Waste management in dairy cattle farms in Aydin region. Potential of energy application

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Abstract: In this paper the dairy cattle waste management systems at farms in Aydın region of Turkey were investigated. Number of farms and livestock size, type of housing, overall farm, type of machinery and a farm labour force were studied. The milking handling systems of dairy farms and waste management, system of collection and storage methods of produced the manure in the dairy cattle were taken into consideration.

Additionally, biogas amount, which is produced from animal waste, was calculated for all districts of Aydın by using the number of livestock animals and also considering various criteria such as the rate of dry matter.

Results show that typical and representative farm for Aydın region is facility with a total head over 100 heads. 89.6% of the farms have heads in range of 100 to 200.

The amount of biogas that can be produced from manure collected in Aydın region in the biogas plants is approximately 160,438 m^3/day (based on 0.5 m^3/day biogas per cattle). It gives a production of electricity on level 99,552 MWh/year that can be used for own needs of farms owners.

INTRODUCTION

Nowadays, expansion and intensification of large-scale animal feeding operations have resulted in not only an increase the size of farms but also have an impact on environment and public health. The pollution from farm waste has become a serious problem in rural areas.

According to the FAOSTAT (2016) [1] in Turkey, the most of livestock production belongs to cattle farms (14,223,109 head of cattle). A dairy cattle represents 635.6 billion tons and 82.7% of the total milk production.

Table 1 presents total amount of animal species production in Turkey in last years. The breeding and agricultural activity, especially livestock production on an industrial scale, is seen as one of the main sources of natural environment pollution. Depending on the farming system, animal farms generate solid (dung) and liquid (liquid manure) animal excrements. In this day and age, no-mulch system is becoming more and more popular, particularly in the livestock production on a large scale. Excrement in this system is the so-called liquid manure, i.e. liquid, or semiliquid mixture of faeces, urine, water and feed leftovers.

It is estimated that the cattle residues produced in Turkey reached value 128 million tonnes/year [2]. The amount of wet waste of animals could be a major problem for farms and cannot be utilized properly. The best way to utilize waste is to produce biogas.

The biogas energy potential of Turkey was found to be 2,177,553,000 m^3 (2.18 Gm^3) based on the animal numbers in the last agricultural census. The total biogas potential is originated from 68% cattle, 5% small ruminant and 27% poultry. Biogas energy equivalence of Turkey is approximately 49 PJ [3].

Table 1 Total amount of animal production in Turkey [1]

Animal	Unit	2008	2010	2012	2014
Buffaloes	Head	84,705	87,207	107,435	121,826
Camels	Head	1,057	1,041	1,315	1,442
Cattle	Head	11,036,753	10,723,958	13,914,912	14,223,109
Sheep	Head	25,462,292	21,794,508	27,425,233	31,140,244
Chickens	Head x1,000	269,368	229,969	253,712	293,728
Goats	Head x1,000	6,286,358	5,128,285	8,357,286	10,344,936
Turkeys	Head x1,000	2,675	2,755	2,761	2,990

There are a number of studies about cattle in Turkey [3,4,5,6,7]. However, region-based studies are few and limited [8,9].

The aim of this study was to investigate the collection and manure management in the cattle farms of Aydın region. Number of farms and livestock size, type of housing, overall farm, type of machinery and a farm labour force and waste management were studied.

MATERIALS AND METHODS

Study Area

Aydın province is located in Aegean Region of western Turkey. Total area of province is 8,007 km^2 and the province is divided into 17 districts. In 2013, population was 989 862 with density 120 people/km^2.

Cultivated area is 395,494 ha and corresponds to 49.3 % of soil sources. Main agricultural products are fig, olive, chestnut, cotton and fruits. Cereals are cultivated on an area of about 75,000 ha. According to TÜİK [10] in 2010 293,071 heads of cattle were produced.

Methods

The aim of this study was to investigate the collection and manure management in cattle farms in Aydın region of Turkey and to determine the energy potential of waste generated on farms.

For this purpose, a survey was conducted among owners of farms located in 17 districts of Aydin province.

The survey form included such issues as:

- livestock size,
- type of housing,
- overall farm,
- type of machinery for collecting wastes and a farm labour force,
- storage mature system,
- methods of waste application.

Surveys were conducted in 87 farms as a visit to each farm. A teach survey, each farm was photographically documented.

RESULTS AND DISCUSSION

In Aydın province most of farms are located in Efeler (18 farms), Cine and Kuyucak (12 farms) and Söke (10 farms). Table 2 presents total amount of cattles in Aydın's districts.

Typically farms have more than 100 cattles. 89.6% of the farms have heads ranging from 100 to 200.

Table 2 Total amount of cattle in Aydın's districts

Aydın's districts	**Number of cattle, head**
Efeler	34,300
Bozdoğan	26,244
Buharkent	2,025
Çine	62,376
Didim	3,047
Germencik	19,144
İncirliova	9,048
Karacasu	10,219
Karpuzlu	27,027
Koçarlı	23,953
Köşk	8,757
Kuşadası	1,283
Kuyucak	21,713
Nazilli	26,000
Söke	24,145
Sultanhisar	4,595
Yenipazar	17,000
Total	**320,876**

Results of study showed that 48.2% farms have closed-wall barns, 41.4% semi-open barns, and rest of them has open sheltered barn. On Fig. 1 semi-open barns are shown.

Fig. 1. Semi-open barns.

Generally, the one of farm animal waste disposal problem is the collection and holding of manure until it can be utilized on the land. Manure storage facilities in farms should be considered as a temporary solution. The facility must minimize impact on water quality, especially including groundwater and surface water. It is indicated that the manure storage facility should be located at least 100 metres away from water resources [11]. Another problem is to minimize odour from manure storage locations, which depends on the size of the intensive livestock operation, the type of livestock or manure management system and time of storing.

Manure is usually stored for many months, often in outdoor pits (lagoons). As it decomposes, the manure emits unpleasant gases such as ammonia and hydrogen sulphide and has impact on the health or comfort of surrounding people.

In Aydın region the distance between open-air manure storage and water resources as well as source of drinking water supplies is 96 m on average. Çayır and Atılgan [12] examined about 74 farms in Burdur province and determined the distances as 1-10 m in 39 farms, 11-20 m in 20 farms and 21-30 m in 10 farms, and 31 m and more in 5 of 74 farms. According to Mutlu [13], Jacopson at al. [14] and Nizam and Armağan [15] this distance should be much more larger.

In study area, manure storage facilities are located in the open area. Mostly used type of mature storage is midden (60%), 30% of farms store manure on flat ground and 10.3% on leak-proof pits. Fig. 3 presents the types of storage used in Aydın region and flat ground storage is shown in Fig. 4.

It has been determined that there exists a huge difference between sizes of storage in flat ground, ranging from 1.5 x 2 m to 50 x 5 m.

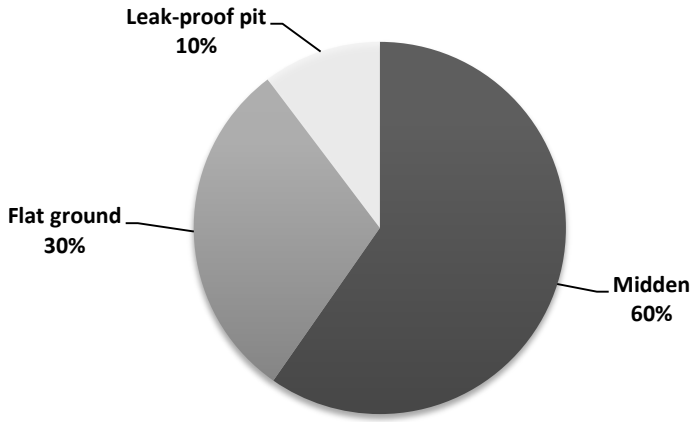

Fig. 3. Types of storage used in Aydın region.

The conventional method of handling manure has been to use sufficient bedding to keep the manure relatively dry and then to move it out of the confinement area and deposit it into a manure pile [16]. In large production units, manure is handled both mechanically and hydraulically. Mechanical removal of the wastes is normally done with tractors, manure spreaders or scrapers with permanently installed equipment, such as shuttle conveyors, floor augers or pumps.

Fig. 4. Manure storage on flat ground.

Types of manure collecting systems in studied farms are presented on Fig. 5.

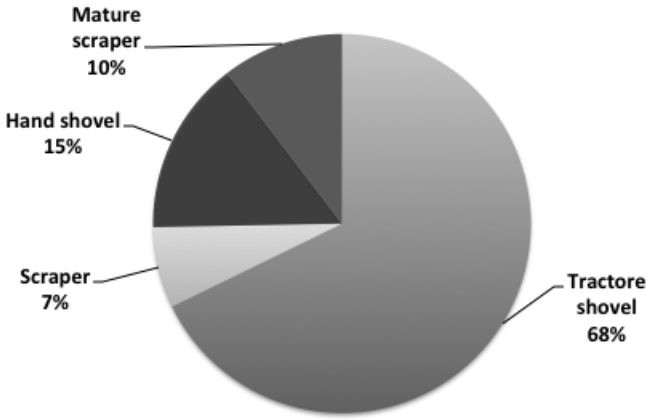

Fig. 5. Types of manure collecting system.

The information collected from the dairy farms assessed in this study showed that 67.8% of the farms use tractor shovels for the collection of manure produced in barns. The percentage of manual collection is 14.9%, and there were only 9 farms (10.4% of the farms evaluated) in which the manure was collected with scrapers equipped with chain. 89.7% of the farms do not have any impermeable manure pits.

The most common waste management strategy in farms is the application manure onto the land. All produced manure in studied farms is used in agriculture as fertilizer mostly for own purposes, and only 12.6% farms sell it.

Baytekin [17] claims that, under normal conditions, a healthy cow produces 40-45 kg of manure per day. According to this value, the total manure amount obtained from the research area is presented in Table 3.

Table 3 Total amount of produced waste in farms

	Daily tonnes	Weekly tonnes	Monthly tonnes	Annual tonnes
Production of waste	13,637.23	95,460.61	409,116.90	4,977,588.95

The manure can be in solid, solid-liquid and liquid form. Atılgan et al. [18] divided it according to content of solids, i.e. above 25% - solid fertilizer; 10-20% semi-solid and 0-10% content of soils is called liquid manure. The studied farms utilize only the solid manure, which provides minimum benefit because of losing organic, nitrogen content during long storage and it can also cause serious environmental pollution.

The production of biogas from manure waste in particular is one of the alternative utilization of organic wastes that can be implemented in this region.
The biogas production can have a lot of benefits for environment such as reducing methane and odours emission, which occurs during manure storage, also pathogens and weed seeds are destroyed. From agronomic point of view, transformation of the liquid manure and the manure into a fertilizer (by-product of biogas production) is more easily assimilated by the plants, with a reduction in the odours and the disease-causing agents.

Biogas can be used for heating and electricity production that can give local autonomy in terms of decreasing the cost of fossil fuels. Economic efficiency of biogas plant depends on the investment costs, costs for operating and on the optimum methane production.

For the Aydın province, based on the amount of produced wastes it is possible to obtain about 160,438 m^3/day, assuming 0.5 m^3/day biogas per cattle. Table 4 contains total amount of produced biogas in Aydın and LPG equivalent.

Predicted CH_4 content of biogas, which is produced by the cattle and poultry manure is about 62%. LHV of CH_4 is known to be about 34 MJ/m^3. Based on this LHV, the value of biogas is about 21 MJ/m^3. According to Demirer [19], from 1 m^3 biogas (with heating value 21 MJ/m^3) can produces 1.7 kWh electricity, in cogeneration process: 1.7 kWh electricity and 2 kWh heat.

Table 4 Total amount of produced waste and biogas in Aydın and its LPG equivalent

	Daily m^3	Weekly m^3	Monthly m^3	Annual m^3	Equivalent of LPG m^3/year
Production of biogas	160,438	1,123,066	4,813,140	58,559,870	93,895,792

It gives production of electricity on level 99,552 MWh annually. In Aydın in 2012 electricity consumption was 1,860,667 MWh. In the case of using biogas, which can be substitution of conventional fuels, 5.4%, electricity can be cover by biogas.

CONCLUSIONS

The animal production sector plays a significant role in agricultural development not only in terms of the products but also because it generates added value and employment opportunities as much as other sub-sectors of agriculture.

The difficulties connected with animal production is the waste disposal which involves the system of storing the manure, the odours and gases released, and in some cases, the difficulty of mixing the contents before disposal on the land.

In this study, biogas potential from cattle waste produced in Aydın region was determined and theoretical biogas potential was calculated. This province with the surrounding towns has an economy depending on agriculture and this production. Results show that representative farm is a facility with a cattle population over 100 heads. The produced waste is mostly used as a fertilizer on lands of owners. Typical type of storage is midden, which can have a negative influence on environment.

The amount of biogas that can be produced from manure collected in Aydin region is approximately 160,438 m^3/day, equivalent to about 99,552 MWh/year of electricity, which can be used for own needs of farms owners.

Conversion of animal waste to biogas through anaerobic digestion processes can provide added value to manure as an energy resource and reduce environmental problems associated with animal wastes. It is worth mentioning that dairy cattle manure is endowed with a considerable biogas production that offers numerous benefits of environmental, agricultural and socio-economic standards.

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