B-12.1 Development of Systems and Methodologies for Impact Assessment on Urban Environment

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Abstract The objectives are to identify each effect of global warming on urban environment and infrastructure and to systematically assess integrated impacts including interrelation and/or multiplication of each effect. Effects of global warming on urban environments in many cities in the world were reviewed and their information was input to the integrated knowledge-base system including fuzzy model. Individual information related to global warming effects on urban environment was integrated into it systematically.

The landfill technology method for reducing greenhouse effect gas emissioned from municipal solid waste landfill site was studied. Aerobic landfill cell and anaerobic landfill cell were set up on the scales, respectively. The amounts of gas emissioned from each cell were evaluated based on mass balance. The empirical models were derived from these experimental data and applied to actual landfill sites. It was found that the contribution of the semi-aerobic landfill site decreased by the
half of the anaerobic landfill site.

Key Words Urban environment, Integrated assessment, Fuzzy model, Knowledge-base system,
Municipal solid waste

Introduction

Complex systems are formed in urban area and much property and infrastructure is greatly accumulated. Each effect of global warming on individual systems in urban environment would be integrated and/or extended through interactions within the complex urban systems and expected to be serious impacts on urban environment.

Objectives

The objectives are to identify each effect of global warming on urban environment and infrastructure and to systematically assess integrated impacts including interrelation and/or multiplication of each effect.

As a case study, field studies in the actual landfill site and laboratory-scale experiment were carried out in order to establish the landfill technology method for reducing greenhouse effect gas emissioned from municipal solid waste landfill site.

Development of Knowledge-Based System on Urban Environment

Global climate change could have an influence on urban environment and infrastructure. These effects are interrelated each other and/or are multiplied. It is essential to identify various effects of global warming and to estimate the extent and intensity of these

effects. We have developed a computer system for supporting these evaluation processes.

Several techniques such as the check list methods, the matrix method, the network method and so on are developed for systematically identifying environmental impacts. It is, however, difficult to apply these existing methods to assess the effects of global warming. The problems lie in subjectivity of identified structure, limitation of available variables, difficulty of obtaining quantitative models from structure identification and so on. For these difficulties, we applied the Knowledge-Based System developed at the National Institute for Environmental Studies. This system is designed for logically relating, computing and filing the knowledge-based data obtained from experts. Cause-effect relations among these data are identified in the form of graphs, so that we can simulate interaction among important factors. We improve the Knowledge-Based System for the evaluation of the effects of global warming on urban environment quantitatively (Fig.1).

The data on the effects of global warming were collected and stored in this system. Knowledge data on urban energy system, air pollution, urban greenbelts, urban agriculture,

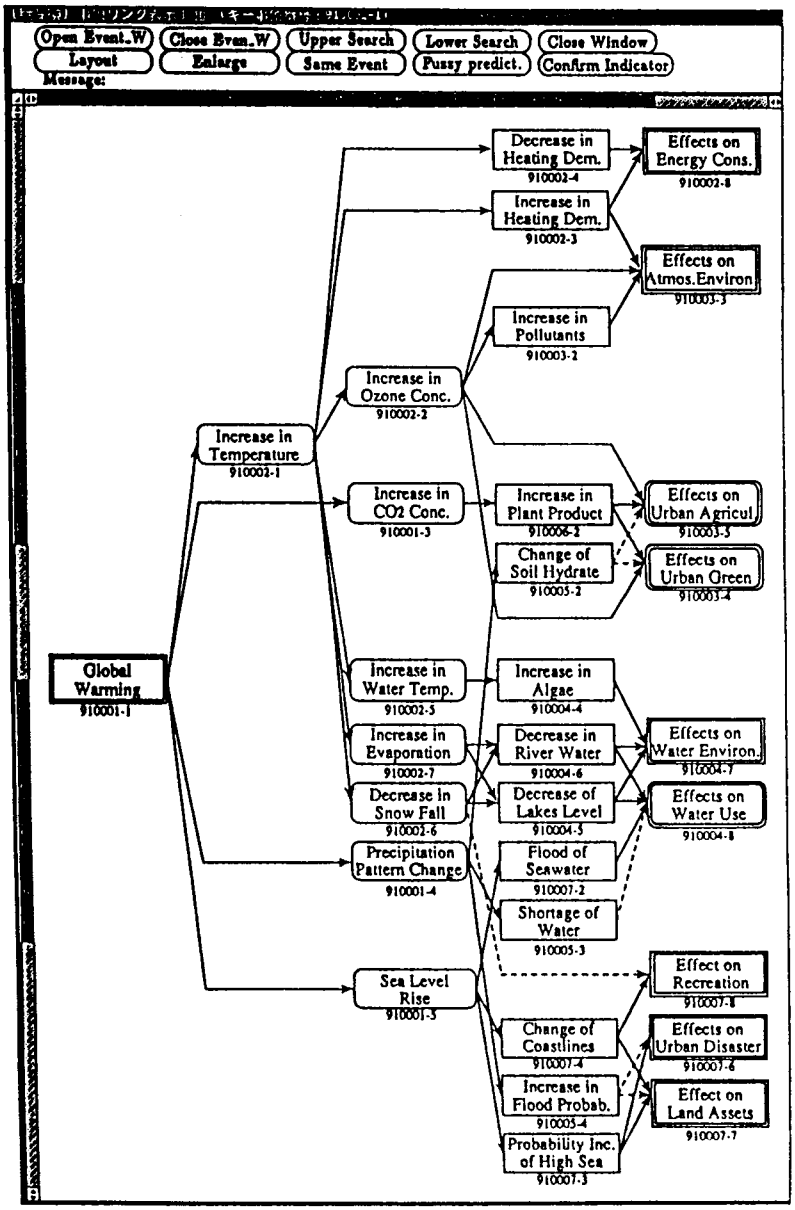

Fig. 1 Effects of global warming identified by the Knowledge-Based system

water environment, water use system, recreation environment, urban disaster, land assets and so on were stored in the system and the structure of the causal relations were obtained. This system is useful for identifying the urban environmental structures and obtaining simulation model of global warming effects.

We also developed the methods for evaluating the effects of global warming by money scale. First, we reviewed the methods for accounting economical values of warming effects, such as methods of estimating values from market data, indirectly estimating values from land prices and travel costs, estimating values based on the results of questionnaire to consumers. Next, we applied the economical accounting to recreation and natural environment and framed a plan for accounting environmental values.

As for knowledge data to input into the Knowledge-Based System, more than sixty research reports on global warming impacts on urban system and human settlements were collected, and data files were made based on these reports. However, these knowledge data are not sufficient to identify the structure of global warming impacts. In order to supplement knowledge data, we plan to collect knowledge data made by expert's judgements, and to develop a structural identification methodology which can be applied to uncertain situation.

Landfill Technology

(1) Methane emission from gas venting pipe in waste landfill site

We investigated methane emissions from a municipal solid waste landfill site. The landfill site was closed in 1983 and part of the site has been used for recreation and a parking lot. Gas generated from landfilled waste has been emitted naturally into the atmosphere through venting pipes.

We set up the gas chamber to measure methane emissions from a gas venting pipe under natural conditions in November of 1990. The gas chamber was equipped with a blower and ducts in order to ventilate the inside air of the chamber with the outside fresh air. Part of the gas withdrawn from the chamber was measured every ten minutes through a non-methane hydrocarbon analyzer. Additionally, the meteorological parameters were monitored at the site every ten minutes.

Gas emission rates were affected by changes in atmospheric pressure. This phenomenon was also observed during the periods of diurnal changes in atmospheric pressure by the atmospheric tides on clear days (Fig.2). Auto-correlation analysis showed that there was the cycle of 12 hours and 24 hours both emission rate and atmospheric pressure during clear days.

(2) Methane and carbon dioxide emission from surface of final cover in waste landfill site

Gas generated from landfilled waste is expected to be emissioned into the atmosphere through gas venting pipes and surface of final cover in waste landfill site. We investigated methane and carbon dioxide emissions from surface of final cover in the above mentioned waste landfill site.

We set up two gas chambers and analyzed methane and carbon dioxide concentration in side chamber continuously using portable gas chromatography with TC detector. One chamber was equipped with a pump in order to ventilate constantly the inside air of the chamber with the outside fresh air. In this chamber gas emission rate was calculated from ventilation gas flow and steady-state gas concentration inside chamber. Other chamber had no pump and only the outlet portion connecting to gas chromatography. Gas emission rate in the chamber was calculated from the rate of increasing gas concentration inside chamber. At the same time meteorological parameters such as atmospheric pressure and air temperature and soil moisture and temperature in the surface of final cover were monitored.

There was no significant difference between gas emission rates estimated from both two chamber systems. The important factors which affected gas emission rate from surface of final cover were soil moisture and atmospheric pressure. High gas emission rate was observed in the condition of low soil moisture. Gas emission rates increased when the rate of change in atmospheric pressure decreased. This phenomenon was similar to that of gas emission from gas venting pipe. Ratios of methane to carbon dioxide in the gas inside chamber changed from hours to hours and were much smaller than those in the gas taken from gas venting pipe. These results suggested that methane generated in the landfilled waste is oxidized by methane oxidizing bacteria in the final cover of the landfill site where oxygen is provided from atmosphere through the gas exchange between surface soil and air.

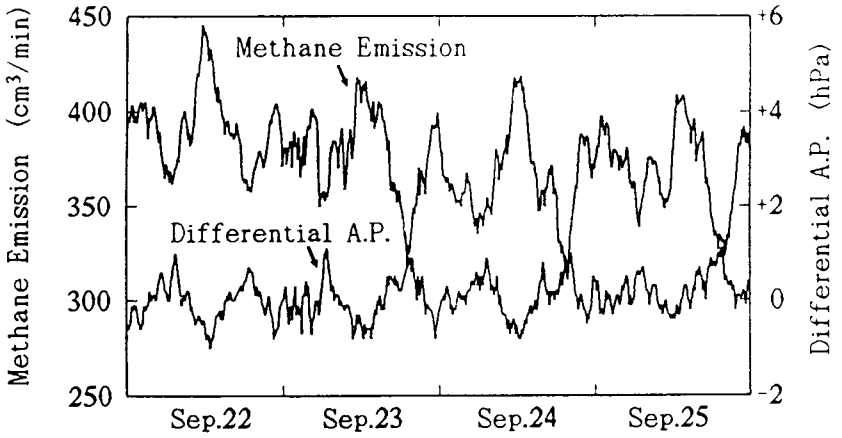

Fig. 2 Relationship between methane emissions and differential atmospheric pressures during the period of September 22 - 25 in 1991.

(3) Reduction of greenhouse effect gas in waste landfill site

The landfill technology method for reducing greenhouse effect gas emissioned from municipal solid waste landfill site was studied. An aerobic landfill cell and an anaerobic landfill cell were set up on the scales, respectively. The amounts of gas emissioned from each cell were evaluated based on mass balance. The empirical models on degree of degradation and gasification of municipal solid waste landfilled were derived from these experimental data and applied to various types of landfill sites. It was found that the contribution of the semi-aerobic landfill site decreased by the half of the anaerobic landfill site (Table 1).

Table 1 Cumulative amount of greenhouse effect gas generated from waste landfill site

Structure of landfill	Cumulative CO_2 * generated for ten years	Cumulative CH_4 * generated for ten years	Cumulative gas generated for ten years converted to a CO_2 ** basis
Aerobic Landfill	132	397	12,000
Semi-Aerobic Landfill	228	171	5,360
SEmi-Aerobic Landfill with Leachate Recirculation	256	85.5	2,830
Aerobic Landfill	271	42.7	1,550

* L/kg easy-degradable organic matter contained within municipal solid waste

** Methane gas was converted to a carbon dioxide basis using the relative value of methane's heat absorption (i.e., 30).