amazingly their casts had contained eight times as many microorganisms as they fed. Their cast did not contain any disease pathogens, as pathogenic bacteria were reliably killed in the worm gut. It required low energy input, it provided a product with a valuable end use (fertilizer) and it relied on simple natural processes without the input of natural chemicals or relied on large scale industrial processes.

Maurya *et al* (2006) stated that the recycling of organic refuse through earthworm was called vermin-composting. It provided nitrogen, phosphorus, potassium, calcium, magnesium and micro-nutrients such as iron, molybdenum, and Copper. It also contained growth producing substances such as cytokinine.

Hemavathy and Balaji (2007) reported that the use of animal manure completed the nutrient cycle allowing for a return of energy and fertilization nutrients to the soil. Use of manure from livestock, feedlots and dairies and their compost in commercial organic agriculture was promising. Compost was beneficial in number of ways. It contained antibiotics and antagonists to soil pests allowing for increased plant resistance to attacks, increased crop yields, was important in weed control and builds up soil organic matter.

Senthilkumar *et al.* (2008) stated that vermicomposting was the method of composting aided by earthworms. Worms fed on the organic waste converting it into castings which have high manurial value. Vermicomposting achieved abatement of organic pollution by reduction in waste's bulk density and reduction of foul odour. They opined that vermiculture was the latest technique, which was 100 times more efficient than any other conventional techniques. Use of earthworms for waste disposal achieved three ideal objectives such as upgrading the value of the original waste materials so that they could be reduced, production of the upgraded materials *in situ* without having to transport waste material over long distance ,yielding of a final product free of chemical or biological pollutants.

Senthilkumar *et al.* (2008) stated that the composting was a more ecofriendly method of recycling waste which provided several advantages like increased availability of plant nutrients, destruction of pathogens, elimination of unfavorable odours and easy handling.

Singh (2008) stated that an economic and eco-friendly method and an alternative to existing methods for organic waste disposal was composting. Nowa days vermimanure production had become a lucrative business for commercial producers and an additional income for the farmers. Verbiotechnology also helped in maintaining clean and healthy environment and promotion of sustainable agriculture,

Sunil and Manjula (2009) stated that the production of NPK fertilizers in India were less than the required quantity and it was estimated that about 5 to 7 million metric tonne of NPK fertilizers would be the short fall in the next two decades. Organic manures such as vermicompost, bio-fertilizers would form the source to bridge this concerning gap.

2.2.5.1. Vermiculture / Vermibiomanuring/ Vermiwash

Praveen *et al.* (2004) stated that it was a simple biotechnological process of composting in which animal and farm waste harbor species of earthworms and microorganisms which were used to enhance and accelerate the process of waste conversion into value added organic products of vermibiomanure and nutriwash. Earth worm digested animal dung and farm waste. These organic matters had undergone complex microbial and biochemical changes in earthworm gut and excreted out in granular form with earthy smell. The multiplication of earthworms and favorable microorganisms (using earthworm as bioreactors) in organic waste was called vermiculture. These vermicasting were rich in diverse microbial and enzymatic activity and moisture holding capacity and contained nutrients such as nitrogen, potassium, phosphorus, calcium and magnesium in the forms readily taken by plants.

Preetha *et al.* (2004) opinioned that the vermiculture technology involving the use of earth worms as versatile natural bioreactors was an effective method of recycling non toxic organic waste. The earth worms in the compost would increase the nutrient content of the compost.

Sulochana and Tirkey (2006) stated that the vermi-composting being an eco-friendly and cost effective process, could be used as a means to overcome the hazards as well as to substantiate a part of organic matter required for fields and aquaculture.

Kumar *et al.* (2007) stated that the vermicomposting was a method of preparation of organic manure from bio agro wastes with the help of earthworm and the excreta of earthworms was called as vermicast. These castings were biologically active and very available to plants. .

Singh (2008) stated that the liquid extracts from vermibiomanure and wash of earth worms were termed s nutriwash. Nutriwash promoted growth when sprayed or watered on around the plants.

2.2.6 Biogas technology

Senthilkumar *et al.* (2008) reported that, one Kg of cattle dung produces about $0.073m^3$ (1.3 cubic feet) of biogas at atmospheric pressure. The availability of dung from a medium size cow was approximately 10 kg per day. For the smallest plant producing 1.7 m^3 (60 cubic feet) of biogas, waste from at least 5 head of cattle was necessary. Biogas (1.7 m^3) produced from this small plant was considered sufficient to meet the cooking and lighting needs of a four member family. He opined that two products obtained from the plant were biogas and fermented slurry. Biogas was non-poisonous, with a characteristic odour, which disappears on burning. When mixed with air, it burned with a non-luminous blue flame without producing any stroke. It had a very low level of inflammability. Biogas was used for household cooking, lighting and power. Special lamps are available for lighting where biogas could be used.

Thomas (2008) observed biogas plants were attracting the attention of farmers and research workers, as it fulfil two purposes- one to provide fuel and the other to give quality manure.

2.3 IMPACT OF DAIRY FARM WASTE ON ENVIRONMENT

Shelton (2004) stated that effective management of manure had become a focus of many livestock producers due to increasing environmental concerns such as water quality and odour control, and to better capitalize on the fertilizer value of manure. A best management practice was to incorporate manure into the soil to maximize nutrient availability especially nitrogen, and to minimize odours and potential degradation of surface water quality through run off .Incorporation of manure reduce odour levels upto 90% compared with surface broadcasting.

2.3.1 Water

Overcash *et al.* (2000) stated that the water quality impact of animal waste could be evaluated in terms of organic matter, plant nutrients and pathogenic microorganisms. They opined that livestock wastes were the potential source of nitrogen and phosphorus of the surface waters.

2.3.2 Air

Overcash *et al.* (2000) stated that without adequate handling capabilities, manure became an ever accumulating liability, whose odour served as a incessant reminder of the deficiencies of the system.

2.4. ASSESSMENT OF IMPACT OF DAIRY FARM WASTE ON ENVIRONMENT

2.4.1. On water

Latha *et al.* (2003) stated that water is an important and unique environmental source required for the growth and development of a healthy community. They observed that routine assessment of microbiological quality of drinking water sources was essential for ensuring supply of safe and wholesome water.

In India, wells formed the main source of water supply. Bacteriological quality of well water was studied by many workers in India. Oommen (1981) noticed that gross contamination of well water occurs mainly with bacterial organisms present in animal excreta. The assessment of water quality using coliform and *Escherichia coli* counts was conducted by Rameteke et al. (1990, 1992) Guar et al. (1992) Gomathinarayanan *et al.* (1994) and Choudhury *et al.* (1996).

2.4.1.1. Biological Oxygen Demand

Overcash *et al.* (2000) stated that the bio degradable organic matter concentration of waste water was characterized by Biological Oxygen Demand test (BOD_5). BOD_5 was determined by measuring the quantity of dissolved oxygen utilized by aerobic micro organism in stabilizing the organic or carbonaceous matter during a specified period of time and at a constant temperature usually 5 days and 20^0C.

Maurya *et al.* (2006) stated that animal manure used in organic farming include FYM, biogas slurry etc. Even though organic manure contain low nitrogen, potassium and phosphorus as compared to inorganic fertilizers, it was superior due to supply of micro-nutrients improves physical condition of soil. They hastened the growth and development by populating growth regulators where as organic manure acted as slow releasing fertilizers. Because of slow release of ammonia and slow conversion to nitrates, the leaching losses of N was low in the presence of organic manures.

Singhvi *et al.* (2006) stated that materials of vegetable and animal origin formed could be added to soil regardless of stage of decomposition. Organic manure which were bulky in nature but supplied the plant nutrients in small quantities were termed as bulky organic manure. Eg. FYM.

Senthilkumar *et al* (2008) reported that the FYM was the decomposed mixture of dung and urine of farm animals along with litter, left over fodder fed to the animals. It was estimated that FYM from all animal excreta in India could supply 6.33 million tones of nitrogen, P_2O_5 and K_2O per annum. A well decomposed FYM contained 0.7-1.3 per cent nitrogen, 0.3-0.8 per cent P_2O_5 and 0.4-1.0 per cent K_2O on dry weight basis. It was also influenced by the processed of handling and storage. Under normal conditions, there was invariable loss of nutrients either by leaching or volatilization when manure remained exposed to rain and sun.

2.4.1.2. E.coli

Oommen (1981) noticed that gross contamination of well water occurred mainly with bacterial organisms present in animal excreta.

Shaiju *et al.* (2007) stated that presence of coliform bacteria was used as an indicative of pathogenic bacteria and feacal pollution. The reason for the microbial pollution of wells was the poor construction of wells.

2.5 WASTE IS WEALTH

Overcash *et al.* (2000) opined that additional advantage of a ruffed confinement system for beef production were increased conservation of plant nutrients, high level of insect, odour and pollution control that was possible, for that, need a waste management system rather than a separate solid-liquid handling.

Durham (2003) reported that composting is one of several technologies used to treat animal manure, sewage sludge, and other organic residues which may contain pathogens or parasites of public health concern. In any manure slurry system, solids can be composed. The demand for animal manure is projected to increase. As organic vegetables and fruits gain popularity, more growers value its benefits to soil quality and to the environment.

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Materials and Methods

3. MATERIALS AND METHODS

3.1 STUDY AREA

Study area comprised of Thrissur, Malappuram, and Ernakulam districts and adjoining area of these three districts.

3.2 SURVEY

Local veterinary doctors were interviewed to find out the profile of dairy farms.

3.2.1 FARMS UNDER STUDY AND THEIR PROFILE

Forty five dairy farms were identified and visited. Data regarding general outlay of the farms, selected management practices in the farm, livestock details and existing waste management methods in the farms were collected and studied.

3.3 ANIMAL HOLDING CAPACITY OF THE FARM

The dairy farms under study were classified based on the animal holding capacity as those with less than six animals (class 1), 6-20 animals (class 2), 21-50 animals (class 3),and 51-100 animals (class 4), and above 100 animals(class 5). The classification was based on the recommendations of Ministerial level conference (Reports of Ministerial level conference, 2006).

3.4 EXISTING WASTE MANAGEMENT METHOD IN THE FARM

The farms under study were visited and details taken, regarding sustainability of existing waste disposal method, different aspects waste management like frequency of waste removed, separation of liquid and solid waste exist and quantity of waste generated in the farm.

3.3.1 Manure Pit

In the farms under study where manure pit was used as existing waste management method, the pits were classified as Earthen/ Concrete/ Allnutt's manure pit .The distance of the pit from the farm, whether it was covered or not and frequency of waste removal from the manure pit were also recorded.

3.3.2 Compost

In the farms under study where compost was used as existing waste management method the composting systems were classified as Trench/Raised. The measurement of the unit size (in m^3) and frequency of waste removal from the compost unit were also recorded.

3.3.3 Biogas plant

In the farms under study where biogas unit was used as existing waste management method, the biogas units were classified based on the data on type of the biogas unit *viz* Dome/ Drum. The measurement of the unit (in m^3) and presence of slurry tank associated with unit as mode of utilization of slurry were studied.

3.3.4. Combination of methods

The farms using two or more of methods of waste disposal were used were classified as compost – manure pit method, manure pit-land fill, biogas-compost, and combination of manure pit, biogas and compost method.

Based on the overall findings on waste management system followed the farms under study were randomly grouped into four groups *viz* group I (farms with manure pit as waste management method-conventional), group II (farms with compost units as waste management) group III (farms with biogas as waste management method) and group IV (farms with a combination of different waste management methods).

3.4.1. Soil

3.4.1.1 Sampling and analysis of soil l

Soil samples were collected from 30 farms selected at random from the waste management sites and at a distance of 5mfrom the farm point in each farm. Sampling was done according to Department of Agriculture, Government of Kerala recommendations. (2006). . Samples were dried under shade and analyzed in the laboratory for Nitrogen, Phosphorus, Potassium, Total carbon and pH by methods described by Tandon (1994) and Vijayan (2000).

3.5.2. Water

Water samples were collected from nearest available water bodies within a distance of 10m from waste management site using standard sampling techniques in 30 farms selected at random.(Kim and Feng, 2001).

3.5.2. 1 Coliform count

Coliform count of water sample was estimated using the procedure described by Kornacki and Johnson (2001).

3.5.2.2 Escherichia coli Count

Escherichia coli count per ml of water sample was estimated according to the procedure described by Kornacki and Johnson (2001) using Eosin Methylene Blue (EMB) Agar.

3.5.2.3 pH of water sample

The pH of water samples collected was measured, using the method described by Scott *et al* (2001). The pH was recorded using a digital pH meter. (LI 612 ELICO)

3.5.2.4. BOD_5 of **water sample**

The BOD_5 of water samples were determined by the standard photometric method (Chapman and Kimstach,1996) using the instrument by Spectroquant NOVA 60, Merck photometer (Merck, Germany)

3.5.3. Air

3.5.3.1. Collection and estimation of microbial load in the air

The Total Viable Count (TVC) of air samples were estimated by air samples collected from livestock farms under study using the direct exposure method described by Evancho et al(2001)

3.5.3.2. Odour annoyance

The odour annoyance was studied using a nine point hedonic scale (McGinley, 2005).

3.9 STATISTICAL ANALYSIS OF THE DATA

The data collected was analyzed statistically as per methods described Snedecor and Cochran (1994) and Statistical Package for the Social sciences(SPSS,2007).

Results

4. RESULTS

4.1 AREA OF THE STUDY

Kerala with an area of 38,863 sq. km. and a total population of 29.099 million is one of the thickly populated states of our country. The ever increasing demand for milk leads to the intensification of the cattle rearing in Kerala. Lack of scientific knowledge in animal husbandry practices, eventually resulted in the ineffective waste management and subsequent environmental pollution and neighborhood problems. Forty five commercial dairy farms identified randomly for studying the nature of existing waste management systems, were located Thrissur, Malappuram and Ernakulam districts and adjoining areas of Kerala.

4.1.1 Animal holding capacity

The details of the classification of dairy farms are presented in Table 4.1 and depicted in Figure 1 and per cent of farms available in each class. Among the forty five farms under study, four per cent belonged to class 1, forty nine per cent belonged to class 2, thirty five per cent belonged to class 3, seven per cent in class 4 and four per cent in class 5.

4.2 EXISTING WASTE MANAGEMENT METHOD

The different waste management systems adopted in different farms in each class are presented in Table 4.2 and figure 2 The major existing waste management method adopted by commercial dairy farms is manure pit. Forty per cent of the farms had manure pit alone as the waste disposal method where as eleven per cent of the total farms had biogas as the waste disposal method. The rest forty nine per cent of the farms had combined waste management methods.

Table 4.3 indicates the frequency of waste removal and facility for separating liquid and solid waste including fodder waste. Only eleven per cent of the farms under study had a separation facility.. In most of the farms the removal of dung from the shed is mainly just before milking. Regarding the frequency of dung removal since eighty five per cent of farms practiced three times milking, and three times removal of dung. Four per cent of farms had a frequency of two per day where as in rest eleven per cent it was more than three times a day.

4.2.1 Manure pit as waste disposal method

The details of manure pits based on the type, distance of the pit from the farm, covered or not and frequency of the dung removal from the pit in different farms were presented in Table 4.4. The main type of manure pits in commercial dairy farms in Kerala is of concrete type (84.61 per cent). Rest were earthen type.

In all the farms belonging to class 1 category the distance of the pit from the farm is less than five meters. In class four and five it was placed beyond five meters from the farm. Among class 2 farms, 25.64 per cent of farms had their manure pits within a range of 5m. from the farm where as in class 3 the percentage of farms in the same group was only 12.82. In the rest of the farms in both groups the manure pit was located more than 5 meters from the farm.

Covered manure pit was observed in 74.35% of farms under study. More than half of the farms (69.23 per cent) had no regular dung removal, and it was carried upon demand. But 30.76 per cent of the farms showed regularity in the removal of dung. Among this, 23.07 per cent of farms were removing the dung from the pit once in six months where as the remaining 7.69 per cent were practicing this twice in a year.

4.2.2 Compost as Existing waste management system in the farm

Table 4.5 depicts the details of the features of different compost units based on the type, volume frequency of removal of the compost in different farms. Among the six farms having compost unit in association with dairy, only one was with trench type compost unit and rest were raised types.

The classification of compost units based on the size is presented in Table 4.5. Small units of 2 m^3 were present only in two farms. Three had more than $20m^3$ capacity units.

Frequency of removal of compost are presented in Table 4.5.In almost all farms except one there is regular removal of compost. In five farms regular removal and selling was done in once in six months but in one farm regular removal was carried out only once in a year.

4.2.3 Biogas method

The details of the features of different biogas units based on the type, presence of slurry as well as the capacity of unit in different farms were presented in the Table 4.6. The biogas units were of drum type in class four and five category of farms. In class 2 and 3 the biogas unit was of dome type.

Based on the presence of slurry tank the farms are classified in to two.. In most of the farms with a biogas unit there is a slurry tank. Slurry tank was present in fourteen out of eighteen farms. Rest of the farms directly applied the slurry to the fields.

Based on the unit size of biogas plant, the plants were classified into three based on the capacity like less than $2m^3$, 2-10 m^3 and more than $10m^3$. Class 2 farms had only small units that is 2 m^3 mainly. Class four and five category farms were having a capacity upto 10 m^3 where as the farms in class three had biogas units in intermediate sizes.

4.2.4. Combination of methods

The different combinations of waste management employed in different farms in different classes were presented in the table 4.7. Different combinations noted in different farms under study as in table 4.7 are manure pit and biogas, manure pit and land fill, manure pit, biogas and compost as well as biogas and compost. Farm category of class 1 had no combined waste management systems. In class 2 a combination method of manure pit and landfill was seen in highest per cent (45.46) followed by manure pit and biogas (36.36) and manure pit, biogas and compost (18.18). Farms in class 3 also showed a similar pattern but the more number of farms in this group employed manure pit and biogas followed by manure pit and landfill. Manure pit and biogas, manure pit, biogas and compost and biogas and compost were seen in class 4 in equal proportions (one each). In class 5 farms only either manure pit and biogas or manure pit, biogas and compost were seen.

4.3 IMPACT OF DAIRY FARM ON WASTE MANAGEMENT

Based on the existing waste management systems as described above, the farms under study were grouped into group I – the farms in which conventional waste management system exists, group II – farms with compost method alone as the waste management method, group III - farms with biogas unit as the waste management method and group IV – farms with combination of waste disposal methods. The detailed classification is presented in table 4.8. Group IV showed highest per cent of farms (49) followed by group I (40) and group II (11). No farms in the study fell under the category of group III. (Table 4.8 and Figure 4)

4.4. EVALUATION OF SOIL, WATER AND AIR

The details of evaluation of soil, water and air respectively were presented in the table 4.9, 4.10 and 4.11.

4.4.1 Soil

The detailed evaluation of soil based on different parameters like pH, organic carbon, nitrogen, phosphorous and potassium content in the soil were Presented in the table 4.9. The over all mean pH, Organic carbon, Nitrogen(N), Phosphorous(P)and Potassium(K) were 5.77±0.90, 0.64±0.06, 0.06±0.01, 30.02±0.85 and 429±58.08 respectively. Except organic carbon and phosphorous, no other parameters showed a significant difference between groups. Group wise means of the above parameters are also presented in Table 4.9.

The mean pH value for group III was highest (5.92 ± 0.28) followed by group I (5.75 ±0 .17) and group IV (5.74 ± 0.11).

The mean organic carbon level in the soil of different groups were 0.88 ± 0.15, 0.59 ± 0.11 and 0.51± 0.05 respectively in the descending order for groups I, III and IV respectively. Mean value of organic carbon in groups IV and I differed significantly.

The mean value of nitrogen in different groups had only minor variations. The value ranged between 0.05± 0.01 and 0.08 ±0.02.

The mean values of phosphorus content in the soil of different groups differed significantly. The farms in which conventional waste management system exists showed a significantly higher mean than other groups. Group I had a higher mean (34.93± 0.02) followed by group III (29.06 ± 1.80) and group IV (27.07± 0.61). The mean values of phosphorus in the soil content of group III and group IV did not differ significantly.

Potassium content in the soil of different groups, group I showed a higher mean (534.00 ±163.37) followed by group IV (400.73 ± 39.87) and group III (308.60± 13.74) Kg/ha.

4.4.2 Water

The detailed evaluation of biological quality of water based on the pH, BOD_5, coliform count l and *E. coli* count are presented in the Table 4.10

The overall mean pH value of water was 6.27±0.21. Group III showed a slightly higher mean (6.56 ± 0.42) than group I (6.55 ± 0.24). Group IV showed the acidic pH of 5.98 ± 0.35.

The biological oxygen demand of the water provided in the farms ranged from 95.40 ± 74.69(group I) to 350.00 ± 199.02 (group IV). The overall mean BOD reported in the study was 179.63±77.56.

The overall mean value of coliform count is presented in the Table 4.10, along with the group wise means and the count was 2.32±1.9. With respect to the coliform count in the water, the cfu per 100ml ranged from 2.16 ± 1.7(Group IV) to 2.4 ± 1.9 (Group I).

The counts for *E.coli* was more or less same in all groups and the details have been presented in Table 4.10. The overall mean value of E.coli was 1.70±0.77.

4.4.3 Air

The detailed evaluation of air quality based on microbial load and odour annoyance based on nine point hedonic scale were presented in Table 4.11. The microbial load in air samples collected from the three groups showed high microbial load *i.e* more than 300 cfu/ft^2/min. Odour annoyance of farms under study was assessed by nine point hedonic scale. The hedonic tone is an important odour property for assessment of annoyances and determined by means of test persons. The mean value is given by 23.17 and 45.53 and 60.38 for the groups I, II and IV respectively. The result shows higher odour annoyance in farms with dung pit alone as waste management method. It is noted that the majority of manure pits were covered in commercial farms; even then a odour annoyance was reported . In group III where biogas plant was established to manage the waste generated in the farm had a mean value of 45.53 in nine point hedonic scale for odour annoyance. In group IV had scored the highest score (60.38).

Table 4.1. Classification of farms based on the animal holding capacity

Category	Animal holding capacity	Number of farms	Percent
Class 1	Farms below 6 animals	1	4.44
Class 2	6-20 animals	22	48.88
Class 3	21-50 animals	16	35.55
Class 4	51-100 animals	3	6.66
Class 5	>100 animals	2	4.44

N=45

Table 4.2. Classification of farms based on waste management systems.

Farm category	Manure pit	Compost	Biogas	Combination
Class 1	2	_	_	-
Class 2	7	_	4	11
Class 3	9	_	1	6
Class 4	_	_	_	3
Class 5	_	_	_	2
Total	18(40)		5(11)	22(49)

Figures in parenthesis is the per cent of total

Table 4.3. Frequency of waste removal and separation of solid and liquid waste

Sl No	Frequency of waste removal from the farm			Separation of liquid and solid waste including fodder waste	
	2 times	3 times	>3 times	Yes	No
Class 1	-	-	2	0	2
Class 2	-	20	2	2	20
Class 3	2	13	1	1	15
Class 4	-	3	-	1	2
Class 5	-	2	-	1	1
Total	2(4.44)	38(84.44)	5(11.11)	5(11.11)	40(88.89)

Figures in parenthesis is the per cent of total

Total No. of farms under study is 45 (n1:2, n2:22, n3:16, n4:3 and n5:2)

Table 4.4. Details of manure pits in the farms

Class of farm	Type of manure pit			Distance of the pit from the farm		Covered		Frequency of the dung removal from the pit		
	Concrete	Earthen	Allnutt's manure pit	< 5 m	>5m	Yes	No	Once in 6 months or below	Within 6-12 months	Not regular
Class 1	1	1	-	2	-	1	1	-	-	2
Class 2	14	4	-	10	8	12	6	2	2	14
Class 3	14	1	-	5	10	12	3	3	1	11
Class 4	2	-	-	-	2	2	-	2	-	-
Class 5	2	-	-	-	2	2	-	2	-	-
Total	33 (84.61)	6 (15.38)		17	22	29 (74.35)	10 (25.64)	9 (23.07)	3 (7.69)	27 (69.23)

Figures in parenthesis is the per cent of total

Total No. of farms under study is 39 (n1:2, n2:18, n3:15, n4:2 and n5:2)

Table 4.5 Type and measurement of compost unit and frequency of removal of compost

Farm category	Type of the unit		Volume of the unit (m^3)			Frequency of removal of the compost		
	Raised	Trench	2	2-20	>20	Once in 6 months	Within 6-12 months	Not regular
Class 1	-	-	-	-	-	-	-	-
Class 2	2	-	2	-	-	-	1	1
Class 3	-	1	-	1	-	1	-	-
Class 4	2	-	-	-	2	2	-	-
Class 5	1	-	-	-	1	1	-	-

Total No. of farms under study is 6 (n1:0, n2:2, n3:1, n4: 2 and n5:1)

Table 4.6. Type and capacity of biogas units

Class	Type of the biogas unit		Presence of a slurry tank		Capacity of the unit (m^3)		
	Drum	Dome	Yes	No	<2	2-10	>10
Class 1	-	-	-	-	-	-	-
Class 2	-	10	7	3	10	-	-
Class 3	-	5	4	1	-	5	-
Class 4	2	-	2	-	-	-	2
Class 5	1	-	1	-	-	-	1

Total No. of farms under study is 18 (n1:0, n2:10, n3:5, n4:2 and n5:1)

Table 4.7 different combinations of waste management system in dairy farms

Farm category	Manure pit and biogas	Manure pit and land fill	Manure pit, biogas and compost	Biogas and compost
Class 1	–	–	–	–
Class 2	4(36.36)	5(45.46)	2(18.18)	–
Class 3	3(50.00)	2(33.33)	1(16.67)	–
Class 4	-	1(33.33)	1(33.33)	1(33.33)
Class 5	-	1(50.00)	1(50.55)	-

Figures in parenthesis is the per cent of total
Total No. of farms with combined waste management system under study is 22
(n1:0, n2:11, n3:6, n4:3 and n5:2)

Table 4.8 Grouping of farms based on the existing waste management method

Farm type	No of farms	Percentage
Group I	18	40
Group II	0	0
Group III	5	11
Group IV	22	49

Total no of farms under study is 45

Group I – conventional waste management system

Group II –compost method

Group III - biogas unit

Group IV –combination of above

Table 4.9 Mean pH, Organic carbon, Nitrogen, Phophorus and Potassium content of soil

n1=10, n2=0, n3=5and n4=15

Group	pH	Organic carbon (per cent)	Nitrogen% (per cent)	Phosphorus (kg/ha)	Potassium (kg/ha)
I	5.75 ±0 .17	0.88 ± 0.15[a]	0.08 ±0.02	34.93± 0.02[a]	534.00 ±163.37
II	No farms available under this group				
III	5.92 ± 0.28	0.59 ± 0.11[ab]	0.06 ±0.03	29.06 ± 1.8[b]	308.60± 13.74
IV	5.74 ± 0.11	0.51± 0.05[b]	0.05± 0.01	27.07± 0.61[b]	400.73 ± 39.87
Overall	5.77±0.09[ns]	0.64±0.06*	0.06±0.01[ns]	30.02±0.85**	429.80±58.08[ns]

**Significant at 1%level, *significant at 5%level, [ns]-nonsignificant

Letters with different superscript in a column differs significantly($p<0.05$)

Table 4.10 Mean pH, BOD_5 Coliform and *E.coli* count of water

n1=10, n2=0, n3=5and n4=15

Group	pH	BOD_5 (mg/dl)	Coliform count/100 ml	*E.coli* count/100ml
I	6.55 ± 0.24	95.40 ± 74.69	2.4 ± 0.9	1.20 ± 1.01
II	No farms available under this group			
III	6.56 ± 0.42	350.00 ± 199.02	2.27 ± 1.1	1..60±1.0
IV	5.98 ± 0.35	179.00± 77.56	2.16± 1.2	1.67 ± 0.9
Overall	6.27±0.21[ns]	179.63±77.56[ns]	2.32±1.6[ns]	1.70±.77[ns]

ns: Non significant

Table 4.11 Mean microbial load and odour annoyance of air samples

n1=10, n2=0, n3=5and n4=15

Farm Group	Microbial load	Odour Annoyance
I	Above 300	23.17
II	No farms available under this group	
III	Above 300	45.53
IV	Above 300	60.38

Fig 1. Classification of farms based on the animal holding capacity

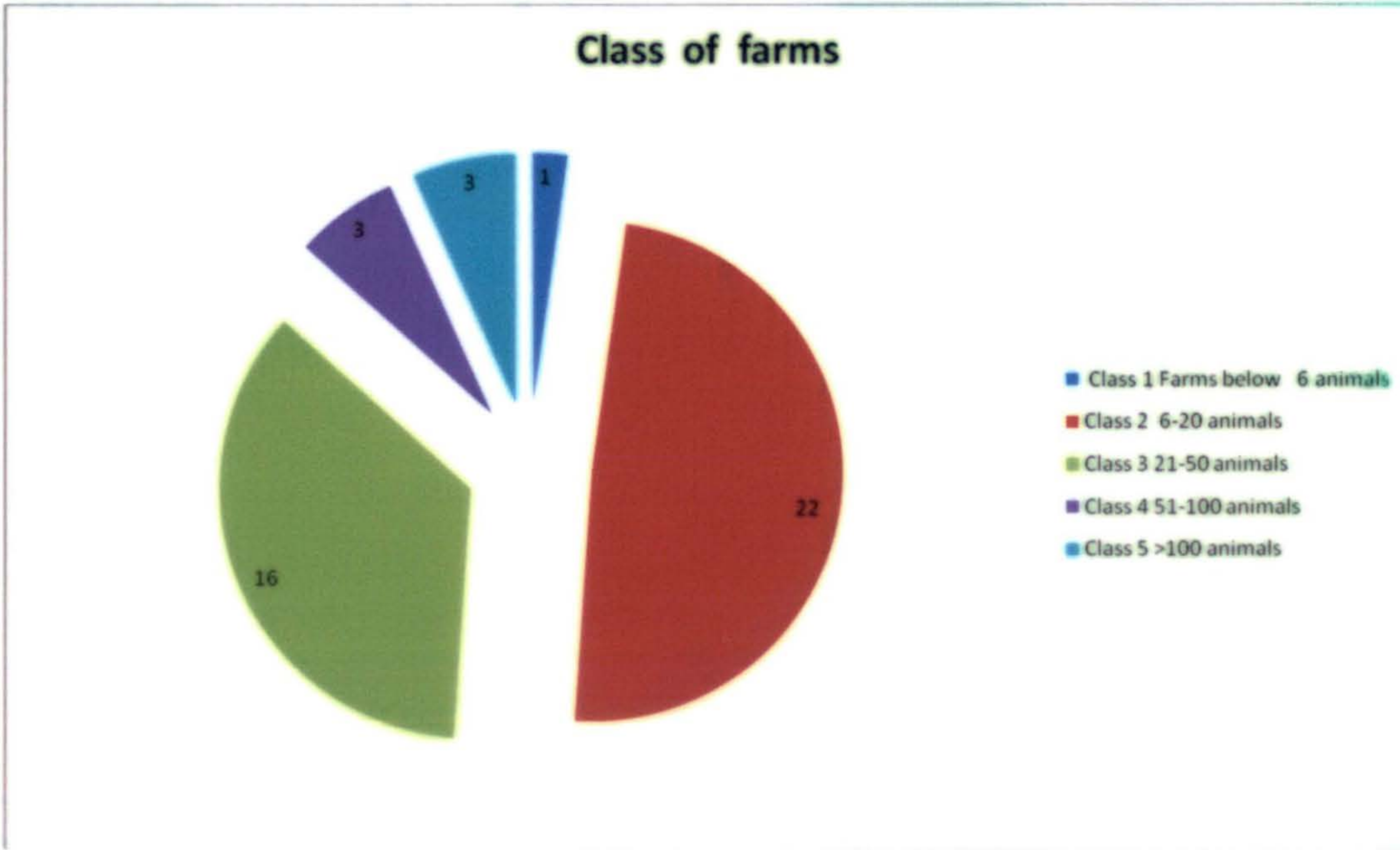

Plate 1. No separate dung and urine channel

Plate 2. Separation between dung and urine

Plate 3. Separate urine channel

Fig 2. Classification of farms based on waste management systems.

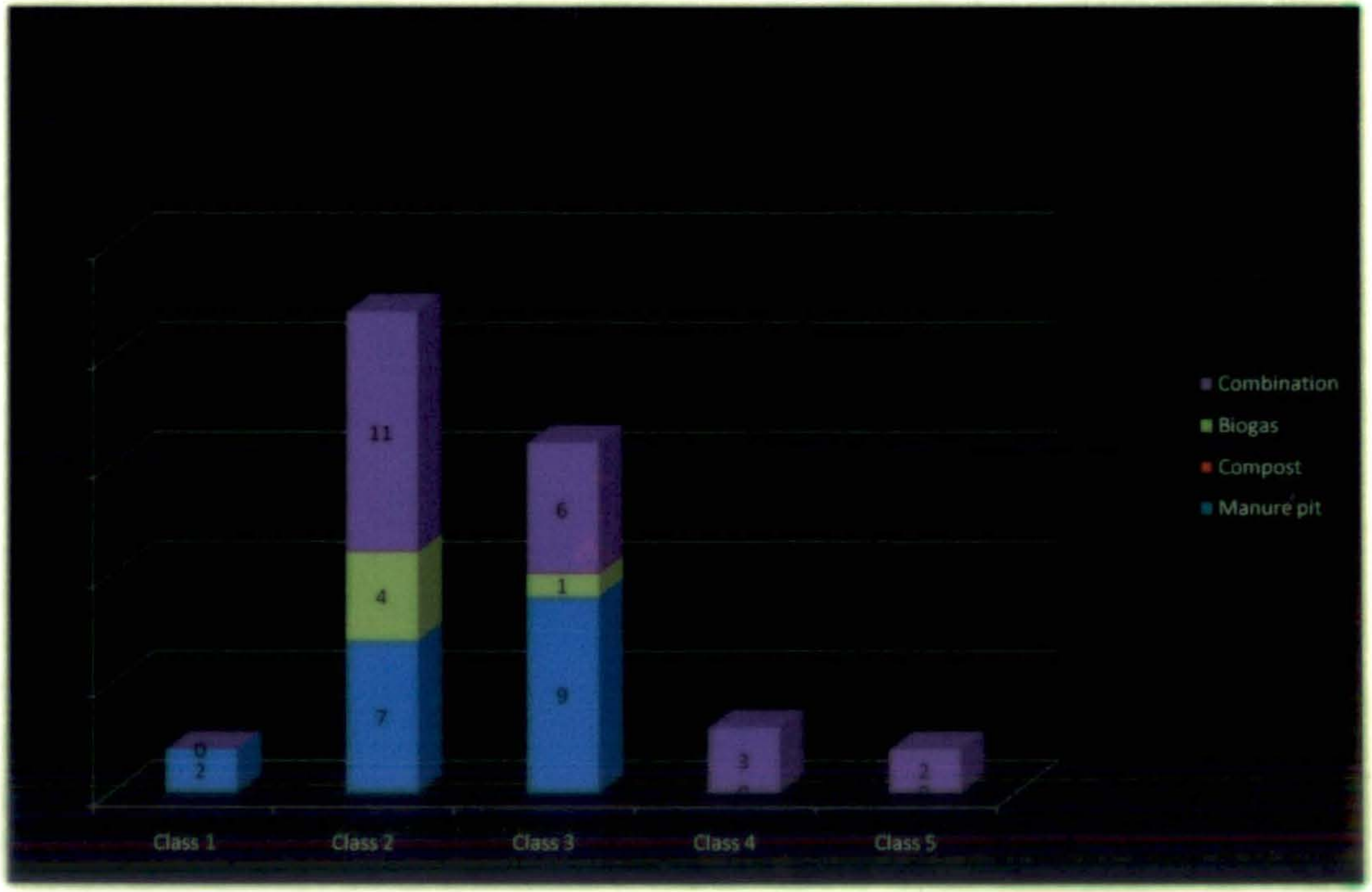

Fig 3 Farms with combination of waste management methods

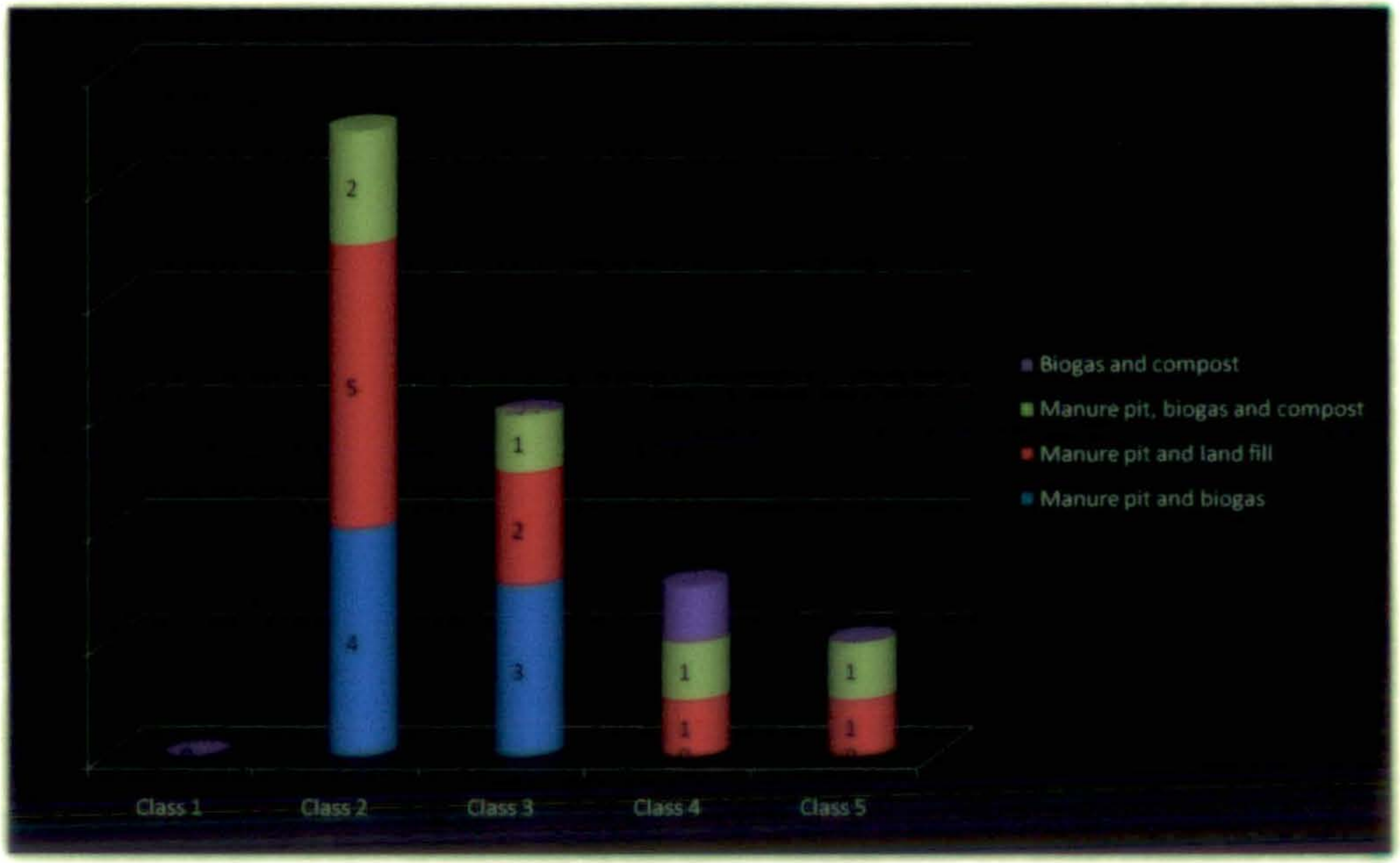

Fig 4. Grouping of farms based on the existing waste management method

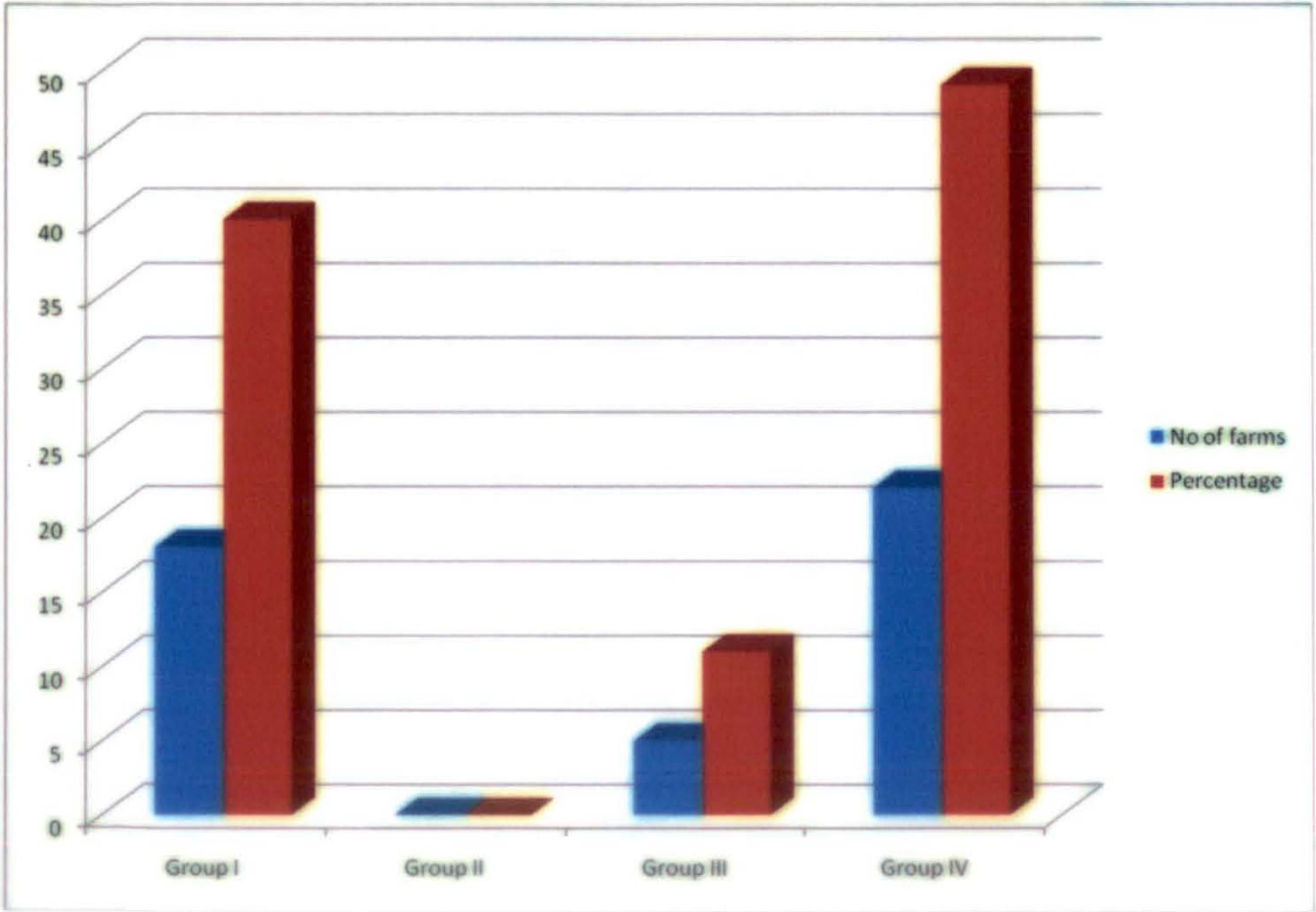

Plate 1. No separate dung and urine channel

Plate 2. Separation between dung and urine

Plate 3. Separate urine channel

Plate 7. Biogas unit

Plate 8. Inlet of biogas unit

Plate 9. Slurry from biogas unit

Plate 4. Dung pit adjacent to animal shed

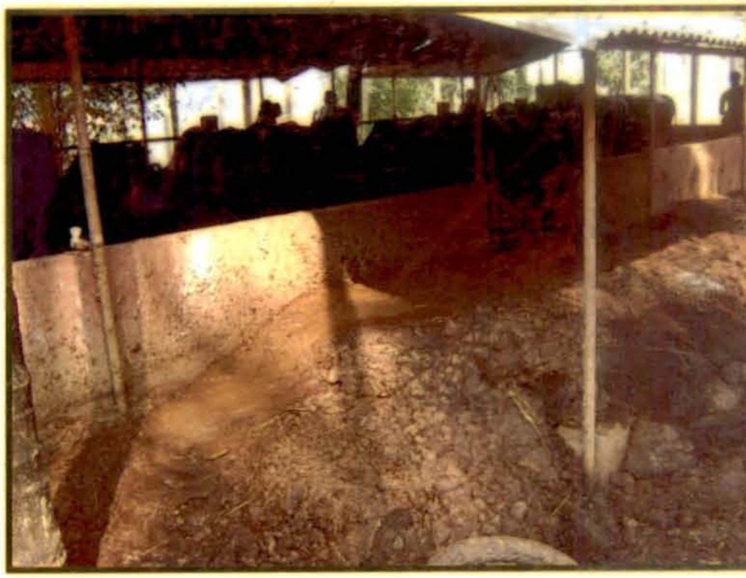

Plate 5. Dung pit away from cow shed

Plate 6. Landfill of dung

Plate 7. Biogas unit

Plate 8. Inlet of biogas unit

Plate 9. Slurry from biogas unit

Plate 10. KVIC Model biogas unit

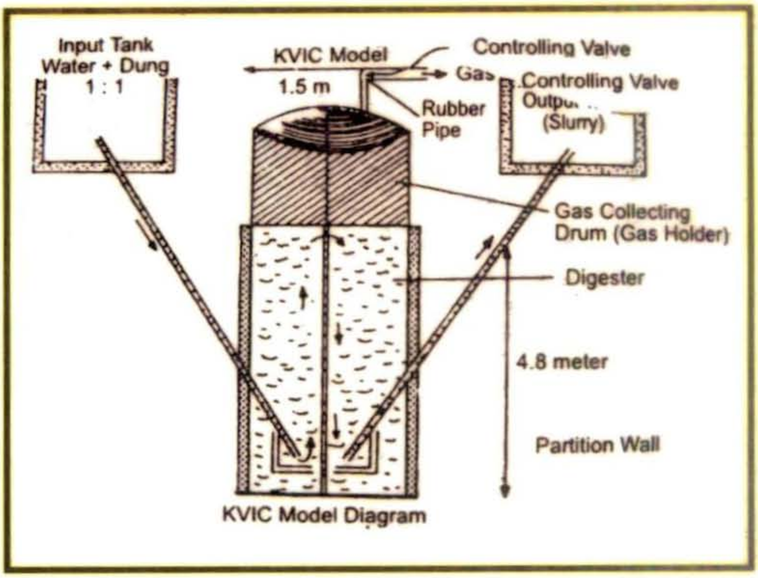

Plate 11. Compost unit

Plate 12. Compost unit

Discussion

5. DISCUSSION

5.1 Animal holding capacity

The dairy farms under study were classified based on the animal holding capacity. Among the 45 farms under study, four percent belonged to class 1, forty nine percent belonged to class 2, thirty five belonged to class 3, six percent farms came under the class 4 and four per cent come under class 5.(Table 4.1and figure 1) The highest percent of farms came under the class 2. This finding is in accordance with the data furnished by *Farms/ Farmers According to Livestock's Data (2003)*, where it states that the average number of animal holding in dairy farms in India is around 17. The number of farms with more than hundred animals are two (four percent) among the farms under study. These findings indicate that there is a transitional change from the traditional small holder dairy units with less than five animals to medium or large scale units demanding new strategies for management and waste disposal. Large scale dairy units which can provide employment for unemployed or under employed people is also a tool to fill the gap between demand and supply of milk in states like Kerala.

5.2 land holdings of the farmers

From the table 4.2 and figure 2 it is clear that the different types of waste management methods adopted in commercial dairy farms are manure pit, compost, biogas and land fill. Senthilkumar *et al.* (2008) also reported the different waste management methods associated with commercial dairy farms as manure pit, compost, biogas and land fill. The highest percent of farms adopted conventional manure Pits. (Forty per cent) This indicates that even though intensification occurred in cattle rearing, there is lack of scientific knowledge in the area of waste management. Linton, (1952) observed the common practice of depositing the manure in a dump immediately outside the buildings.

From the Table 4. 3 it is clear that eighty five percent of farms practiced three times removal of dung from the animal shed. In four percent of farms the frequency is only two per day where as in rest eleven percent, it was more than three per day. Linton (1952) observed that the collection of solid manure in animal habitations under ordinary management is usually carried out once or twice daily. Sastry and Thomas (2008) also stated under ideal managemental conditions solid manure is usually collected and removed from shed twice daily. The increase in the removal frequency is associated with the increase in the milking frequency. Usually dung removal is done in the farm just before milking. Most of the dairy farms were used wheelbarrow for collection and removal of dung from shed. Linton (1952) also observed that the practice of using wheelbarrow or similar vehicle for dung removal as and when the same accumulates.

From the Table 4.3 that liquid separation facility in the waste management system existed only in eleven per cent of total farms. The rest eighty nine per cent farms had no facility to separate solid manure from liquid manure which consisted of urine voided and wash water from sheds. Sastry and Thomas (2008) reported about the practice of direct application of liquid manure to fields of fodder grasses or can be fed as a slurry to bio-gas plants. He exemplified that in Arey Milk Colony, Bombay, fodder grasses are being cultivated economically by irrigating them with wash water from cattle sheds. In Kerala the intensification in the field of dairy sector is an emerging one adopting the conventional system of liquid waste treatment along with solid manure. The lack of separation of liquid manure consisting of urine and shed wash from solid waste leads to increased volume off waste to be treated. Hence a judicious separation of solids and liquid waste is essential for keeping high hygienic status.

5.3 Manure pit

From the Table 4.4 it is clear that eighty four per cent of manure pits are concrete .Rest sixteen per cent was earthen type. In no farms there was an Allnutt's type of manure pit described by Linton (1952) and Sastry and Thomas (2008). This finding reveals that there was no scientific managemental practice adopted by commercial dairy farms in Kerala. It is clear that in all the farms belonging to class 1 category the distance of the pit from the farm is less than five meters. In class four and five it was placed beyond five meters from the farm. Among class 2 farms, 55.56 per cent of farms had their manure pits within a range of 5m. from the farm where as in class 3 the percentage of farms in the same group was only 33.33. In the rest of the farms in both groups the manure pit was located more than 5 meters from the farm. It is recommended in the Draft Proposal for Waste Disposal in Commercial Dairy farms of ministerial level conference (2006) the manure pit must be located at least 25 meter away from dwelling. It is also noted that out of forty five studied, 10 farms had no covering for manure pits. The lack of cover leads to accumulation of water during rainy season leading to serious hazards in environmental pollution. From Table 4.4, it can be seen that more than half of the farms (71%) had no regularity in dung removal from the manure pit , and it was carried upon demand. But twenty nine per cent of the farms showed regularity in the removal of dung. Among this, twenty one per cent of farms were removing the dung from the pit once in six months where as the remaining eight per cent were practicing this twice in a year. The above said ministerial level conference (2006) recommended the waste should not be allowed to accumulate in the pit, in order to avoid pollution issues. The waste disposals in dairy farms were carried out upon demand only. So this may sometimes lead to accumulation in the farm, if there is less demand for cow dung especially in rainy season. There should be a regular outlet for cow dung.

5.4 Compost

From the table 4.5 it is noted that out of the forty five studied six farms has raised type of compost unit and only one had trench type it is noted that the advantages of traditional composting as a waste management method was not fully exploited by the farmers. The frequency of removal of compost is not regular in farm. In five farms regular removal and selling were done. Four farms had more than 20m^3 capacity units. Frequency of removal of compost in different farms are presented in table 4.5.In almost all farms except one there is regular removal of compost. In five farms regular removal and selling was done in once in six months but in one farm regular removal was carried out only once in a year. Mahto and Yadav (2005) studied the compost making using cow dung and reported it was the best method to adopt as an ecofriendly waste management strategy.

5.7 Biogas Units

From table 4.6 it is clear that two types of biogas plants were established in commercial dairy farms *viz,* drum as well as dome types. The biogas units were of drum type in class four and five of farms. Rest was of dome type in class 2 and 3. Depending on the presence of slurry tank the farms are classified in to two and the details are figured in table 4.6. In most of the farms with a biogas unit there is a slurry tank except three in class two. Slurry tank was present in 75% of farms. Twenty five per cent farms directly applied the slurry to the fields. The biogas units are classified into three based on the capacity like less than 2m^3, 2-10 m^3 and more than 10m^3. Class 2 farms had only small units that is 2 m^3 mainly.

Class four and five category farms were having a capacity >10 m^3 where as the farms in class three had biogas units in intermediate sizes. The advantage of biogas plant technology is that the plant can be constructed based on the raw materials to digest is available the plant can be constructed. Hence it is better establish to a biogas plant associated with each dairy farm. In the commercial farms in which biogas had existed as the waste management strategy had a ready source of energy for cooking purpose especially to meet the kitchen needs of resident labours of the farm. Institute of Science and Technology (2005) recommended establishment of biogas plants in all dairy farms in India, based on the availability of waste generated in the farm. The biogas technology open avenue for the most efficient waste management system in which biofuel is tapped from the organic waste without reducing the manorial value of the organic waste.

5.6 Combined waste management system

The different combinations of waste management employed in different farms in different classes were presented in the Table 4.7 and Figure 4, as manure pit and biogas, manure pit and land fill, manure pit, biogas and compost as well as biogas and compost. Farm under class 1 had no combined waste management systems. In class 2 a combination of manure pit and landfill was seen in highest per cent (55.56) followed by manure pit and biogas (44.44) and manure pit, biogas and compost (22.22). Farms in class 3 also showed a similar pattern but the more number of farms in this group employed manure pit and biogas followed by manure pit and landfill. Manure pit and biogas, manure pit, biogas and compost and biogas and compost were seen in class 4 in equal proportions (one each). In class 5 farms only either manure pit and biogas or manure pit, biogas and compost were seen. Senthilkumar *et al.* (2008) also reported the different waste management methods associated with commercial dairy farms as manure pit, compost and biogas.

Thus there will not be a single "best "design. It is particularly important that the already existing design can be modified in response to climatic condition, species, building type, enterprise size, proximity and type of neighbors.

Based on the existing waste management systems as described above, the farms under study were grouped into group I – the farms in which conventional waste management system exists, group II – farms with compost method alone as the waste management method, group III - farms with biogas unit as the waste management method and group IV – farms with combination of waste disposal methods. The detailed classification is presented in table 4.8. Group IV showed highest per cent of farms (49) followed by group I (40) and group II·(11). No farms in the study fell under the category of group II (Table 4.8 and Figure 4).

5.7 Soil, Water and Air Quality

From Table 4.9 it can be seen that average phosphorus content of farms under study in the three groups are above 25 kg/hectare which is high the rating chart of soil testing data. Here in three of the groups P value came under 25 kg/hectare. It is in accordance with the reports of Organic Agriculture Center of Canada (OACC). Irrespective of the waste management method, the soil K level remained more than 280 kg/ha according to rating chart for soil test. Here in three groups the value is high. Irrespective of the waste management method the soil nitrogen level remained high (above 0 .05 %.) It is reported even though the dairy wastes are commonly applied to crop lands as fertilizer, the nitrogen release and transformation is difficult to predict. (Shi et *al.,* 1976) .The soil nitrogen content in different groups of dairy farm showed no significant difference. PH of the soil of the farms remained acidic. In general Kerala soil pH is estimated as acidic as per reports of Department of agriculture, Government of Kerala (5.5-6.5).

Presented in the table 4.10 are the results of evaluation of biological quality of water based on the pH, BOD, Coli form count per 100ml and *E. coli* count.

The overall mean pH value of water was 6.27±0.21. Group III showed a slightly higher mean (6.56 ± 0.42) than group I (6.55 ± 0.24). Group IV showed the acidic pH of 5.98 ± 0.35. The results show the pH is within the range 6-9 which is recommended by IS2296 (1974).

Presented in Table 4.10 are the BOD_5 of the three groups as well as over all value The biochemical oxygen demand of the water provided in the farms ranged from 95.40 ± 74.69(group I) to 350.00 ± 199.02 (group IV). The overall mean BOD reported in the study was 179.63±77.56. According to IS2296 (1974) standards BOD_5 of drinking water should be 3 mg/dl. All the groups had very high value of BOD_5 than recommendation.

The highest BOD_5 value from water samples collected from the farms under study indicate that the lack of systematic and scientific waste management methods in all the farms. This is an emerging issue demanding predestined waste management model for different classes of dairy farms. Intervention by the government, local bodies and scientific institutions must be made in this area supporting the farmers to develop awareness in this serious issue and also providing necessary technical and financial support for the farmers to construct proper waste management system.

The overall mean value of coliform count is presented in the table 4.10 along with the group wise means and the count was 209.53±48.68. With respect to the Coliform count in the water, the cfu per 10 0ml ranged from 146.13 ± 62.19 (Group IV) to 315.00 ± 85.52 (Group I). The result obtained indicates that all the groups have the value higher than the recommended microbial load permitted, irrespective of the waste management method adopted in the farm. The counts for *E.coli* count was more or less same in all groups and the details are presented in table 4.10. The overall mean value of E.coli was 50.17±6.00. This value is also higher than the BIS (1993) recommendation that is drinking water should be devoid of any *E coli* in 100 ml of sample.

From Table 4.11 it can be noted that the microbial load in air samples collected from the three groups showed high microbial load *i.e* more than 300 cfu/ft^2/min. The counts obtained in the present study from various farms were above the standards prescribed by APHA (Hickley, *et al.* 1992). The observation on the microbial load in the air samples collected from the farm indicate that serious interventions are essential to reduce the air pollution in the farm.

Odour annoyance of farms under study was assessed by nine point hedonic scale. The mean value is given by 23.17 and 45.53 and 60.38 for the groups I II and IV respectively. The result shows higher odour annoyance in farms with dung pit alone as waste management method. It is noted that the majority of manure pits were covered in commercial farms; even then there reported a odour annoyance. In group III where biogas plant was established to manage the waste generated in the farm had a mean value of 45.53 in nine point hedonic scales for odour annoyance. In group IV had scored the highest score (60.38). The scale consists of a grade ranging from -4 to +4 indicates value from 0-100 in the hedonic scale. Farms with manure pit existed as waste management system had scored least mean i.e, 23.17. Farms with biogas unit existed as waste management system had scored 45.53 and farms with combined waste management method, scored highest mean 60.38. The hedonic tone is an important odour property for assessment of annoyances and determined by means of test persons.. Observation in the odour annoyance tested, reveals that biogas technology and combination of different waste management methods are effective tools to improve the quality of air in the farm vicinity.

Summary

6. SUMMARY

There are many farms in Kerala with alleged complaints. So the study of the existing waste management method is a necessity of today. The dairy farms under study were classified based on the animal holding capacity as those with less than six animals (class 1), 6-20 animals (class 2), 21-50 animals (class 3),and 51-100 animals (class 4), and above 100 animals (class 5). Among the 45 farms under study, four per cent belonged to class 1 and 5, forty nine percent belonged to class 2, thirty five belonged to class 3, six percent farms came under the class 4 The highest percent of farms came under the class 2. The number of farms with more than a hundred animals are three (six per cent) among the farms under study. These findings indicate that there is a transitional change from the traditional small holder dairy units with less than five animals to medium or large scale units demanding new strategies for management and waste disposal. Large scale dairy units which can provide employment for unemployed or under employed people is also a tool to fill the gap between demand and supply of milk in states like Kerala. Eighty five percent of farms practiced three times removal of dung from the animal shed. In four percent of farms the frequency is only two per day where as it is eleven percent in the remaining farms in which , it was more than three per day. Linton (1952) observed that the collection of solid manure in animal habitations under ordinary management is usually carried out once or twice daily. The rest 89 %farms had no facility to separate solid manure from liquid manure which consisted of urine voided and wash water from sheds. Sastry and Thomas (2008) reported about the practice of direct application of liquid manure to fields of fodder grasses or can be fed as slurry to bio-gas plants. In Kerala, the intensification in the dairy sector is an emerging one adopting the conventional system of liquid waste treatment along with solid manure. The lack of separation of liquid manure consisting of urine and shed wash from solid waste leads to increased volume of waste to be treated. Hence a judicious separation of solids and liquid waste is essential for keeping high hygienic status . 84% of manure pits are concrete .Rest 16% are earthern type. The waste

disposal in dairy farms was carried out upon demand only. So this may sometimes lead to accumulation in the farm, if there is less demand for cow dung especially in rainy season. There should be a regular outlet for cow dung. Out of the forty five studied, six farms has raised type of compost unit and only one had trench type. It is noted that the advantages of traditional composting as a waste management method was not fully exploited by the farmers. Mahto and Yadav (2005) studied the compost making using cow dung and reported that it was the best method to adopt as a ecofriendly waste management strategy.

Two types of biogas plants were established in commercial dairy farms *viz,* drum as well as dome types. The biogas units were of drum type in class 4 and 5 of farms. Rest was of dome type in class 2 and 3. Depending on the presence of slurry tank the farms are classified into two. . In most of the farms with a biogas unit there is a slurry tank except three in class two. Slurry tank was present in 75% of farms. Twenty five per cent farms directly applied the slurry to the fields. The biogas technology open avenue for the most efficient waste management system in which biofuel is tapped from the organic waste without reducing the manorial value of the organic waste. the different combinations of waste management employed in different farms in different classes as manure pit and biogas, manure pit and land fill, manure pit, biogas and compost as well as biogas and compost. Thus there will not be a single "best "design. It is particularly important that the already existing design can be modified in response to climatic condition, species, building type, enterprise size, proximity and type of neighbors.

Based on the existing waste management systems, as described above, the farms under study were grouped into group I – the farms in which conventional waste management system exists, group II – farms with compost method alone as the waste management method, group III - farms with biogas unit as the waste management method and group IV – farms with combination of waste disposal methods. The detailed classification is presented in table 4.8. Group IV showed highest per cent of farms (49) followed by group I (40) and group II (11). No farms in the study fell under the category of group II. Irrespective of the waste management method the soil nitrogen,phosphorus and potassium level remained high The results shows the pH is within the range 6-9 which is recommended by IS2296 (1974). According to IS2296 (1974) standards BOD_5 of drinking water should be 3 mg/dl. All the groups had BOD_5 values much higher than recommendation The highest BOD value from water samples collected from the farms under study indicate that the lack of systematic and scientific waste management methods in all the farms. This is an emerging issue demanding predesigned waste management model for different classes of dairy farms. Intervention by the government, local bodies and scientific institutions must be made in this area supporting the farmers to develop awareness in this serious issue and also providing necessary technical and financial support for the farmers to construct proper waste management system The overall mean value of E.coli was 50.17±6.00. This value is also higher than the BIS (1993) recommendation which is drinking water should be devoid of any *E coli* in 100 ml of sample. The observation on the microbial load in the air samples collected from the farm indicate that serious interventions are essential to reduce the air pollution in the farm. Observation in the odour annoyance tested, reveals that biogas technology and combination of different waste management methods are effective tools to improve the quality of air in the farm vicinity.

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Appendix 1

Questionnaire on Waste Management System

A) Name of the owner of the farm:

B) Address of the farm:

C) Sex : a) Male ☐ b) Female ☐

D) Land holding of the farm: a) Five or above acres ☐ b) Between 2-5 acres. ☐

c) Less than two acres ☐

Q1) No. of total animals in the farm: a) Less than six animals ☐ b) 6-20 animals ☐

c) 21-50 animals ☐ d) 51-100 animals ☐

e) Above 100 animals ☐

Q 2) Frequency of waste removal from the farm in a day: a) 2 times ☐ b) 3 times ☐

c) >3 times ☐

Q 3) Separation of liquid and solid waste including fodder waste: a) Yes ☐ b) No ☐

Q 4) whether i\there is separation of liquid and solid waste: a) Yes ☐ b) No ☐

Q 5) Existing waste management system in the farm

a) Manure pit a) Yes ☐ b) No ☐
If yes,

i) Type of manure pit : a) Concrete ☐ b)Earthen ☐ c) Allntt's manure pit ☐

ii) Distance of the pit from the farm: a) < 5 m ☐ b) >5m ☐

iii) Whether it is covered: a) Yes ☐ b) No ☐

iv) Frequency of dung removal from the pit: a) Once in 6 months or below ☐

b) Within 6-12 months ☐

c) Not regular ☐

b) Compost unit: a) Yes ☐ b) No ☐
If yes,

i) Type of the unit: a) Raised ☐ b) Trench ☐

ii) Measurement of the unit (m^3): a) 2 ☐ b) 2-20☐

c) >20☐

iii) Frequency of removal of the compost: a) once in 6 months ☐

b) Within 6-12 months ☐

c) Not regular☐

c) Biogas unit: a) Yes ☐ b) No ☐
If yes,

i) Type of the unit: a) Drum☐ b) Dome ☐

ii) Capacity of the unit (m^3) : a) <2 ☐ b) 2-10 ☐ c) >10 ☐

iii) Presence of a slurry tank: a) Yes☐ b) No ☐

d) Combination of waste management systems: a) Yes ☐ b) No ☐
If yes,

a) Manure pit and biogas ☐ b) Manure pit and land fill☐

c) Manure pit, biogas and compost ☐ d) Biogas and compost ☐

WASTE MANAGEMENT SYSTEM EVALUATION IN COMMERCIAL DAIRY FARMS

SANY THOMAS

Abstract of the thesis submitted in partial fulfillment of the

requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University, Thrissur

2009

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ABSTRACT

The present study on "Waste management system evaluation in commercial dairy farms" was conducted to assess the usefulness of the different waste management methods adopted in dairy farms of Kerala. Study area comprised of Thrissur, Malappuram and Ernakulam districts and adjoining area of central and northern Kerala. Forty five dairy farms were identified and visited in and their profile of the study area .Data regarding general outlay of the farms selected management practices in the farm, livestock details and existing waste management methods in the farms were collected and studied. The dairy farms under study were classified based on the animal holding capacity as those with less than six animals (class 1), 6-20 animals (class 2), 21-50 animals (class 3)and 51-100 animals (class 4), and above 100 animals (class 5). Among the 45 farms under study, four per cent belonged to class 1, forty nine per cent belonged to class 2, thirty five belonged to class 3, six per cent farms came under the classes 4 and 5.There was no commercialization of waste management methods adopted by the farms. The majority farms had dung pit as waste disposal method and no regularity in dung removal from pit, it was upon demand. Regarding the soil quality, there was no significant difference in the soil nutrients quantity between different groups of farms. Regarding water quality, the water samples collected from the nearby water bodies were inferior in quality in terms of microbiology and BOD. Air quality stands below the permitted standards in all groups of farms. Intervention by the government, local bodies and scientific institutions must be made in this area supporting the farmers to develop awareness in this serious issue and also providing necessary technical and financial support for the farmers to construct proper waste management systems such as compost unit as well as biogas plants because they provide a support for the most efficient waste management system in a dairy farm proving that waste is wealth.

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DECLARATION

I hereby declare that this thesis, entitled **"WASTE MANAGEMENT SYSTEM EVALUATION IN COMMERCIAL DAIRY FARMS"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

SANY THOMAS

Mannuthy,
31-10-2009.

CERTIFICATE

Certified that this thesis, entitled **"WASTE MANAGEMENT SYSTEM EVALUATION IN COMMERCIAL DAIRY FARMS"** is a record of research work done independently by **Sany Thomas**, under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Sany Thomas

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Dedicated to Palamattam

1. INTRODUCTION

Man has utilized livestock for many purposes like food and as a source of draught power throughout history. During the past twenty years, however, there has been a major change in livestock production practices due to specialization and intensification. As animals have been concentrated and the number increased in individual enterprises, the quantity of manure, requiring management, has increased. When animals are dispersed in woodland, pasture, or range areas, manure is distributed and the soil provides continuous assimilation. But in confined and intensified production systems, the manure disposal requires special techniques for handling and often proves staggering to confinement producers. In addition to the manure quantities produced by various livestock and poultry species, there are the additional volumes of bedding, waste water and wasted fodder which adds to the total bulk of waste produced which has to be managed. In this respect manure disposal problem became evident and there has emerged a need for development of livestock waste management technology.

India is basically an agrarian country. Livestock and crop production activities generate huge amount of biodegradable waste. Annually, India generates about 1677 million tonne animal waste, 500 million tonne agro waste, 4.5 million tonne food and fruit processing waste and 27.4 million tonne municipal solid waste. With increasing economic development resulting due to a rise in the population, there is increasing potential for livestock farming in India. Livestock sector in India has experienced remarkable growth during the last two decades due to

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increased demand for livestock based products. Increased livestock population can lead to the multiplication in production of livestock wastes. The safe disposal of huge quantity of biodegradable organic waste has become major problem in preserving environmental quality. This organic waste accumulates and causes pollution unless directed to biological pathways to return into active ecosystem. (Singh, 2008)

Waste can be defined as an unnecessary, unusable commodity at a given place, at a given time. The same substance becomes an usable commodity or a product, when properly managed and at a different place or different time So the term waste is a misnomer, because ultimately it is a usable commodity or livestock product which must be utilized carefully and productively. Livestock waste management is important for the economic survival of an enterprise. The large quantity of manure generated, if properly handled and utilized, is an asset.

Environmental issues relating to livestock farming are nowadays increasing and create a bottleneck in the establishment and running of animal farms. Since, livestock farming enterprises have a great potential in employment generation, food security and sustainable development, it is highly essential to formulate strategies for designing environment friendly livestock production system. Presently commercial dairy farms are not following a pattern of waste management system. The pollution caused by different farms varies due to their difference in the waste management system followed. So there is an emerging need for suggesting a cost efficient system for waste management in commercial dairy farms. Under these circumstances the present study was envisaged with the following objectives:

1 .To study the existing animal farm waste management in commercial dairy units

2. To study the effect of animal stocking on the quality of water, soil and air.

3. To suggest possible improvement in the existing waste management systems for dairy farms in Kerala

Review of Literature

2. REVIEW OF LITERATURE

2.1 WASTE GENERATED IN A DAIRY FARM

Bewick (1980) reported that the livestock waste include farm yard manure, which is the solid manure (where straw and other bedding is mixed with dung, urine and feed waste.) and the slurry and the liquid manure (which is the mixture of feces, urine and wash water from the animal houses).

Sastry and Thomas (2008) classified manure as (i) solid- (dung, feed wastes, soiled bedding) and (ii) liquid-(urine and wash water).

2.1.1 Quantity of waste generated

Tunney (1977) opinioned that the daily waste production by cattle was around 40-50Kg per day per livestock unit.

Bewick (1980) observed that the waste products from livestock could be enormous, on an average daily undiluted fresh manure production was equalent to five to eight per cent of animal live weight.

Sastry *et.al.* (1994) estimated that the livestock waste production in cattle farming was forty Kg per day per adult animal unit.

Sastry and Thomas (2008) reported the density of manure is as 700 to 1000 kg/m^3 and that of stored and decomposed manure as 1000 to 1300 kg/m^3 The size and number of manure pits required, depended on the production of manure on the farm, which was on an average 40 kg per day per adult unit or AU.

2.1.2 Composition of dairy solid waste

Dewi *et al.* (1994) observed that the nutrient content of farm yard manure and slurry was highly valuable. They reported average values of Nitrogen. Phosphorus, Potassium content of farm yard manure as 2, 0.4 and 1.7 per cent respectively.

Sastry and Thomas (2008) had found out that cattle dung has 77.5% water, 20.3% organic matter, 0.34%nitrogen, 0.16% phosphoric acid, 0.04% potash and 0.31% lime.

Senthilkumar *et al.* (2008) reported that undigested protein was also excreted in the faeces and the excess nitrogen from the digested protein was excreted in urine as urea. Potassium was absorbed during digestion, but most of it was excreted through urine. Calcium, manganese, iron and phosphorus were excreted mostly in faeces. The faeces of ruminants consisted mainly of undigested materials and it also contained residues from digestive fluids, waste mineral matter, worn out cells from gastrointestinal tract, bacteria and foreign matter.

2.1.3 Removal of manure from farm sheds

Linton (1952) observed that the collection of solid manure in animal habitations under ordinary management was usually carried out once or twice daily. Removal from the building was usually effected either by means of a wheelbarrow or similar vehicle, or often by simply throwing the manure through an open door on to a dump situated immediately outside the buildings.

Sastry and Thomas (2008) stated that under ideal managemental conditions solid manure was usually collected and removed from shed twice daily. Provisions were to be made to carry off and store liquid manure as and when the same accumulates.

2.1.4 Liquid manure

Kaneko *et.al.* (1997) stated that the most important livestock products were the cow dung and cow urine. Cow produces 17-45 ml of urine per Kg body weight per day. This means production of 6-15 liters of cow urine per animal per day.

2.1.4.1 Liquid manure removal

Sastry and Thomas (2008) stated that the liquid manure and wash water from the shed drained by a shallow 'U' shaped gutter located longitudinally to the long axis of the shed.

Sastry and Thomas (2008) stated that the mixed wash water could be directly led to fields of fodder grasses or could be fed as slurry to bio-gas plants. In Arey Milk Colony, Bombay, fodder grasses were being cultivated economically by irrigating them with wash water from cattle sheds.

Sastry and Thomas (2008) observed that the width of the drains might vary from thirty to forty cm. A slope of 1 in 40 should be provided to the drains towards storage tank so that liquid might flow down easily. Shallow 'U' shaped drains were preferable to drains with cut sides,

2.2 WASTE DISPOSAL METHODS IN A DAIRY FARM

Senthilkumar *et al.* (2008) observed that there were various methods for handling and treating animal waste in which the simplest and most effective method was to utilize them as a soil nutrient by recycling it back to the soil. Methods that were available for applying animal excreta into the soil included,. direct surface application followed by immediate ploughing, application after processing as Farm Yard Manure (FYM), conversion into compost, vermicomposting and biogas plants to produce gas and slurry manure.

2.2.1 Direct surface application

Sharma (2007) stated that the traditional method of utilization of livestock waste products was their direct application to their crop fields.

Senthilkumar *et al.* (2008) opinioned that both liquid and solid waste were directly spread on the open fields and subjected to sun drying under natural conditions. This was the oldest and cheapest method of recycling animal waste; the end products were carbon dioxide and water with an accumulation of nitrogen, sulphur, phosphorus and minerals in the soil. This method was environmentally undesirable. There was partial decomposing of organic matter with valuable losses of nitrogen and energy.

2.2.2. Spreading or drying of manure

Linton (1952) opinioned that, the spreading was a method which was suitable in hot, dry climates which consisted of spreading of manure within 24 hours of its being voided each day's output of manure in a thin layer. In certain circumstances, manure might be carted direct from the animal buildings to the land without any period of storage intervening. He also observed the common practice of depositing the manure in a dump immediately outside the buildings, and into which the drainage system empties, was most objectionable. A concrete pathway should connect the buildings and the manure pit and, where it was possible, accessibility to the latter from a hard road was an advantage when it comes to transferring the manure to the land.

Linton (1952) proposed that a proper system for hygienic disposal of animal excreta. As far as the livestock sanitation was concerned, the disposal of animal manure should be simple and as practicable as possible. So that they did not serve as a vehicle for the propagation of disease or become a source of public nuisance.

ICAR (2002) recommended that the application of animal manure to crops was considered as a method of disposing waste and of clearing storage system. Average daily amount of dung and feaces produced on a farm vary depending on the feed material and body weight of animal. The disposal of the manure might be done as solid, liquid or separated manure. Manure pits or slurry pits could be used for the manure disposal. Manure deposited could be scraped daily by tractor and blades, mechanical scraper, or flushed periodically with water for cleaning.

2.2.3 Manure pit

Sastry and Thomas (2008) stated that the manure pit should be placed as far from the buildings and they recommended that for reasons of hygiene, manure pits should be at a minimum distance of 10m from wells, rivers and tanks and from the boundary of the adjoining land property. Further, they must be impermeable to water.

2.2.4 Composting

Helton (2008) stated that livestock manure had been applied throughout recorded history as a soil amendment to improve soil properties and supply required nutrients for growth. Raw and composted manures generally acted as slow-release nutrient sources that could improve soil physical and chemical properties by increasing organic matter content while providing plant nutrients. Composting was a manure management strategy being evaluated because it produced a product that was more easily handled and stored than manure due to reduced weight and volume. Compost had less odour and temperatures developed during the composting process killed most pathogens and viable weed seeds.

Senthilkumar *et al.* (2008) stated that composting was a natural process in which organic matter was decomposed by micro-organisms forming humus like substance. This process was in practice for centuries by farmers who stock dung into piles or in pits. Composting was either aerobic or anaerobic. The advantages of aerobic decomposition were shorter stabilization time, absence of foul smell and destruction of weeds and pathogens.

2.2.5 Vermicomposting

Hamza (2004) stated that the all crops removed enormous quantity of nutrients through produce. In order to make the soil sustainable we must had to replenish the nutrient removed by the produce. Organic manures were essential to sustain crop production and preserves soil health and soil bio diversity.

Isaac and Nair (2004) stated that the decomposition was essentially a biological process that resulted in the breakdown of the organic material and release of nutrients entrapped in the tissues.

Sharma and Agarwal (2004) stated that the main goal and benefit of using earth worms for waste management was to convert organic waste into fertilizer. Vermicompost basically consisted of wormcasts in addition to some decayed organic matter. Earthworms actually consume the organic matter along with the microorganisms and amazingly their casts had contained eight times as many microorganisms as they fed. Their cast did not contain any disease pathogens, as pathogenic bacteria were reliably killed in the worm gut. It required low energy input, it provided a product with a valuable end use (fertilizer) and it relied on simple natural processes without the input of natural chemicals or relied on large scale industrial processes.

Maurya *et al* (2006) stated that the recycling of organic refuse through earthworm was called vermin-composting. It provided nitrogen, phosphorus, potassium, calcium, magnesium and micro-nutrients such as iron, molybdenum, and Copper. It also contained growth producing substances such as cytokinine.

Hemavathy and Balaji (2007) reported that the use of animal manure completed the nutrient cycle allowing for a return of energy and fertilization nutrients to the soil. Use of manure from livestock, feedlots and dairies and their compost in commercial organic agriculture was promising. Compost was beneficial in number of ways. It contained antibiotics and antagonists to soil pests allowing for increased plant resistance to attacks, increased crop yields, was important in weed control and builds up soil organic matter.

Senthilkumar *et al.* (2008) stated that vermicomposting was the method of composting aided by earthworms. Worms fed on the organic waste converting it into castings which have high manurial value. Vermicomposting achieved abatement of organic pollution by reduction in waste's bulk density and reduction of foul odour. They opined that vermiculture was the latest technique, which was 100 times more efficient than any other conventional techniques. Use of earthworms for waste disposal achieved three ideal objectives such as upgrading the value of the original waste materials so that they could be reduced, production of the upgraded materials *in situ* without having to transport waste material over long distance ,yielding of a final product free of chemical or biological pollutants.

Senthilkumar *et al.* (2008) stated that the composting was a more ecofriendly method of recycling waste which provided several advantages like increased availability of plant nutrients, destruction of pathogens, elimination of unfavorable odours and easy handling.

Singh (2008) stated that an economic and eco-friendly method and an alternative to existing methods for organic waste disposal was composting. Nowa days vermimanure production had become a lucrative business for commercial producers and an additional income for the farmers. Verbiotechnology also helped in maintaining clean and healthy environment and promotion of sustainable agriculture,

Sunil and Manjula (2009) stated that the production of NPK fertilizers in India were less than the required quantity and it was estimated that about 5 to 7 million metric tonne of NPK fertilizers would be the short fall in the next two decades. Organic manures such as vermicompost, bio-fertilizers would form the source to bridge this concerning gap.

2.2.5.1. Vermiculture / Vermibiomanuring/ Vermiwash

Praveen *et al.* (2004) stated that it was a simple biotechnological process of composting in which animal and farm waste harbor species of earthworms and microorganisms which were used to enhance and accelerate the process of waste conversion into value added organic products of vermibiomanure and nutriwash. Earth worm digested animal dung and farm waste. These organic matters had undergone complex microbial and biochemical changes in earthworm gut and excreted out in granular form with earthy smell. The multiplication of earthworms and favorable microorganisms (using earthworm as bioreactors) in organic waste was called vermiculture. These vermicasting were rich in diverse microbial and enzymatic activity and moisture holding capacity and contained nutrients such as nitrogen, potassium, phosphorus, calcium and magnesium in the forms readily taken by plants.

Preetha *et al.* (2004) opinioned that the vermiculture technology involving the use of earth worms as versatile natural bioreactors was an effective method of recycling non toxic organic waste. The earth worms in the compost would increase the nutrient content of the compost.

Sulochana and Tirkey (2006) stated that the vermi-composting being an eco-friendly and cost effective process, could be used as a means to overcome the hazards as well as to substantiate a part of organic matter required for fields and aquaculture.

Kumar *et al.* (2007) stated that the vermicomposting was a method of preparation of organic manure from bio agro wastes with the help of earthworm and the excreta of earthworms was called as vermicast. These castings were biologically active and very available to plants. .

Singh (2008) stated that the liquid extracts from vermibiomanure and wash of earth worms were termed s nutriwash. Nutriwash promoted growth when sprayed or watered on around the plants.

2.2.6 Biogas technology

Senthilkumar *et al.* (2008) reported that, one Kg of cattle dung produces about $0.073m^3$ (1.3 cubic feet) of biogas at atmospheric pressure. The availability of dung from a medium size cow was approximately 10 kg per day. For the smallest plant producing 1.7 m^3 (60 cubic feet) of biogas, waste from at least 5 head of cattle was necessary. Biogas (1.7 m^3) produced from this small plant was considered sufficient to meet the cooking and lighting needs of a four member family. He opined that two products obtained from the plant were biogas and fermented slurry. Biogas was non-poisonous, with a characteristic odour, which disappears on burning. When mixed with air, it burned with a non-luminous blue flame without producing any stroke. It had a very low level of inflammability. Biogas was used for household cooking, lighting and power. Special lamps are available for lighting where biogas could be used.

Thomas (2008) observed biogas plants were attracting the attention of farmers and research workers, as it fulfil two purposes- one to provide fuel and the other to give quality manure.

2.3 IMPACT OF DAIRY FARM WASTE ON ENVIRONMENT

Shelton (2004) stated that effective management of manure had become a focus of many livestock producers due to increasing environmental concerns such as water quality and odour control, and to better capitalize on the fertilizer value of manure. A best management practice was to incorporate manure into the soil to maximize nutrient availability especially nitrogen, and to minimize odours and potential degradation of surface water quality through run off .Incorporation of manure reduce odour levels upto 90% compared with surface broadcasting.

2.3.1 Water

Overcash *et al.* (2000) stated that the water quality impact of animal waste could be evaluated in terms of organic matter, plant nutrients and pathogenic microorganisms. They opined that livestock wastes were the potential source of nitrogen and phosphorus of the surface waters.

2.3.2 Air

Overcash *et al.* (2000) stated that without adequate handling capabilities, manure became an ever accumulating liability, whose odour served as a incessant reminder of the deficiencies of the system.

2.4. ASSESSMENT OF IMPACT OF DAIRY FARM WASTE ON ENVIRONMENT

2.4.1. On water

Latha *et al.* (2003) stated that water is an important and unique environmental source required for the growth and development of a healthy community. They observed that routine assessment of microbiological quality of drinking water sources was essential for ensuring supply of safe and wholesome water.

In India, wells formed the main source of water supply. Bacteriological quality of well water was studied by many workers in India. Oommen (1981) noticed that gross contamination of well water occurs mainly with bacterial organisms present in animal excreta. The assessment of water quality using coliform and *Escherichia coli* counts was conducted by Rameteke et al. (1990, 1992) Guar et al. (1992) Gomathinarayanan *et al.* (1994) and Choudhury *et al.* (1996).

2.4.1.1. Biological Oxygen Demand

Overcash *et al.* (2000) stated that the bio degradable organic matter concentration of waste water was characterized by Biological Oxygen Demand test (BOD_5). BOD_5 was determined by measuring the quantity of dissolved oxygen utilized by aerobic micro organism in stabilizing the organic or carbonaceous matter during a specified period of time and at a constant temperature usually 5 days and 20^0C.

Maurya *et al.* (2006) stated that animal manure used in organic farming include FYM, biogas slurry etc. Even though organic manure contain low nitrogen, potassium and phosphorus as compared to inorganic fertilizers, it was superior due to supply of micro-nutrients improves physical condition of soil. They hastened the growth and development by populating growth regulators where as organic manure acted as slow releasing fertilizers. Because of slow release of ammonia and slow conversion to nitrates, the leaching losses of N was low in the presence of organic manures.

Singhvi *et al.* (2006) stated that materials of vegetable and animal origin formed could be added to soil regardless of stage of decomposition. Organic manure which were bulky in nature but supplied the plant nutrients in small quantities were termed as bulky organic manure. Eg. FYM.

Senthilkumar *et al* (2008) reported that the FYM was the decomposed mixture of dung and urine of farm animals along with litter, left over fodder fed to the animals. It was estimated that FYM from all animal excreta in India could supply 6.33 million tones of nitrogen, P_2O_5 and K_2O per annum. A well decomposed FYM contained 0.7-1.3 per cent nitrogen, 0.3-0.8 per cent P_2O_5 and 0.4-1.0 per cent K_2O on dry weight basis. It was also influenced by the processed of handling and storage. Under normal conditions, there was invariable loss of nutrients either by leaching or volatilization when manure remained exposed to rain and sun.

2.4.1.2. *E.coli*

Oommen (1981) noticed that gross contamination of well water occurred mainly with bacterial organisms present in animal excreta.

Shaiju *et al.* (2007) stated that presence of coliform bacteria was used as an indicative of pathogenic bacteria and feacal pollution. The reason for the microbial pollution of wells was the poor construction of wells.

2.5 WASTE IS WEALTH

Overcash *et al.* (2000) opined that additional advantage of a ruffed confinement system for beef production were increased conservation of plant nutrients, high level of insect, odour and pollution control that was possible, for that, need a waste management system rather than a separate solid-liquid handling.

Durham (2003) reported that composting is one of several technologies used to treat animal manure, sewage sludge, and other organic residues which may contain pathogens or parasites of public health concern. In any manure slurry system, solids can be composed. The demand for animal manure is projected to increase. As organic vegetables and fruits gain popularity, more growers value its benefits to soil quality and to the environment.

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Materials and Methods

3. MATERIALS AND METHODS

3.1 STUDY AREA

Study area comprised of Thrissur, Malappuram, and Ernakulam districts and adjoining area of these three districts.

3.2 SURVEY

Local veterinary doctors were interviewed to find out the profile of dairy farms.

3.2.1 FARMS UNDER STUDY AND THEIR PROFILE

Forty five dairy farms were identified and visited. Data regarding general outlay of the farms, selected management practices in the farm, livestock details and existing waste management methods in the farms were collected and studied.

3.3 ANIMAL HOLDING CAPACITY OF THE FARM

The dairy farms under study were classified based on the animal holding capacity as those with less than six animals (class 1), 6-20 animals (class 2), 21-50 animals (class 3),and 51-100 animals (class 4), and above 100 animals(class 5). The classification was based on the recommendations of Ministerial level conference (Reports of Ministerial level conference, 2006).

3.4 EXISTING WASTE MANAGEMENT METHOD IN THE FARM

The farms under study were visited and details taken, regarding sustainability of existing waste disposal method, different aspects waste management like frequency of waste removed, separation of liquid and solid waste exist and quantity of waste generated in the farm.

3.3.1 Manure Pit

In the farms under study where manure pit was used as existing waste management method, the pits were classified as Earthen/ Concrete/ Allnutt's manure pit .The distance of the pit from the farm, whether it was covered or not and frequency of waste removal from the manure pit were also recorded.

3.3.2 Compost

In the farms under study where compost was used as existing waste management method the composting systems were classified as Trench/Raised. The measurement of the unit size (in m^3) and frequency of waste removal from the compost unit were also recorded.

3.3.3 Biogas plant

In the farms under study where biogas unit was used as existing waste management method, the biogas units were classified based on the data on type of the biogas unit *viz* Dome/ Drum. The measurement of the unit (in m^3) and presence of slurry tank associated with unit as mode of utilization of slurry were studied.

3.3.4. Combination of methods

The farms using two or more of methods of waste disposal were used were classified as compost – manure pit method, manure pit-land fill, biogas-compost, and combination of manure pit, biogas and compost method.

Based on the overall findings on waste management system followed the farms under study were randomly grouped into four groups *viz* group I (farms with manure pit as waste management method-conventional), group II (farms with compost units as waste management) group III (farms with biogas as waste management method) and group IV (farms with a combination of different waste management methods).

3.4.1. Soil

3.4.1.1 Sampling and analysis of soil l

Soil samples were collected from 30 farms selected at random from the waste management sites and at a distance of 5mfrom the farm point in each farm. Sampling was done according to Department of Agriculture, Government of Kerala recommendations. (2006). . Samples were dried under shade and analyzed in the laboratory for Nitrogen, Phosphorus, Potassium, Total carbon and pH by methods described by Tandon (1994) and Vijayan (2000).

3.5.2. Water

Water samples were collected from nearest available water bodies within a distance of 10m from waste management site using standard sampling techniques in 30 farms selected at random.(Kim and Feng, 2001).

3.5.2. 1 Coliform count

Coliform count of water sample was estimated using the procedure described by Kornacki and Johnson (2001).

3.5.2.2 Escherichia coli Count

Escherichia coli count per ml of water sample was estimated according to the procedure described by Kornacki and Johnson (2001) using Eosin Methylene Blue (EMB) Agar.

3.5.2.3 pH of water sample

The pH of water samples collected was measured, using the method described by Scott *et al* (2001). The pH was recorded using a digital pH meter. (LI 612 ELICO)

3.5.2.4. BOD_5 of water sample

The BOD_5 of water samples were determined by the standard photometric method (Chapman and Kimstach,1996) using the instrument by Spectroquant NOVA 60, Merck photometer (Merck, Germany)

3.5.3. Air

3.5.3.1. Collection and estimation of microbial load in the air

The Total Viable Count (TVC) of air samples were estimated by air samples collected from livestock farms under study using the direct exposure method described by Evancho et al(2001)

3.5.3.2. Odour annoyance

The odour annoyance was studied using a nine point hedonic scale (McGinley, 2005).

3.9 STATISTICAL ANALYSIS OF THE DATA

The data collected was analyzed statistically as per methods described Snedecor and Cochran (1994) and Statistical Package for the Social sciences(SPSS,2007).

Results

4. RESULTS

4.1 AREA OF THE STUDY

Kerala with an area of 38,863 sq. km. and a total population of 29.099 million is one of the thickly populated states of our country. The ever increasing demand for milk leads to the intensification of the cattle rearing in Kerala. Lack of scientific knowledge in animal husbandry practices, eventually resulted in the ineffective waste management and subsequent environmental pollution and neighborhood problems. Forty five commercial dairy farms identified randomly for studying the nature of existing waste management systems, were located Thrissur, Malappuram and Ernakulam districts and adjoining areas of Kerala.

4.1.1 Animal holding capacity

The details of the classification of dairy farms are presented in Table 4.1 and depicted in Figure 1 and per cent of farms available in each class. Among the forty five farms under study, four per cent belonged to class 1, forty nine per cent belonged to class 2, thirty five per cent belonged to class 3, seven per cent in class 4 and four per cent in class 5.

4.2 EXISTING WASTE MANAGEMENT METHOD

The different waste management systems adopted in different farms in each class are presented in Table 4.2 and figure 2 The major existing waste management method adopted by commercial dairy farms is manure pit. Forty per cent of the farms had manure pit alone as the waste disposal method where as eleven per cent of the total farms had biogas as the waste disposal method. The rest forty nine per cent of the farms had combined waste management methods.

Table 4.3 indicates the frequency of waste removal and facility for separating liquid and solid waste including fodder waste. Only eleven per cent of the farms under study had a separation facility.. In most of the farms the removal of dung from the shed is mainly just before milking. Regarding the frequency of dung removal since eighty five per cent of farms practiced three times milking, and three times removal of dung. Four per cent of farms had a frequency of two per day where as in rest eleven per cent it was more than three times a day.

4.2.1 Manure pit as waste disposal method

The details of manure pits based on the type, distance of the pit from the farm, covered or not and frequency of the dung removal from the pit in different farms were presented in Table 4.4. The main type of manure pits in commercial dairy farms in Kerala is of concrete type (84.61 per cent). Rest were earthen type.

In all the farms belonging to class 1 category the distance of the pit from the farm is less than five meters. In class four and five it was placed beyond five meters from the farm. Among class 2 farms, 25.64 per cent of farms had their manure pits within a range of 5m. from the farm where as in class 3 the percentage of farms in the same group was only 12.82. In the rest of the farms in both groups the manure pit was located more than 5 meters from the farm.

Covered manure pit was observed in 74.35% of farms under study. More than half of the farms (69.23 per cent) had no regular dung removal, and it was carried upon demand. But 30.76 per cent of the farms showed regularity in the removal of dung. Among this, 23.07 per cent of farms were removing the dung from the pit once in six months where as the remaining 7.69 per cent were practicing this twice in a year.

4.2.2 Compost as Existing waste management system in the farm

Table 4.5 depicts the details of the features of different compost units based on the type, volume frequency of removal of the compost in different farms. Among the six farms having compost unit in association with dairy, only one was with trench type compost unit and rest were raised types.

The classification of compost units based on the size is presented in Table 4.5. Small units of 2 m^3 were present only in two farms. Three had more than $20m^3$ capacity units.

Frequency of removal of compost are presented in Table 4.5.In almost all farms except one there is regular removal of compost. In five farms regular removal and selling was done in once in six months but in one farm regular removal was carried out only once in a year.

4.2.3 Biogas method

The details of the features of different biogas units based on the type, presence of slurry as well as the capacity of unit in different farms were presented in the Table 4.6. The biogas units were of drum type in class four and five category of farms. In class 2 and 3 the biogas unit was of dome type.

Based on the presence of slurry tank the farms are classified in to two.. In most of the farms with a biogas unit there is a slurry tank. Slurry tank was present in fourteen out of eighteen farms. Rest of the farms directly applied the slurry to the fields.

Based on the unit size of biogas plant, the plants were classified into three based on the capacity like less than $2m^3$, 2-10 m^3 and more than $10m^3$. Class 2 farms had only small units that is 2 m^3 mainly. Class four and five category farms were having a capacity upto 10 m^3 where as the farms in class three had biogas units in intermediate sizes.

4.2.4. Combination of methods

The different combinations of waste management employed in different farms in different classes were presented in the table 4.7. Different combinations noted in different farms under study as in table 4.7 are manure pit and biogas, manure pit and land fill, manure pit, biogas and compost as well as biogas and compost. Farm category of class 1 had no combined waste management systems. In class 2 a combination method of manure pit and landfill was seen in highest per cent (45.46) followed by manure pit and biogas (36.36) and manure pit, biogas and compost (18.18). Farms in class 3 also showed a similar pattern but the more number of farms in this group employed manure pit and biogas followed by manure pit and landfill. Manure pit and biogas, manure pit, biogas and compost and biogas and compost were seen in class 4 in equal proportions (one each). In class 5 farms only either manure pit and biogas or manure pit, biogas and compost were seen.

4.3 IMPACT OF DAIRY FARM ON WASTE MANAGEMENT

Based on the existing waste management systems as described above, the farms under study were grouped into group I – the farms in which conventional waste management system exists, group II – farms with compost method alone as the waste management method, group III - farms with biogas unit as the waste management method and group IV – farms with combination of waste disposal methods. The detailed classification is presented in table 4.8. Group IV showed highest per cent of farms (49) followed by group I (40) and group II (11). No farms in the study fell under the category of group III. (Table 4.8 and Figure 4)

4.4. EVALUATION OF SOIL, WATER AND AIR

The details of evaluation of soil, water and air respectively were presented in the table 4.9, 4.10 and 4.11.

4.4.1 Soil

The detailed evaluation of soil based on different parameters like pH, organic carbon, nitrogen, phosphorous and potassium content in the soil were Presented in the table 4.9. The over all mean pH, Organic carbon, Nitrogen(N), Phosphorous(P)and Potassium(K) were 5.77±0.90, 0.64±0.06, 0.06±0.01, 30.02±0.85 and 429±58.08 respectively. Except organic carbon and phosphorous, no other parameters showed a significant difference between groups. Group wise means of the above parameters are also presented in Table 4.9.

The mean pH value for group III was highest (5.92 ± 0.28) followed by group I (5.75 ±0 .17) and group IV (5.74 ± 0.11).

The mean organic carbon level in the soil of different groups were 0.88 ± 0.15, 0.59 ± 0.11 and 0.51± 0.05 respectively in the descending order for groups I, III and IV respectively. Mean value of organic carbon in groups IV and I differed significantly.

The mean value of nitrogen in different groups had only minor variations. The value ranged between 0.05± 0.01 and 0.08 ±0.02.

The mean values of phosphorus content in the soil of different groups differed significantly. The farms in which conventional waste management system exists showed a significantly higher mean than other groups. Group I had a higher mean (34.93± 0.02) followed by group III (29.06 ± 1.80) and group IV (27.07± 0.61). The mean values of phosphorus in the soil content of group III and group IV did not differ significantly.

Potassium content in the soil of different groups, group I showed a higher mean (534.00 ±163.37) followed by group IV (400.73 ± 39.87) and group III (308.60± 13.74) Kg/ha.

4.4.2 Water

The detailed evaluation of biological quality of water based on the pH, BOD_5, coliform count l and *E. coli* count are presented in the Table 4.10

The overall mean pH value of water was 6.27±0.21. Group III showed a slightly higher mean (6.56 ± 0.42) than group I (6.55 ± 0.24). Group IV showed the acidic pH of 5.98 ± 0.35.

The biological oxygen demand of the water provided in the farms ranged from 95.40 ± 74.69(group I) to 350.00 ± 199.02 (group IV). The overall mean BOD reported in the study was 179.63±77.56.

The overall mean value of coliform count is presented in the Table 4.10, along with the group wise means and the count was 2.32±1.9. With respect to the coliform count in the water, the cfu per 100ml ranged from 2.16 ± 1.7(Group IV) to 2.4 ± 1.9 (Group I).

The counts for *E.coli* was more or less same in all groups and the details have been presented in Table 4.10. The overall mean value of E.coli was 1.70±0.77.

4.4.3 Air

The detailed evaluation of air quality based on microbial load and odour annoyance based on nine point hedonic scale were presented in Table 4.11. The microbial load in air samples collected from the three groups showed high microbial load *i.e* more than 300 cfu/ft^2/min. Odour annoyance of farms under study was assessed by nine point hedonic scale. The hedonic tone is an important odour property for assessment of annoyances and determined by means of test persons. The mean value is given by 23.17 and 45.53 and 60.38 for the groups I, II and IV respectively. The result shows higher odour annoyance in farms with dung pit alone as waste management method. It is noted that the majority of manure pits were covered in commercial farms; even then a odour annoyance was reported . In group III where biogas plant was established to manage the waste generated in the farm had a mean value of 45.53 in nine point hedonic scale for odour annoyance. In group IV had scored the highest score (60.38).

Table 4.1. Classification of farms based on the animal holding capacity

Category	Animal holding capacity	Number of farms	Percent
Class 1	Farms below 6 animals	1	4.44
Class 2	6-20 animals	22	48.88
Class 3	21-50 animals	16	35.55
Class 4	51-100 animals	3	6.66
Class 5	>100 animals	2	4.44

N=45

Table 4.2. Classification of farms based on waste management systems.

Farm category	Manure pit	Compost	Biogas	Combination
Class 1	2	_	_	-
Class 2	7	_	4	11
Class 3	9	_	1	6
Class 4	_	_	_	3
Class 5	_	_	_	2
Total	18(40)		5(11)	22(49)

Figures in parenthesis is the per cent of total

Table 4.3. Frequency of waste removal and separation of solid and liquid waste

Sl No	Frequency of waste removal from the farm			Separation of liquid and solid waste including fodder waste	
	2 times	3 times	>3 times	Yes	No
Class 1	-	-	2	0	2
Class 2	-	20	2	2	20
Class 3	2	13	1	1	15
Class 4	-	3	-	1	2
Class 5	-	2	-	1	1
Total	2(4.44)	38(84.44)	5(11.11)	5(11.11)	40(88.89)

Figures in parenthesis is the per cent of total

Total No. of farms under study is 45 (n1:2, n2:22, n3:16, n4:3 and n5:2)

Table 4.4. Details of manure pits in the farms

Class of farm	Type of manure pit			Distance of the pit from the farm		Covered		Frequency of the dung removal from the pit		
	Concrete	Earthen	Allnutt's manure pit	< 5 m	>5m	Yes	No	Once in 6 months or below	Within 6-12 months	Not regular
Class 1	1	1	-	2	-	1	1	-	-	2
Class 2	14	4	-	10	8	12	6	2	2	14
Class 3	14	1	-	5	10	12	3	3	1	11
Class 4	2	-	-	-	2	2	-	2	-	-
Class 5	2	-	-	-	2	2	-	2	-	-
Total	33 (84.61)	6 (15.38)		17	22	29 (74.35)	10 (25.64)	9 (23.07)	3 (7.69)	27 (69.23)

Figures in parenthesis is the per cent of total

Total No. of farms under study is 39 (n1:2, n2:18, n3:15, n4:2 and n5:2)

Table 4.5 Type and measurement of compost unit and frequency of removal of compost

Farm category	Type of the unit		Volume of the unit (m^3)			Frequency of removal of the compost		
	Raised	Trench	2	2-20	>20	Once in 6 months	Within 6-12 months	Not regular
Class 1	-	-	-	-	-	-	-	-
Class 2	2	-	2	-	-	-	1	1
Class 3	-	1	-	1	-	1	-	-
Class 4	2	-	-	-	2	2	-	-
Class 5	1	-	-	-	1	1	-	-

Total No. of farms under study is 6 (n1:0, n2:2, n3:1, n4: 2 and n5:1)

Table 4.6. Type and capacity of biogas units

Class	Type of the biogas unit		Presence of a slurry tank		Capacity of the unit (m^3)		
	Drum	Dome	Yes	No	<2	2-10	>10
Class 1	-	-	-	-	-	-	-
Class 2	-	10	7	3	10	-	-
Class 3	-	5	4	1	-	5	-
Class 4	2	-	2	-	-	-	2
Class 5	1	-	1	-	-	-	1

Total No. of farms under study is 18 (n1:0, n2:10, n3:5, n4:2 and n5:1)

Table 4.7 different combinations of waste management system in dairy farms

Farm category	Manure pit and biogas	Manure pit and land fill	Manure pit, biogas and compost	Biogas and compost
Class 1	–	–	–	–
Class 2	4(36.36)	5(45.46)	2(18.18)	–
Class 3	3(50.00)	2(33.33)	1(16.67)	–
Class 4	-	1(33.33)	1(33.33)	1(33.33)
Class 5	-	1(50.00)	1(50.55)	-

Figures in parenthesis is the per cent of total
Total No. of farms with combined waste management system under study is 22
(n1:0, n2:11, n3:6, n4:3 and n5:2)

Table 4.8 Grouping of farms based on the existing waste management method

Farm type	No of farms	Percentage
Group I	18	40
Group II	0	0
Group III	5	11
Group IV	22	49

Total no of farms under study is 45

Group I – conventional waste management system

Group II –compost method

Group III - biogas unit

Group IV –combination of above

Table 4.9 Mean pH, Organic carbon, Nitrogen, Phophorus and Potassium content of soil

n1=10, n2=0, n3=5and n4=15

Group	pH	Organic carbon (per cent)	Nitrogen% (per cent)	Phosphorus (kg/ha)	Potassium (kg/ha)
I	5.75 ±0 .17	0.88 ± 0.15^{a}	0.08 ±0.02	34.93 ± 0.02^{a}	534.00 ±163.37
II	No farms available under this group				
III	5.92 ± 0.28	0.59 ± 0.11^{ab}	0.06 ±0.03	29.06 ± 1.8^{b}	308.60± 13.74
IV	5.74 ± 0.11	0.51 ± 0.05^{b}	0.05± 0.01	27.07 ± 0.61^{b}	400.73 ± 39.87
Overall	5.77 ± 0.09^{ns}	$0.64 \pm 0.06^{*}$	0.06 ± 0.01^{ns}	$30.02 \pm 0.85^{**}$	429.80 ± 58.08^{ns}

**Significant at 1%level, *significant at 5%level, ^{ns}-nonsignificant

Letters with different superscript in a column differs significantly($p<0.05$)

Table 4.10 Mean pH, BOD_5 Coliform and *E.coli* count of water

n1=10, n2=0, n3=5and n4=15

Group	pH	BOD_5 (mg/dl)	Coliform count/100 ml	*E.coli* count/100ml
I	6.55 ± 0.24	95.40 ± 74.69	2.4 ± 0.9	1.20 ± 1.01
II	No farms available under this group			
III	6.56 ± 0.42	350.00 ± 199.02	2.27 ± 1.1	1..60±1.0
IV	5.98 ± 0.35	179.00± 77.56	2.16± 1.2	1.67 ± 0.9
Overall	6.27 ± 0.21^{ns}	179.63 ± 77.56^{ns}	2.32 ± 1.6^{ns}	$1.70 \pm .77^{ns}$

ns: Non significant

Table 4.11 Mean microbial load and odour annoyance of air samples

n1=10, n2=0, n3=5and n4=15

Farm Group	Microbial load	Odour Annoyance
I	Above 300	23.17
II	No farms available under this group	
III	Above 300	45.53
IV	Above 300	60.38

Fig 1. Classification of farms based on the animal holding capacity

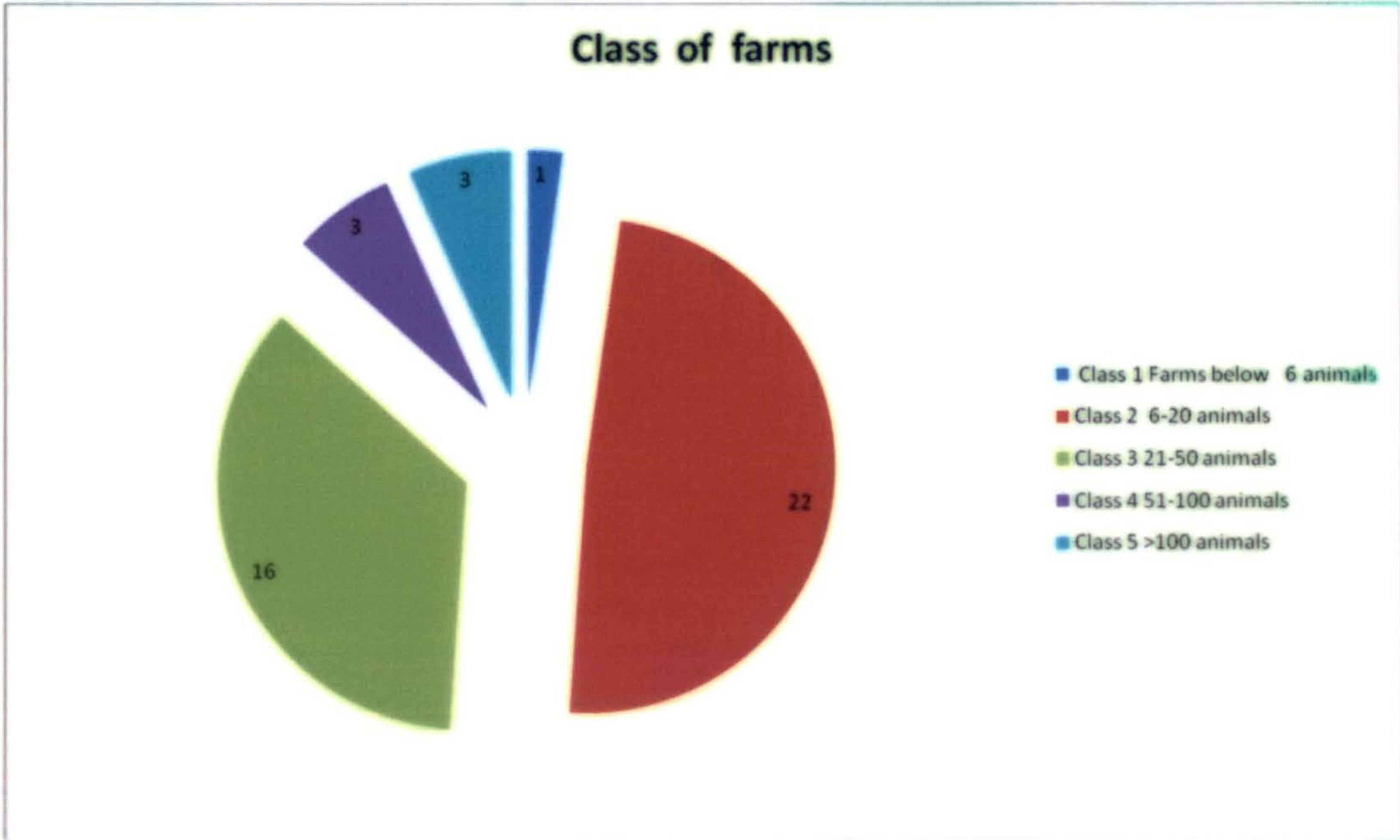

Plate 1. No separate dung and urine channel

Plate 2. Separation between dung and urine

Plate 3. Separate urine channel

Fig 2. Classification of farms based on waste management systems.

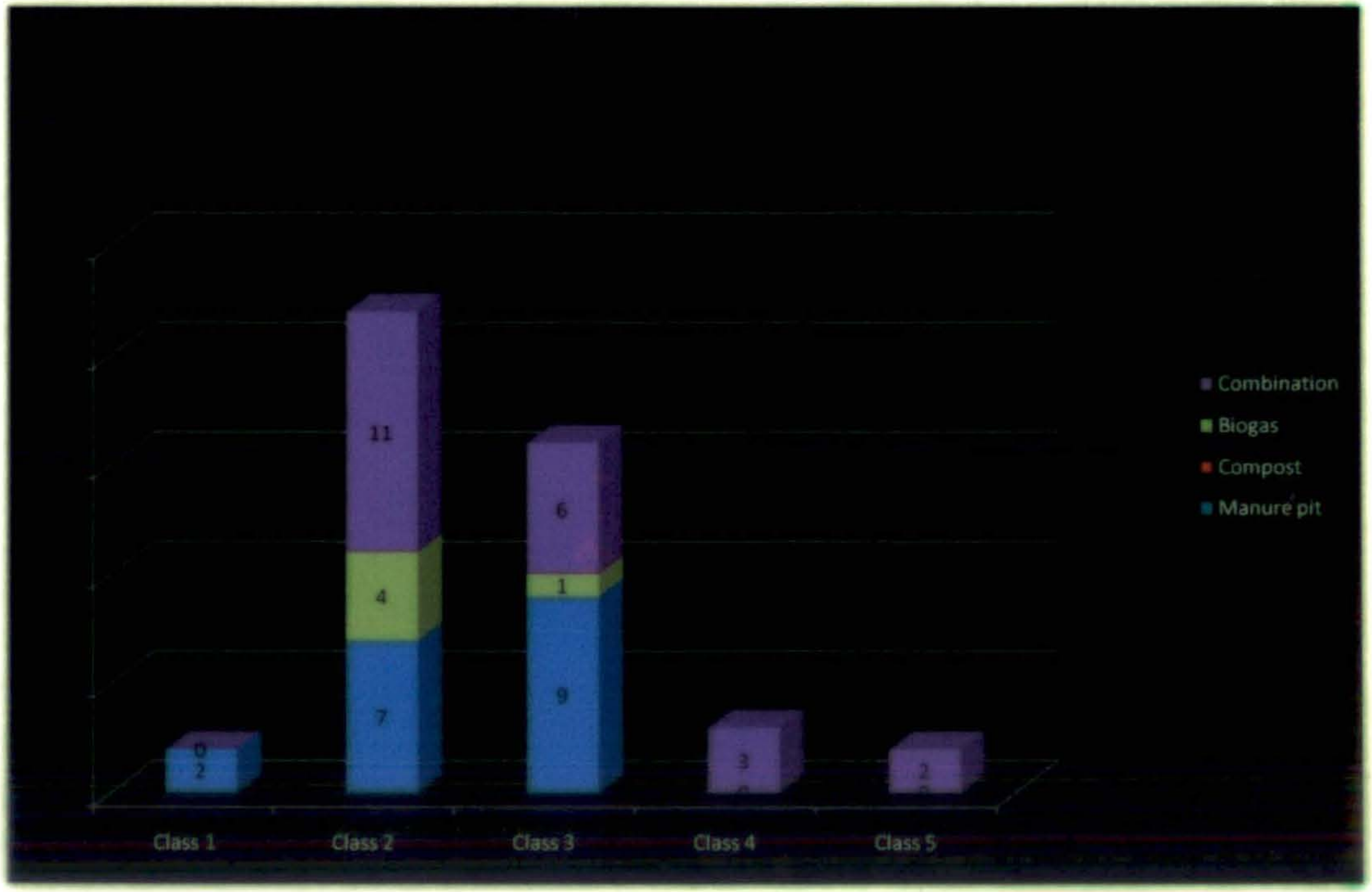

Fig 3 Farms with combination of waste management methods

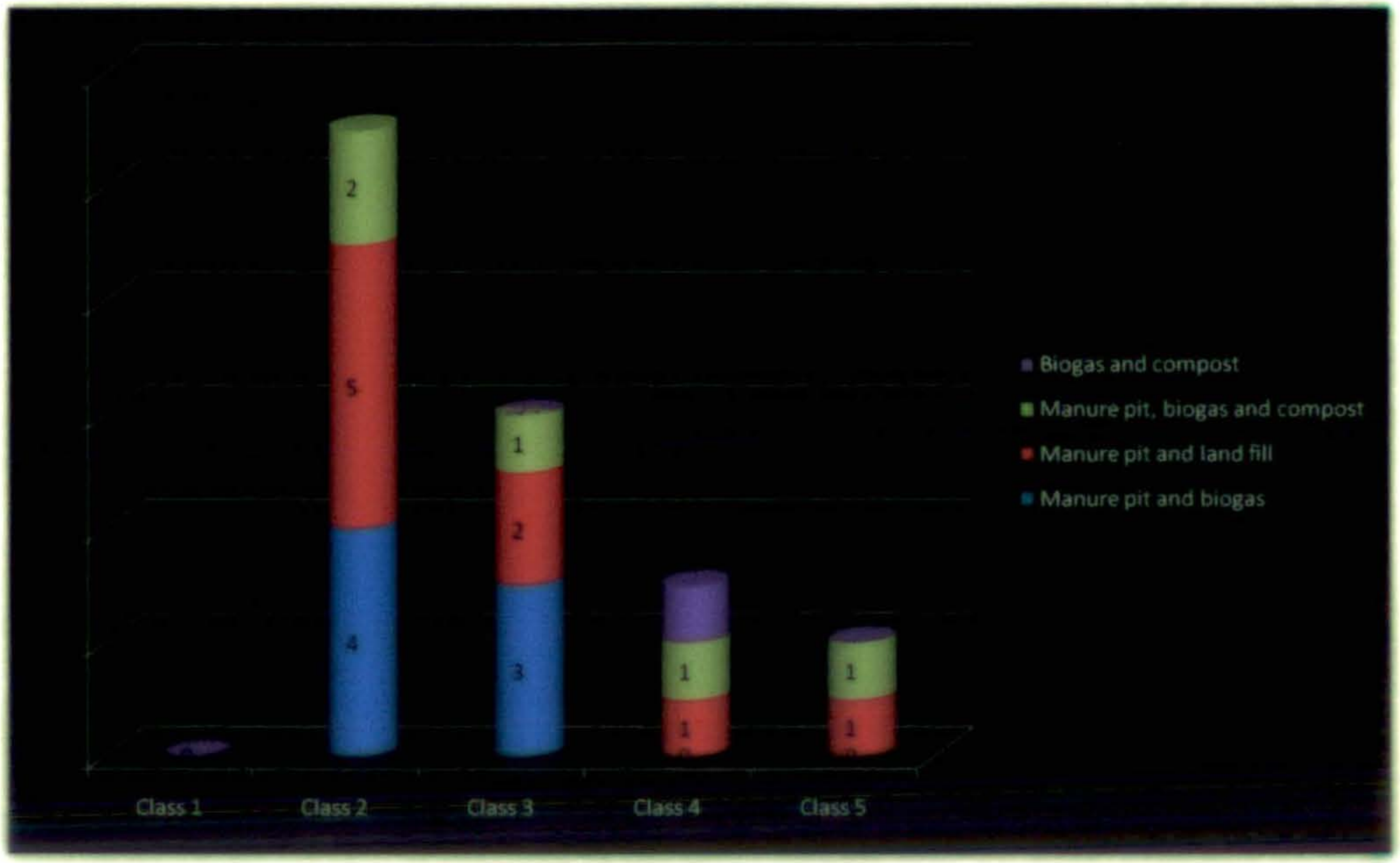

Fig 4. Grouping of farms based on the existing waste management method

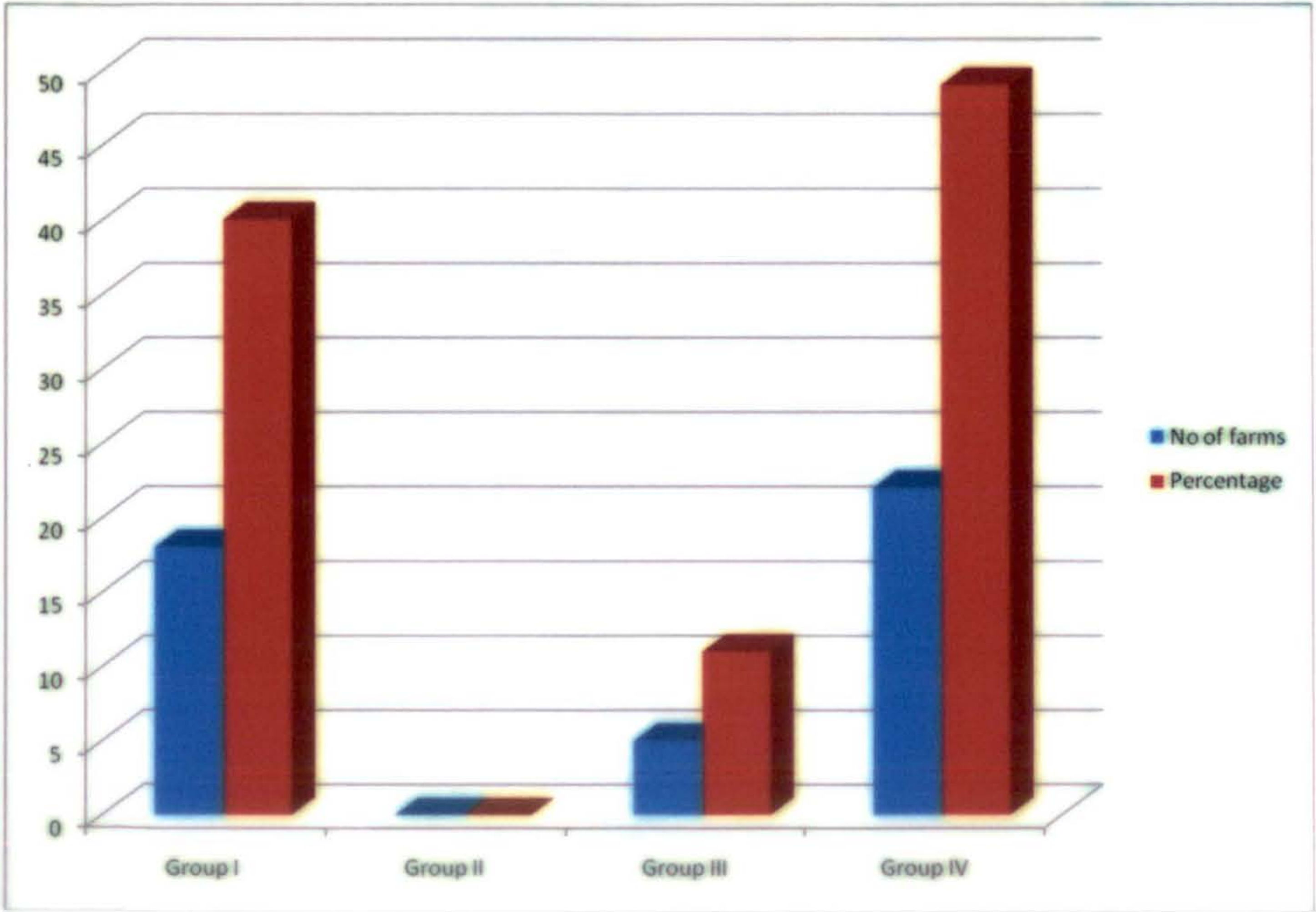

Plate 1. No separate dung and urine channel

Plate 2. Separation between dung and urine

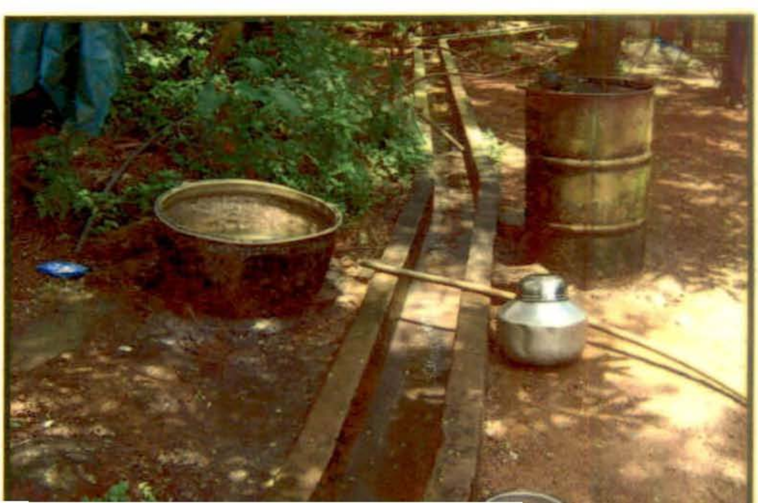

Plate 3. Separate urine channel

Plate 7. Biogas unit

Plate 8. Inlet of biogas unit

Plate 9. Slurry from biogas unit

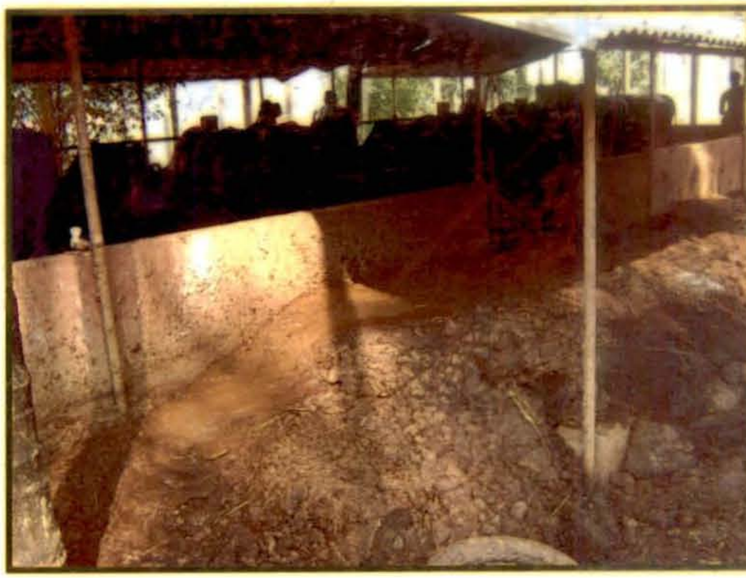

Plate 4. Dung pit adjacent to animal shed

Plate 5. Dung pit away from cow shed

Plate 6. Landfill of dung

Plate 7. Biogas unit

Plate 8. Inlet of biogas unit

Plate 9. Slurry from biogas unit

Plate 10. KVIC Model biogas unit

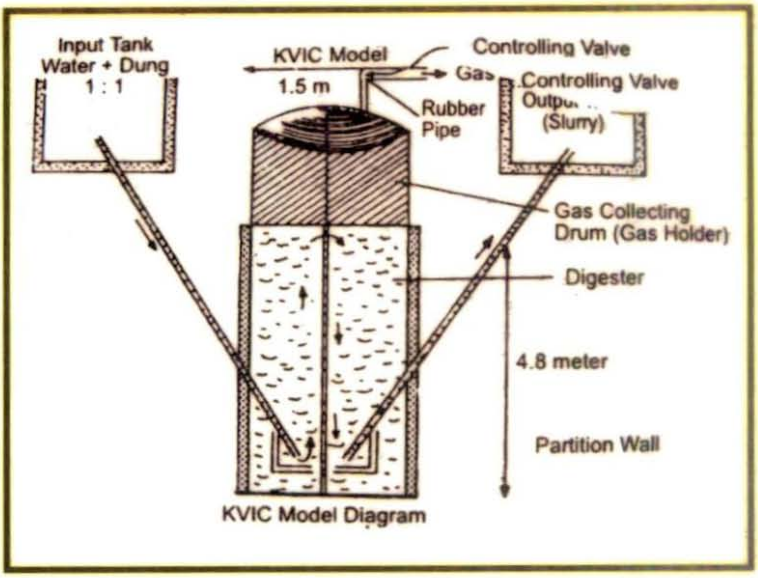

Plate 11. Compost unit

Plate 12. Compost unit

Discussion

5. DISCUSSION

5.1 Animal holding capacity

The dairy farms under study were classified based on the animal holding capacity. Among the 45 farms under study, four percent belonged to class 1, forty nine percent belonged to class 2, thirty five belonged to class 3, six percent farms came under the class 4 and four per cent come under class 5.(Table 4.1and figure 1) The highest percent of farms came under the class 2. This finding is in accordance with the data furnished by *Farms/ Farmers According to Livestock's Data (2003)*, where it states that the average number of animal holding in dairy farms in India is around 17. The number of farms with more than hundred animals are two (four percent) among the farms under study. These findings indicate that there is a transitional change from the traditional small holder dairy units with less than five animals to medium or large scale units demanding new strategies for management and waste disposal. Large scale dairy units which can provide employment for unemployed or under employed people is also a tool to fill the gap between demand and supply of milk in states like Kerala.

5.2 land holdings of the farmers

From the table 4.2 and figure 2 it is clear that the different types of waste management methods adopted in commercial dairy farms are manure pit, compost, biogas and land fill. Senthilkumar *et al.* (2008) also reported the different waste management methods associated with commercial dairy farms as manure pit, compost, biogas and land fill. The highest percent of farms adopted conventional manure Pits. (Forty per cent) This indicates that even though intensification occurred in cattle rearing, there is lack of scientific knowledge in the area of waste management. Linton, (1952) observed the common practice of depositing the manure in a dump immediately outside the buildings.

From the Table 4. 3 it is clear that eighty five percent of farms practiced three times removal of dung from the animal shed. In four percent of farms the frequency is only two per day where as in rest eleven percent, it was more than three per day. Linton (1952) observed that the collection of solid manure in animal habitations under ordinary management is usually carried out once or twice daily. Sastry and Thomas (2008) also stated under ideal managemental conditions solid manure is usually collected and removed from shed twice daily. The increase in the removal frequency is associated with the increase in the milking frequency. Usually dung removal is done in the farm just before milking. Most of the dairy farms were used wheelbarrow for collection and removal of dung from shed. Linton (1952) also observed that the practice of using wheelbarrow or similar vehicle for dung removal as and when the same accumulates.

From the Table 4.3 that liquid separation facility in the waste management system existed only in eleven per cent of total farms. The rest eighty nine per cent farms had no facility to separate solid manure from liquid manure which consisted of urine voided and wash water from sheds. Sastry and Thomas (2008) reported about the practice of direct application of liquid manure to fields of fodder grasses or can be fed as a slurry to bio-gas plants. He exemplified that in Arey Milk Colony, Bombay, fodder grasses are being cultivated economically by irrigating them with wash water from cattle sheds. In Kerala the intensification in the field of dairy sector is an emerging one adopting the conventional system of liquid waste treatment along with solid manure. The lack of separation of liquid manure consisting of urine and shed wash from solid waste leads to increased volume off waste to be treated. Hence a judicious separation of solids and liquid waste is essential for keeping high hygienic status.

5.3 Manure pit

From the Table 4.4 it is clear that eighty four per cent of manure pits are concrete .Rest sixteen per cent was earthen type. In no farms there was an Allnutt's type of manure pit described by Linton (1952) and Sastry and Thomas (2008). This finding reveals that there was no scientific managemental practice adopted by commercial dairy farms in Kerala. It is clear that in all the farms belonging to class 1 category the distance of the pit from the farm is less than five meters. In class four and five it was placed beyond five meters from the farm. Among class 2 farms, 55.56 per cent of farms had their manure pits within a range of 5m. from the farm where as in class 3 the percentage of farms in the same group was only 33.33. In the rest of the farms in both groups the manure pit was located more than 5 meters from the farm. It is recommended in the Draft Proposal for Waste Disposal in Commercial Dairy farms of ministerial level conference (2006) the manure pit must be located at least 25 meter away from dwelling. It is also noted that out of forty five studied, 10 farms had no covering for manure pits. The lack of cover leads to accumulation of water during rainy season leading to serious hazards in environmental pollution. From Table 4.4, it can be seen that more than half of the farms (71%) had no regularity in dung removal from the manure pit , and it was carried upon demand. But twenty nine per cent of the farms showed regularity in the removal of dung. Among this, twenty one per cent of farms were removing the dung from the pit once in six months where as the remaining eight per cent were practicing this twice in a year. The above said ministerial level conference (2006) recommended the waste should not be allowed to accumulate in the pit, in order to avoid pollution issues. The waste disposals in dairy farms were carried out upon demand only. So this may sometimes lead to accumulation in the farm, if there is less demand for cow dung especially in rainy season. There should be a regular outlet for cow dung.

5.4 Compost

From the table 4.5 it is noted that out of the forty five studied six farms has raised type of compost unit and only one had trench type it is noted that the advantages of traditional composting as a waste management method was not fully exploited by the farmers. The frequency of removal of compost is not regular in farm. In five farms regular removal and selling were done. Four farms had more than 20m^3 capacity units. Frequency of removal of compost in different farms are presented in table 4.5.In almost all farms except one there is regular removal of compost. In five farms regular removal and selling was done in once in six months but in one farm regular removal was carried out only once in a year. Mahto and Yadav (2005) studied the compost making using cow dung and reported it was the best method to adopt as an ecofriendly waste management strategy.

5.7 Biogas Units

From table 4.6 it is clear that two types of biogas plants were established in commercial dairy farms *viz,* drum as well as dome types. The biogas units were of drum type in class four and five of farms. Rest was of dome type in class 2 and 3. Depending on the presence of slurry tank the farms are classified in to two and the details are figured in table 4.6. In most of the farms with a biogas unit there is a slurry tank except three in class two. Slurry tank was present in 75% of farms. Twenty five per cent farms directly applied the slurry to the fields. The biogas units are classified into three based on the capacity like less than 2m^3, 2-10 m^3 and more than 10m^3. Class 2 farms had only small units that is 2 m^3 mainly.

Class four and five category farms were having a capacity >10 m^3 where as the farms in class three had biogas units in intermediate sizes. The advantage of biogas plant technology is that the plant can be constructed based on the raw materials to digest is available the plant can be constructed. Hence it is better establish to a biogas plant associated with each dairy farm. In the commercial farms in which biogas had existed as the waste management strategy had a ready source of energy for cooking purpose especially to meet the kitchen needs of resident labours of the farm. Institute of Science and Technology (2005) recommended establishment of biogas plants in all dairy farms in India, based on the availability of waste generated in the farm. The biogas technology open avenue for the most efficient waste management system in which biofuel is tapped from the organic waste without reducing the manorial value of the organic waste.

5.6 Combined waste management system

The different combinations of waste management employed in different farms in different classes were presented in the Table 4.7 and Figure 4, as manure pit and biogas, manure pit and land fill, manure pit, biogas and compost as well as biogas and compost. Farm under class 1 had no combined waste management systems. In class 2 a combination of manure pit and landfill was seen in highest per cent (55.56) followed by manure pit and biogas (44.44) and manure pit, biogas and compost (22.22). Farms in class 3 also showed a similar pattern but the more number of farms in this group employed manure pit and biogas followed by manure pit and landfill. Manure pit and biogas, manure pit, biogas and compost and biogas and compost were seen in class 4 in equal proportions (one each). In class 5 farms only either manure pit and biogas or manure pit, biogas and compost were seen. Senthilkumar *et al.* (2008) also reported the different waste management methods associated with commercial dairy farms as manure pit, compost and biogas.

Thus there will not be a single "best "design. It is particularly important that the already existing design can be modified in response to climatic condition, species, building type, enterprise size, proximity and type of neighbors.

Based on the existing waste management systems as described above, the farms under study were grouped into group I – the farms in which conventional waste management system exists, group II – farms with compost method alone as the waste management method, group III - farms with biogas unit as the waste management method and group IV – farms with combination of waste disposal methods. The detailed classification is presented in table 4.8. Group IV showed highest per cent of farms (49) followed by group I (40) and group II·(11). No farms in the study fell under the category of group II (Table 4.8 and Figure 4).

5.7 Soil, Water and Air Quality

From Table 4.9 it can be seen that average phosphorus content of farms under study in the three groups are above 25 kg/hectare which is high the rating chart of soil testing data. Here in three of the groups P value came under 25 kg/hectare. It is in accordance with the reports of Organic Agriculture Center of Canada (OACC). Irrespective of the waste management method, the soil K level remained more than 280 kg/ha according to rating chart for soil test. Here in three groups the value is high. Irrespective of the waste management method the soil nitrogen level remained high (above 0 .05 %.) It is reported even though the dairy wastes are commonly applied to crop lands as fertilizer, the nitrogen release and transformation is difficult to predict. (Shi et *al.,* 1976) .The soil nitrogen content in different groups of dairy farm showed no significant difference. PH of the soil of the farms remained acidic. In general Kerala soil pH is estimated as acidic as per reports of Department of agriculture, Government of Kerala (5.5-6.5).

Presented in the table 4.10 are the results of evaluation of biological quality of water based on the pH, BOD, Coli form count per 100ml and *E. coli* count.

The overall mean pH value of water was 6.27±0.21. Group III showed a slightly higher mean (6.56 ± 0.42) than group I (6.55 ± 0.24). Group IV showed the acidic pH of 5.98 ± 0.35. The results show the pH is within the range 6-9 which is recommended by IS2296 (1974).

Presented in Table 4.10 are the BOD_5 of the three groups as well as over all value The biochemical oxygen demand of the water provided in the farms ranged from 95.40 ± 74.69(group I) to 350.00 ± 199.02 (group IV). The overall mean BOD reported in the study was 179.63±77.56. According to IS2296 (1974) standards BOD_5 of drinking water should be 3 mg/dl. All the groups had very high value of BOD_5 than recommendation.

The highest BOD_5 value from water samples collected from the farms under study indicate that the lack of systematic and scientific waste management methods in all the farms. This is an emerging issue demanding predestined waste management model for different classes of dairy farms. Intervention by the government, local bodies and scientific institutions must be made in this area supporting the farmers to develop awareness in this serious issue and also providing necessary technical and financial support for the farmers to construct proper waste management system.

The overall mean value of coliform count is presented in the table 4.10 along with the group wise means and the count was 209.53±48.68. With respect to the Coliform count in the water, the cfu per 10 0ml ranged from 146.13 ± 62.19 (Group IV) to 315.00 ± 85.52 (Group I). The result obtained indicates that all the groups have the value higher than the recommended microbial load permitted, irrespective of the waste management method adopted in the farm. The counts for *E.coli* count was more or less same in all groups and the details are presented in table 4.10. The overall mean value of E.coli was 50.17±6.00. This value is also higher than the BIS (1993) recommendation that is drinking water should be devoid of any *E coli* in 100 ml of sample.

From Table 4.11 it can be noted that the microbial load in air samples collected from the three groups showed high microbial load *i.e* more than 300 cfu/ft^2/min. The counts obtained in the present study from various farms were above the standards prescribed by APHA (Hickley, *et al.* 1992). The observation on the microbial load in the air samples collected from the farm indicate that serious interventions are essential to reduce the air pollution in the farm.

Odour annoyance of farms under study was assessed by nine point hedonic scale. The mean value is given by 23.17 and 45.53 and 60.38 for the groups I II and IV respectively. The result shows higher odour annoyance in farms with dung pit alone as waste management method. It is noted that the majority of manure pits were covered in commercial farms; even then there reported a odour annoyance. In group III where biogas plant was established to manage the waste generated in the farm had a mean value of 45.53 in nine point hedonic scales for odour annoyance. In group IV had scored the highest score (60.38). The scale consists of a grade ranging from -4 to +4 indicates value from 0-100 in the hedonic scale. Farms with manure pit existed as waste management system had scored least mean i.e, 23.17. Farms with biogas unit existed as waste management system had scored 45.53 and farms with combined waste management method, scored highest mean 60.38. The hedonic tone is an important odour property for assessment of annoyances and determined by means of test persons.. Observation in the odour annoyance tested, reveals that biogas technology and combination of different waste management methods are effective tools to improve the quality of air in the farm vicinity.

Summary

6. SUMMARY

There are many farms in Kerala with alleged complaints. So the study of the existing waste management method is a necessity of today. The dairy farms under study were classified based on the animal holding capacity as those with less than six animals (class 1), 6-20 animals (class 2), 21-50 animals (class 3),and 51-100 animals (class 4), and above 100 animals (class 5). Among the 45 farms under study, four per cent belonged to class 1 and 5, forty nine percent belonged to class 2, thirty five belonged to class 3, six percent farms came under the class 4 The highest percent of farms came under the class 2. The number of farms with more than a hundred animals are three (six per cent) among the farms under study. These findings indicate that there is a transitional change from the traditional small holder dairy units with less than five animals to medium or large scale units demanding new strategies for management and waste disposal. Large scale dairy units which can provide employment for unemployed or under employed people is also a tool to fill the gap between demand and supply of milk in states like Kerala. Eighty five percent of farms practiced three times removal of dung from the animal shed. In four percent of farms the frequency is only two per day where as it is eleven percent in the remaining farms in which , it was more than three per day. Linton (1952) observed that the collection of solid manure in animal habitations under ordinary management is usually carried out once or twice daily. The rest 89 %farms had no facility to separate solid manure from liquid manure which consisted of urine voided and wash water from sheds. Sastry and Thomas (2008) reported about the practice of direct application of liquid manure to fields of fodder grasses or can be fed as slurry to bio-gas plants. In Kerala, the intensification in the dairy sector is an emerging one adopting the conventional system of liquid waste treatment along with solid manure. The lack of separation of liquid manure consisting of urine and shed wash from solid waste leads to increased volume of waste to be treated. Hence a judicious separation of solids and liquid waste is essential for keeping high hygienic status . 84% of manure pits are concrete .Rest 16% are earthern type. The waste disposal in dairy farms was carried out upon demand only. So this may sometimes lead to accumulation in the farm, if there is less demand for cow dung especially in rainy season. There should be a regular outlet for cow dung. Out of the forty five studied, six farms has raised type of compost unit and only one had trench type. It is noted that the advantages of traditional composting as a waste management method was not fully exploited by the farmers. Mahto and Yadav (2005) studied the compost making using cow dung and reported that it was the best method to adopt as a ecofriendly waste management strategy.

Two types of biogas plants were established in commercial dairy farms *viz,* drum as well as dome types. The biogas units were of drum type in class 4 and 5 of farms. Rest was of dome type in class 2 and 3. Depending on the presence of slurry tank the farms are classified into two. . In most of the farms with a biogas unit there is a slurry tank except three in class two. Slurry tank was present in 75% of farms. Twenty five per cent farms directly applied the slurry to the fields. The biogas technology open avenue for the most efficient waste management system in which biofuel is tapped from the organic waste without reducing the manorial value of the organic waste. the different combinations of waste management employed in different farms in different classes as manure pit and biogas, manure pit and land fill, manure pit, biogas and compost as well as biogas and compost. Thus there will not be a single "best "design. It is particularly important that the already existing design can be modified in response to climatic condition, species, building type, enterprise size, proximity and type of neighbors.

Based on the existing waste management systems, as described above, the farms under study were grouped into group I – the farms in which conventional waste management system exists, group II – farms with compost method alone as the waste management method, group III - farms with biogas unit as the waste management method and group IV – farms with combination of waste disposal methods. The detailed classification is presented in table 4.8. Group IV showed highest per cent of farms (49) followed by group I (40) and group II (11). No farms in the study fell under the category of group II. Irrespective of the waste management method the soil nitrogen,phosphorus and potassium level remained high The results shows the pH is within the range 6-9 which is recommended by IS2296 (1974). According to IS2296 (1974) standards BOD_5 of drinking water should be 3 mg/dl. All the groups had BOD_5 values much higher than recommendation The highest BOD value from water samples collected from the farms under study indicate that the lack of systematic and scientific waste management methods in all the farms. This is an emerging issue demanding predesigned waste management model for different classes of dairy farms. Intervention by the government, local bodies and scientific institutions must be made in this area supporting the farmers to develop awareness in this serious issue and also providing necessary technical and financial support for the farmers to construct proper waste management system The overall mean value of E.coli was 50.17±6.00. This value is also higher than the BIS (1993) recommendation which is drinking water should be devoid of any *E coli* in 100 ml of sample. The observation on the microbial load in the air samples collected from the farm indicate that serious interventions are essential to reduce the air pollution in the farm. Observation in the odour annoyance tested, reveals that biogas technology and combination of different waste management methods are effective tools to improve the quality of air in the farm vicinity.

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Appendix 1

Questionnaire on Waste Management System

A) Name of the owner of the farm:

B) Address of the farm:

C) Sex : a) Male ☐ b) Female ☐

D) Land holding of the farm: a) Five or above acres ☐ b) Between 2-5 acres. ☐

c) Less than two acres ☐

Q1) No. of total animals in the farm: a) Less than six animals ☐ b) 6-20 animals ☐

c) 21-50 animals ☐ d) 51-100 animals ☐

e) Above 100 animals ☐

Q 2) Frequency of waste removal from the farm in a day: a) 2 times☐ b) 3 times ☐

c) >3 times☐

Q 3) Separation of liquid and solid waste including fodder waste: a) Yes ☐ b) No☐

Q 4) whether i\there is separation of liquid and solid waste: a) Yes ☐ b) No☐

Q 5) Existing waste management system in the farm

a) Manure pit a) Yes☐ b) No ☐
If yes,

i) Type of manure pit : a) Concrete☐ b)Earthen☐ c) Allntt's manure pit ☐

ii) Distance of the pit from the farm: a) < 5 m ☐ b) >5m☐

iii) Whether it is covered: a) Yes ☐ b) No ☐

iv) Frequency of dung removal from the pit: a) Once in 6 months or below ☐

b) Within 6-12 months ☐

c) Not regular ☐

b) Compost unit: a) Yes ☐ b) No ☐
If yes,

i) Type of the unit: a) Raised ☐ b) Trench ☐

ii) Measurement of the unit (m^3): a) 2 ☐ b) 2-20 ☐

c) >20 ☐

iii) Frequency of removal of the compost: a) once in 6 months ☐

b) Within 6-12 months ☐

c) Not regular ☐

c) Biogas unit: a) Yes ☐ b) No ☐
If yes,

i) Type of the unit: a) Drum ☐ b) Dome ☐

ii) Capacity of the unit (m^3) : a) <2 ☐ b) 2-10 ☐ c) >10 ☐

iii) Presence of a slurry tank: a) Yes ☐ b) No ☐

d) Combination of waste management systems: a) Yes ☐ b) No ☐
If yes,

a) Manure pit and biogas ☐ b) Manure pit and land fill ☐

c) Manure pit, biogas and compost ☐ d) Biogas and compost ☐

WASTE MANAGEMENT SYSTEM EVALUATION IN COMMERCIAL DAIRY FARMS

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ABSTRACT

The present study on "Waste management system evaluation in commercial dairy farms" was conducted to assess the usefulness of the different waste management methods adopted in dairy farms of Kerala. Study area comprised of Thrissur, Malappuram and Ernakulam districts and adjoining area of central and northern Kerala. Forty five dairy farms were identified and visited in and their profile of the study area .Data regarding general outlay of the farms selected management practices in the farm, livestock details and existing waste management methods in the farms were collected and studied. The dairy farms under study were classified based on the animal holding capacity as those with less than six animals (class 1), 6-20 animals (class 2), 21-50 animals (class 3)and 51-100 animals (class 4), and above 100 animals (class 5). Among the 45 farms under study, four per cent belonged to class 1, forty nine per cent belonged to class 2, thirty five belonged to class 3, six per cent farms came under the classes 4 and 5.There was no commercialization of waste management methods adopted by the farms. The majority farms had dung pit as waste disposal method and no regularity in dung removal from pit, it was upon demand. Regarding the soil quality, there was no significant difference in the soil nutrients quantity between different groups of farms. Regarding water quality, the water samples collected from the nearby water bodies were inferior in quality in terms of microbiology and BOD. Air quality stands below the permitted standards in all groups of farms. Intervention by the government, local bodies and scientific institutions must be made in this area supporting the farmers to develop awareness in this serious issue and also providing necessary technical and financial support for the farmers to construct proper waste management systems such as compost unit as well as biogas plants because they provide a support for the most efficient waste management system in a dairy farm proving that waste is wealth.