

Climate change mitigation in sewerage

- biomass and energy technologies

Hiromasa YAMASHITA, Kensuke SAKURAI, Toyohisa MIYAMOTO, and Seiichiro OKAMOTO
Recycling Research Team, Material and Geotechnical Engineering Research Group,
Public Works Research Institute

1. Introduction

In response to a demand for climate change mitigation, attention has turned to the use of energy produced using waste biomass, a source which does not compete with food production. But regardless of the vast reserves of energy in waste biomass, its use is now limited by problems such as transport and collection costs, pre-processing costs, and so on.

However, types of biomass such as biosolids from wastewater produced by urban life and grass or pruned wood produced by the maintenance of public properties along roads and rivers are not only stable in terms of both quality and quantity, they are produced mainly in and around cities and their control systems are firmly in place. They are, therefore, types of biomass considered to be extremely valuable sources of usable energy.

And many sewerage treatment plants are already equipped with facilities which use energy: methane fermenting tubs, fuel conversion facilities etc. as part of their biosolids processing systems. And if it were possible for these facilities to use biomass energy from grass or wood produced by public property maintenance, it would be possible to perform the preprocessing necessary for its use extremely efficiently, spurring its use.

2. Outline of the research

Maintaining roads, rivers, parks, airports, and other infrastructures produces vast quantities of pruned wood, driftwood, grass clippings, and so on every year, but maintenance funds are invested to process and dispose of much of this material. And large quantities of biomass are produced from local raw garbage and excreta from livestock farms. The Public Works Research Institute (PWRI) is conducting research to develop technologies to efficiently use these types of biomass. This report introduces an outline of past research by the PWRI on the efficient use of biomass produced by the above public works activities.

2.1 Provision of an inventory of biomass from public works

Biomass produced by public works on roads, rivers, in parks, and at airports is, as stated above, an extremely valuable source of usable energy, and it is assumed that its reserves are relatively large.

To use the waste plant biomass which has been produced as a resource, the production volume, locations and times of the production, and its state when produced must be

accurately measured and numerically controlled. Surveys of the composition and of the production mass of the grass and trees necessary to construct such a biomass inventory have been performed. A past survey has obtained an estimate of the quantity of grass clippings from a single mowing of the slopes on a river or roadway as an average of between 0.2 to 0.3kg-DS/(m²• time). These analysis results have been summarized as Technical Note of PWRI. The use of plant biomass as an energy source can be studied using these data.

The PWRI plans future research to build a utilization process control system to use biomass in a most appropriate way, from both the cost perspective and energy perspective (CO₂ reduction).

2.2. Development of Biomass Utilization Technologies Using Sewerage Facilities

The primary way biosolids has been used to produce energy in sewage treatment plans has been the recovery of methane by anaerobic digestion, with approximately 300 such facilities now installed throughout Japan. In recent years, technologies such as fuel conversion facilities or gasification facilities have come into practical use.

The technologies introduced below have been developed by the Public Works Research Institute as biomass utilization technologies using sewerage facilities or as technologies for the effective use of regional biomass.

(1) Mixed methane fermentation technology

Woody material or dried grass is difficult to ferment while still in organic form: a problem which had to be resolved. This was done by adopting the steam explosion method to develop methane recovery technology based on mixed fermentation with biosolids.

The steam explosion method, which is a method of instantaneously releasing pressure after steaming the material for a short period using high temperature and high pressure water steam in a pressure vessel, explodes the plant biomass, refining and modifying it and lowering its molecular weight. It has been confirmed that mixed fermentation of broad-leafed tree type steam exploded material with biosolids results in methane fermentation of good quality without acid fermentation, even at solid material mix proportion (DS base) of 1:1 or more, and that methane can be generated approximately proportionally to the mixing ratio.

Dewatering the product of fermentation of the steam explosion material and biosolids has obtained water content lower than that of biosolids, confirming its good dewatering properties. Pilot testing to achieve adaptation to an actual facility will be performed in the future.

(2) Biomass energy conversion technology (PFBI: pressurized fluidized bed incinerator)

In order to maximize use of calorific value of biosolids and to use energy from processing residue and fermentation residue of regional biomass accumulated in sewage treatment plants, the pressurized fluidized bed incinerator which is a new combustion system has been developed (joint research with Tsukishima Kikai Co. Ltd., Sanki Engineering Co. Ltd., and Advanced Industrial Science and Technology).

The basic technology which has been developed includes a pressurized fluidized bed incinerator which burns biosolids etc. under pressure of about 0.2MPa. The high

temperature high pressure combustion gas which it produces drives a turbocharger, producing compressed air which can then be converted to usable energy.

And the emissions of N_2O can be cut by high temperature combustion under pressure, which makes it an effective climate change mitigation technology.

Trial operation of a demonstration plant (approx. 5t-dewatered biosolids/day) installed at the Oshamanbe Sewage Treatment Plant in Hokkaido has confirmed that combustion of biosolids and mixed combustion with plant biomass can both be performed stably.

It has also been confirmed that this technology obtains energy conservation effects which can reduce CO_2 emission reduction of about 40% if it is installed at a scale of 100t dewatered biosolids/day.

(3) Biogas utilization technology as automobile fuel

Biogas can be used in the same way as natural gas. The method of use which has been the most socially effective until now is judged to be its use as automobile fuel, and joint research (City of Kobe and Kobelco Eco-Solutions Co., Ltd.) has been carried out to study the conversion of biosolids digestion gas to bio-natural gas. The research included a study of methods of refining digestion gas and repeated automobile running trials, and a plant to supply gas for use by city busses in the City of Kobe has been recently completed, bringing this technology to the practical stage. As technology to support use, the absorption storage technology, which effectively stores large quantities of biogas, has also been developed.

(4) Biogas engine system - electric power production technology

In order to promote the use of biogas produced by methane fermentation in medium and small scale sewage treatment plant, a biogas engine system for electric power production from biogas using a low-price general purpose engine has been developed (joint research with Raito Kogyo Co., Ltd. and Inoue Masa Syouten Co., Ltd.). An engine system which operates stably (power generation efficiency of 20% or higher) at the normal biogas composition of CH_4 concentration of about 55% has already been developed. At this time, a long-term proving operation trial based on biosolids digestion gas is in progress at an actual sewage treatment plant, achieving continuous operation of about 1 month.

3. Conclusion

Trends in the strengthening of efforts to implement climate change mitigation technologies include a growing interest in unused or underused waste biomass such as biosolids or plant biomass. Sewage treatment plants which have already been improved as urban facilities under these circumstances can, as centers for the use of other biomass, potentially aim to play a role as basic facilities to support a recycling society. We intend to continue our efforts to conduct supporting research and technology development to take advantages of such conditions.