JOURNAL OF ENVIRONMENTAL SCIENCES 28 (2015) 178–186

Available online at www.sciencedirect.com

ScienceDirect

www.journals.elsevier.com/journal-of-environmental-sciences

JOURNAL OF ENVIRONMENTAL SCIENCES
www.jesc.ac.cn

Effects of introducing energy recovery processes to the municipal solid waste management system in Ulaanbaatar, Mongolia

Kosuke Toshiki[1,*], *Pham Quy Giang*[1,2], *Kevin Roy B. Serrona*[3], *Takahiro Sekikawa*[1], *Jeoung-soo Yu*[3], *Baasandash Choijil*[4], *Shoichi Kunikane*[1]

1. *Graduate Division of Nutritional and Environmental Sciences, University of Shizuoka, 52-1, Yada, Suruga-ku, Shizuoka 4228526, Japan*
2. *Faculty of Land Management, Vietnam National University of Agriculture, Trau Quy, Gia Lam, Hanoi, Viet Nam*
3. *Department of Interregional Environmental System, Graduate School of International Cultural Studies, Tohoku University, 41 Kawauchi, Aoba-ku, Sendai City 980-8576, Japan*
4. *School of Mechanical Engineering, The Mongolian University of Science and Technology, 3dr khoroo, Chinggis Avenue, Khan-Uul District, Ulaanbaatar, Mongolia*

ARTICLE INFO

Article history:
Received 20 March 2014
Revised 28 June 2014
Accepted 1 August 2014
Available online 24 December 2014

Keywords:
Municipal solid waste management
Energy recovery
Greenhouse gas emissions
Landfill volumes
Developing country
Refuse derived fuel

ABSTRACT

Currently, most developing countries have not set up municipal solid waste management systems with a view of recovering energy from waste or reducing greenhouse gas emissions. In this article, we have studied the possible effects of introducing three energy recovery processes either as a single or combination approach, refuse derived fuel production, incineration and waste power generation, and methane gas recovery from landfill and power generation in Ulaanbaatar, Mongolia, as a case study. We concluded that incineration process is the most suitable as first introduction of energy recovery. To operate it efficiently, 3Rs strategies need to be promoted. And then, RDF production which is made of waste papers and plastics in high level of sorting may be considered as the second step of energy recovery. However, safety control and marketability of RDF will be required at that moment.

Introduction

According to the fourth report of the Intergovernmental Panel on Climate Change (IPCC), the global contribution of waste and wastewater to greenhouse gas (GHG) emissions in 2004 was 2.8%. Majority of this was due to methane gas produced from landfill (Intergovernmental Panels on Climate Change working group III, 2007). In most developing countries, there has been remarkable increase in population, economic growth, accompanying urbanization and lifestyle changes. As a consequence, municipal solid waste (MSW) generations have rapidly increased and the composition of MSW has become more diverse. Mongolia is no exception to this which keeps rapidly growing with the development of mineral resources mining in recent years. Presently, Ulaanbaatar, which is the capital of Mongolia, is seeking to establish a new MSW management system. In the "Solid Waste Management Plan for Ulaanbaatar City, Mongolia" drawn up by the Japan International Cooperation Agency (JICA), a process of separating paper and plastic from waste, using them as raw materials for producing refuse derived fuel (RDF) and using the RDF as a coal substitute fuel in a coal

* *Corresponding author*. E-mail: k.toshiki28@gmail.com (Kosuke Toshiki).

http://dx.doi.org/10.1016/j.jes.2014.08.018

fired power station is proposed (Japan International Cooperation Agency, 2007). The goals of this plan include recovering energy from waste in Ulaanbaatar's MSW and reducing landfill volumes.

Most developing countries in Asia have not set up MSW management systems with a view of using energy from waste or reducing GHG emissions. However, among the developed countries in Asia, Japan and South Korea are energetically working toward these goals. In Japan, about 70% of MSW are incinerated and electricity is generated by waste power generation plants in large municipalities. In the 1990s, the production of RDF from MSW attracted interest as a solution for local governments concerned with landfill volumes in MSW management. However, there were many accidents in the production of RDF and the demand for the RDF was low, so this interest has waned. On the other hand, in South Korea, incineration is not yet widely used and the emphasis has mainly been on recycling and landfill. With regard to energy recovery, methane recovery and power generation plant with a capacity of 50 MW (among the largest in the world), have started to operate at a landfill site in Seoul Metropolitan area. During interviews in Seoul Special City in September 2011, the authorities indicated that they would actively promote incineration and waste power generation for Seoul in the near future (Toshiki, 2012). Moreover, now RDF production has been introduced there. In 2011, we confirmed that RDFs were made using plastic and paper from household waste in a landfill site. And during interviews in the city in October, 2013, we confirmed that RDFs were made from sewage mixed with kitchen waste.

In regard to energy recovery processes in MSW management, the efforts of these two Asian developed countries in waste power generation, methane recovery and power generation deserve attention as showing the way for future MSW management systems in Asian developing countries.

After that plan was drawn up, JICA firstly addressed the reinforcement of MSW collection ability in Ulaanbaatar. Therefore, collection rate of household waste gradually improved. Currently, incineration has not been installed but a RDF production facility was built in 2011 by Korea International Cooperation Agency (KOICA). However, this facility has not operated in earnest so far. Therefore, MSW disposal depends on landfilling even now. When we went to the landfill sites in Ulaanbaatar and interviewed the administrator in 2012, it is said that the quantity of MSW brought to the landfill site was increasing. Ulaanbaatar city government newly built a small landfill site which has operated from 2012 to deal with the problem, although the landfill sites in the city are open-dumpsites with large environmental loads. Combustible gases generated from dumpsites catch fire and smokes always go up. In addition, there is the specific problem in Mongolia that domestic cattle of neighbor nomads often enter an open dumpsite to seek food. Therefore, MSW management that depends on landfilling is unpreferable. Accordingly, we have studied the likely effects of introducing the above energy recovery processes either as a single or combination approach in a future MSW management system in Ulaanbaatar.

The reason for having selected Ulaanbaatar as a case study is as follows: In order to examine the energy recovery processes from MSW, it is necessary to calculate the calorific value of the kinds of waste. Therefore, the composition data of MSW is required and the data of Ulaanbaatar had been investigated and released by JICA. Such data is usually unavailable except for the data of metropolises in developing countries. There are many local cities on a scale of a few million people in developing countries and the data of such rural cities is unavailable. Thus, having Ulaanbaatar as a case study is significant, when examining the directions of the future energy recovery in these cities.

1. Material and method

Firstly, on the basis of interviews and collected documents, we estimated population change, economic growth and other factors in Ulaanbaatar. MSW generation was then predicted. After that, we specified scenarios in which a number of energy recovery processes would be used in the MSW management system, such as RDF production, incineration and waste power generation, and methane recovery from landfill and power generation. Then we quantitatively evaluated their effects on energy recovery, GHG emissions and landfill volumes. Working from the results of this evaluation, we compared the attributes of the different scenarios.

1.1. Assumptions for scenario analysis

1.1.1. Population changes in Ulaanbaatar

There are roughly two residential areas in Ulaanbaatar. One is "the planned area" where residents live mainly in the apartment and infrastructure is maintained. The other is "the ger area" which spreads out to surround the apartment area. The ger area residents live in gers which are the Mongolian traditional yurt, or houses.

When predicting future MSW generation volumes in the SWMP, JICA used population change predictions shown in an urban master plan that was approved by Ulaanbaatar in 2001. However, there are two problems with this master plan. Firstly, many of the residents of the ger area did not register as citizens when they migrated to Ulaanbaatar from the provinces, so these people were not reflected in statistics published by the central government (National Statistical Office of Mongolia, 2002). Secondly, the master plan stated that the population of the ger area would be greatly reduced by subsequent housing policy. In reality, apartment construction has not kept up with the influx of people from the provinces and, because living in a ger is overwhelmingly less expensive; the population of the ger area is even now steadily increasing. The population change predictions in the master plan have already diverged greatly from the realities on the ground. For example, the master plan predicted that the population of Ulaanbaatar would be around 870,000 in 2005, of which around 52%, or 450,000 people, would be in the planed area and around 48%, or 420,000 people, in the ger area (Japan International Cooperation Agency, 2007). Hence, with the construction of apartments, the master plan estimated that in 2008 the population of the planned area would be around 610,000 and the population of the ger area around 310,000. However, according to a World Bank report, the population of Ulaanbaatar in 2007 was over 1 million, of whom around 60% were estimated to be living in the ger area. The report predicted that the population of Ulaanbaatar would be around 1.3 million in 2015 (Kamata et al., 2010).

Therefore, using the population change predictions in the World Bank report, we specified a population of Ulaanbaatar in 2015 of around 1.3 million and, taking account of the steadily increasing proportion of the population in the ger area, we specified the population changes of the respective areas in three steps as shown in Table 1. When this predicted population of Ulaanbaatar is compared with the population of Mongolia predicted by the Department of Economic and Social Affairs, United Nations (Department of Economic and Social Affairs Homepage, United Nations), we think that the predicted population in Table 1 is appropriate. In Mongolia, there is no big city except Ulaanbaatar, where industry is underdeveloped and employment is not enough in the provinces. There is a