GOVERNANCE AND MANAGEMENT OF CHEMICAL WASTE IN SMALL HOLDER DAIRY FARMS: CASE OF KABETE SUB-COUNTY, KIAMBU COUNTY

A Thesis Submitted in Partial Fulfillment of the Requirement for Masters degree in Environmental Governance

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DECLARATION

Declaration by the Student

I hereby declare that this thesis is my original work and has never been submitted or presented, to the best of my knowledge, to any other institution for the award of any degree.

Signature..... DATE…….....

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Declaration by the Supervisors

This thesis has been submitted with our approval as University of Nairobi Supervisors.

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DEDICATION

To my family members and supervisors; your encouragement and support throughout my study is insurmountable

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LIST OF ABBREVIATIONS

EPCs	Empty Pesticide Containers
FAO	Food and Agricultural Association
SPSS	Statistical Package for Social Science
HF	Holstein Friesian
GoK	Government of Kenya
IDF	International Dairy Federation
NEMA	National Environment Management Authority
EMCA	Environmental Management and Conservation Act
GDP	Gross Domestic Product
EPAT	Environmental Protection Administration Taiwan
DAI	Development Alternatives Inc
NGO	Non-Governmental Organization
ODK	Online Data Kit
PVC	Polyvinyl Chloride
HDPE	High-density polyethylene

ABSTRACT

The livestock sector in developing countries is rapidly growing from increasing demand for animal protein, products and services. This growth, however, poses a possible challenge in terms of loss of ecosystem health in terms of environmental degradation from emissions of methane and resultant effluents of dangerous chemical wastes used in farms. This thesis describes the state of governance instruments used for management of chemical waste in smallholder dairy farms in Kenya using a case of Kabete sub-county, Kiambu County. The thesis concentrated on the situational analysis of the types of chemical wastes existing in smallholder dairy farms, the knowledge, attitude and practices of farm workers in regard to management of chemical waste in the farms and how this management interphases with the existing regulatory framework of the chemical management in such farms. The study was designed as a cross sectional descriptive survey that incorporated both retrospective and prospective attributes of the management practices. A random sampling of 100 farm workers was carried out from randomized samples of twenty smallholder farms drawn from the five wards (Gitaru, Muguga, Nyadhuna, Kabete and Uthiru) of Kabete Sub-county. Five key informant interviews of relevant environment officers were also conducted to triangulate the results and obtain information of existing governance instruments. Data was coded and analyzed SPSS® version 23.0 to generate tables, figures and relevance statistics. The main types of chemical wastes existing in smallholder dairy farms were antimicrobials, pesticides, detergents, disinfectants, and herbicides. It was noted that most farm personnel lacked requisite skills (knowledge, attitudes and practices) to effectively manage chemical waste in dairy farms (X^2 (5, N=100) =2.15, p=1.63). The interviewed respondents also were also not capacity built within farms to be aware of the existing protocols/processes for management of

chemical wastes in dairy farms (X^2 (5, N=100) =70.4, p=0.0027). Formal and informal channels of awareness creation is needed to be institutionalized within dairy to capacity build farm owners and farm workers on skills of chemical waste management in order to achieve sustainability in management of chemical waste in smallholder farms in Kenya. Capacity building could be sought through training from companies selling the chemical products, NEMA and/or farmer cooperative societies as suggested by respondents.

CHAPTER ONE

1.0: INTRODUCTION

1.1: Background of the Study

In developing countries, the livestock sector is experiencing rapid growth due to unmet demands in animal protein, products and services (Thornton, 2010). With the currently 33% and an additional 27% through linkages to other sectors including manufacturing and distribution and services, the need for increased share of livestock sector in Kenya in national agricultural GDP continues to rise (Thornton, 2010; Mutembei and Kilonzi, 2018). Despite significant advances across the economy in innovation and entrepreneurship, private sector enterprise and infrastructure, agriculture continues to be the bedrock of the development of our nation and the key to creating equitable and sustainable growth for the country (GoK, 2017). This expansion is fueled by increasing demand for livestock products and services (Thornton, 2010). This demand, in turn, is driven by a burgeoning human population, rapid urbanization, and increasing affluence (FAO, 2017). Correspondingly, this "livestock revolution" could represent challenges in terms of loss of ecosystem health through environmental degradation from emitted methane and resultant effluent of chemical waste used in farms (FAO, 2017).

Although commercial dairy farming began in the early twentieth century in Kenya, indigenous Kenyans were not allowed to participate in the same practice until the mid-1950s (Muriuki, 2011). Thus, although during the 1960s the number of livestock per capita in Kenya was among the highest in Africa, this number reduced in the following four decades due to rapid population growth and poor economic performance but eventually rebounded from 57.0

million to 108.1 million head from 2000-2001 (Dietz *et al.*, 2014). This trend a dangerous challenge of not grounding the indigenous residence involved in dairying on sustainable dairy practices, including management of chemical waste, especially so in the slowly industrializing mixed crop/livestock non-industrial smallholder systems (Thorpe *et al.*, 2000; Seré *et al.*, 2008; Mutembei and Kilonzi, 2018).

Dairy smallholders constitute 80% of the overall dairy sector in Kenya and remain the crucial part of the dairy and agriculture sector (Karanja, 2013). The swynnerton Plan of 1954, along with increasing population pressure gradually transformed traditional farming system into means of livelihood for the rural households (Delgado and Jahnke, 2006). Thus, after independence, smallholder dairy commercial/improved farming by local farmers, now able to keep high-end dairy breeds, begun to take shape and benefit from the already existing infrastructure, knowledge and extension services (Karanja, 2013). With exit of colonial dairy farmers most of existing dairy farms were transferred to the indigenous people, however, without exposure to sustainable dairying practices (Delgado and Jahnke, 2006).

The ensuing practice by upcoming dairy farmers was to take command of the dairy industry and this led to advancement of the existing dairy strong livestock sector today in Africa albeit lacking infrastructure for sustainability, including in management of chemical waste effluents (Lesschen *et al.*, 2004; Muriuki, 2011; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017)Progressively the sector has continued to grow through continued dairy development programs that pushes a strategy of replacing local cattle breeds with mainly the Holstein Friesian breed commonly loosely referred to as the "Holsteinization" of dairy farming (Theunissen, 2012; Mutembei and Kilonzi, 2018). This intensification of dairy production brought with it a considerable impact on the environment, with devastating losses of

biodiversity due to habitat destruction from effluents, including waste chemicals (Sizemore, 2015).

The growth of the sector has resulted in increased use of antibiotics, antiseptics/disinfectants and agrochemicals that are used in treatment of animal diseases and or control of parasites, whose waste is not well managed leading to negative impact on biodiversity from ensuing residues (Dinki and Balcha, 2013; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017).

This study aimed to shed some light on the connection between the need to advance dairy sector that protect the environment by means of sustainable chemical waste management. It was thus prudent to establish a scientific connection between the types of existing chemical waste in dairy farms and how management of such chemicals could be sustainably achieved through appropriate skills of farm workers (knowledge, attitudes and practices) within the confines of existing legal frameworks of management of such chemicals.

1.2: Problem Statement

In Kenya much is being done to address solid waste management currently, but management of chemical waste is to a last extent lagging behind. To date issues of land, water and air pollution from chemicals and their byproducts is rampant and require attention. Worldwide there is a trend of increasing loss of biodiversity and development of antimicrobial resistance that threaten human life due to environmental chemical waste.

Smallholder farms worldwide continue to be sources of chemical waste resulting from acaricides, insecticides, veterinary antimicrobials and herbicides used in dairying. Since these wastes find their way into the soils, rivers and carbon chains they end up posing threats to

ecosystems health and environmental protection (Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017).

Sustainable management of such waste can only take place through a well-defined process that interphases between generators of such waste in farms and their attitude and practices of managing the same. The governance processes of managing such waste need to directly communicate to end-users and currently this is not the case in Kenya.

1.3: Research Objectives

1.3.1 Overall objective

To assess instruments for sustainable management of chemical waste in smallholder dairy farms in Kenya using a case study of Kabete Sub-location of Kiambu County

1.3.2 Specific Objectives

a) To evaluate types of chemical waste in smallholder dairy farms in Kabete sub-county
b) To determine knowledge, attitudes, and practices of farm workers regarding management of chemical waste in smallholder dairy farms in Kabete sub-county
c) To analyze the association between the practices used by dairy farm personnel to manage chemical waste in dairy farms in Kabete sub-county in relation to documented governance processes (protocols) for management of the same in dairy farms

1.4: Researchable hypothesis

The study was guided by the following researchable hypothesis: -

There are various types of chemicals waste present in smallholder dairy farms which are well managed by farm workers with requisite skills (knowledge, attitude and practices) within the laid down governance processes for this waste.

Hence, expected outputs of the study: -

i) A list of types of chemical waste likely to be found in dairy farms was generated

ii) Likelihood of finding farm personnel with requisite skills (knowledge, attitudes and practices) to effectively manage chemical waste in dairy farms as per documented protocols/processes of its management was tested using Chi Square Test (X^2 (5, N=100), $P \leq 0.05$).

iii) Likelihood of finding farm personnel who were well versed with documented protocols/processes for management of chemical waste through institutional built capacity was tested using Chi Square Test (X^2 (5, N=100), $P \leq 0.05$).

1.5: Justification

The dairy revolution sweeping over developing countries like Kenya as a source of livelihood comes with cost to ecosystem health through environmental degradation from emitted methane and chemical pollution from resultant chemical waste effluents (Walpole *et al.*,

2013). The potential effects associated with chemical effluents vary widely depending on the types of chemicals involved but the hazardous impact would be difficult to reverse (U.S. Environmental Protection Agency., 2018).

Chemical waste becomes hazardous whenever practices for its proper disposal are not put in place resulting in pollutions such as land, air, and water spills that lead to detrimental effects on human health and loss of biodiversity (FAO, 2017; U.S. Environmental Protection Agency., 2018). Small scale dairy systems in Africa and south Asia are particularly suspected to be affected by this menace of poor chemical waste management leading to higher chemical footprints (FAO, 2010).

Proper management of chemical waste would entail equipping farm workers with requisite skills (knowledge, attitude and practices) in identification of types of chemical waste and awareness of the processes for their disposal (EPAT, 1994). However, in developing countries such forums of skills development are not only lacking but also policies to make corporate sector responsible for selling of such chemicals to farms to undertake such capacity building for affected farms are absent or inadequate (EPAT, 1994).

There is a reported low adherence of the manufacturers' labelled instructions in handling and disposal of chemicals in Kenya (defra, 2004). Consequently, hazardous chemical effluents have not only been detected in the environment but also their toxic effects have been documented in the country (Mutembei *et al.*, 2017).

This study aimed at documenting a framework of resolving the existing problem affecting the processes of sustainable management of chemical waste in smallholder farms by generating

evidence that can inform policy of management of this waste in order to protect the environment.

1.6: Scope and Limitations of the Study

This study focused on the processes for management of chemical waste management in Kenya. A case study of one sub-county that practices dairy farming was the scope of the study. The study was limited to sampling of five farms per ward and twenty workers within same ward based on complexity of the distribution and sizes of farms. None the less random selection of farms and equal sampling from all the five wards of Kabete sub-county became adequate sampling frame for a representative sample to represent real case scenario of what exist in Kenyan smallholder dairy farms. It is worth noting that the study scope is adequate because all smallholder dairy farms are exposed to similar chemical waste profiles because they use similar insecticides, herbicides, fungicides and veterinary antimicrobials and medicines.

1.7: Assumption of the Study

All respondents provided honest responses to the questions posed to them.

CHAPTER TWO

2.0: LITERATURE REVIEW

2.1: Current structure of small holder dairy farming in relation to chemical use in Kenya.

In recent years, Kenya like many other developing countries has been increasingly rearing purebred and crossbred dairy cows to boost milk production (Thornton, 2010). Besides being high-quality feed dependent, such breeds require intensive tick protection to survive and hence chemicals such as acaricides are used at least twice a week on them (FAO, 2017). In addition, smallholder farmers have reported a serious effect on bees and butterfly habitats, as well as insect eating birds. The soils and health of people living in the affected areas has also been affected (Ocaido *et al.*, 2009; Aikiriza, 2015).

Another factor that contributes to the heavy use of agro-chemicals is a breeding strategy in which local breeds are gradually replaced by breeds with a higher production capacity, indiscriminate crossbreeding resulting in animals that are less suited to the local environment and that need extra care and medicines (Groot and van't Hooft, 2016).

There is widespread and extensive use of chemicals in smallholder dairy farms. in Kenya it is informally done according to farmers preferences and convenience with no laid out chemical waste management procedures.

2.2: Chemicals commonly used in Dairy Farms

Agrochemicals commonly used on farms include herbicides, insecticides, fungicides and veterinary medicines (DAI'S Africa Lead II Initiative, 2015). These agro-chemicals can be extremely toxic and mostly contain carcinogens and heavy metals which have potentially fatal effects on humans and extremely dangerous to animals and the environment (DAI'S Africa Lead II Initiative, 2015; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017). Most of the time they are used in fairly small amounts but can have large environmental impact due to continued use and cumulative effect especially if used or disposed off incorrectly. It is very essential for small-holder dairy farmers to practice correct management, storage and disposal to avoid detrimental effects to the environment and human health (Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and M'ikiugu, 2018; Mutembei and Kathambi, 2018).

Other chemicals used on farms that have environmental effects include paints, turpentine, and creosote which are often used in significant amounts for maintenance on farm property. The waste materials and containers are often not disposed in the correct manner leading to health and environmental effects of solvents, heavy metals and other problematic chemicals (DAI'S Africa Lead II Initiative, 2015).

Following the ban on organochlorides, the introduction of other synthetic insecticides– organophosphate (OP) insecticides in the 1960s, carbamates in 1970s and pyrethroids in 1980s and the introduction of herbicides and fungicides in the 1970s–1980s contributed greatly to pest control and overall agricultural output (Aktar *et al.*, 2009).

The secondary benefits are the less immediate or less obvious benefits that result from the primary benefits. They may be subtle, less intuitively obvious, or of longer term. It follows that for secondary benefits it is therefore more difficult to establish cause and effect, but nevertheless they can be powerful justifications for pesticide use. Vector-borne diseases are most effectively tackled by killing the vectors as diseases control strategy crucially important for livestock. Ideally a pesticide must be lethal to the targeted pests, but not to non-target species, including man. Unfortunately, this is not the case, hence the controversy of use and abuse of pesticides (FAO, 2017).

If the credits of pesticides include enhanced economic potential in terms of increased production, and amelioration of vector-borne diseases, then their debits have resulted in serious health implications to man and his environment. Pesticides can contaminate soil, water, turf, and other vegetation (Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and M'ikiugu, 2018; Mutembei and Kathambi, 2018). In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects, and non-target plants. Insecticides are generally the most acutely toxic class of pesticides, but herbicides can also pose risks to non-target organisms (FAO, 2017; Pérez-Lucas *et al.*, 2018).

Pesticides can reach surface water through runoff from treated plants and soil (Pérez-Lucas *et al.*, 2018). Contamination of water by pesticides is widespread in Kenya (Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and M'ikiugu, 2018; Mutembei and Kathambi, 2018; Pérez-Lucas *et al.*, 2018). Pesticides are often considered a quick, easy, and inexpensive solution for controlling weeds and insect pests in urban landscapes. However, pesticide use comes at a significant cost. Pesticides have contaminated almost every part of

our environment (Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and M'ikiugu, 2018; Mutembei and Kathambi, 2018). There exists many chemicals used in smallholder dairy farms in Kenya on a regular basis for a variety of needs. Due to the harzadous nature of most of them, there is a need for the chemical waste to be managed within a regulatory framework.

2.2: Storage and Disposal of chemicals

Chemicals intended for use, or being held prior to disposal, must be stored in a secure, well ventilated and dry area that is out of direct sunlight (NEMA, 2015). The area should only be used for storing chemicals and have binding to contain chemical spills. When chemicals are properly stored as required, expedited break-down is avoided. The instructions and other information needed for proper storage for each specific product is contained in the label (The National Academies Press, 2015). In most developed countries there are clear laid out protocols for disposal of chemical waste by different environmental institutions. On the other hand, in Kenya where environmental institutions still use informal management practices and there lacks a laid down structure for use by small holder dairy farmers to manage chemical wastes from their farms.

2.3: Disposal of Empty Pesticide Chemical Containers

Used high-quality plastic and metal Empty Pesticide Containers (EPCs) have considerable value to Small scale farmers in developing countries for use as storage vessels (DAI'S Africa

Lead II Initiative, 2015). Risks to human health, safety and environment arise commonly at the small holder or small scale farmer sector, where un-rinsed EPCs may be discarded in the field or streams, burned, or worse, Re- used for storing water, milk, cooking oil, drinks or food (Devendra, 2001).

All empty containers should be triple rinsed before disposal, as empty, unrinsed chemical containers are hazardous to the environment and public health. Used high quality plastic and metal Empty Pesticide Containers (EPCs) have considerable value to small scale farmers in developing countries for use as storage vessels (Groot and van't Hooft, 2016). Risks to the environment and human health arise commonly at the smallholder or small scale farmer sector, where unrinsed EPCs may be discarded in the field or streams, burned or worse reused for storing water, milk, cooking oil, drinks or food (DAI'S Africa Lead II Initiative, 2015).

The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others (Aktar *et al.*, 2009).

The countries with the most successful EPC disposal and recycling schemes have developed local non-profit organizations and NGOs that operate these programs by bringing together resources from numerous sources (DAI'S Africa Lead II Initiative, 2015). Most tropical and subtropical EPC management programs require supplementary funding (subsidies, tax breaks, rebates, donations) from public resources as well as combined financial and coordination efforts of 'partners' from the private sector, governments, especially ministries of agriculture and health, non-governmental organizations, as well as multilateral and bilateral donors.

There are many constraints that hamstring EPC disposal and recycling programs and lack of funding is the biggest hurdle. Most jurisdictions consider unwashed EPCs (that still contain pesticide residues) to be Hazardous Materials (HazMats), and thus require a separate recycling stream, adding complexity and cost (Aktar *et al.*, 2009). Insufficiently cleaned EPCs can only be incinerated, and those that are properly cleaned are recycled into agricultural or industrial plastic items, not domestic ones (DAI'S Africa Lead II Initiative, 2015).

2.4: Policy and Regulatory Framework for Management of Chemical Waste in Dairy Farms

Studies conducted in some developing countries in Africa report that some of the policy challenges in chemical waste management in dairy farming systems include the ambiguity of dairy policies, the minimal stakeholder consultation in formulating the policy and legal framework, and inconsistencies between the policies/legal framework and the prevailing situation at the farms (IDF/FAO, 2004). Many stakeholders in the dairy industry are not aware of the effects of their actions on the environment (Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018). Most of the smallholder farmers and informal traders who dominate and influence the dairy industry have little to no awareness on environmental issues surrounding dairy farming activities (Rodić and Wilson, 2017).

Institutions involved in the dairy sector include regulators, input suppliers, service providers, market agents, research and development organizations and dairy farmers and their

organizations. In Kenya, Milk product safety is managed through the existing food safety standards and regulations contained in two main laws - the Dairy Industry Act (CAP 336) and the Public Health Act (CAP 242), with neither of them being effective is such cases (Muriuki, 2011). Regarding the regulatory framework, Vision 2030 recognizes that the agricultural sector (including dairy) has been operating under outdated traditional colonial legislation dating back to the 1930s, which is hindering growth in the sector and the government has set to amend this legislation and other areas that need streamlining (Muriuki, 2011).

The cessation of open dumping is the essential stepping stone toward environmentally sound waste disposal, which is definitively addressed by Target 12.4: "By 2020, Achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment" (IDF/FAO, 2004).

Governance approach used for this could determine the success of transition from traditional management practices to accredited chemical waste management protocols and processes. There exists a gap to understand how regulatory and institutional frameworks can streamline chemical waste disposal sustainably in Kenya.

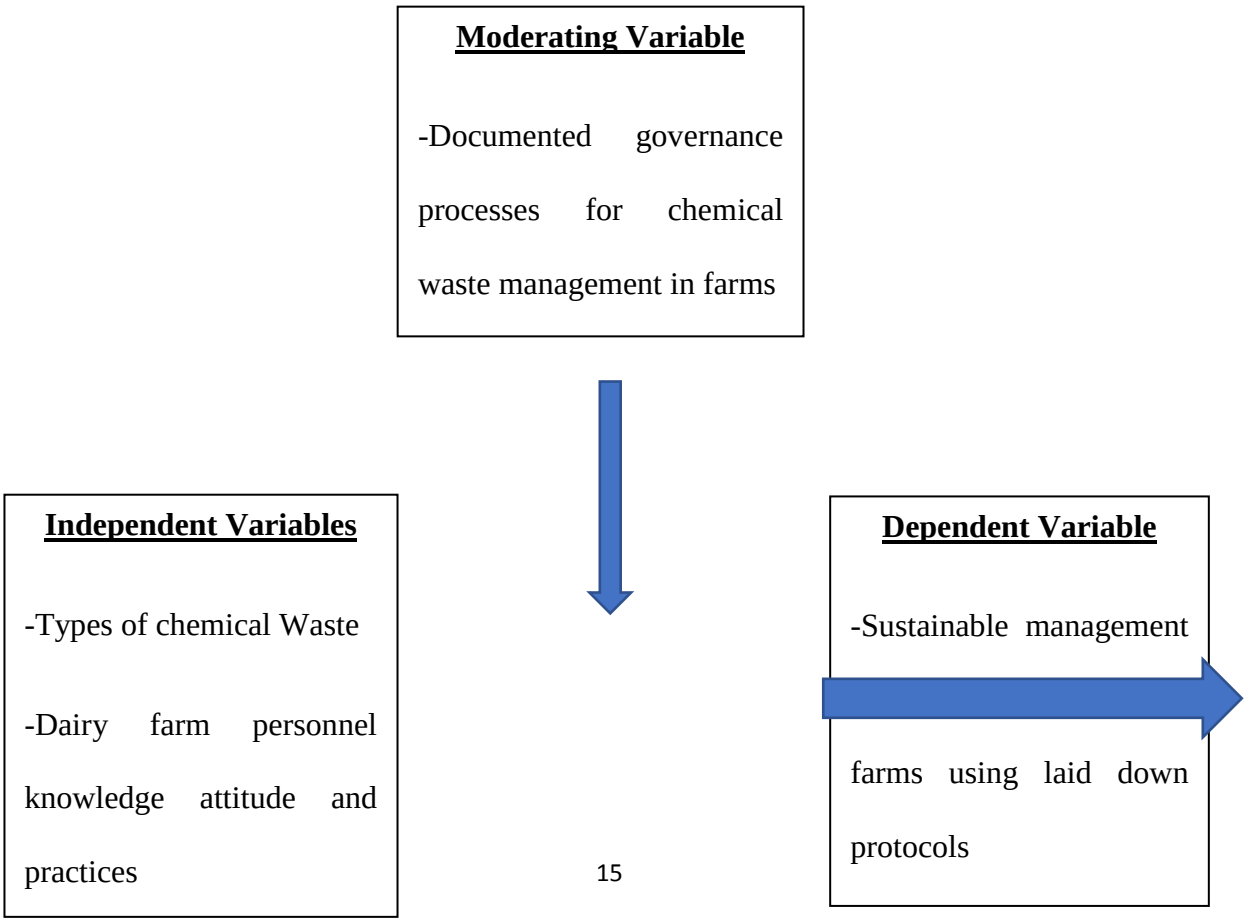
2.5: Summary of gaps

- There is widespread and extensive use of chemicals in smallholder dairy farms. in Kenya it is informally done according to farmers preferences and convenience with no

laid out chemical waste management procedures. There is need to understand the knowledge, attitude and practices of persons responsible for chemical waste disposal.

- There are many different chemicals used in small holder dairy farms in Kenya, most of which are hazardous and hence need to be managed within regulatory framework. In Kenya where environmental institutions still use informal management practices and there lacks a laid down structure for use by small holder dairy farmers to manage chemical wastes from their farms. A gap is noted in existence of institutional and regulatory framework for effective management of chemical waste disposal.

2.5: Conceptual framework



Sustainable management of chemical waste in smallholder dairy farms (dependent variable) is dependent upon types of chemicals present in the farm and requisite capacity built skills (knowledge, attitude and practices) of the dairy farm personnel to effectively manage the waste using laid down protocols (documented governance processes, which becomes moderating variable).

2.6: Theoretical Framework

The results of this study will be argued out based on institutional theory. Institutional theory outlines a deeper and more adaptable aspects of social structure whereby the processes by which structures, including schemes, rules, norms, and routines, become accepted as authoritative guidelines for social behavior (Scott, 2004). Thus different components of chemical waste management in smallholder farms (dependent, independent and moderating variables) will be fitted into this theory to explain how these elements were created, diffused, adopted, and adapted over space and time, to either lead in effective management or how they declined to achieve the same.

Organizational structures and processes (farm workers knowledge, attitude and practices) will tend to acquire meaningful behavior of taking care of the environment by taking personal responsibility of managing chemical waste within the documented governance processes and achieve stability in their own right, or through laid down farm (institutional processes) in achieving desired results (the mission and goals of the organization) (Lincoln, 1995).

Institutions (in this case the farms), through established norms of laid down procures on management of the chemical waste becomes a critical component in the protection of environment from chemical effluents by providing means for shaping stable social behavior of its workers (Scott, 2008). Institutions establish protocols, procedures, customs and social and professional norms, to shape the workers in forming cultures and ethics of flowing laws and instructions that influence the ability of the same institution/ organization to effectively achieve certain practice like environmental protection from chemical waste (Hawley, 1968).

This theory will be used to argue is such elements exist for sustainable management of chemical waste in the case study based on tested likelihood of finding farm personnel with requisite skills (knowledge, attitudes and practices) to effectively manage chemical waste in dairy farms as per documented protocols/processes for its management when tested using Chi Square Test (X^2 (5, N=100), $P \leq 0.05$). Similarly, a likelihood of finding farm personnel who were well versed with documented protocols/processes for management of chemical waste through institutional built capacity would be tested using Chi Square Test (X^2 (5, N=100), $P \leq 0.05$) and fitted into the theory to understand institutional processes used to define the social behavior of the farm personnel.

CHAPTER THREE

3.0: MATERIALS AND METHODS

3.1: Study Design

The study was designed as a cross sectional descriptive survey that incorporated both retrospective and prospective attributes of the management practices. A random sampling of 100 farm workers was carried out from randomized samples of twenty smallholder farms drawn from the five wards (Gitaru, Muguga, Nyathuna, Kabete and Uthiru) of Kabete Sub-county. Five key informant interviews of relevant environment officers were also conducted to triangulate the results and obtain information of existing governance processes for management of chemical waste in farms. Only farms who had been conducting dairying activities for the last 12 months were included in the study. A systematic review of processes used in management of chemical waste in dairy industry was incorporated into the study targeting processes for chemical waste control, disposal of chemical containers, re-use and recycling.

Qualitative quantitative methods were used to collect data using questionnaires that were administered. Individually in farms and in offices for the case of key informant interviews. Statistical inferences were made by testing the likelihood of finding farms that understood the different types of chemical waste and were effectively managing the waste through built capacity skills of workers (Knowledge, attitude and practices) that followed documented protocols of the same management. Five degrees of freedom was used (95% confidence interval).

3.2: Study Area

The study was carried out in Kabete Sub-county of Kiambu County that is in the Central highlands of Kenya in the former Central Province, close to Kenya's capital, Nairobi. Kabete sub-county was chosen because dairying in this area is widely practiced commercially and structures of the farm had great influence from colonial settlers who had practiced good practices for environmental protection. Thus the case study area, as previously described, would serve to represent practices within dairy farms in Kenya in terms of institutional practices for environmental protection (Mburu, 2016).

Kiambu County has twelve sub-counties; Gatundu South, Gatundu North, Juja, Thika Town, Ruiru, Githunguri, Kiambu, Kiambaa, Kabete, Kikuyu, Limuru and Lari. The sub-county covers an area of 2,543.42 square kilometers and it is considered as one of the wealthiest sub-counties in Kenya (County Government of Kiambu, accessed from http://www.kenya-information-guide.com/kiambu-county.html on 20/05/2019).

The study area has smallholder farms who practice mixed farming that integrated dairying and crop production. The area is further sub-divided into five wards from the five wards (Gitaru, Muguga, Nyadhuna, Kabete and Uthiru) and has an approximated number of 1985 of farms that practice dairying and deliver milk to the registered cooperative societies. Farm sizes range between 0.25-1.0 acres (County Government of Kiambu, accessed from http://www.kenya-information-guide.com/kiambu-county.html on 20/05/2019).

The dairy farms in the study are practiced mainly zero-grazing of either pure or crossbred cows who are treated at the farm against parasites and diseases using procured chemicals which are disposed within the same farm. Again, due to the mixed farming practiced within the farm it is common to find other chemical waste such as herbicides, insecticides and pesticides. The county of Kiambu borders Nairobi, Muranga, Nakuru and Machakos counties (Fig. 1) while the wards of the Kabete sub-county are distributed geographically according to their location (Fig. 2).

Figure 1: Map showing Kiambu County in Kenya

County Government of Kiambu, 2018: accessed from:

http://www.kiambu.go.ke/about/position-size

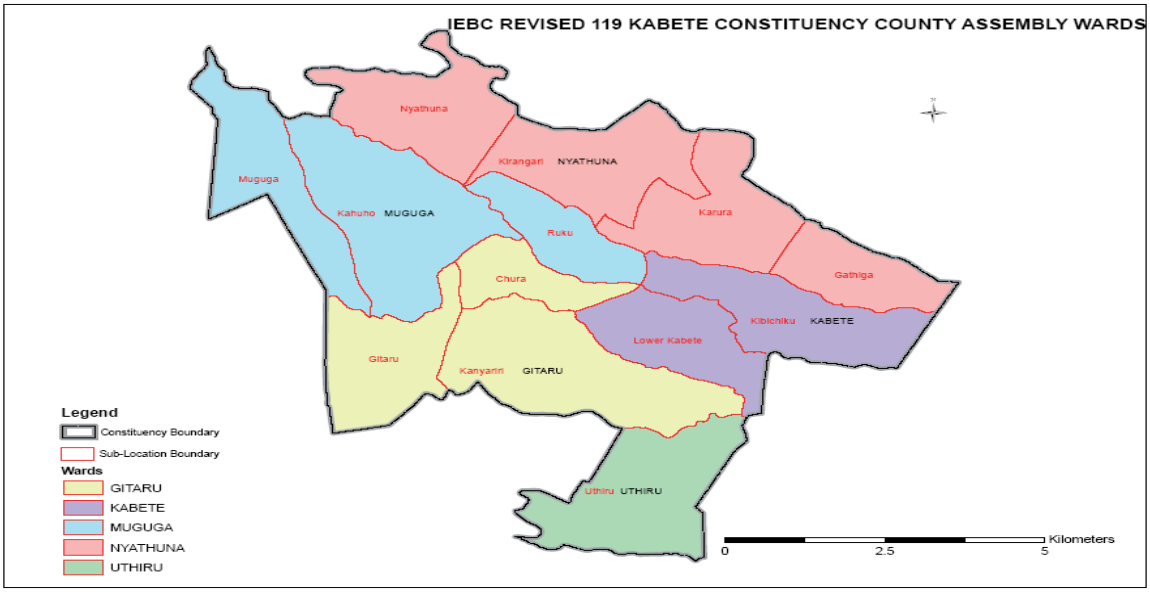


Figure 2: Map showing Kabete sub-county, Kiambu County.

3.3: Research Methodology

Data collection was carried out using survey of respondents through individualized interviews using a questionnaire that had been developed and pretested in a reconnaissance study using three farms. All workers present in the farm, if they did not exceed five, were interviewed starting with the household head, manager of the farm cow attendants. All questions were well explained to the respondents and data was captured within the spaces provided in the questionnaire. The researcher moved from one farm to the next by skipped 10 households systematically. All key informants were interviewed in their offices and using similar questions as those used to interview respondents in farms and some additional questions tailored to the different key informants. A systematic review of agreed upon processes for chemical management in dairy farms was done and recorded as baseline processes.

3.4: Target Study population

The target population for this study included small-holder dairy farms in the sub-county of Kabete and a key informant each from NEMA as a regulator, two cooperative saccos and two milk processors. A baseline report from Kiambu Annual reports for the Department of co-operative there were 1985 registered dairy farms in Kabete sub-county (Mburu, 2016).

3.5: Sample Size and Sampling

A sample size of 100 farms represented over 10% of dairy farms that delivered milk to registered milk cooperative societies. The sample size was generally in agreement with documented formulae calculations, using a registered of N=1985 farms in Kabete sub-county. The calculated sample size was expanded from 90 to n=100 to uniformly divide it equally to 20 farms per ward because the sub-county has five wards.

$$\mathrm{n} = \frac{z^2 \mathrm{pqN}}{e^2\,(N-1) + z^2 pq}$$

Kothari's (2004) sample size determination formula above was used to calculate the sample size at an approximate 90% confidence level, where:

Z is the Z – value = 1.96

Q = 1-P

n = is the sample size for a finite population

N= size of population which is the number of dairy farmers

p = Population proportion, considered as 0.50 in this study

e = margin of error considered as 10% for this study. As this is a fairly new area of study, a margin of error of ±10% is acceptable.

$$n = \frac{1.96^2 * 0.5 * 0.5 * 1985}{0.1^2 (1985 - 1) + 1.96^2 * 0.5 * 0.5}$$

n=90.6078. The figure was rounded off to n=100 for ease of distribution within five wards of the sub-county, where sample size per ward was 20 households/farms.

The farms were sampled by use of random-walk technique in which every 10^{th} farm/household practicing dairying was sampled along the walking tracks of the ward. A local guide was used to guide on the tracks and sampling routes started systematically from administrative offices of the chief in different directions of the compass (N to S and E to W). Ten farms/ household were sampled in each of the two routes in every ward to achieve sample size of 20 per ward. Records revealed that dairying activities are in over 90% of households and that there was no significant difference in distribution of dairying activities within wards to warrant differential sample size per ward. In the farm/household sampling was systematically conducted following hierarchal pecking order (from household head to low cadre workers), but individually.

3.6: Data Collection

The study utilized both primary and secondary data. Primary data was collected using semi-structured questionnaires administered during interviews. The structure of the questionnaires was derived from the research questions the study sought to answer. Section one collected the biodata of the participants, section two identified the location of the respondents while section 3-5 sought to answers the three research objectives, in a chronological order. These included questions on types of chemical waste in farms, Knowledge, attitude and practices of farm personnel and conformity of practices of chemical waste management with documented processes/protocols for its management in dairy farms. The data collection instrument was pre-tested and revised. Online Data Kit (ODK) tool was used to collect and manage data offline in the field, which was later submitted and uploaded to the server upon connection to the internet. Secondary data was obtained through systematic literature review of relevant documents on protocols/processes for management of chemical waste in dairy farms.

3.7: Data Analysis

Data was entered into an excel sheet, transported to Statistical Package for Social Science (SPSS) for cleaning, coding and analysis. Data was coded and analyzed using SPSS® version 23.0 to generate tables, figures and relevant statistics. A list of types of chemical wastes existing in smallholder dairy farms was generated according to ranking of likely occurrence. Likelihood of finding farm personnel with requisite skills (knowledge, attitudes and practices) to effectively manage chemical waste in dairy farms as per documented protocols/processes of its management was tested using Chi Square Test (X^2 (5, N=100), $P \leq 0.05$). Similarly, a likelihood of finding farm personnel who were well versed with documented

protocols/processes for management of chemical waste through institutional built capacity was tested using Chi Square Test (X^2 (5, N=100), $P \leq 0.05$).

CHAPTER FOUR

4.0: RESULTS AND DISCUSSION

4.1: BASIC DATA

4.1.1: Respondents Response Rate

Of the 100 dairy farm personnel and five key informant respondents interviewed there was 100% response rate. This could be attributed to the fact that individualized interviews were conducted, and importance of the survey was communicated to each respondent. Such response rate have been observed previously (Mugenda and Mugenda, 2003; Babbie, 2015).

4.1.2: Characteristics of the Interviewed Dairy Farm Personnel Respondents

The demographic characteristics of the respondents is shown in Table 1. In brief the respondents age was of mixed categories and mostly (88%) below 50 years. In addition, a majority (69%) of them had formal education background having attained at least secondary level certification. More than half of the respondents (60%) were women. Over half (51%) of the respondents were members of dairy farming board (association). These results are in agreement with other findings reported previously for similar studies (Muriuki *et al.*, 2010; Thornton, 2010; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018). The characterics presented also provides evidence that representative sampling was achieved as it agrees with previous observations (Kothari, 2004).

Table 1: Demographic Characteristics of the Interviewed Dairy Farm Respondents

Gender of the Respondents	**Frequency**	**Percentage**
Less than 20 years	2	2.0
21-30 years	15	15.0
31-40 years	30	30.0
41-50 years	37	37.0
51-60 years	7	7.0
61-70 years	7	7.0
71-80 years	0	0.0
Over 81 years	2	2.0
Total	**100**	**100.0**
Educational level		
No formal education	15	15.0
Primary school level	16	16.0
Secondary school level	31	31.0
Tertiary Level	38	38.0
Total	**100**	**100**
Gender of the Respondents		
Male	40	40.0
Female	60	60.0
Total	**100**	**100.0**
Respondents' membership of dairy cooperatives		
Yes	51	51.0
No	49	49.0
Total	**100**	**100**
Other Associations		
Yes	19	19.0
No	81	81.0
Total	**100**	**100**

4.2: RESULTS FOR SPECIFIC OBJECTIVE 1: TO EVALUATE TYPES OF CHEMICAL WASTE IN SMALLHOLDER DAIRY FARMS IN KABETE SUB-COUNTY

4.2.1: Status of chemical use in smallholder dairy farms in Kiambu

4.2.1.1: Respondents contact with farm chemicals

Majority of interviewed respondents handled farm chemicals directly in the farms (Fig. 3).

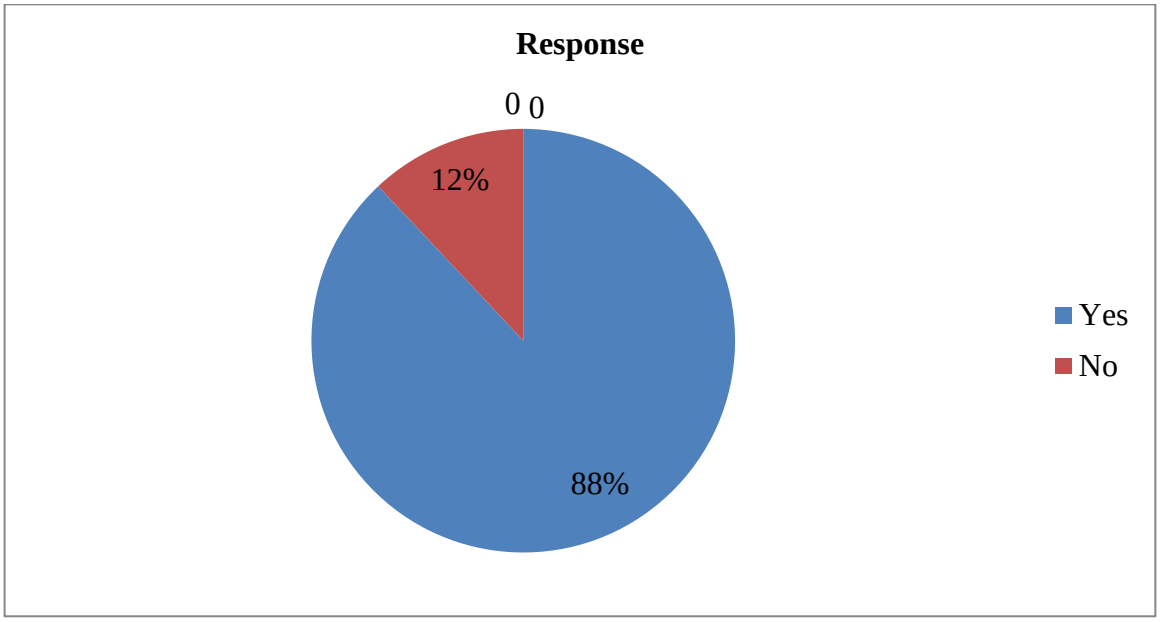


Figure 3: Percentage of Respondents who handled Farm Chemicals directly in Farms

These results indicate that farm personnel ought to be capacity built with requisite skills (knowledge, attitudes and practices) to effectively manage chemical waste in dairy farms as per documented protocols/processes of its management (X^2 (5, N=100) =8.79, P≤0.05). This agrees with previous studies by Fairweather (1999), who concurs that chemical use and disposal in farms ought to be handled by trained personnel.

4.2.2: Type of Chemicals commonly found in Dairy Farms in Kabete Sub-county

Figure 4 below shows types of chemicals commonly used in dairy farms in Kabete Sub-county together with the proportions of their usage.

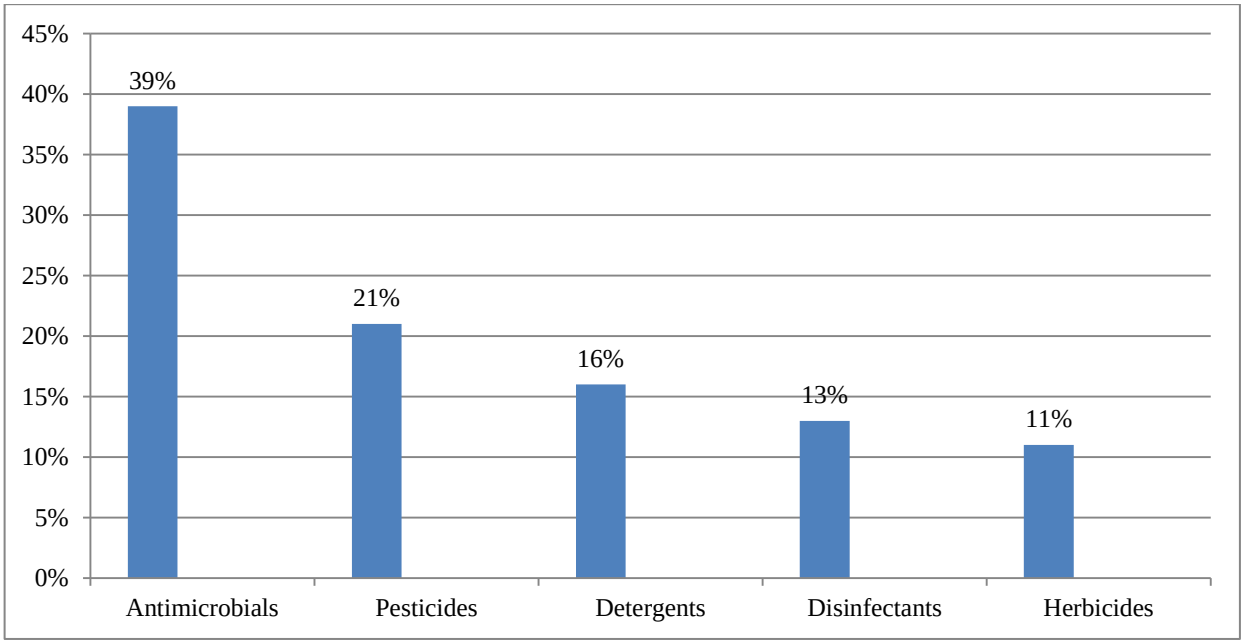


Figure 4: Type of Chemicals used in Dairy Farms in Kabete Sub-county and Percentage of farms using them

Briefly his shows antimicrobials are highly used in the farms with significant reduced usage of herbicides. This is expected in dairy farms (Devendra, 2001). Therefore, there is a significant likelihood of chemical waste pollution eliminating from dairy farms in Kabete Sub-county (X^2 (5, N=100) =6.51, P≤0.05). This agrees again with previous findings of Fairweather (1999), who concurs that chemical waste is problem in dairy farms that use chemicals.

4.2.3: Usage Frequency Chemical in Dairy Farms in Kabete Sub-county

The figure below shows usage frequency of chemicals in evaluated farms (Fig. 5).

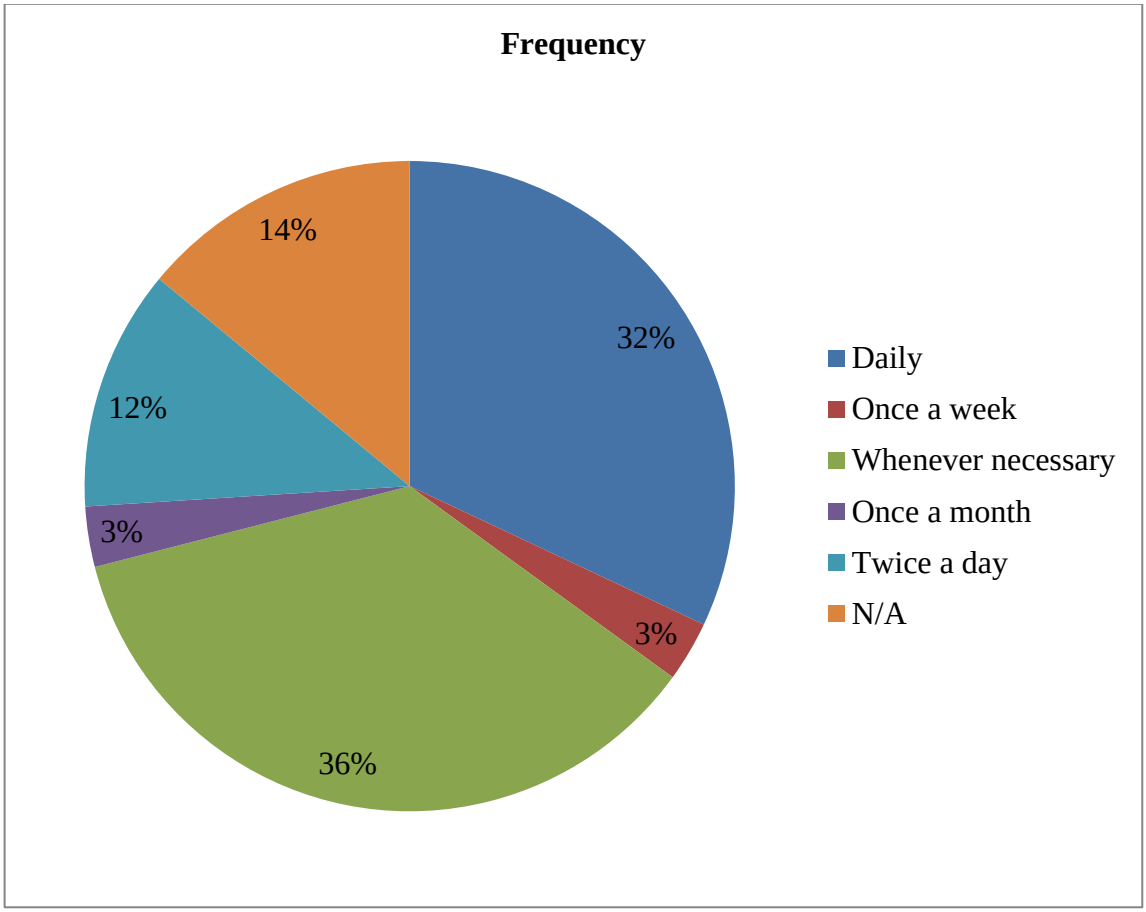


Figure 5: Usage Frequency of Chemical in Dairy Farms of Kabete Sub-county

The study reveals there was significant daily usage of chemicals in the dairy farms (X^2 (5, N=100) =9.1, P≤0.05). This confirms findings by Fairweather (1999), who concurs that there a high likelihood of using chemicals in dairy farms on a daily basis. Such findings have also be explained and were expected where various chemicals are required for management of the

daily enterprise in Kenya (Muriuki *et al.*, 2010; Thornton, 2010; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018).

4.2.4: Source of Chemicals used in Dairy Farms in Kabete Sub-county

Table 2 shows the sources of chemicals used dairy farms.

Table 2: Source of Chemicals used in Dairy Farms

Source	Frequency	Percent
Agro–vets	43	43.0
Retail outlets – supermarkets	42	42.0
Pharmaceutical suppliers	1	1.0
N/A	14	14.0
Total	**100**	**100.0**

Agro-veterinary shops and supermarkets were the significant sources of chemicals used in dairy farms ($X2$ (5, N=100) =9.1, $P \leq 0.05$). This evidence does confirm findings by Fairweather (1999), who demonstrated a high likelihood of access to chemicals by dairy farmers and a likelihood of such chemicals to become environmental pollutants in Kenya (Muriuki *et al.*, 2010; Thornton, 2010; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018).

4.2.5: Observed Chemical waste Management Practices

The figure below shows practices of chemical waste management in dairy farms in Kabete Sub-county as reported by the respondents (Fig. 6).

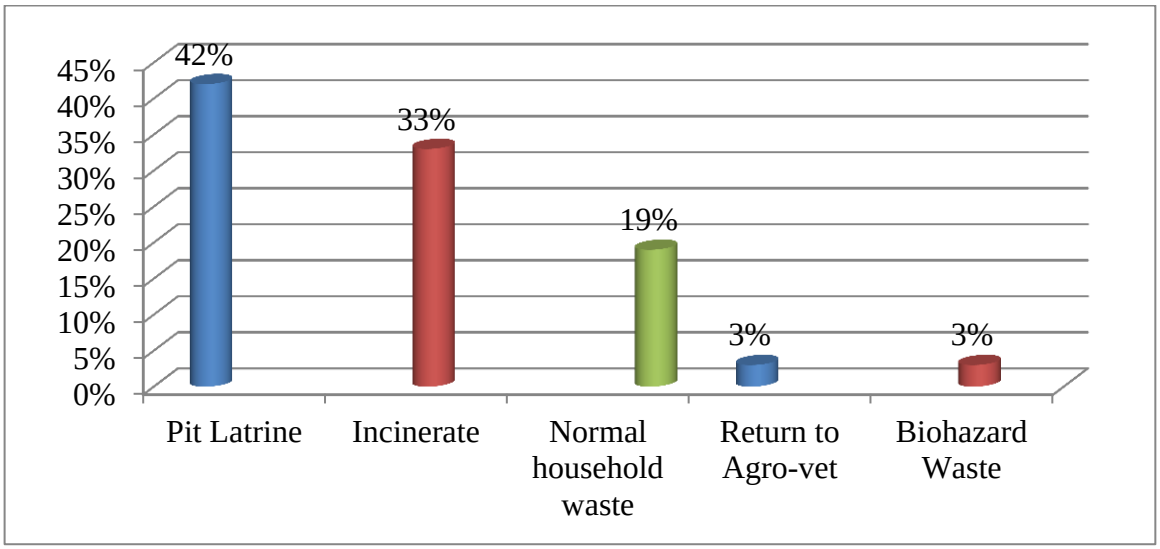


Figure 6: Reported Practices for Chemical Waste Management in Dairy Farms

A significant proportion of respondents (over 60%) reported practicing poor chemical waste management by either dumping in pit latrines or disposing with normal household waste (X^2 (5, N=100) =5.32, P≤0.05). This confirms findings by Fairweather (1999), who concurs that there a high likelihood of using chemicals in dairy farms on a daily basis. Such findings have also be explained and were expected where various chemicals are required for management of the daily enterprise in Kenya (Muriuki *et al.*, 2010; Thornton, 2010; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018). Incinerated chemicals can also yield hazardous gases into the environment although some authors argue it an alternative method to haphazard burning of chemicals (Rahman *et*

al., 2009). Harvey et al. (2002) classify safe disposal of chemical waste to be a process whereby associated risks are either eliminated or minimized through safe burying, landfilling, and recycling /resource recovery.

4.3: RESULTS FOR OBJECTIVE 2: TO DETERMINE KNOWLEDGE, ATTITUDES, AND PRACTICES OF FARM WORKERS REGARDING MANAGEMENT OF CHEMICAL WASTE IN SMALLHOLDER DAIRY FARMS IN KABETE SUB-COUNTY

4.3.1: Knowledge, Attitudes and Practices of Dairy Farm Personnel

4.3.1.1: Respondents Knowledge on the need Follow Manufacturer's Instructions wherever they needed to use chemicals in Farms

Knowledge and attitude regarding whether the respondents read and followed manufacturer's instructions whenever they used and disposed chemicals in farms are shown in the figure below (Fig.7).

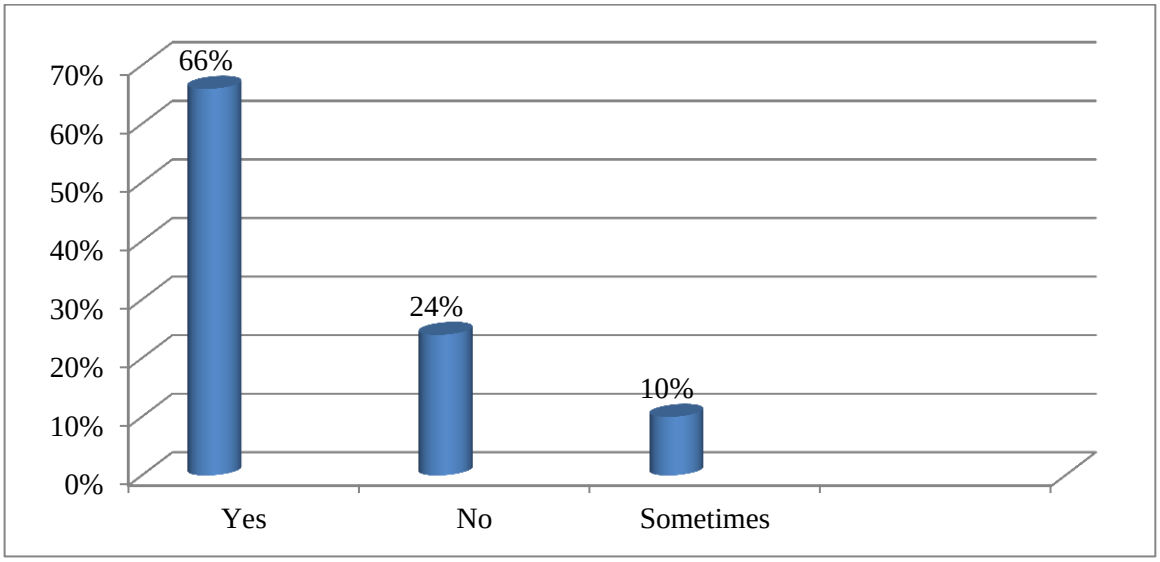


Figure 7: Percentage of Respondents Knowledgeable on the requirement to Read and Follow Manufacturer's Instructions whenever using Chemicals in farms

Majority of the respondents significantly had the knowhow that they were required to read and follow manufacturer's instructions whenever using chemicals in the farm ($X2$ (5, N=100) =1.42, $P \leq 0.05$). As described previously (Fairweather, 1999), such knowledge is necessary skill in management of chemical waste in order to protect the environment (FAO, 2010; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018). The observation however differs with those pointed out by Muriuki (2011), which indicated that about 40% of small-holder farmers fail to read and adhere to instructions presented by manufacturers before using chemicals. This divergence could be attributed to the fact that most of chemicals used in dairy farms are directly administered to animals and failure to take precaution by reading and following manufacturer's instructions might lead to death of animals and loss of livelihoods.

4.3.1.2: Respondents attitudes on reason not to read and follow Manufacturer's Instructions whenever using and disposing Chemicals in Dairy Farms

Table 4 shows the reasoned attitudes of the respondents on why they chose not to read and follow manufacturer's instructions whenever using and disposing chemicals.

Majority of the respondents (66%) who don't read or follow instructions on usage and disposal of the chemicals in dairy farms in Kabete sub-county just chose not to do so out of personal defiance ($X2$ (5, $N=100$) $=1.03$, $P \leq 0.05$).

Table 3: Reasoned Respondents attitudes in failing to follow Manufacturer's Instructions whenever using or disposing Chemicals

Response	Frequency	Percentage
No reason at all	66	66.0
Thinks they already know	10	10.0
Think it is monotonous to keep doing it	19	19.0
Not necessary	5	5.0
Total	**100**	**100.0**

The observation now agrees with those pointed out by Muriuki (2011), which indicated that about 40% of small-holder farmers fail to read and adhere to instructions presented by manufacturers before using chemicals. This points towards a likely scenario by such personnel to underutilize a necessary skill required in sustainable management of chemical waste in farms (Fairweather, 1999) leading to already demonstrated chemical pollution in

Kenya (FAO, 2010; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018).

4.3.1.3: Respondents Precaution Practices for Management of Chemical Waste in Dairy Farms

The precaution practices the respondents used in management of accidental spillage of chemical are shown below (Table 4).

Table 4: Precautions Undertaken by Respondents during Chemical Spillages

Precautions taken	Frequency	Percentage
Rinse contact surfaces with water	25	25.0
None	34	34.0
Spill soil over contact surfaces	41	41.0
Total	**100**	**100.0**

There was no significant difference between those who did nothing about spillages when compared to those who conducted subtle precautions to deal with it ($X2$ (5, N=100) =4.89, $P \leq 0.05$). This agrees with previous reports that chemicals from farms pose a threat to ecosystem health through environmental pollution (FAO, 2010; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018).

4.3.1.4: Respondents Practices on re-use of Chemical and their Containers

The practices by respondents to develop a tendency to re-use chemicals and their containers within farms are indicated in Table 5.

Table 5: Practices by Respondents to Re-use Chemicals and Containers within Farms

Response	Frequency	Percentage
Sometimes	12	12.0
No	31	31.0
Yes	57	57.0
Total	**100**	**100.0**

A significant majority (57%) of the respondents had practiced a tendency to re-use chemicals and their containers within farms (X2 (5, N=100) =8.22, P≤0.05). As described previously (Fairweather, 1999), such practices not only jeopardize governance processes for effective management of chemical waste (EMCA, 1999; NEMA, 2015) but also fail to acknowledge protect the ecosystems from such spillages leading toxic effects (FAO, 2010; Kipyegon *et al.*, 2016, 2017; Mutembei *et al.*, 2017; Kathambi and Mutembei, 2018; Mutembei and Kathambi, 2018). The observation also supports report by Muriuki (2011), which indicated that about 40% of small-holder farmers are unwilling to effectively manage chemical waste in farms.

4.3.1.5: Reasons Advanced by Respondents for Practicing Re-use of Chemicals and Containers in Farms

Table 6 shows the reasons provided by the respondents to support practicing re-use of chemicals and their containers in farms.

Table 6: Respondents Reason for Re-using Chemicals and Containers in Farms

Purpose	Frequency	Percentage
Domestic use to save money	31	31.0
No reason at all	30	30.0
Farm/Household policy	39	39.0
Total	**100**	**100.0**

The respondents significantly re-used chemicals and containers in farms based on the need to conform to the instructions provided for in saving on chemicals and/or household policy ($X2$ (5, N=100) =1.63, $P \leq 0.05$).

These results support institutional theory which outlines an extensive and more adaptable outlooks of social structure whereby the processes by which structures, including schemes, rules, norms, and routines, become established as authoritative guidelines for social behavior (Scott, 2004). Thus, the farm personnel were created, diffused, adopted, and adapted over space and time to develop a behavior of declining to utilize their own knowledge to management of waste in but rather advanced farm/household institutional interest.

As previously described (Scott, 2008), organizational structures and processes tend to influence personnel's knowledge, attitudes and practices that fail to acquire meaningful behavior of taking care of the environment by taking personal responsibility of managing chemical waste within the documented governance processes and achieve stability in their own right, or through laid down protocols but rather serve the mission and goals of the organization (Lincoln, 1995).

This was a clear case where the institution (in this case the farm), through established norms of encouraging re-use of chemicals and containers within farms became a critical component in declining to protect the environment from chemical effluents and became the means for shaping undesirable social behavior of its personnel (Scott, 2008). In this case farms became institutions that established protocols, procedures, customs and social and norms, which shape the personnel into forming cultures and ethics of disregarding laws and instructions for effectively achieving the desired practice of non-re-use of chemicals and containers within farms for environmental protection from chemical waste (Hawley, 1968).

4.4: RESULTS FOR OBJECTIVE 3: TO ANALYZE THE ASSOCIATION BETWEEN THE PRACTICES USED BY DAIRY FARM PERSONNEL TO MANAGE CHEMICAL WASTE IN DAIRY FARMS IN KABETE SUB-COUNTY IN RELATION TO DOCUMENTED GOVERNANCE PROCESSES (PROTOCOLS) FOR MANAGEMENT OF THE SAME IN DAIRY FARMS

4.4.1: Best practices for chemical waste management

Table 7 shows documented processes for effective chemical waste management (Phillips, 2014; The National Academies Press, 2015).

Table 7: Standard processes for chemical waste management

Procedure	**Waste disposal process**
Disposal to Sewer via Waste Sinks	✓ Several substances for example organic solvents are banned from disposal by this kind of disposal. ✓ Proper training is required for the Persons conducting waste disposal via this method ✓ Verify that chemicals disposed this way are not antagonistic and that reactivity issues with plumbing/drains, such as Polyvinyl Chloride (PVC), High-density polyethylene (HDPE) or metal are taken to account ✓ Neutralization and dilution of any caustic chemicals disposed through this method is necessary. Neutralize to a pH of 6-10 using a suitable base solution for the acids and suitable acid solution for the alkaline solutions carefully. ✓ Confirm neutralization is complete using pH test strips, paper or pH meter before releasing to sewers. ✓ Disposal of chemical waste through this method should only be chemicals that don't react or interfere with drainage and should always be followed by a flush with water ✓ When there isn't enough water to flush after waste in waste sinks, it is preferable to dispose of the chemical waste using regular waste collections by a certified contractor. ✓ Where possible waste should be discharged in a sink within a fume hood.
Disposal to Holding Tanks via Waste Sinks	✓ Liquid chemical waste to aggregate in holding tank(s) ✓ The waste tanks are evacuated by a waste contractor with regularity and the levels the disposed wastes have reached should be closely monitored through the Building Management System (BMS)

	✓ Arrange for collection when deemed necessary
Disposal to Atmosphere (Evaporation)	✓ Suitable for chemicals that can be transformed into gases and vapours. It is advisable to use fume cupboards for this method as much as possible. ✓ This method should be used only for chemicals that are not toxic, combustible or hazardous to one health, in minimal amounts.
Inactivation / Neutralization by Chemical Reaction	✓ Suitable for chemicals that can be inactivated through a chemical reaction. ✓ Method should be conducted by a well-trained person and risk assessment is necessary before conducting the reaction.
Disposal via Commercial Contractor	✓ If the chemical waste in need of disposal cannot be disposed of using either of the methods listed above, they are segregated and stored awaiting collection by a contractor better trained to handle that type of waste. ✓ The chemicals should be segregated according to their compatibility and reactivity and their specific hazard level. ✓ Firmly seal all empty and waste chemical containers before disposing/segregating. ✓ Collection is then done regularly by a trained contractor for suitable disposal
Notification	✓ The Health and Safety Adviser coordinates with the waste disposal contractor for a collection and gives notice at least one month before preferred day of collection ✓ Chemical waste collections are to be undertaken every three months or as frequently as deemed necessary. ✓ After the collection is scheduled and confirmed the chemical waste personnel are informed and in turn alert their technical support for effective preparation and disposal.
Storage - prior to collection	✓ Waste should be segregated before the collection date according to their reactivity and compatibility and the hazard level. ✓ There are 2 different types of containers that can be used as disposal vessels; (plastic drum-dangerous goods grade and glass Winchester bottles). The vessel selected depends on the properties of the chemical and the volume. ✓ Flammable chemicals filled into a container should leave some space at the top to allow for build-up and avoid blowing up. ✓ Where feasible, chemical waste should be moved gradually to collection stores and confirm all waste containers are firmly sealed.

Labelling	✓ All containers in storage awaiting collection and disposal must be clearly labelled.
Manifest	✓ A chemical waste disposal manifest with chemical details including ingredients, volume and concentrations and number of packages must be prepared one week before collection by persons requiring chemical waste disposal. ✓ All manifests for each pick up point and categorized and submitted to the contractor for waste disposal.
Collection	✓ At the agreed day and time of collection, the contractor works with a contact person (preferably chemical waste contact) present at the source to gain entrance to collection store and retrieve chemical waste for disposal. ✓ The contractor should provide two copies of a waste transport certificate and a service advise. One copy of the certificate must be delivered to the relevant institutions for chemical waste management. ✓ The rest of the documents are left at source of waste.
Examples of supporting laws/regulations required	✓ Work Health and Safety Act ✓ Environmental Protection Regulation ✓ Health & Safety Policy ✓ Work Health and Safety Regulation ✓ Managing risks of hazardous chemicals in the workplace Code of Practice ✓ Code for the Transport of Dangerous Goods by Road & Rail

The evidence of documented processes for effective chemical waste management that are supported by existing legal frameworks in developed countries demonstrate that it is possible to achieve sustainable chemical waste management (Phillips, 2014; The National Academies Press, 2015). However, in Kenya although the interview from key formants revealed knowledge of existing documented processes for such management, 100% of them indicated such processes are yet to be put in place for chemical waste management in Kenyan farms in general, including the dairy farms. This was not a unique observation and it was expected based on the fact that farming in Kenya is not only informal but also done as the owner deems fit in terms of managing farm activities, including waste management.

It is therefore in agreement with previous authors who documented that chemical waste management is a problem in developing countries and national processes for its management need to be put in place in order to protect the environment and also promote responsible use of chemicals and hazardous materials (defra, 2004; Phillips, 2014; The National Academies Press, 2015).

4.4.2: Respondent Training Needs on Chemical Waste Management in Farms

Respondents expressed needs for training in chemical waste management are shown below (Table 8).

Table 8: Respondents Training Needs on Chemical Waste Management in Farms

Needed Training	Frequency	Percentage
Yes	87	87.0
No	13	13.0
Total	**100**	**100.0**

Majority of the respondents (87%) significantly needed training in chemical waste management (X^2 (5, N=100) =8.71, P≤0.05).

The observation support of others (Fairweather, 1999), who indicated personnel dealing with chemical waste required capacity building and also that intuitions such as farms need to play a role in shaping processes by which structures, including schemes, rules, norms, and routines, become established as authoritative guidelines for social behavior (Scott, 2004).

Organizational structures and processes (farm personnel's knowledge, attitudes and practices) will utilize such training forum to acquire meaningful behavior of taking care of the

environment by taking personal responsibility of managing chemical waste within the documented governance processes and achieve stability in their own right, or through laid down farm (institutional) processes in achieving desired results (the mission and goals of the organization) (Lincoln, 1995).

4.4.3: Association between Practices of Respondents to Manage Chemical Waste in accordance to laid down Governance Processes

4.4.3.1: Knowledge on Laws and Regulations for Chemical Waste Management

The table below shows respondents awareness level on regulation of chemical waste in dairy farms (Table 9).

Table 9: Respondents Awareness on Regulation of Chemical Waste in Dairy Farms

Aware	Frequency	Percent
No	100	100.0
Yes	0	0.0
Total	**100**	**100.0**

All the respondents were not aware of any regulations for management of chemical waste in farmers. The observation support of others (Fairweather, 1999), who indicated personnel dealing with chemical waste required capacity building and also that intuitions such as farms need to play a role in shaping processes by which structures, including schemes, rules, norms, and routines, become established as authoritative guidelines for social behavior (Scott, 2004).

4.4.4: Respondents Suggested Avenues for Compliance of Personnel on Regulatory Frameworks for Chemical Waste Management in Farms

Table 10 shows listed avenues suggested for capacity building of farm personnel in order to comply with regulatory frameworks for management of chemical waste in dairy farms. Significant majority suggested formal training and farm visit extension services as the best ways to build capacity and boost compliance with regulatory frameworks for personnel (X^2 (5, N=100) =7.20, P≤0.05).

Table 10: Means by which Respondents could be capacity built to be made aware and comply with regulatory Frameworks for Chemical Management in Dairy Farms

Response	Frequency	Percent
Formal Training	53	53.0
Farm visit Extension Services	19	19.0
Reward and Subsidies	17	17.0
Remain as is Now	11	11.0
Total	**100**	**100.0**

The observation is in support of others (Fairweather, 1999), who indicated personnel dealing with chemical waste required capacity building and also that institutions such as farms need to play a role in shaping processes by which structures, including schemes, rules, norms, and routines, become established as authoritative guidelines for social behavior (Scott, 2004).

CHAPTER FIVE

5.0: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions of the Study

- The main types of chemical wastes existing in smallholder dairy farms in Kabete sub county were antimicrobials, pesticides, detergents, disinfectants and herbicides
- Farm personnel lacked requisite knowledge, attitude and practices for management of chemical waste in dairy farms
- Farm personnel were completely unaware of regulatory frameworks for management of chemical waste in farms
- Farm personnel were willing to be capacity built on practices and regulatory frameworks for effective management of chemical waste in farms
- Farm personnel suggested formal training and farm visit extension services as means for capacity building on effective chemical waste management in dairy farms

5.2: Recommendations from the Study

1. Relevant authorities like NEMA to develop national policies for effective chemical waste management in farms
2. Dairy farm to endeavor to institute capacity building of farm personnel in order to inculcate requisite skills and behavior, cultures and norms within farms and for the personnel for sustainable chemical waste management in dairy farms.

CHAPTER SIX

6.0: REFERENCES

Aikiriza, S. (2015): Assessment on the State of Dairy Farming and Milk Production in Uganda and the Position of the Different Stakeholders/Organizations in the Dairy Chain.

Aktar, W., Sengupta, D. and Chowdhury, A. (2009): 'Impact of pesticides use in agriculture: their benefits and hazards', Interdisciplinary Toxicology, 2(1), pp. 1–12. doi: 10.2478/v10102-009-0001-7.

Babbie, E. (2015): The Practice of Social Research. 14th editi. Boston: Cengage Learning.

County Government of Kiambu (2018): About Us – Kiambu County Government. Available at: http://kiambu.go.ke/about-us/#2 (Accessed: 22 May 2019).

County Government of Kiambu (2019): About Kiambu County. Available at: http://www.kenya-information-guide.com/kiambu-county.html (Accessed: 22 May 2019).

DAI'S Africa Lead II Initiative (2015): Rwanda empty pesticide container pre-feasibility study. Prepared for and under DAI'S Africa lead II initiative. Available at: https://www.africaleadftf.org/wp-content/uploads/2016/09/2016-Rwanda-Pesticide-Container-Feasibility-Study..pdf (Accessed: 21 May 2019).

defra (2004): Pesticides - Best Practice Guides. Available at: http://adlib.everysite.co.uk/adlib/defra/content.aspx?id=000IL3890W.16NTBWTW6M4U4 (Accessed: 27 May 2019).

Delgado, C. L. and Jahnke, H. E. (2006): 'Livestock Production Systems and Livestock Development in Tropical Africa', American Journal of Agricultural Economics, 65(2), p. 462. doi: 10.2307/1240913.

Devendra, C. (2001): 'Smallholder dairy production systems in developing countries: Characteristics, potential and opportunities for improvement. Review', Asian-Australasian Journal of Animal Sciences. Asian-Australasian Association of Animal Production Societies, 14(1), pp. 104–113. doi: https://hdl.handle.net/10568/30086.

Dietz, T., Foeken, D., Klaver, W. and Soeters, S. (2014): Agricultural dynamics and food security trends in Kenya. Research Report 2013, Developmental Regimes in Africa (DRA)

Project. Available at: www.odi.org.uk (Accessed: 20 May 2019).

Dinki, N. and Balcha, E. (2013): 'Detection of antibiotic residues and determination of microbial quality of raw milk from milk collection centres', Adv Anim Vet Sci. Available at: https://nexusacademicpublishers.com/uploads/files/20130802140831.pdf (Accessed: 20 May 2019).

EMCA (1999): Environmental Management and Co-ordination Act. Nairobi, Kenya. Available at: http://extwprlegs1.fao.org/docs/pdf/ken41653.pdf (Accessed: 2 July 2020).

EPAT (1994): Pesticides and the agrichemical industry in sub-Saharan Africa.

Fairweather, J. R. (1999): 'Understanding how farmers choose between organic and conventional production: Results from New Zealand and policy implications', Agriculture and Human Values. Springer Netherlands, 16(1), pp. 51–63. doi: 10.1023/A:1007522819471.

FAO (2010): 'Small-scale dairy production: a way out of poverty'. Available at: http://www.fao.org/news/story/en/item/44582/icode/.

FAO (2017): Livestock and the environment | FAO | Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/livestock-environment/en (Accessed: 20 May 2019).

GoK (2017): Executive and Growth Strategy Towards a dustainable Agricultural Transformation and Food Security in Kenya - A Bridged Version. Available at: http://www.kilimo.go.ke/wp-content/uploads/2019/01/Download-here.pdf (Accessed: 20 May 2019).

Groot, M. J. and van't Hooft, K. E. (2016): 'The Hidden Effects of Dairy Farming on Public and Environmental Health in the Netherlands, India, Ethiopia, and Uganda, Considering the Use of Antibiotics and Other Agro-chemicals', Frontiers in Public Health. Frontiers, 4, p. 12. doi: 10.3389/fpubh.2016.00012.

Harvey, P., Baghri, S. and Reed, B. (2002): Emergency Sanitation: Assessment and Programme design. Water Engineering and Development Centre (WEDC). Loughborough, UK: WEDC. Available at: https://www.ircwash.org/resources/emergency-sanitation-assessment-and-programme-design (Accessed: 22 May 2019).

Hawley, A. (1968): ‘Human ecology.’, in D. L. Sills (Ed.), International Encyclopedia of the Social Sciences. New York: Macmillan, pp. 328–337.

IDF/FAO (2004): ‘A farm-to-table approach for emerging and developed dairy countries’, in International Symposium on Dairy Safety and Hygiene. Cape Town; South Africa, p. 39. Available at: http://www.fao.org/3/y6007e/y6007e00.pdf (Accessed: 21 May 2019).

Karanja, A. (2013): The dairy industry in Kenya: the post-liberalization agenda. Nairobi.

Kathambi, B. E. and M’ikiugu, M. H. (2018): ‘Implementing sustainable development Goals 1, 3.9, 7, and 13 through adoption of green concept in environmental management: Case of Nairobi, Kenya’, Journal of Biodiversity and Environmental Science, 12(3).

Kathambi, B. E. and Mutembei, H. M. (2018): ‘Determinants of compliance with governance instruments for adoption of green concept in environmental management: Case of Nairobi.” 2018;12(3):28-38. - Google Search’, ournal of Biodiversity and Environmental Science, 12(3)(3), pp. 28–38. Available at: https://www.google.com/search?q=Kathambi+Bessy+Eva%2C+M’Ikiugu+MH.+%22Determinants+of+compliance+with+governance+instruments+for+adoption+of+green+concept+in+environmental+management%3A+Case+of+Nairobi.%22+Journal+of+Biodiversity+and+Environmental+Science (Accessed: 2 July 2020).

Kipyegon, A. N., Mutembei, H. M. and Tsuma, V. T. T. (2016): ‘Effects of Effluent Contaminated River Water on Testicular Histology of Mice’, J Agric Vet Sci, 3(6).

Kipyegon, A. N., Mutembei, H. M. and Tsuma, V. T. T. (2017): ‘Effects of Exposure to Effluent Contaminated River Water on Boar Reproduction’, International Journal of Veterinary Science, 6(1).

Kothari, C. R. (2004): Research methodology : methods & techniques. New Age International (P) Ltd. Available at: https://www.ebooks.com/en-ke/431524/research-methodology/kothari-c-r/?_c=1 (Accessed: 22 May 2019).

Lesschen, J., Stoorvogel, J. and Smaling, E. (2004): Scaling soil nutrient balances: Enabling mesolevel applications for African realities, Aging. doi: 10.1017/CBO9781107415324.004.

Lincoln, Y. S. (1995): ‘Emerging Criteria for Quality in Qualitative and Interpretive Research’, Qualitative Inquiry. Sage PublicationsSage CA: Thousand Oaks, CA, 1(3), pp.

275–289. doi: 10.1177/107780049500100301.

Mburu, G. N. (2016): Factors affecting production of dairy products in Kenya: A case of co-operative societies in Kiambu County. Nairobi.

Mugenda, O. M. and Mugenda, A. G. (2003): 'Research methods', Quantitative and qualitative approaches. African Centre for Technology Studies., pp. 46–48.

Muriuki, H. G. (2011): Dairy development in Kenya. Food and Agricultural Organization. Available at: http://www.fao.org/3/a-al745e.pdf (Accessed: 20 May 2019).

Muriuki, H. G., Wanjohi, P. and Njuguna, D. M. (2010): Improving Livelihoods in the Smallholder Dairy Sector in Kenya.

Mutembei, H. and Kilonzi, E. (2018): 'Determinants of dairy cattle breed biodiversity in rural traditional smallholder farms: Case of Kibugu in Kenya', Journal of Biodiversity and Environmental Science, 12(1).

Mutembei, H. M. and Kathambi, B. E. (2018): 'The Kenyan perspective on adoption of green concept in biodiversity conservation: Case of Nairobi, Kenya', Journal of Biodiversity and Environmental Science, 12(1).

Mutembei, H. M., Kipyegon, A. N. and Mutiga, E. R. (2017): 'Environmental Estrogen-like Endocrine Disrupting Compounds and the Dangers they Pose on Male Fertility: Review Case Study of Nairobi River Water', J. Phys. Sci. Environ. Stud., 3(3).

NEMA (2015): The National Solid Waste Management Strategy. Nairobi, Kenya. Available at: www.nema.go.ke (Accessed: 2 July 2020).

Ocaido, M., Otim, C., Crops, P. and Kakaire, D. (2009): 'Impact of major diseases and vectors in smallholder cattle production systems in different agro-ecological zones and farming systems in Uganda"', lrrd.cipav.org.co. Available at: https://www.lrrd.cipav.org.co/lrrd21/9/ocai21155.htm (Accessed: 21 May 2019).

Pérez-Lucas, G., Vela, N., El Aatik, A. and Navarro, S. (2018): 'Environmental Risk of Groundwater Pollution by Pesticide Leaching through the Soil Profile.', in In Pesticides, Anthropogenic Activities and the Health of our Environment. IntechOpen., p. 28.

Phillips, J. (2014): Chemical Waste Disposal Procedure. Available at:

https://www.griffith.edu.au/__data/assets/pdf_file/0030/327936/Chemical-Waste-Disposal-Procedure.pdf (Accessed: 3 July 2020).

Rahman, S., Dvorak, T., Stoltenow, C. and Mukhtar, S. (2009): Animal carcass disposal options. NDSU Extension Service publication NM-1422.

Rodić, L. and Wilson, D. C. (2017): 'Resolving Governance Issues to Achieve Priority Sustainable Development Goals Related to Solid Waste Management in Developing Countries', Sustainability. Multidisciplinary Digital Publishing Institute, 9(3), p. 404. doi: 10.3390/su9030404.

Scott, R. (2004): 'Institutional theory: Contributing to a theoretical research program.', in In K. G. Smith, & M. A. Hitt, (Eds.) (ed.) Great minds in management: The process of theory development. Oxford: Oxford University Press., p. (pp. 460-484).

Scott, R. (2008): Institutions and Organizations Ideas and interests, Journal of Chemical Information and Modeling. doi: 10.1017/CBO9781107415324.004.

Seré, C., van der Zijpp, A., Persley, G. and Rege, E. (2008): 'Dynamics of livestock production systems, drivers of change and prospects for animal genetic resources', Animal Genetic Resources Information, 42, pp. 3–24. doi: 10.1017/S1014233900002510.

Sizemore, G. C. (2015): 'Accounting for biodiversity in the dairy industry', Journal of Environmental Management. Academic Press, 155, pp. 145–153. doi: 10.1016/J.JENVMAN.2015.03.015.

The National Academies Press (2015): Prudent Practices in the Laboratory, Prudent Practices in the Laboratory. Washington, D.C.: National Academies Press. doi: 10.17226/4911.

Theunissen, B. (2012): 'Breeding for Nobility or for Production? Cultures of Dairy Cattle Breeding in the Netherlands, 1945–1995', Isis, 103(2), pp. 278–309. doi: 10.1086/666356.

Thornton, P. K. (2010): 'Livestock production: recent trends, future prospects', Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), pp. 2853–2867. doi: 10.1098/rstb.2010.0134.

Thorpe, W., Muriuki, H G., Omore, A., Owango, M.O., Staal, S. (2000): 'Dairy development in Kenya: the past, the present and the future. Paper prepared for the Annual Symposium of

the Animal Production Society of Kenya, March 22nd-23rd, 2000, KARI Headquarters, Nairobi.' Available at: https://cgspace.cgiar.org/bitstream/handle/10568/1723/Thorpe et al-2000-Dairy dev past present future-APSK.pdf?sequence=1 (Accessed: 20 May 2019).

U.S. Environmental Protection Agency. (2018): Report on the environment: Wastes. Available at: https://www.epa.gov/report-environment/wastes.

Walpole, Matt, Smith, Jessica, Rosser, Alison, Brown, Claire, Schulte-Herbruggen, Bjorn, Booth, Hollie, Sassen, Marieke Mapendembe, Abisha Fancourt, Bieri Mari, Glaser Satu, Corrigan Colleen, Narloch Ulf, Runsten Lisen, Jenkins Martin, Hutton Jon. (2013): Smallholders, food security, and the environment.

CHAPTER SEVEN

7.0: APPENDICES

APPENDIX 1: FARM PERSONNEL SURVEY QUESTIONNAIRE AND INTERVIEW GUIDE

Investigator: Emily Kilonzi B.V.M (UoN).

PART ONE: CONSENT

A. RESEARCHER'S DECLARATION

We the researchers declare that: -

1. The information from our respondents will not at any time be obtained by false pretense, coercion or intimidation.

2. The information received from the respondents will not be altered or tampered with in any way.

3. The data collected using this questionnaire will be solely used for research purposes.

B. RESPONDENT'S INFORMED CONSENT

I _____willingly give my

consent to be questioned by the researcher for the purpose of her research work

Signed_____ Thumb print_____

Questionnaire Number: _____

Date_____

BIODATA

1) Identity of the farmer (Name-Optional): ……

a) Age …….

b) Education ……

c) Gender ……

d) Member of dairy cooperative? **Yes/No**

e) Any other dairy associations affiliated with…….

2) Location of the farmer:

a) Ward: ……..…

b) Location: …….....

c) Sub-Location: ……

3) Situational analysis

Do you use any chemical products for your animals (pesticides, drugs e.t.c)? **Yes/No**

If yes

a) Do you handle farm chemicals directly in the farm? **Yes/No**

b) What chemical products do you use in the routine management of your farm?

……..

……..

……..

c) How often do you use each of them?

……

……

……

d) Where do you acquire these products from? ……

e) How do you dispose of chemical containers after use? ..... ……

……..

f) Why do you prefer this method(s)? .....

4) Knowledge, attitude and practices of dairy farm personnel

a) Do you read and follow the instructions on use and disposal of empty containers indicated by manufacturer? **Yes/No**

If no, give reason……

b) What precautions do you take in case of accidental spillage or leakage of these chemicals to the environment? .....

c) Do you ever re-use empty chemical containers in the farm operations or in the household? **Yes/No**

If yes, for what purpose(s)? .....

d) Have you at any point undertaken any kind of training on proper chemical waste management with regards to dairy farming? **Yes/No**

If yes, clarify……

5) Governance instruments

e) Are you aware of any laws or regulations governing chemical waste disposal?

Yes/No ……

f) What in your opinion can the government do to enforce chemical waste management policy at the farm level?

Formal training / farm visit extension services / reward and subsidies / remain as is now / other.....

Thank you for your time.

APPENDIX 2: KEY INFORMANT INTERVIEW GUIDE

- Which authority involved in regulating chemical waste from dairy farms? **Yes/No**

  If yes explain…….
- Are there policies in place to regulate chemical waste from smallholder dairy farms? **Yes/No**

  ……
- Do you have knowledge on any documented processes for chemical waste management in farms? **Yes/No ----------**
- If yes describe the implementation and the effectiveness of these policies on chemical waste management in smallholder dairy farms? ……
- What role do you play in ensuring farmers are aware of these laws and policies?

  ……
- How would you define the compliance levels of farmers to these legal and regulatory frameworks? **.....**
- In your opinion what factors influence these compliance levels? ……

  Highlight the most common reasons for non-compliance and challenges farmers face in an effort to comply …….
- Are you aware of the best recommended practices and processes of disposing chemical waste in dairy farms? **Yes/No**

  Read out loud: (waste sinks, waste tanks, evaporation, inactivation, segregation, incineration)
- Are smallholder dairy farmers aware of these practices and processes?
- Do they have the capacity (training and resources) to practice safe disposal of dairy chemical waste?

- Whose mandate is it to advice farmers on safe dairy chemical waste disposal?

  …….

- Are any of your products classified as hazardous to the environment? **Yes/No**
- If yes what is your recommended policy on their disposal? …….
- Are there laws/regulations governing the sale and/or distribution of chemicals to farmers?

  Yes/No

- Are you aware of the best recommended practices and processes of disposing chemical waste in dairy farms? **Yes/No**

  Read out loud: (waste sinks, waste tanks, evaporation, inactivation, segregation, incineration)

- Are smallholder dairy farmers aware of these practices and processes?
- Do they have the capacity (training and resources) to practice safe disposal of dairy chemical waste?
- Whose mandate is it to advice farmers on safe dairy chemical waste disposal?

  …….