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An investigation of biogas production potential from livestock and slaughterhouse wastes

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ABSTRACT

Fossil fuel resources are severely limited and their combustion is a major source of environmental pollution. As a result, scientists avidly seek alternatives to fossil fuels, and biomass can be a viable alternative source of energy. Anaerobic digestion is one of way of converting biomass to biogas. Slaughterhouse wastes and animal husbandry residues are from among the organic waste types utilized to generate biogas. Every year, large amounts of livestock waste discharges and slaughterhouse waste materials are produced worldwide, which provoke environmental pollution and are thus a cause of much concern. In lieu of what is discussed, it is intelligent to use animal wastes to generate biogas and hence reduce pollution. In view of that, the researchers in this study intend to investigate biogas production potential from animal manure in Iran. To this aim, biogas production potential from heavy and light livestock and poultry wastes were examined. Slaughterhouse wastes, containing rumen, intestines, stomach and blood from heavy and light livestock, and also poultry blood were examined. The results indicate that biogas production potential from the available livestock manure in this country is 8600 million m^3 per year, 70% of which is obtained from heavy livestock, 23% of it from poultry, and only 7% from light livestock. Biogas yields potential from slaughterhouse wastes in Iran is approximately 54 million m^3 per annum of which 40% is produced from light livestock rumen, 24% from heavy livestock rumen, 17% from heavy livestock blood, 14% from poultry blood, and 5% from light livestock blood. Tehran Province, as the capital, had the greatest potential for biogas production from slaughterhouse waste; that is about 9 million m^3. From among all other provinces in Iran, Mazandaran Province had the greatest potential, with 828 million m^3 biogas yield per year.

Contents

1. Introduction

Iran is rich in different sources of energy. On the one hand, vast resources of non-renewable fossil fuels such as oil and gas

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reserves, belong to Iran, and on the other hand, it enjoys limitless potential for sustainable solar, geothermal, wind, hydrogen, and biomass energies [1]. Actually, renewable energies are becoming popular everywhere. For one thing, human population is to face fossil energy privation soon. For another, putrescible liquid and solid wastes (biomass) are abundant and the operation of biogas systems is quite simple. Therefore, many countries such as China, Germany, and Sweden have dedicatedly resorted to bio-energy production technology while China and India have installed biogas tanks in the rural areas [2]. The material that flows into the tanks facilitates the production of gas under anaerobic conditions. Once product pollution is minimized, it is used as an agricultural fertilizer [3–6]. Likewise, Industrial waste can also be anaerobically treated in biogas tanks. Besides generating biogas, this process helps reduce their environmental hazards. In 2011, biogas production potential in Iran through anaerobic technology has been about 16146 million m^3 [7]. However, livestock by-products, which are valuable resources of biogas [8], are not efficiently used in developing countries like Iran; While optimal use of livestock products such as intestines, blood, skin, etc. can develop industries, factories and jobs and thus prevent the loss of potentials and result in added value for slaughterhouses, they are discarded as waste and inappropriately processed. Moreover, biogas technology helps the society become healthier through dramatically cutting down on zoonotic disease transmission and consequently medical expenses [9]. Efficiently controlling odor emission from livestock manure and managing environmental hazards associated with livestock productions are some other problems that confront animal husbandries. Biogas technology, therefore, benefits societies by alleviating problems with slaughterhouse wastes and livestock manure, and also by generating a renewable energy source [10,11]. Several researchers have studied the potential of biogas production technology [12–19]. For example, Esen and Yuksel have investigated the benefits of using various renewable energy sources for heating a greenhouse in Turkey [20]. Iran is a vast country with approximately 164.8 million ha land, about 51 million of which is arable, and with 102 million ha of natural forests and pastures, 2700 km of maritime border, and about 120 billion m^3 of exploitable water [21]. It consists of 31 provinces with appropriate climate diversity (14 different types of climate) and in light of the inexhaustible solar energy and skilled human resources, there is a good potential for exploiting land for agricultural, horticultural, animal husbandry, poultry, and fish farming activities. Given the high production rate of the agricultural produce, the waste byproduct is also abundant and so can be used as one of the best sources of biomass [21]. The present paper examines the potential of biogas production from livestock and slaughterhouse wastes in Iran.

2. Materials and methods

2.1. Wastes

Livestock and poultry wastes are rich in organic matter and can be used as raw material for energy production in biomass power plants. Fresh waste, however, is more suitable [22]. In the present paper, livestock manure as well as the contents of rumen, intestines, stomach and the blood of slaughtered livestock were used as biomass.

2.2. Calculating the amount of excreta produced per livestock

To determine the amount of produced excreta, statistics of livestock population in each province were obtained from the Ministry of Agriculture and the Statistical Center of Iran. As shown in Table 1, the amount of feces and urine (produced excreta) depends on various factors such as weight, size, and age of the animal [23,24]. Some studies considered daily feces as 5%, 4% and 5% of the live weight of heavy livestock, light livestock and poultry, respectively [24]. In this paper, cow, calf, buffalo, and camel were considered as heavy livestock, sheep and goat as light livestock, and broilers, laying hens and pullets as poultry. The daily excreta was considered 9% of the weight of the heavy livestock, 4% of the weight of light livestock, and 3% of the weight of poultry. Table 2 describes the amount of excreta produced in each province. (Livestock weight was considered 250, 40, and 1.5 kg for heavy livestock, light livestock and poultry, respectively).

Table 1
Amount of excreta and urine in animal [23,24].

Animal	Excreta (kg)	Urine (kg)
Cow	23	9
Sheep	1.3	0.7
Horse	16	3
Poultry	0.01	0

2.3. Calculating the amount of blood and rumen contents obtained from slaughtered livestock

As a result of scientific and industrial developments, it is possible to process animal waste and remold it into very valuable end-products, especially in the developed countries [9,25]. A large percentage of livestock live weight consists of by-products (waste) which comprises about 65% of the total weight in the young and healthy animals and about 75% of the weight in the old livestock [9]. Table 3 presents the organs of the livestock and the ratio of their weight to the whole body. The number of slaughtered livestock per province in 2011 was obtained from the Ministry of Agriculture and the Statistical Center of Iran (see Table 4).

2.4. Calculating the amount of biogas produced

The amount of produced biogas depends on several factors, one of which is the feed type. Table 5 depicts the amount of biogas produced from different types of feed [24,26,27]. This amount may also vary for each experiment depending on the circumstances. Since animal excreta is not always available and it cannot be collected sufficiently, for producing biogas from excreta, availability coefficients of 50%, 13%, and 99% for heavy livestock, light livestock and poultry were considered, respectively [24]. The amount of total solids in the excreta was another factor affecting biogas production. Table 5 shows the amount of total solids in livestock waste and the amount of biogas produced from it. In this paper, the total amount of total solids was assumed 25% for heavy livestock, 25% for light livestock, and 29% for poultry. The amount of the produced biogas was therefore calculated to be 0.6, 0.4, 0.8 $m^3\ kg^{-1}$ of the total solids ($m^3\ kg^{-1}$ of TS) for heavy livestock, light livestock and poultry, respectively. It was also supposed that the waste was acquired from the same slaughterhouse and transformed into biogas without any loss of moisture. In this paper, the amount of biogas produced from blood and rumen contents was considered 0.3 $m^3\ kg^{-1}$ of fresh material.

3. Results and discussion

Each province's potential for producing fresh excreta by the end of 2011 is given in Table 2. According to the results, Fars,