A-6.2 Research on Environmental Impact Assessment of Technologies for Control of Ozone Layer Depletion Materials

Contact Person Osami Nakasugi
Principal Researcher
Regional Environment Division, National Institute for Environmental Studies, Environment Agency.
16-2 Onogawa, Tsukuba, Ibaraki 305 Japan
Phone +81-298-51-6111 (Ext.313), Fax +81-298-51-4731

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Abstract The comprehensive assessment procedures of environmental impacts caused by the technologies for control of ozone layer depletion materials have been proposed. Environmental impacts caused by using alternetive chemicals for chlorofluorocarbons (CFCs) have been assessed. The model simulating environmental fate of chemical substances has been developed.

Key Words CFCs, Emission Control Technologies, Alternative Chemicals, Environmental Impact Assessment, Environmental Fate Model

1. Research Objectives

In order to prevent the depletion of ozone layer in the stratosphere, technologies to reduce the CFCs emission to environment and alternative chemicals for compensating the regulation on production and usage of CFCs have been developed. But, trichloroethylene and tetrachloroethylene which are alternateive solvents, are much concerned to affect human health by intake of drinking water and breathing. The technologies for preventing the ozone layer depletion should be free from affecting human health and ecosystem in all sides. So, assessment procedures of environmental impacts caused by the technologies for control of ozone layer depletion materials and a model for predicting fate of chemicals in environment have been developed.

2. Research Method

Concerning the development of the assessment procedures, the environmental impacts caused by the technologies were picked up, the procedures for assessing the environ-

mental impacts were proposed, and finally the environmental impacts of direct exposure on human health and ecosystem were quantified, taking example on the alternative solvents.

A model was set up in the following order. Firstly, a box model to estimate time-dependent concentrations in environment elements, and secondary, this model was improved to one to be applicable for evaluating the effect by the chronic exposure.

3. Results and Discussions

(1) Development of Assessing Procedures of Environmental Impacts

In comprehensive assessment of environmental impacts related to human activities, many items such as ozone layer depletion, global warming, acid rain, reduction of tropical forest, regional air and water pollution, subsurface pollution, noise and vibration etc. must be taken into account. Therefore, it is much effective to start with qualitative assessment for all items and next quantitatively assess the items to likely cause serious environmental effects based on collected information. In order to execute the comprehensive assessment, total environmental impacts should be taken into account during a life-cycle of resources like facilities and chemicals used in technologies.

Various environmental impacts caused by the technologies can be qualitatively assessed from several view points. The important aspects for assessing the environmental impacts are the following terms; 1. how much energy are consumed, 2. how much resources like water, wood etc. are used, 3. whether it requires hazardous chemicals or not, 4. whether hazardous substances are formed or not, 5. how much wastes are generated, and 6. whether the public work is destructive to the natural environment or not etc.

(2) Qualitative Evaluation of Environmental Impacts

① Emission Control Technology

Concerning technologies for destruction, the energy consumption amount, usage of hazardous chemicals and formation of toxic substances are main loads for envionment. The formation of toxic compounds such as chlorinated dioxins and phosgene caused by thermally destruction is able to be controlled by the proper operation of treatment plants, for example enough high temparature and residence time. The thermally destructing noncombustible CFCs needs considerable amount of energy. Though the emission control of CFCs is capable of lowering the progression of global warming, the

treatment technology with less energy consumption is desired.

In case of removal and recovery technologies of CFCs, the energy consumption amou nt and type of wastes etc. are pointed out as significant assessment subject.

② Usage of Alternatives Chemicals

Concerning usage of alternative chemicals, use of hazardous chemicals and formation of toxic substances in the production and disposal of the chemicals. Among alternative chemicals, the organochlorine compounds are most harmful to human health and ecosystem. The production and usage of trichloroethylene and tetrachloroethylene, which are candidate of alternative chemicals, have been controlled in Japan, because they were detected in the subsurface environment across the nation. Therefore, the production and use of methylene chloride has been increasing year and year due to the applicability of facilities utilized for CFCs without any modification. But, methylene chloride is possible to damage human health via environmental pollutions.

In addition to organochlorine compounds, aliphatic hydrocarbons, isopropanol, higher alcohol, ketones, carbon dioxide etc. are used as cleasing solvent, spray gas, refrigerant and forming agent in place of CFCs. However, the toxicity of thier compounds are not high to damage human health via environmental pollution. Hydrocarbon is one of substances causing photochemical smog and isopropanol and higher alcohol may cause water pollution, but their emission by alternative usage of CFCs is small.

(3) Environmental Impact by Usage of Methylene Chloride as Alternatives

Based on the comprehensive investigation in environment conducted by Japan Environment Agency in 1983, methylene chloride was detected in almost air samples at the concentrations of 0.007 - 20 $\mu g/m^3$. The USEPA concluded that methylene chloride including in breathing air at 0.02$\mu g/m^3$, causes cancer at the rate of 10^{-6}. The concentrations of almost air samples takin in 1983 exceeded this value and the maximum concentration is far high above this value. Methylene chloride was also detected in groundwater. The groundwater investigation in 1991 revealed that methylene chloride was detected at the rate of 10% of groundwater samples and about 3% of them exceeded the standard of ambient water quality in Japan.

As methylene chloride holds a chemical feature of high water solubility, compared with other volatile organochlorine compounds, methylene chloride in water is hardly remove by means of usual techniques like air stripping and activated carbon adsorption. In addition to these characteristics, in case of recovery of methylene chlo-

ride from discharged gas the operation temperature should be lowered. As a result, the usage of methylene chloride as alternative chemicals for cleansing solvent and forming agent is not improper option.

(4) Development of Environmental Fate Model

In order to quantitatively assess environmental impacts caused by hazardous substances emitted from the technologies for control of ozone depletion materials, a model predicting the local distribution of cross-media contamination has been developed. In the model, the object area is divided to boxes making up of five environmental media such as air, river water, marine water, soil and sludge. And behaviours of substances in environment such as transfers between media, decompositions in each medium and migrations between boxes, are expressed by mathematical equation.

The model made in this study was verified using the data of trichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane and benzene observed in air and surface water of some inland city of Japan. As to the air the calculated value averaged for one hour was compared with the observed one obtained from three hours air sampling, and the observed value of surface water is compared with the calculated one at the water sampling time. The calculated concentrations of air except benzene were lower than the observed values. The results of surface water showed that both of calculated and observed values was consistent. The cause for this error was considered to be due to no consideration of background concentration, possibility of unknown emission source, lack of information about discharge pattern of contaminants, possibility of underestimation of migration between environmental elements etc.

Among effects by exposure of toxic substances, the effects by chronic exposure are more important than the effects caused by acute toxicity. So, the model are improved to be applicable for estimating the averaged concentrations. In this model, it is supposed that equlibrium is keeping between environmental media. The results of calculation by improved model are similar as that of time-dependence model.

4. Main Results of This Study

The environmental impacts caused by the technologies for control of ozone layer depletion materials were picked up and clasified. The important aspects for assessing the environmental impacts were pointed out. From the assessment, it is pointed out that usage of methylene chloride is improper. For quantitative assessment, a model estimating environmental fate of substances were developped.