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Potential of Camel Dung as Promising Organic Manure in Saudi Arabia

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Abstract

Energy consumption in Saudi Arabia (KSA) is growing rapidly due to the high living standards, population growth and urbanization rates. KSA has planned for the development and use of biomass renewable energy sources, which are available abundantly, carbon-neutral and climate mitigation source. The main purpose of this review article is to analyze and discuss the challenges and opportunities of Camel Manure (CM) as an effective management of the livestock waste, and its potential development in the management of biomass and energy technology (BETM). The trends in the camel population growth projected at approximately 1.6 million camels in the Arab Peninsula and approximately 53% of the total in KSA with untapped manure falling along with the Municipal Solid Waste (MSW) making them ideal for energy extractions and applications in remote and rural areas. Research is needed to assess camel manure resources (supply and demand), the technology scope for economic, energy capacity and application evaluation to fill energy potential and challenges applications for KSA.

SCAN ME

Introduction

The Kingdom of Saudi Arabia (KSA) has been classified as having a high standard of living, population growth and urbanization [1,2] resulting in increased waste generation types, and energy consumption such as water and electricity requirements [3-6]. According to Saudi Vision 2030 [7], KSA plans to meet the ever-increasing demand for energy by exploring new sources and opportunities for new renewable and sustainable energy sources in the region to track its economy, and environment.

Energy production in KSA depends exclusively on fossil fuels (oil and natural gas), generating high emissions of greenhouse gasses (GHGs) that lead to global climate change. The major polluters countries are Qatar (QAT), Trinidad and Tobago (TO), Aruba (ABW), Bahrain (BHR), United Arab Emirates (ARE), Luxembourg (IUX) that have the highest records in 2009 (41.8, 34.0, 25.9, 23.8, 21.3, 20.9 and 22.0 metric tons, respectively). Since GHG emissions from Burundi (BDI) was 0.02, KSA recorded 17.6 metric tons, i.e. near by the lower highest production and far away from the lowest record that supporting the Planet Development Indicators (PDI). [1-2,8]. Notwithstanding, Renewable Energy accounts for about 19% of global final energy consumption and Waste to Energy (WTE) that being used globally as environmental protection measures and associated with an economical choice for the world energy demand [3,9]. Though KSA is a leading producer of oil, it is interested in finding and developing new of new renewable energies resources [7,9]. Therefore, there is a significant potential for Camel Manure (CM) in the area as the substantial number of camels is high, i.e. camel population growth trends are assessed at around 1.6 million camels in the Arab Peninsula and approximately 53% of the total in KSA [10,11]. Besides, the camel untapped manure dropping with the Municipal Solid Waste (MSW) shows potential emissions of house gases that increase in the region from 5 to 8 $MtCO_2$-eq over 2014 [8,10-12]. However, up to now, there has been no clear mission/policy objective statement for renewable energy (RE) relating to the camel's solid waste management within the KSA, which may incorporate a high potential for generating and supplying biomass energy in remote and rural areas.

The main purpose of this review article is to analyze and discuss the challenges and opportunities of Camel Manure (CM) as an effective management of the livestock waste, and its potential development in the management of biomass and energy technology (BETM).

Methods

Literature search strategy and selection criteria

The scope analysis was conducted to identify sources of evidence from Web of Science, Google Scholar, Google Webpage, and different webpages that include clear, consistent and transparent methods, besides accountable, replicable, updated and all relevant literature on camel manures' challenges and opportunities and its potential development in the management of livestock biomass and energy technology (BETM).

Our search strategies include interdisciplinary databases and sciences with no limitation on date of publications, due to resources limitations, that matches the investigate keywords: Camel biodiversity and demography, livestock biomass, present and potential uses of livestock and camel manure, specified application around the world, besides future prospects in KSA. These data have been quantitatively and qualitatively summarized the evidence of current livestock's management, the current gap in the literature as well as research areas that need revision and research in KSA.

Discussion

Camel biodiversity and demography

The camel (Family: Camelidae) has great importance in an arid environment (Figure 1) and it was domesticated worldwide in the social culture of the ancient nomadic tribes for thousands of years [13-15].

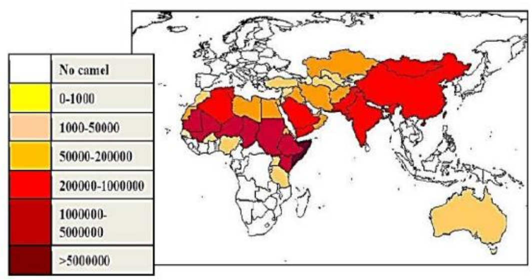

Figure 1: Demographic data on camel for 2010 [14].

Camels occur in either two distinct phenotypes forms, one-humped, the dormancy (*Camelus dromedaries* Linnaeus, 1758) that inhibits the Middle East, and the region of eastern Africa, or the two-humped Bactrian (*C. Bactrianus* Linnaeus, 1758) that inhibit central Asia (Figure 1 and 2). In addition to the other four members (i.e. the Llamas, Vicunas, Alpacas, and Guanacos) from the New World camelids that inhibit the high and the shrubbery areas of South America [16,17]. Therefore, the original range of the camel wild ancestors was probably south Asia and the Arabian Peninsula (Figure 2).

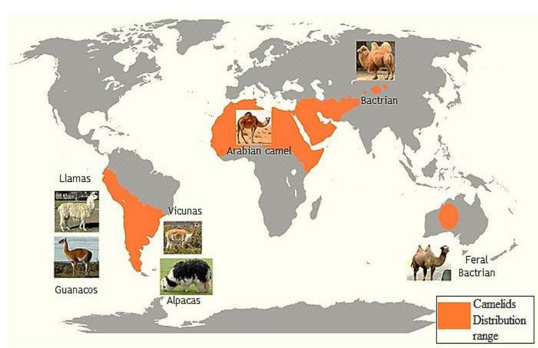

Figure 2: Current range of camelids, i.e. all camel species old and new world one [16].

In 2010, around 14 million camels were alive worldwide, with 90% of them being dromedaries, as well as around seven hundred feral in Australia, coming down from those introduced as a method of transport in the 19th and early 20th centuries [18]. According to Food and Agriculture Organization (FAO) [10] and Faye and Bonnet [14], the number of the camel head has consistently increased since 1961, but the growth rate varies across the regions, i.e. from 2.1% in the former Soviet Republics to 13% in Somalia.

According to Faye [15], the most essential issue concerning camel demography is not the development of the camels' heads number, but its number inside the total livestock that is calculated by the extend of Tropical Animal Units (TLU) for each country. Nevertheless, the relative camel density is related to particular discernment perception such as social, financial matters, and their other global socio-economic profiles [19-21]. Wherever camels' drawn 25% of the complete TLU in KSA but the most elevated density is discovered inside the Horn of Africa (more than 2 camels/km²), and the Middle Eastern Arabian Peninsula (1 camel/km²). Inside the KSA, the farming system shifts from ancient and straight forward simple shapes to a semi-intensive farms that would oversee the organic biomass of livestock natural waste with the value of an economic and sustainable component for the commonplace production [14,22].

Present and potential uses of biological products from the camel

Livestock resources have played a considerable range of roles in human life from the initial days of recorded history. Human beings have accustomed to the employment of Livestock for food, cloth, organic fertilizer, medicine and fuel since the past [22,24]. In addition to different areas of concern in religion, art, music, and literature and several other different cultural manifestations of humankind [22].

Nevertheless, camel is a unique mammalian vertebrate animal inhibiting the hot and arid desert habitat, due to its adaptation mechanisms in behavioral, anatomical and physiological functions [23].

Camels manure is used for the decomposition of organic compounds spilled within the soil/water in Sharjah (UAE) since it may be a suitable agent for filtration due to its higher fiber contents [22]. Also, it employed as a fuel, particularly among the rural communities because it is prepared to burn after a number of minutes unlike cow dung and other organic trashes that takes several days in sunshine to dry [22,24].

However, CM and its scale of production are specific in various camel varieties as a dairy camel weighing 600 kg produces 15-17 kg dry manure every day whilst the drought regular camel produce about 11kgs of manure [22,24,25]. As well as, consumption of 82 kg from weather-eaten zag flora (*Haloxylon bungee*) would end in 129 kg horse manure and 100 kg dried CM [22,26].

In North-Eastern Baluchistan (Pakistan) and Southern Afghanistan, the CM is used in the small-scale farming system as a fertilizer for the garden, Pomegranate and grape trees [22]. In addition, it combats desertification and fixes sand dunes, an innovation for bio-paper and power generation [20,25].

In Bolivia, a country of west-central South America, the dung of the Llama's camelid is employed to neutralize the acidic, metal-laden water with the aid of capability of manure as a brilliant agent for filtration due to the fact of its higher fiber contents [26].

In China, the livestock manure is used in terms of energy and heat for biogas production in relation to animal feed technology [27-29]. According to FAO statistic [11], the livestock manure provided 115 Mt annually, only 27 MT that was applied as fertilizers (Figure 3).

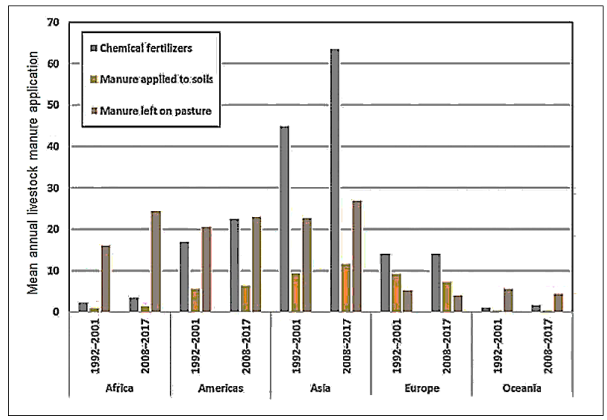

Figure 3: Livestock synthetic fertilizers application during 1992-2001 and 2008-2017 [11].

Globally, the level of livestock development is 0.6 per annum, but for the period 2008-2017 it was 1.3% per annum because the livestock population was 75% higher during that time [10-11]. Regionally, CM is going waste especially in locations with high camel density per unit area such as in the Emirates (UAE), Bahrain and Qatar [19]. Locally, i.e. in the KSA, livestock dung without separation from solid waste material and municipal waste in years from 2007 to 2012 was increased from 12.5 million to 15.2 million tons [30]. Therefore, the CM production (volume and type) is reasonable and the camel rearing enterprise fits well with such necessities due to data availability assessments, as the livestock growth is high especially in Asia (Figure 3 and 4).

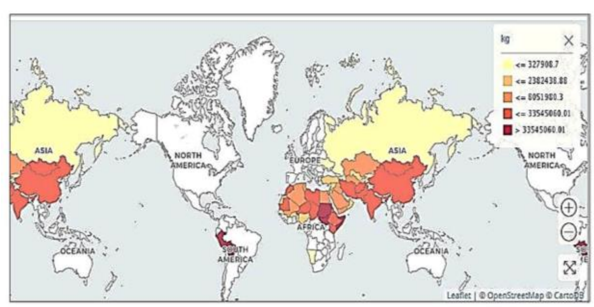

Figure 4: Manure left in pasture by Camel and Llama [11].

Livestock manure assessment in waste-to-energy potential

Livestock manure can be turned into nutrients, composts and fertilizers of various kinds if properly and wisely handled [22,24,26] as only 9% of the total biomass generated by livestock is estimated worldwide for biogas recovery [26,31]. Still, the use of livestock manure as organic fertilizer and fuel is common in developing countries [11,25,28], but manure trade is less common in the crop-livestock sector of the KSA, as the region is in need for an accurate geographic estimation of the current biomass resources available in Saudi Arabia.

Other than end-use applications [25,27-29], the possibilities for converting CM to energy are plentiful and can include a wide range of camel biological product sources, and conversions technologies.

Biomass is the only sustainable organic petroleum substitute due to its high volatility and high reactivity, partly due to its generally high moisture content and high oxygen content, which provides the necessary benefits as a combustion feedstock [32,33]. However, biomass contains less carbon and extra gas that of a low heating worth than the fossil fuels [34]. As well as, biomass co-firing helps coal firing and reduces GHG emission and electricity generation costs [32,34]. Even the meat and milk production system for peri-urban camel farming is growing today in several cities in Saudi Arabia where the selling of the previous products is a critical economic activity as a consumer-oriented process, reflecting the diverse roles of camels with gradual market integration. In addition, the expansion of the KSA economy affects camel farming system [35,36].

Approximately 150 million tons of cow-dung is currently used worldwide as fuel and India accounts for 40% of the total [33]. Therefore, the new cost-effective and eco-friendly energy techniques for the use of livestock waste biomass for energy generation are required as a remedial measure. On the contrary, researchers have found that camel dung has almost the same value as that of cow dung [24,33]. Dried cow-dung [33] has been used in many countries to produce electricity (calorific value 14 MJ / kg), as it generates the same amount of fuel energy as dried firewood (calorific value 16-20 MJ / kg).

Nevertheless, biomass is an abundant, naturally occurring source of energy, and one that is also carbon-neutral, i.e. it generates an equal amount of carbon dioxide to that it consumes; biomass can therefore play a key role in meeting energy requirements [32,33]. Although biomass energy has a long history of satisfying the basic illumination, heating and cooking needs of humanity, its capacity as an electrical source has been steadily developed since the oil crisis in different parts of the world [31].

In the KSA, as the state of electricity grid provide electrical supply for just 80% for population in general [4,37]. KSA has planned to double its energy capacity up to 120GW by investing $117 billion in the power sector over the next 25 years [7], while the biomass energy is the third-largest global source of energy, among the primary energy sources after coal and oil, comprising up to 40%-50% of vitality utilization in numerous creating nations like India [33]. Globally, 64% is the major share of biomass energy from wood and wood squanders, 24% MSW, 5% agricultural waste, and 5% landfill gases [37,38].

Conversion of biomass technologies: Possible Process Overview

There are three main processes' technologies used to convert biomass to energy [30,31]: thermochemical, biochemical, and physiochemical (Figure 5).

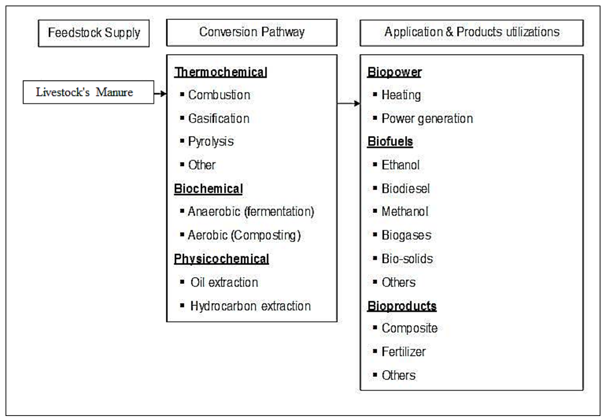

Figure 5: Flow diagram for Livestock's manure technology based on their conversion processes.

Conversion of biomass to energy: Scope of practice options

General background information in the previous section (Figure 5) provides a brief overview of the energy transformation options. Biomass provides more than 10% of global energy consumption and 35 million tons of manure feedstock form USA annually [9]. However, many international corporations, like the AGRO-EKO, have been engaged in animal manure to extract energy from the biological waste products that would be best-utilized on-farm or close to the source [25]. Therefore, CM quality for engineering choices will rely on the chemical, biological and physical properties of biomass and the major organic components of biomass could be categorized as cellulose, hemicelluloses, and lignin, so that atmospheric CO_2 and C-neutral are simply recycled [8,39,40,41]. Nevertheless, we present data for the surplus and undiscovered domesticated CM from the general worldwide and regional knowledge by FAO (2019) statistic (Figure 6).

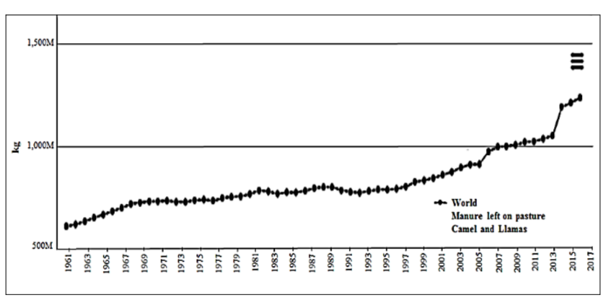

Figure 6: Global manure productions by Camel and Llamas [11].

Figure (7) provides an overview of feasible and predictable future uses of camel biomass as a renewable capacity for assembly of biofuels, heat generation, other generations, other chemicals, and alternative materials.

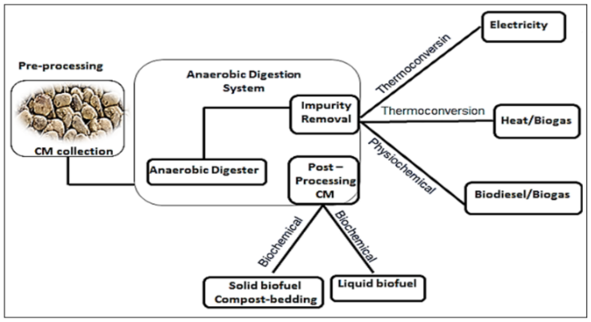

Figure 7: Flow diagram for Camel Manure (CM), the energy transformation options and end-point products.

Energy Efficiency and Renewable Energy Technologies [25,41,43-44], allow livestock manure to be used to its full potential, and not just for soil nutrients, various products such as biogas, fertilizer, and other by-products that could be produced by the three previous technologies platforms (Figure 5).

In any case, two main systems are the most suitable techniques for processing organic biomass: the thermochemical and biochemical (biological) platforms. However, the source and quantity of biomass and the required form of energy, are factors that affect conversion processes. Given this, accurate information of CM quantity and quality is so critical for multi-scale applications.

Thermochemical Technology Application

Thermochemical processing is a physical transformation of CM biomass to energy including hydrocarbon fuels, and/or residual charcoal [40]. Three technologies are used in the thermochemical cycle: pyrolysis, gasification, and incineration [40,41]. The previous treatment protocols can be configured within these processes to solve odor problems, reduce experiment duration, recover nutrients supplements, and reduce emission potential during the energy recovery [41-44].

Waste management planning includes strategies for manure handling, collection, transportation, storage and processing in relation to the desired end-product, and management techniques as integrated parts for manure transfer, processing, and treatment [30,41].

Finally, animal waste can be managed properly through the implementation of Best Management Practices (BMPs), efficiency processes, and sustainable processing that can be used as secure product in the form of fertilizer, composting, and others [5,6,41- 44].

Biochemical Technology Application

Biochemical methods use biological agents, whether living organisms or their products, to turn organic waste into energy in the form of fluid or vaporous power [44]. The bio-products can be processed and used in additional products via a method of pretreatment using acid or catalysts [44]. Such processes of conversion into biochemical processes can be carried out using both anaerobic and fermentation methods for processing gaseous and liquid fuels, while organic material rots in an oxygen-free environment or in an oxygen-poor atmosphere [29].

Recovery of anaerobic methane is accelerating in bio-digesters, where organic matter is digested by fermentation techniques, producing a fuel called biogas [44]. On top of that, the solid/slurry-phase residual by-products are rich in nutrients that can act as an alternative fertilizer from that processes [41-44].

Nevertheless, biological conversion processes require an extended response time (i.e. days, weeks, or even months), while the forms of thermochemical change (TCC) may generate numerous complex end-products very rapidly, i.e. in seconds or minutes [41,43].

Conclusion

Energy is a necessity in our daily lives and biomass is attracting growing attention as a safe option compared to other renewable energies. Due to the wide range of unused CM biomass, the use of fossil fuels and high CO_2 emissions in KSA, camel manure can be used for bioenergy generation, especially for 20% of remote rural communities that require an independent source of electrical energy. In addition to camel biological waste potential as a source of energy and environmental protection measure for sustainable solution, the KSA vision 2030 will be fulfilled to satisfy the national needs and the international accreditation requirements. This can be seen as the triple benefits of cameling biological biomass that will enhance waste management, reduction of gases emissions and improve Green Energy Sustainable Solutions throughout the region. Still research is needed to assess camel manure resources (supply and demand), the technology scope for economic, energy capacity and application evaluation to fill energy potential and challenges applications for KSA. In conclusion, decision-makers and planners need to be work together and take steps forward to entrain the 2030 Saudi Vision for sustainable developments, i.e. perfect utilization of CM, and the other waste-to-energy applications.

Authors' Contribution

All authors contributed equally to this study in collection of literature, writing manuscript and shaping it into publishable form.

Conflict of interest

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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