Drafting Guidelines on Environmental Risk Assessment and Management procedure for the CO2 capture process: An easy-to-understand and cost-effective approach

Hajime Kimura¹, Yu Akiyama¹, Tatsuki Aoki¹, Toshiaki Kubo¹, Takao Wada¹, Hideo Kitamura², Koshito Fujita³, Kenji Yamamoto¹, Makoto Akai⁴

¹Mizuho Information & Research Institute
²Toshiba Energy Systems & Solutions Corporation
³Toshiba Corporation
⁴National Institute of Advanced Industrial Science and Technology (AIST)

1. Introduction

Emissions from post-combustion CO2 capture plants using amine solution may affect the human health and environment. Amines themselves are known to have specific toxicity mechanisms against aquatic organisms. And some degraded amines, such as nitrosamines, may also pose risks to the human health. It is, therefore, important to evaluate the environmental impacts by conducting environmental risk assessment, and to, if necessary, employ emission reduction technologies, for effectively introducing CCS.

Case studies on amine emissions from the CO2 capture process and the results of environmental risk assessment have been reported, and several technical guidelines on other aspects of CCS have been already published [1-4]. However, there are no guidelines on environmental risk assessment method for the CO2 capture process which enable plant owners to reduce the environmental impact of the process, to increase understanding of local residents (near CO2 capture plants) and public, and to promote the introduction of CCS. Communications between local residents and plant owners about environmental risk are important. Also from the perspective of “environmental justice (especially procedural justice)”, it is preferable that the results of risk assessment are easy to understand.

In this study, as part of the project by Ministry of the Environment (Japan), Mizuho Information & Research Institute, Inc. (MHIR) and Toshiba Corporation drafted the guidelines presenting the basic principles (methods, basic points) of environmental risk assessment with regard to exhaust gas and other parameters involved in the CO2 capture process. Based on Toshiba’s emission data from 10 ton-CO2/day scale pilot plant using MEA solution at Mikawa thermal power plant (Figure 1), MHIR conducted a trial of environmental risk assessment for the CO2 capture process, examined the risk assessment procedure, and drafted technical guidelines. The guidelines are expected to enable plant owners to make reasonable judgement on “how far emission should be reduced”, and thus to decide “to what extent they should employ emission reduction technologies”. And, the guidelines include “whole-mixture approach”, which not only helps to overcome the issues typical of the CO2 capture process but also is easy to understand and thus familiar to local residents and public, and cost-effective [5].

Figure 1. Toshiba Mikawa post combustion capture pilot plant (at Omuta, Fukuoka Prefecture)
2. The framework of environmental risk assessment and management for the CO2 capture process

We consider the procedure shown in Figure 2 to conduct environmental risk assessment and management for the CO2 capture process. Here, we combine the conventional “component-based approach” with the “whole-mixture approach” to deal with the challenges for environmental risk assessment for the CO2 capture process as described below.

Environmental risk assessment involves, in general, various steps such as determining the chemical substances emitted into the environment and the amount of emissions, toxicity assessment, exposure assessment, and risk characterization (component-based approach). In the CO2 capture process, numerous substances are generated secondarily and it is economically and technically not feasible to identify “all” these degradation products. From the perspective of environmental risk assessment, there are concerns that highly toxic substances (e.g., nitrosamines) with very small amount of emissions (below detection limits) might be emitted into environment. Thus, conventional methods of risk assessment and management may not sufficiently ensure environmental safety, and whole-mixture approach is needed to deal with the problem.

![Figure 2. The framework of environmental risk assessment and management for the CO2 capture process (provisional)](image)

3. Whole mixture approach

Although a general risk assessment is conducted through the component-based approach, such as in the case of the CO2 capture process using amine solvents, when some substances are unidentified...
due to the detection limit, or substances without toxicity information are included, complementation with the whole-mixture approach is effective.

In the future, bioassays targeting “exhaust gas” (impact assessment on human health) and bioassays targeting “exhaust gas solution” (impact assessment on aquatic organisms) are expected to be implemented (for the latter, see Figure 3). Since the whole-mixture approach enables assessment even when the presence of unidentified substances, it is suitable not only when substances without toxicity information are present, but also when the components of the CO2 absorbent solution cannot be disclosed owing to intellectual property protection (Table 1). In addition, in performing a toxicity assessment using the exhaust gas or exhaust gas solution itself, the method is easy to understand and persuasive. Furthermore, by utilizing whole-mixture approach, the development of next-generation CO2 absorbents based on environmental considerations could be expected.

Figure 3. The concept of bioassay targeting “exhaust gas solution” (assessment of impact on aquatic organisms and human health)

<table>
<thead>
<tr>
<th>Component-based approach</th>
<th>Whole-mixture approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment feasible without substance identification?</td>
<td>No</td>
</tr>
<tr>
<td>Ease of “publishing” the results</td>
<td>Inconclusive</td>
</tr>
<tr>
<td>Ease of “understanding” the results</td>
<td>Inconclusive</td>
</tr>
<tr>
<td>Ease of establishing emission reduction measures targeted to specific causative substances</td>
<td>Positive</td>
</tr>
</tbody>
</table>

4. Conclusion

We drafted guidelines on environmental risk assessment method for the CO2 capture process, which enable plant owners to reduce the environmental impact of the process, to increase understanding of local residents (near CO2 capture plants) and public, and to promote the introduction of CCS. Now, in order to complete the framework of environmental risk assessment and management (Figure 2), we are trying to overcome the remaining issues, through the demonstration using post-
combustion CO2 capture pilot plant, the environmental monitoring, the bioassay targeting exhaust gas solution (assessment of the impact on aquatic organisms and human health), and etc.

Acknowledgements

This study was carried out as a part of the project funded by Ministry of the Environment, Government of Japan. The authors would like to acknowledge the subcommittee for environmental impact of CO2 separation and capture absorbent.

References


