Estimation of Homologue-based Emissions of Short-Chain Chlorinated Paraffins in Japan

Junichiro Koshiba[1*], Takaaki Nagano[1], Yasuhiro Hirai[1], Shinichi Sakai[1]

1: Environmental Preservation Research Center, Kyoto University, Yoshida-Honmachi, Sakyo-ku, Kyoto 606-8501, Japan

*corresponding author: j-koshiba@eprc.kyoto-u.ac.jp

Keywords: short-chain chlorinated paraffins, emission estimation, material flow analysis

INTRODUCTION

Short-chain chlorinated paraffins (SCCPs) are one of the persistent organic pollutants (POPs). SCCPs have been produced and widely used in Japan in many applications for many years (Tsunemi et al., 2010). Even if their production had stopped since 2006, SCCPs have been detected in various Japanese environmental media (Li et al., 2012). Furthermore, emissions of SCCPs may occur from the long-term use of products containing SCCPs.

Studies have been carried out to estimate the emission of SCCPs in Japan (Tsunemi et al., 2010; Glüge et al., 2016). However, little information is available on the applications, emission factors, and volatilization factors from long-term use of products with SCCPs. In addition, although the physical-chemical properties and volatilization factors differ greatly between homologues, only estimations of total SCCP emission have been made.

MATERIALS AND METHODS

This study estimated the material flow and emission of SCCPs from 1950 to 2050 (Fig. 1). The material flow model explicitly includes a material recycling process for PVCs so that the recirculation of SCCPs contained in the recycled PVC products can be simulated. Estimations of material flow and emissions were conducted 1000 times, assuming that parameters such as the distribution of SCCP applications, emission factors, and lifetimes of long-term use products follow a uniform distribution with lower and upper bounds.

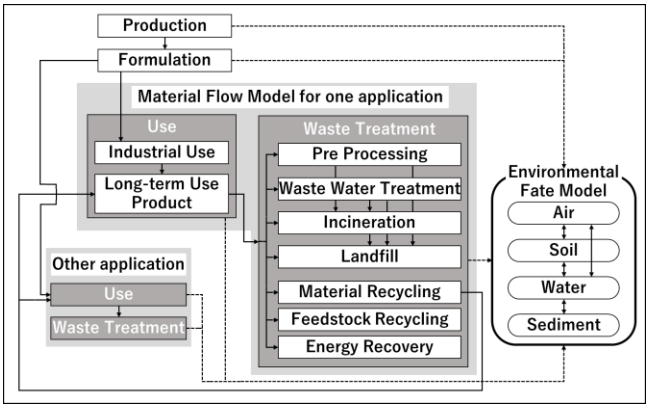

Fig. 1 Material Flow and Emission of SCCPs

SCCP concentrations in air, water, soil, and sediment in Japan were also estimated for each homologue using an environmental fate model. Yearly average emissions were used for the estimation.

RESULTS AND DISCUSSION

Fig. 2a shows the atmospheric total-SCCP emission (sum of homologue emissions); the solid line shows the average emission, and the error bar shows the maximum and minimum emission for each year. It was estimated that the air emissions had increased since 1950, and the average emission reached its peak around 1990. After that, the emissions showed decreasing trends and in recent years were estimated to be lower than

10 tons (average). Most of the air emissions were caused by volatilization from long-term use products. It was estimated that the contribution of film to volatilization was largest until around 1975 where paint materials became the largest contributors. Moreover, the contribution of wire coating materials, which were assumed to have a long product life and considered as closed-loop recycling materials, might have also been a large contributor in the recent years and might continue to be one in the future.

While the average value of the estimated atmospheric concentrations of total-SCCPs was lower than the measured concentrations in 2008 (Li et al., 2012), the maximum value of the estimated atmospheric concentrations laid within the range of the measured values. In addition, the comparison of homologue patterns (Fig. 2b and 2c) showed an overestimation of the proportion of lower chlorinated and shorter carbon length homologues. Therefore, there might be some inconsistencies in the assumed homologue distributions in long-term use products and volatilization factors from long-term use products.

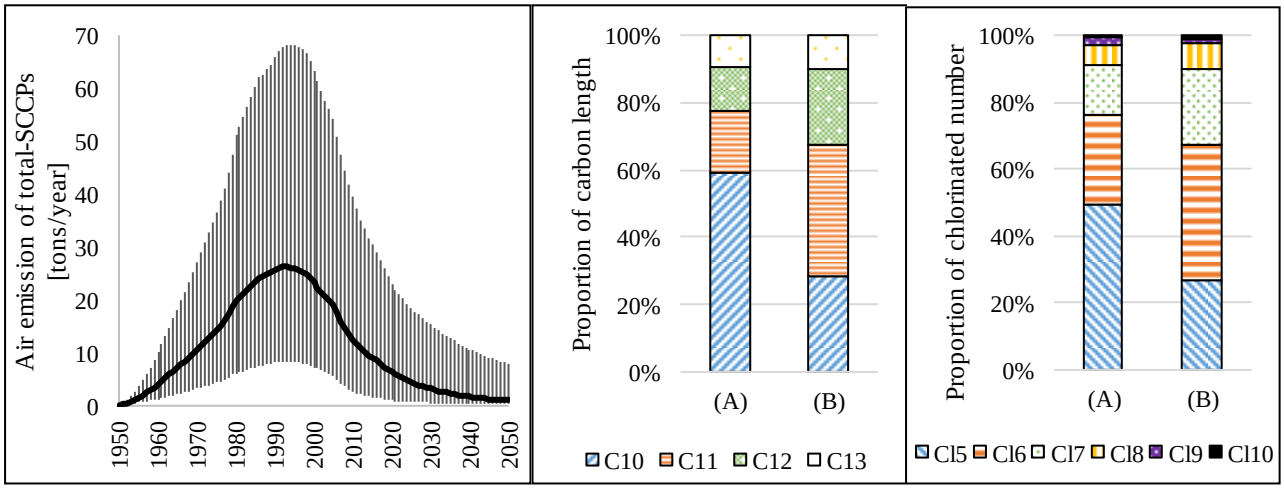

Fig. 2 The estimated emissions and concentrations in air. (A) shows the estimated values in this study, and (B) shows the measured values by Li et al, 2012.

CONCLUSION

In this study, we conducted homologue-based emission estimation considering parameter uncertainties and material recycling. The estimated atmospheric concentrations were lower than the measured values and suggested some inconsistencies in homologue patterns and volatilization factors.

ACKNOWLEDGEMENT

This research was supported by the Environmental Research and Technology Development Fund (JPMEERF18S20306) of the Ministry of Environment, Japan.

REFERENCES

Glüge, J. et al., Global production, use, and emission volumes of short-chain chlorinated paraffins–A minimum scenario, Sci. Total Environ., 573, 15, 1132-1146, 2016.

Li, Q. et al., Atmospheric Short-Chain Chlorinated Paraffins in China, Japan, and South Korea, Environ. Sci. Technol., 46, 21, 11948-11954, 2012.

Tsunemi, K. et al., Risk Assessment of Short-chain Chlorinated Paraffins in Japan, Handb, Environ. Chem. Chlorinated Paraffins, 155-194, 2010.