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An assessment of anaerobic digestion capacity in Bangladesh

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ABSTRACT

This work scopes the potential for existing common feedstocks to be used in existing types of anaerobic digester units to produce biogas in Bangladesh. A preliminary study identified three commonly occurring scenarios of smallholdings with cattle, poultry farms and daily cattle markets, which produce dung, poultry litter, and dung mixed with rice straw, respectively. This third feedstock is proposed as a novel and significant newly recognised prevalent source. The main study involved carrying out surveys of representative samples of each of these (N=125, 125, and 30) for the district of Gazipur in order to determine the distribution of herd and flock sizes, and thus the relevant biogas plant types and potential yields. The results were scaled up for nationwide figures, which approximated the total potential biogas energy from these feedstock types at 240×10^6 MJ (240 TJ) per day, or 66.7×10^6 kWh, which in principle could meet the current cooking energy requirements of 30 million people in Bangladesh. Of this, 70% of the potential energy from AD could come from cattle feedstock (with 87% of this from domestic-sized plant); 16% from poultry feedstock (with 63% of this from medium-sized plant); and 14% from rice straw bedding from cattle markets (all requiring very large or extremely large plant). There is potential for around 2 million domestic units, 340,000 medium units and 19,000 large units, as well as 500 very large units that might be more suited for larger users such as businesses, schools or hospitals.

Contents

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1. Introduction

1.1. Geographical information for Bangladesh

Bangladesh is one of the least developed and most densely populated countries in the world [1], with a land area of 147,570 km^2 and a population density of 1063 people per km^2, with an income per capita 1/100th of the UK [2]. A humid, low-lying, alluvial region, Bangladesh is composed mainly of the great combined delta of the Ganges, Brahmaputra, and Meghna rivers. Except for the Chittagong Hills along the Myanmar border, most of the country is less than 90 m above sea level.

1.2. Energy status

The population of over 144 million people faces severe problems of environmental degradation, shortage of food supply, reduction of soil fertility and scarcity of energy [3]. The economy of Bangladesh is agriculture-based, with more than 60% of the workforce engaged in agriculture [4], and agriculture contributes about half of the Gross Domestic Product (GDP). Per capita electricity consumption is only 146.5 kWh in Bangladesh, whereas in India it is 480.5 kWh, and in Pakistan, it is 456.2 kWh, and for developed countries the average per capita electricity consumption is 8009.5 kWh [5].

Except for natural gas found along its eastern border, limited quantities of oil in the Bay of Bengal, coal, and some uranium, Bangladesh possesses few fossil fuel reserves. More than 55% of the country's energy requirement comes from traditional biomass energy sources, which are crop residues, twigs, leaves, firewood and dung cake [6]. Traditional biomass energy is used mostly for cooking. Excessive use of biomass energy causes deforestation and in the long run increases the likelihood of environmental disasters like cyclones and floods, compromising agricultural productivity and economical development [6].

Commercial energy consumption comes from around 66% natural gas, met by the country's reserves of natural gas, and the other 34% by oil and limited amounts of hydropower and coal. The gas is used in the manufacturing of fertiliser, generation of electricity, direct use in certain industries, and as cooking fuel in major urban areas. Economically, it is not feasible to supply the gas to the rural areas through pipelines. Petroleum products such as high speed diesel oil and superior kerosene oil are the main fuel for transport and rural lighting [4].

1.3. Waste scenario and management

General waste management in Bangladesh is known to require further improvements to be effective. To illustrate this point we note that every day 3500 t of waste is produced in Dhaka, the capital of Bangladesh. This includes Municipal Solid Waste (MSW), agricultural waste and a minor amount of animal waste (cattle dung and poultry litter) [7]. Although 511,000 t of waste are disposed at simple controlled landfills near Dhaka annually, a further 509,248 t per year are 'lost' or illegally dumped [8]. for example, only 42% of waste for disposal in landfill is collected: much can be found on roadsides, near open drains, and in the low-lying areas of the city [9]. The dumping of waste has led to major problems such as transmission of diseases, greenhouse gas emissions (GHG) and pollution of ground water [10].

Most non-urban families in Bangladesh have a 'smallholding', including a few cattle where possible. The dung is collected and dried as a cake for fuel for cooking. Open storage of cow dung in smallholdings is common, creating breeding grounds for mosquitoes and disease vectors [11]. Some families have a poultry farm; the litter is usually disposed of at the edge of nearby fields and can cause environmental and land pollution. Inadequate collection and uncontrolled disposal of waste generally creates a health hazard to inhabitants and the environment in Bangladesh [12]. A small amount of cattle dung and poultry litter is reportedly used as a biogas feedstock [6], which shows that such a pathway can in principle work. The waste from the cattle markets, comprising of dung, rice straw and urine and which is increasing year by year, is currently landfilled.

Apart from landfill, the two major common practices relating to organic waste in Bangladesh are composting of household waste and anaerobic digestion of animal manure. Both serve to stabilise organic waste, make it hygienic, and reduce its mass. Furthermore, they facilitate the return to the earth of organic compounds and some nutrients. Anaerobic digestion processes can also be designed to allow the collection of a useful amount of biogas, even when waste management is the main purpose. Composting and digestion can be used as complementary approaches, depending on parameters such as the kind and variety of waste material; anaerobic and aerobic steps may also be combined in one treatment facility [13]. Climate change has been a significant recent driver leading to a move away from the landfilling of biodegradable wastes (a major source of methane emissions) and to a renewed focus on energy recovery from waste [14]. Due to these multiple potential benefits of waste management, GHG control, potential energy production and possible nutrient production, AD has become an important option for developed and developing countries.

1.4. Anaerobic digestion

Anaerobic digestion (AD) is a biological process of the breakdown of organic matter by naturally occurring bacteria in the absence of air, and this produces biogas and a solid digestate. Biogas comprises of mostly methane and carbon dioxide with a small amount of hydrogen sulphide and hydrogen. Depending on the type of input material, the residual solid matter or digestate can be a nutrient-rich bio-fertiliser [15]. According to a report by the Bangladesh Centre for Advance Studies [16], the 8.44 million households of Bangladesh have 22.29 million cattle and buffalo, and there are 116,000 poultry farms which produce 22,139 t of litter per day. Traditional use of dung and litter has a big impact on the environment and cultivable land in Bangladesh because when it is dumped on low ground adjoining dwelling areas it causes them to be affected by smell, dust and surface water pollution [17]. Bangladesh already has nearly 40,000 domestic biogas plants using cow dung or poultry litter, but the full potential has been estimated at 3 million plants [6]. The traditional use of biomass for cooking or the burning of renewably harvested fuel wood has often been assumed to be greenhouse gas neutral as eventually all the CO_2 will be recycled and taken up by vegetation in the next growing season. But this process is not emissions-neutral unless the biomass fuel is burnt efficiently and completely, and burning of biomass fuels in stoves typically achieves only about 10–25% overall efficiencies, emitting a significant portion of pollution in the form of products of incomplete combustion (PIC) that have higher global warming impact per carbon atom than CO_2. Biogas derived from AD using cow dung as feedstock when used in stoves is cleaner and has a higher combustion efficiency of around 60%.

Bangladesh has a suitable climate for biogas production. The ideal temperature for biogas is around 35 °C. The temperature in Bangladesh usually varies from 6 °C to 40 °C, but the internal temperature of a biogas digester in Bangladesh usually remains at 22 °C to 30 °C, which is very near to the optimum requirement [18]. Suitable raw feedstocks for biogas such as cow dung and poultry litter are easily and cheaply available throughout the country.