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EFFECT OF MANURE MANAGEMENT STRATEGIES IMPLEMENTED IN DAIRY FARMS ON ANIMAL HEALTH AND MILK HYGIENE IN KHARTOUM, SUDAN

Nahid M.T. Fawi* **and Amira A. Ahmed**

University of Khartoum, Faculty of Animal Production,
Department of Dairy production, Khartoum North, Sudan

Email: nahidfawi@gmail.com

ABSTRACT

Purpose: This research aimed to assess the effect of manure management strategies implemented in dairy farms in Khartoum on animal health and milk hygiene. Results were based on primary data collected via scientifically structured questionnaires that targeted farm owners in dairy farms scattered at various geographical locations in Khartoum North.

Design / Methodology / Approach: A judgmental non probability sampling method was performed where a total number of 70 dairy farms constituted the sample of the study during 2017. Collected data was analysed to obtain the frequency distributions and chi-square values using the statistical package for social studies (SPSS ver., 11.5). Results showed that (57.1%) of dairy producers collect manure from the barn > once / week and (55.7 %) of them produced 2–6 ton / month.

*Corresponding Author

Findings: The majority of the producers (75.7%) had no assigned place for manure collection. Most of the owners (88.6%) do not use manure as fertiliser in their farms, and the majority of owners (71.4%) believe that manure causes diseases. (54.3%) of farm owners were satisfied with their manure management strategies. There were non-significant relationship between diseases occurrence and assigning specific places for manure collection and non-significant ($p \leq 0.05$) relationship between diseases occurrence and rate of manure collection.

Conclusion / Recommendations: The study was concluded with recommendations that aim to leverage the efforts of Institutes and Research centers to provide extension services tailored to meet the requirements of dairy farmers specially in the traditional sector and that could assist them in valuing adequate manure management practices in the simplest modes using proper scientific disciplines that can decrease health risks; increase milk quality and provide value added manure product to the market, a fact that could turn dairy business into a profitable enterprise.

Keywords: manure management strategies; health risks; milk hygiene; dairy; Khartoum North

INTRODUCTION

Choosing the environment in which lactating dairy cows will spend most of their time is an important decision for dairy producers. This choice has considerable influence on productivity, health, milk quality, reproduction, animal well-being, and farm profitability. In the decision-making process, dairy producers must consider what system will work best for their respective situations, given local climatic conditions, construction and building costs, labour availability, long-term maintenance and upkeep costs, and return on investment (Bewley et al., 2017). Throughout history, people who raised livestock and poultry have used manure as a fertiliser, soil amendment, energy source, and even construction material. Manure contains many useful, recyclable components, including nutrients, organic matter, solids, energy, and fiber. With today's science and technology, manure can be used more efficiently and in more ways than ever (www.epa.gov, 2015). Manure is composed of animal feces and urine and may contain livestock bedding, additional water and wasted feed (Manitoba Agriculture, 2015). Manure is a valuable resource and can be used for multiple purposes as fertiliser for crop production and improved soil health, a source of energy, or as basis for construction material, while manure is a valuable source of nutrients and renewable energy, if poorly managed; it poses serious human health and environmental risks. (Teenstra et al., 2014). In several countries, an equilibrium between the amount of manure produced and the availability of an agricultural area to recycle this manure is difficult to achieve (Bernal, 2017). Manure from different animals varies in density, water content, and nutrient content (Zhang, 2011). Manure quality is a function of it's management (handling, storage, and transport) (Ewusi-Mensah et al., 2015). Methods of collection, storage, and use of dairy cattle manure have undergone increased scrutiny during the last 15 to 20 years are in response to local increases in manure quantities (from increases in herd size) and to heightened environmental awareness concerning adverse effects of manure on the quality of surface water and groundwater, the primary issue with dairy cattle manure, both now and for the future, is the development of management systems that use the resource without adverse environmental impacts (Hubbard and Lowrance, 1998). Manure storage structures are defined in the state CFO and CAFO rules as any pad, pit, pond, lagoon, tank, building, or manure containment area used to store or treat manure (Jones and Sutton, 2008). Manure may be stored as a liquid, semisolid or solid; unroofed storage facilities need to be sized and managed to account for the incident precipitation

that will result in extra volumes during the required storage period (MOA, 2014). The purpose of a manure treatment process is to convert the manure to a more stable product; treatment processes fall into three categories, physical, chemical, and biological (PEI, 2000). As for methane, Livestock production is responsible for an estimated 18% of global anthropogenic greenhouse gas (GHG) emissions (Steinfeld et al., 2006). Methane (CH4) released from enteric fermentation and manure management accounts for about a third of these livestock related emissions or 41% of total carbon dioxide-equivalent emissions. It is estimated that between 2000 and 2020, global CH_4 emissions from livestock production will increase about 30%, as population growth and higher incomes increase demand for meat and dairy products (USEPA, 2006). The key emissions to the atmosphere of environment concern from dairy farms are ammonia (NH_3) and the green house gases methane (CH_4) and nitrous oxide (N_2O). (Misselbrook et al., 2011).

Environmental conditions must be comfortable to ensure the genetic potentials of dairy cows, the hygiene of cows is one of these conditions, for dairy cows, the cost of poor hygiene is an increased risk of mastitis and lameness (Cook,2002). Manure management affects hygiene, animal welfare, work organisation and costs on dairy farms. (Barbari and Ferrari, 2006; Barbari et al., 2007). All manure contains fecal coliforms and fecal streptococcus, however because of the diet fed to livestock, stressful and often unsanitary living conditions, antibiotics fed to livestock in low daily doses, and the massive concentration and lack of treatment for livestock manure, can pose serious risks to human health. Livestock manure can contain many pathogens (FAO, 2010). The type of bedding chosen and daily bedding (stall) management can have a major impact on udder health and the incidence of mastitis infection, when bedding materials become mixed with manure and urine, rapid growth of environmental mastitis pathogens starts because of available nutrients (Novàk et al.,2004). The major pathogens associated with bedding materials are the environmental *Streptococci* (including *Streptococcus uberis*) and coliform such as *E. coli and Klebsiella spp.* (Smith and Hogan, 2000; Zehner et al,1986). The introduction of bedding dairy cows on recycled manure solids (RMS) in the UK led to concern by competent authorities that there could be an increased unacceptable risk to animal and human health, where a cross-sectional study by (Bradley et al., 2018) was designed to evaluate the microbial content of different bedding materials, when used by dairy cows and its impact on the microbial content of milk; the detection of zoonotic pathogens in a small proportion of milk samples, independent of bedding type indicated that pasteurisation of milk prior to human consumption remains an important control measure. In addition, raw milk may be contaminated by bacteria from several sources these include. Udder and udder flanks, milker, milking environment, milking equipment and vessels used for milk storage and transportation (Khan et al., 2008). Thus cleaning the udder and teats is important to keep milk hygiene, to reduce odor and contamination where there is need to give attention to manure disposal because in small holder manure handling was commonly poor (Yuni et al., 2015).

On the other hand, Lameness is an important disease to the dairy industry that results in economic losses by decreasing milk production (Juarez et al., 2003; Hernandez et al., 2005), increase culling (Booth et al., 2004; Sprecher, 1997), decrease reproductive efficiency (Sprecher et al., 1997; Hernandez et al., 2001). Further, lameness is a sign of pain

(O'Callaghan et al., Whay et al., 1997) that results in changes in cow behaviour (Galindo and Broom, 2002) and is therefore a significant threat to the well-being of dairy cows. The objective of this study was to determine the association among different housing and management practices on the prevalence of lameness, hock lesions, and thin cows on US dairy operations. In a study conducted as part of the National Animal Health Monitoring System's Dairy 2014 study, which included dairy operations in 17 states, (Adams et al., 2017) highlighted management practices that may reduce the prevalence of lameness, hock lesions, and thin cows on operations in the United States.

This study aimed to elaborate the relationship between traditional manure management strategies implemented in dairy farms in Khartoum North and it's effect on milk hygiene and some common diseases that occur occasionally in dairy farms due to mismanagement procedures, specifically mastitis and lameness. The objective of the study is to provide guidelines for manure management strategies in dairy farms that can reduce negative environmental and health effects.

MATERAILS AND METHODS

Area and Time of Study

The research targeted dairy farms in Khartoum North the third largest locality in Khartoum the capital of Sudan during 2017. Khartoum North was chosen as an area for the research being known to contain the majority of dairy farms in the capital Khartoum, due to its mild climatic environment that is considered suitable for raising dairy cows.

Data Collection and Sampling

The research was based mainly on primary data collection using a cross-sectional scientifically structured questionnaire that intended to meet the objectives and aims of the research, where dairy farm owners' were interviewed. Due to the sensitivity of the respondents in participating in the study for culture reasons; a judgmental non probability sampling method was performed, where owners who were willing to contribute in the study were chosen as the sample of the study. A judgmental sampling is a form of convenience sampling in which the population elements are selected on the researcher's judgment (Malhotra, 2014). A total number of 70 farms constituted the sample of the research scattered at various geographical locations in Khartoum North (Shambat, Elhalfaia, Elkadro, Samrab, Elfaky Hashim, Haj Yousif, Hasania, East Soba), in an attempt to cover as vast as possible geographical area in Khartoum North.

Statistical Analysis

Since the variables were qualitative in nature the collected data was analysed using the computerised Statistical Package for Social Sciences (SPSS ver., 11.5) to obtain the frequency of distributions, in addition to performing Chi-square analysis on some variables.

RESULTS AND DISCUSSIONS

The demographic profile of farm owners and farm profile was presented in Table 1 where (58.5%) of dairy farmers gained secondary level, graduate level and post graduate level education, while illiterate and primary education level represented a percentage of (41.4%). This result reveals that dairy farming business is an attractive and good investment for educated people, an observation in agreement with (Fawi and Osman, 2013) who indicated that dairy production appears to be an attractive investment for educated people with ownership, management and supervision being in the hands of the farmer. Regarding years of experience (14.3%) of the sample under study had experience of less than 5 years, (27.1%) had experience of 5–10 years and (58.6%) had experience of more than 10 years. Moreover the table showed that (48.6%) of producers raise only cows in their farms whilst (26.7%) raised mixed herd with goats and sheep. This result indicated that cows represent the primary source of income in most dairy farms, a result that coincides with (Fawi, 2012) who pointed that cows are the main source of milk, been in most aspects more economical and profitable. (31.4%) of the dairy farm owners owned more than 40 cows,while (68.6%) owned less than 40 heads.

TABLE 1 Producer's demographic profile and farm's profile

Item	*No*	*%*
Education level		
Illiterate	12	17.1%
Primary education	17	24.3%
Secondary	19	27.1%
Graduate	17	24.3%
Post graduate	5	7.1%
Years of experience		
<5 year	10	14.3%
5–0 years	19	27.1%
>10 years	41	58.6%
Types of animals in the farm		
Cows only	34	48.6%
Mixed herd	36	51.4%
No. of Cows		
5–10	9	12.9%
11–20	21	30.0%
21–40	18	25.7%
>40	22	31.4%

Upon analysing manure management strategies implied in farms under study, Table 2 revealed that most dairy producers (57.1%) collected manure from the barn > once / week, while (35.7%) collected manure once / week and only (7.1%) collected manure once / month, this result indicates that the producers are concerned about cleanness of the barn to avoid mal odorous, ticks and diseases. A result that agrees with (Kelly and Michael, 2014) who found that accumulated manure can cause health problems, oduor, and water quality problems if not properly dealt with. On the other hand, the majority of the producers (75.7%) had no assigned place for manure collection, however (24.3%) of the producers had an assigned place for manure collection, where about (18.6%) of them kept manure outside the barn; (2.9%) kept manure inside the barn and (2.9%) kept manure in a specific place in the farm. This result showed that most producers showed no interest in allocating a specific place for manure collection may be due to the high cost of establishment, in addition to the absence of economic benefits when compared to the amount of manure produced from small size herds, furthermore producers sold manure frequently thus there is no need for storage areas.

TABLE 2 Manure management strategies

Item	*No*	*%*
Quantity of manure produced / month		
< 1 ton / month	12	17.1%
2 – 6 ton / month	39	55.7%
7 – 15 ton / month	13	18.6%
> 15 ton / month	6	8.6%
Manure rate collection in the farm		
Once / week	25	35.7%
>once / week	40	57.1%
Once / month	5	7.1%
Prevalence of an Assigned place for manure collection in the farm		
There is an assigned place	17	24.3%
No assigned place	53	75.7%
Place of manure collection		
Inside the barn	2	2.9%
Outside the barn	13	18.6%
Specific place in the farm	2	2.9%
No specific place in the farm	53	75.7%
Prevalence of manure records		
Yes there are records	7	10%
No records	63	90%
Owner considers manure as		
Source of income	40	57.1%
Source of pollution and disease	30	42.9%

On the contrary (Bourque and Koroluk, 2003) found that the majority of dairy farms (57.3%) in Canada had solid/semi-solid manure storage systems, while (42.7%) of dairy cattle used liquid manure storage systems. (90%) of farm owners had no records for manure keeping which reveals the lack of awareness about keeping official records for manure as management tool, this result agrees with (Mohammed and El Zubair, 2015) who stated that keeping records were rare in dairy farms and the records were not well regulated. The majority of owners (57.1%) considered manure as a source of income in comparison to (42.9%) who considered manure as source of pollution and diseases, the result indicated that most owners under study do not recognise the economic value of manure. (IAEA, 2008) indicated that manure is a valuable resource if used appropriately and can be a source of pollutant through the bad management. On the other hand the quantity of manure produced/month on dairy farms showed that a percentage of (55.7%) produced 2–6 ton/month in comparison to (17.1%) that produced <1 ton/month,(18.6%) produced 7–15 ton/month and only (8.6%) produced >15 ton/month. The variation in manure quantity produced by the farms could be referred to different herd sizes, type of nutrition, age of animals and health status, a result that coincides with (Ogejo, 2005) who found that animal type, diet, animal age and environment affect the quantity of manure production.

Table 3 showed that (88.6%) of the owners do not use manure as fertiliser in the farm, this could be explained by lack of farm land and high cost of labour needed. Moreover (7.14%) use manure without any treatment while (4.3%) who use manure as fertiliser, use various types of treatment such as drying (2.9%) where manure is dried for one month before use (2.9%) while (1.4%) dried manure for two months before use (1.4%) convert it to compost. This result indicates that farm owners prefer to use small ruminants manure (goat and sheep) for fertilisation instead of using cattle manure due to its good texture, small size and slow decomposition, a result that coincides with (Harris, 2001) who found that the preference for the small ruminant manure is due to its fine texture, which makes it easy to apply. (54.3%) of farms owners were satisfied with their way of management of farm manure where about (21.4%) of these have plans for future manure management improving. This is a good result that showed the possibility of owners accepting ideas and new management techniques, which can lead to increase the exploitation of manure. (Teenstra et al., 2014) indicated that knowledge dissemination by government and non-government extension workers is the key to bridge this knowledge gap, and that there are opportunities to change manure management practices at farm level through training of extension workers. Regarding milking husbandry practices, it was found that most of the owners (87.1%) milked their animals inside the barn, while (12.9%) had separate milking parlours. (60%) of the owners washed the udder before milking while (40%) did not perform washing, this clearly indicates that most owners value producing clean milk. Also (61.4%) of the owners do not agree with the fact that manure affect milk quality, while (30%) agree that manure affects milk quality, this is due to the fact that owners believe that animal udder is clean and does not need to be cleaned with every milking process, a fact that needs to be changed through proper extension services. On the other hand (71.4%) of the owners believe that manure causes disease, compared to (18.6%) who disagree with this opinion. (Spiehs and Goyal, 2007) indicated that livestock waste contains many micro-organisms such as bacteria, viruses, and protozoa, some

of these microorganisms do not cause sickness in animals or humans, however, some others are pathogens, meaning they are capable of causing disease in animals and/or humans. Regarding most common diseases present in farms under study (38.6%) indicated mastitis as most prevailing, (25.7) indicated ticks and (1.4%) indicated lameness. This result showed that the owners are aware that poor management of manure is associated with increased incidence of mastitis in addition to the spread of ticks nevertheless they lack adequate knowledge about effect of manure on causing lameness. Also the study showed that less than 5% of the animals in the farms under study had lameness and mastitis (20%, 47.1%) respectively,while some farms with more than 6%–11% of the animals had mastitis (2.9%), this result showed the prevalence of mastitis in different farms. A result that agrees with (Barkema et al., 2009; Burnevich et al., 2003; Vangroenweghe et al., 2005) who indicated that cattle manure and slurry are accumulated at large quantities in rural areas and may potentially contaminate soil and groundwater and pathogens that exist in the manure bedding may cause mastitis, which results in reduction in milk yield and quality.

TABLE 3 Manure treatment strategies; effect of manure management on animal's health and milk quality

Item	*No*	*%*	*Item*	*No*	*%*
Use of manure as fertiliser in the farm			*Place of milking*		
Use	8	11.4%	Inside the barn	61	87.1%
Don't use	62	88.6%	Separate milking parlour	9	12.9%
Prevalence of manure treatment method			*Washing udder before milking*		
Yes	3	4.3%	Washed	42	60.0%
No	5	7.14%	Not washed	28	40.0%
No opinion	62	88.6%	*Manure affects milk quality*		
Type of manure treatment			Agree	21	30.0%
Drying manure	2	2.9%	disagree	43	61.4%
compost	1	1.4%	No opinion	6	8.6%
No treatment	67	95.7%	*Manure vs. disease in farm*		
Period of manure treatment			Causes disease	50	71.4%
One Month before use	2	2.9%	Does not cause disease	13	18.6%
Two month before use	1	1.4%	No opinion	7	10.0%
Farmer is satisfied with manure management			Mastitis and ticks	11	15.7%
Agree	38	54.3%	No opinion	13	18.6%
Disagree	20	28.6%	*Percentage of Animal infected by lameness*		
No -opinion	12	17.1%	>5%	14	20%
Prevalence of future plans for improving manure management			No lameness	56	80%
			Percentage of Animals infected by mastitis		
There are plans	15	21.4%	>5%	33	47.1%
No plans	5	7.1%	6%–11%	2	2.9%
No opinion	50	71.4%	No mastitis	35	50%

In Table 4 a Chi-square test was performed to deduct the *p* value, to study the relationship between collecting manure in specific places and diseases occurrence; in addition to studying the relationship between disease occurrence and rate of manure collection. A *p* value of 0.282 which is more than 0.05 for manure place of collection and diseases occurrence a result that indicates no obvious effect of manure collection place and diseases. On other hand, the *p* value for rate of manure collection versus disease occurrence was 0.90, thus indicating non-significant effect. These results could be attributed to the limited number of the sample of population used in this study in addition to the inapprehension of owners under study, to the proper manure management and adequate dairy farming husbandry practices.

TABLE 4 The relationship between effect of manure on diseases occurrence / specific place for manure collection; the relationship between rates of manure collection diseases occurrence

Item	*Effect of manure on diseases occurrence*	
	p value	
specific place for manure collection	0.282	(N.S)
rate of manure collection	0.90	(N.S)

N.S=Non–significant

CONCLUSION

The study was concluded with recommendations that aim to leverage the efforts of Institutes and research centers to provide extension services tailored to meet the requirements of dairy farmers specially in the traditional sector and that could assist them in valuing adequate manure management practices in the simplest modes using proper scientific disciplines that can decrease health risks; increase milk quality and provide value added manure product to the market, a fact that could turn dairy business into a profitable enterprise.

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BIOGRAPHIES

NAHID M.T. FAWI Associate professor - University of Khartoum with a PhD in Marketing and a Freelance marketing consultant. Specialized in Agribusiness with focus on Agricultural marketing. Certified Trainer and Head of Animal Production Training center in the University of Khartoum. A main speaker in several summits in Dubai, London and Khartoum.

AMIRA A. AHMED Lecturer and active researcher in the Faculty of Animal Production, University of Khartoum. BSc. Animal Production, MSc. Dairy Production & Technology.