Input-output analysis of reactive nitrogen flows in industry and industrial nitrogen footprint: the case of Japan

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Abstract

Various nitrogen (N) compounds, collectively called reactive nitrogen (Nr) in industry, account for considerable proportions in the global N cycle. Complication of the interactions between the industrial sectors has hindered our understanding of their dynamics. We developed a new model based on input-output analysis to investigate the direct and indirect Nr flows in Japanese industry. The model revealed that the final chemical production sector received the biggest amount of Nr as feedstocks among sectors in 2011 (intermediate compounds: Urea, nitric acid, and others). Applying the model, the Japanese N footprint of industrial products was found to be 770 Gg-N.

Keywords: Industrial nitrogen, Input-output analysis

1. Introduction

Nr in industry accounts for considerable proportion in the global N cycle. Complicated interactions between the industrial sectors has hindered our understanding of their dynamics. In this study, we introduced a novel method based on input-output analysis, to reveal the direct and indirect Nr flows for industry.

2. Methodology

The 2011 Japanese input-output table was connected to the Nr flow analysis by Katagiri et al. (2018). We set up "Input coefficient of ammonia derivatives" to estimate the Nr input from each industrial sector and calculate the Nr flow to the first destinations using the following formula (1):

$$X_k = \sum_i \nu_i \mu_{i \to k} Z_k \quad (1)$$

where ν is the intensity of Nr in ammonia derivatives, μ is the intensity of each ammonia derivative in each industry, and Z is the production value of industry.

We then estimated how much Nr is induced due to the final demand of each sector by using the following formula (2):

$$X_{Nr} = \nu\mu \cdot [I-(I-M)A]^{-1} \cdot [(1-M)F+E] \quad (2)$$

where I is the identity unit, M is the import coefficient, A is the input coefficient, F is the domestic final demand, and E is the export.

3. Results and discussions

3.1 Nr flows in industry

The top five sectors account for ~90% of the flow (Fig. 1). Acrilonitrile and urea are the main carriers of Nr. N footprint of Japanese industry, total inflows into industry, was 770 Gg-N.

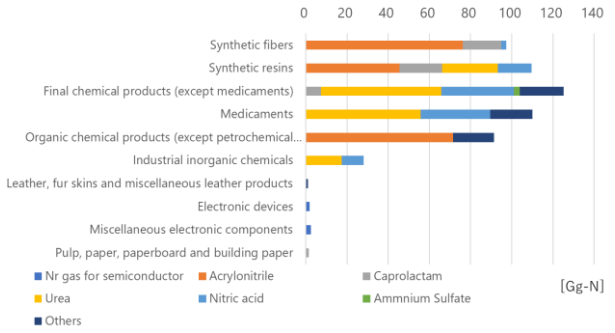

Fig. 1 The Nr amount of flows to first destinations of ammonia derivatives in Japan in 2011.

3.2 Nr-induced final demand of economic sectors

Medical services induced the largest amount of Nr. Health-related services induced large amounts of Nr consumption (Fig. 2). Due to the increasing demand of these services associated with the aging population, Nr demand will increase.

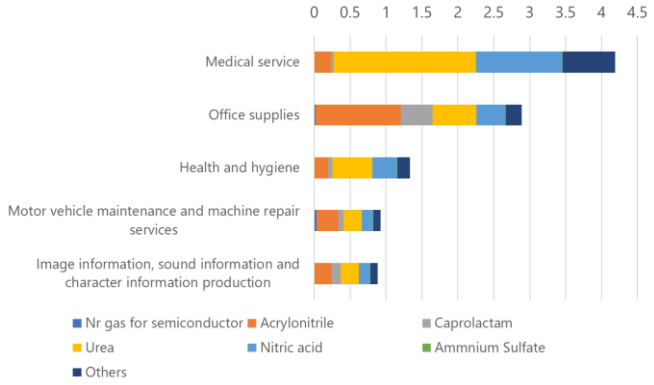

Fig. 2 Nr Ripple effects induced by final demand; the amounts of ammonia derivatives induced by the one million JPY final demand of industries in Japan in 2011.

4. Conclusion

Applying an input-output analysis to Nr flow analysis can provide the details of Nr flows in industry. This model can be connected to other input-output tables and will be useful for analyzing changes of Nr flows induced by other countries' economic activities.

Acknowledgments

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References

Katagiri K, Mizoguchi M, Matsubae K and Nagasaka T 2018 Material Flow Analysis of Nitrogen Around Industries in Japan from 2005 to 2015 *J Life Cycle Assessment, Japan* **14** 319–331