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− Original Article (authors' provisional translation) −

Reliability of the Pollutant Release and Transfer Register Data in Terms of the Employed Estimation Techniques

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Abstract

This paper discussed the reliability of the reported release and transfer of chemical substances under the Japanese Pollutant Release and Transfer Register (PRTR) in terms of the estimation techniques. Our questionnaire surveys to PRTR-reporting facilities revealed the following. The reported releases/transfer to public water bodies, soil, on-site landfill, and sewage treatment were reported as zero in most cases due to that no releases/transfers were expected at the facilities. Regarding the release to air and the transfer to waste treatment, in half the cases where the reported data estimated based on mass balance (10% of the total reported data), the releases/transfers occupy less than 0.01 of the production/use amounts, suggesting that these data may deviate from the actual amount by one order of magnitude. Half of the reported data estimated using direct monitoring (5% of the total reported data) were not sufficiently reliable because they were based on annual or biannual measurements, even though the emission concentration variations were unknown. Approximately 30-40% of the reported data estimated using emission factors (10% of the total reported data) were based on the factors from literature or unknown sources. The reliability of these releases/transfers depends on the applicability of the factor to individual facility.

Key words: Pollutant Release and Transfer Register (PRTR), chemical substance, estimation techniques, substance flow, emission inventory

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1. Introduction

An understanding of the emission inventories and substance flows of chemical substances is needed at national and local government levels towards comprehensive management of chemical substances through their entire life cycle, which is required in the Fifth Basic Environmental Plan of Japan. The Japanese Pollutant Release and Transfer Register (PRTR) system operated under the Act on the Assessment of Releases of Specified Chemical Substances in the Environment and the Promotion of Management Improvement continuously gains and publishes information on releases and transfers of a broad range of 462[1] chemical substances, which would be useful as part of the emission inventory and the substance flow for chemical substances. However, PRTR primarily aims at voluntary management by individual facilities and not at constructing the complete emission inventories and substance flows of chemical substances. Even the annual reports of in the aggregated results published by the national government[1)] state the reported releases and transfers and the 'releases outside notification,' which are estimated by the government in the Japanese PRTR (collectively referred as 'PRTR data') do not cover the entire releases and transfers and the accuracy of the collected PRTR data contains 'certain limitations'. For this reason, it is needed to determine the usability of the PRTR data based on its characteristics when using the data to understand the environmental emissions and substance flows of chemical substances.

Previous reports on specific substances and business types have shown the incompleteness of the PRTR data in representing the entire environmental releases. For example, several in the series of detailed risk assessment documents issued in the 2000s by the National Institute of Advanced Industrial Science and Technology of Japan (AIST) additionally estimated emissions not captured by the PRTR within the phases from manufacture to use of chemical substances in the scope of the PRTR.[2-5)] Furthermore, almost all the assessment documents in the series estimated emissions from emission sources not captured by the PRTR data such as emissions from use and disposal phases of final products. Several assessment documents[6,7)] also analysed the gap between the PRTR data and the independently estimated entire releases and transfers and pointed out the possible existence of emission sources not captured by the PRTR data. A case study which compared the PRTR data for

[1] As of November 2021. Scheduled to increase to 515 substances in April 2023 due to the addition and removal of the subject substances.

mercury with the independently prepared atmospheric emission inventory[8] reports that only approximately 0.1% (0%–80% for each emission sources) of the atmospheric emission of mercury in the emission inventory was captured in the PRTR data. The main factors given are the presence of emissions from industries that are not subject to reporting under the Japanese PRTR, as well as emissions deriving from impurities in raw materials and fuels that are not captured by the PRTR. A case study that assessed the reported releases of metals from the sewage industry, which are estimated and reported based on direct monitoring as a facility subject to special requirements under the PRTR system,[9] reports that, while the measured concentration of metals for effluent fell below the lower limit of measurement, which is set only one order of magnitude lower than the effluent standard concentration, the actual emission concentration was several orders of magnitude smaller, and thus the reported releases estimated using the value of the lower limit did not reflect actual environmental releases. Furthermore, case studies that compared atmospheric concentrations estimated by air dispersion modelling using the PRTR data with environmental monitoring data[10,11] found that the estimated concentrations for some substances were underestimated by a range of several orders of magnitude below the concentrations of environmental monitoring, even when correcting for background concentration, and the PRTR data may be too low to accurately describe environmental releases.

Based on these examples, when using the PRTR data, it is important to understand whether the PRTR data appropriately reflect the actual values of environmental releases and transfers. However, such examinations have been limited to individual substances, as in the above-mentioned case studies. Given that the PRTR data is or could be used for a variety of purposes, it is important to assess and summarise the reliability of the PRTR data comprehensively over a broad range of substances subject to the PRTR.

Accordingly, this study evaluated the reliability of the reported release and transfer data under the PRTR in terms of the employed estimation techniques. We first summarised the applicability of the estimation techniques and then conducted questionnaire surveys to PRTR reporting facilities to understand the techniques used in estimating reported release and transfer data. By summarising whether appropriate estimation techniques were used according to the situation of each facility and substance, we discussed how reliable the reported release and transfer data are as information indicating the actual values of environmental releases and transfers.

2. Materials and methods

2.1 Applicability of estimation techniques for the PRTR-reported releases and transfers

The PRTR-reported releases and transfers in Japan are estimated based on any one or a combination of mass balance, direct monitoring, emission factors, engineering calculations using physical property values, or any other techniques considered appropriate, as shown in the "Manual for PRTR Release Estimation Methods'[12] (hereafter referred to as 'Government Manual'). The releases and transfers reported by individual facilities are only estimates, and whether they appropriately reflect the actual environmental releases and transfers depends on whether appropriate estimations and supporting data are being used.

The Government Manual and the OECD technical document[13] provide notes for estimating using each estimation technique and framework for selecting estimation techniques according to the release point, available data, and other factors. Based on that information, this study summarises the cases in which the estimated reported releases and transfers may deviate from the actual environmental releases and transfers for each estimation technique and the characteristics thereof.

2.2 Survey of estimation techniques employed for the PRTR-reported releases and transfers

This study discusses to what extent the reported release and transfer data can be relied upon as information indicating environmental releases and transfers by considering whether the estimation techniques, supporting data, and additional information that are used to estimate the PRTR-reported releases and transfers are appropriate based on the applicability of each estimation technique summarised in Section 2.1. However, the current Japanese PRTR regime does not include estimation techniques, supporting data, and additional information for reported releases and transfers in the matters to be reported, which means that information must be gathered on them. Thus, this study conducted questionnaire surveys to the PRTR reporting facilities to understand the estimation techniques and supporting data they use for reporting the releases and transfers.

The surveys were conducted over two periods from February to March 2021 (Period 1) and October–November 2021 (Period 2) in four prefectures in Japan where we were able to engage in cooperation with the relevant department. Questionnaires were sent to 777 PRTR reporting facilities in ten manufacturing industries: pulp, paper, and paper products; chemical and allied products;

pharmaceutical products; plastic products; rubber products; iron and steels; non-ferrous metals and products; fabricated metal products; electrical machinery equipment; transport equipment, that are thought to contribute greatly to the overall release and transfer volume based on an aggregation and summary of the reported data (nationwide)[2]. We requested responses on the reports from the most recent data year that had been published when the survey was conducted (i.e. FY2018 for Period 1; FY2019 for Period 2). The questions asked in the surveys were as follows:

(1) Annual amounts of the handled chemical substance subject to reporting (responses for each substance; numerical values entered)

(2) Estimation techniques used for reported releases and transfers (responses for each substance and medium; multiple choice)

(3) Details of the used estimation techniques (responses for each substance, environmental media, and estimation technique)

• [Mass balance] the specific estimation equation (multiple choice)

• [Direct monitoring]: monitoring frequency (numerical values entered), level of fluctuation in release concentration (multiple choice), how to calculate the average concentration for estimation (multiple choice), and how to estimate the releases and transfers when the measured concentration was below the limit of measurement (multiple choice)

• [Emission factors]: source of emission factors (multiple choice; open-ended written responses for specific literature titles) and whether emission factors are reviewed and revised (multiple choice)

• [Engineering calculations]: the physical property values used (multiple choice) and specific calculation method (open-ended written responses)

• [Set at zero]: the reason for setting the releases/transfers at zero (multiple choice)

• [Other techniques]: the specific estimation technique (open-ended written responses)

In addition to the 777 facilities, we conducted interview surveys containing the same questions as the questionnaire survey on nine facilities from August to September 2020. The survey results,

[2] After we organised the top emission sources that account for over 80% of the total releases/transfers (reporting industries and sources of estimated releases outside notification) in total, it was found that these ten industries were main sources for many substances.

including the responses from these nine facilities, are shown in Results and discussion section.

3. Results and discussion

3.1 Applicability of estimation techniques of the PRTR-reported releases and transfers

Table 1 shows the key points from the notes shown for each estimation technique of the PRTR-reported releases and transfers in the Government Manual[12] and the OECD technical document[13] as well as the cases in which the reported releases and transfers may deviate substantially from the actual releases and transfers as summarised based on these resources. As this summary shows, the estimated releases and transfers may deviate from the actual environmental releases and transfers if appropriate estimation techniques and supporting data are not used according to the situation at the facility concerning the ratio of releases and transfers to the amount of handled chemical substances (hereafter referred to as 'release/transfer ratio'), fluctuations of the concentration of subject substances in flue gas, wastewater, waste, etc., the processes and equipment, etc.

Table 1. Cases in which the reported releases and transfers may deviate from the actual releases and transfers as summarised based on the applicability of estimation techniques

Estimation technique	Outline	Notes for use in release/transfer estimation (summarised from Government manual and OECD technical document)	Cases in which the estimated releases and transfers may deviate from the actual releases and transfers
(1) Mass balance	Estimates the release/transfer to the target medium by sbtracting the releases/transfers to other media, etc. from the handled amount.	- Should not be used when the release/transfer is a small fraction of the handled amount, as errors in the handled amount or the releases/transfers to other media can significantly affect the accuracy of the estimates.	- When the release/transfer to the target medium is A small fraction of the handled amount.
(2) Direct monitoring	estimates the release/transfer by multiplying directly monitored concentration of the target substance in flue gas, wastewater, waste, etc. by those amount.	- Continuous monitoring or monitoring at an appropriate frequency over a long time period will improve the representativeness of the estimates. Average concentration of multiple measurement should be used when the concentration would fluctuates. - Should be careful about the accuracy of the monitored concentration.	- When the concentration highly fluctuates and the frequency of monitoring is low. - When the accuracy of the monitored conventration is low.
(3) Emission factors	Estimates the release/transfer by multiplying the handled amount and fixed emission factors (ratio of release/transfer to the handled amount).	- Use of emission factors which appropriately reflect the situation at the facility is preferable. - When using emission factors from literature, it is necessary to carefully consider whether they are appropriate for the processes, conditions, etc. at the facility. - Preferable to check whether any change has made on emission factors in guidelines or manuals. Emission factors should be reviewed for changes due to emission control measures or equipment aging (if necessary).	- When the assumed situation for emission factors in literature is significantly different from that of the facility. - When the emission factors are not reviewed according to the changes of emission control measures, raw materials, processes, etc.
(4) Engineering calculation	Estimates the concentration of the target substances in glue gas, wastewater, waste, etc. by engineering calculation using physical property values and	- Inappropriate application of theoretical formulas or calculation models, calculations under inappropriate assumptions or hypotherical conditions, or insufficient information in input data may result in inaccurate estimation.	- When appropriate formulas, models, calcluation conditions, and input data including physical property values are not used.

Mass balance estimates the releases and transfers to the target medium by subtracting the releases and transfers to other media and/or the amount of transfer out as products (hereafter referred to as 'the other releases/transfers' collectively) from the amount handled. It thus appears to appropriately reflect the actual values in cases with large release/transfer ratios. However, especially if the releases and transfers to the target medium are much smaller than the amount handled, the estimation accuracy of the other releases/ transfers, which is to be subtracted, has a significant influence on the estimation accuracy of the releases and transfers to the target medium, and the estimated releases/transfers may significantly deviate from the actual values.

Direct monitoring estimates the releases and transfers by directly monitoring the concentration of the subject substance in flue gas, wastewater, waste, etc. and multiplying it by those amount. Therefore, the errors in or the representativeness of the monitored concentration directly determine the accuracy of the estimated releases and transfers. Accordingly, the accuracy of estimated releases and transfers may decrease in cases with highly fluctuating concentrations and low direct monitoring frequencies. Furthermore, if the actual concentration is significantly lower than the lower limit of measurement, as in the above-mentioned example,[9)] the values of estimated releases and transfers may greatly deviate from the actual values because they are sometimes estimated with the release concentration being deemed to be equal to or half of the lower limit of measurement or zero. Direct monitoring may not be suitable in such cases.

Emission factors estimates the releases and transfers by multiplying the amount handled and fixed emission factors. Therefore, it is needed to use the emission factors which appropriately reflect the situation concerning releases and transfers at the facility to reflect the actual releases and transfers. Especially when using the emission factors from publication (e.g. estimation manuals from the government or industry groups and other literature), the degree to which the estimated releases and transfers reflect the actual releases and transfers is affected by whether the situation concerning handling, releases, transfers, etc. of the substances including the processes and equipment as set or assumed in the literature is similar to the situation at the facility. In addition, even when using emission factors suitable for the facility, it is necessary to review and revise the emission factors when any measures or actions are taken to greatly reduce the releases and transfers to reflect the reduction by those measures or actions. If this is not conducted, the estimates may deviate greatly from the actual values.

Furthermore, since engineering calculations using physical property values use theoretical calculations, the degree to which they reflect the actual releases and transfers should be influenced by whether appropriate physical property values and calculation conditions are used.

3.2 State of estimation techniques used for the PRTR-reported releases and transfers

Table 2 shows the results from the questionnaire surveys (including nine facilities surveyed by interview). Of the 786 facilities surveyed, 473 facilities responded, producing a response rate of approximately 60%. The number of reported substances at each responding facility in the reporting year that was targeted for responses ranged from 1 to 56 substances with a mean of 4.8 substances and a median of 3 substances.

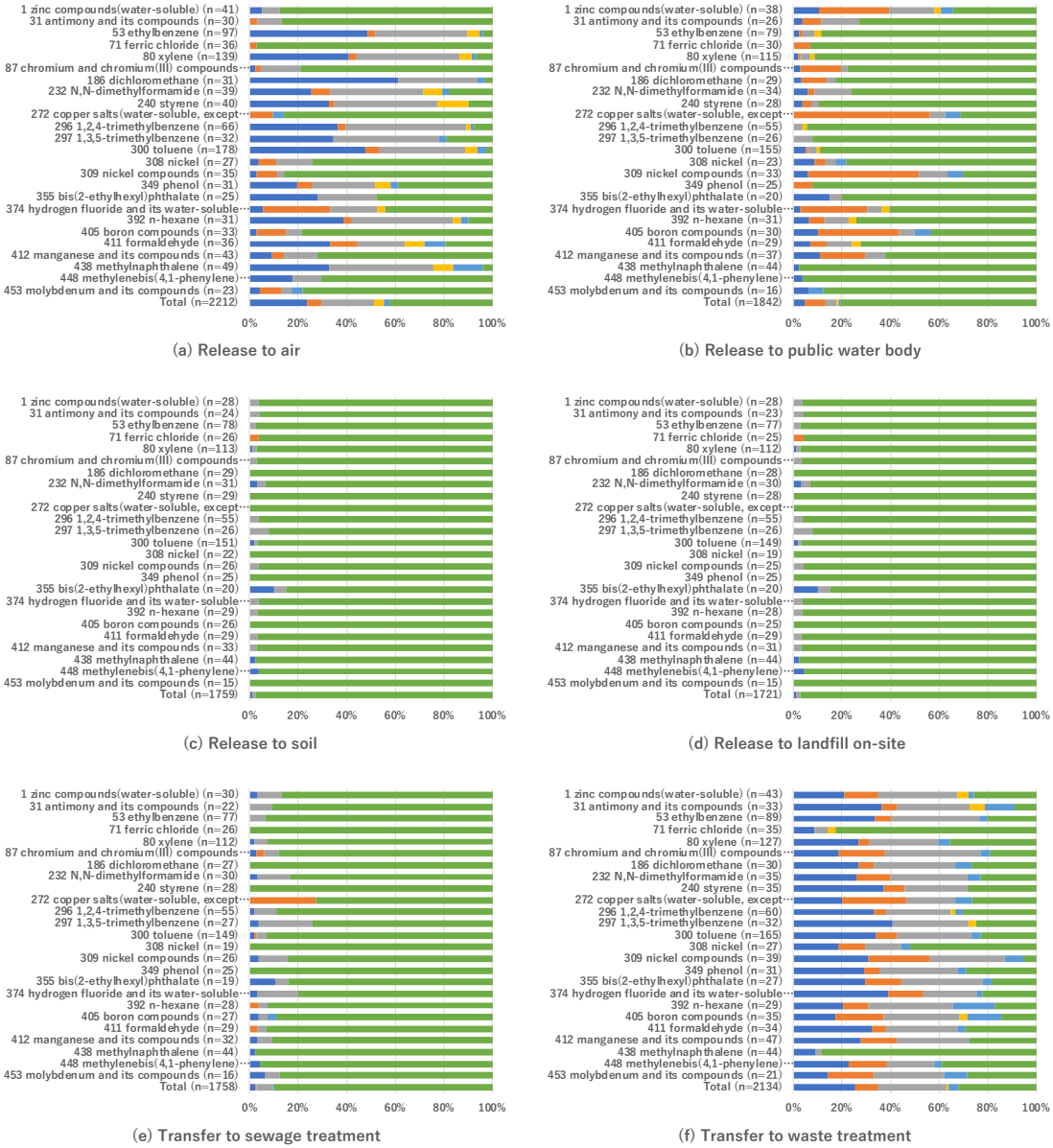
Table 2. Questionnaire survey results (including nine facilities surveyed by interviews).

Industry code	Industry	Questionnaire distributed	Returned	Response rate	No. of substances reported			
					Mean	Median	Min.	Max.
1800	Pulp, paper, and paper products manufacturing	22	12	55%	3.6	2.5	1	34
2000	Chemical and allied products manufacturing	203	144	70%	9.1	5.5	1	56
2060	Pharmaceutical products manufacturing	22	18	81%	2.2	2	1	8
2200	Plastic products manufacturing	127	66	52%	2.9	2	1	13
2300	Rubber products manufacturing	40	22	54%	5.1	4	1	19
2600	Iron and steel manufacturing	17	11	65%	3.6	3	1	9
2700	Non-ferrous metals and products manufacturing	44	26	59%	5.3	3	1	37
2800	Fabricated metal products manufacturing	114	68	60%	2.5	2	1	9
3000	Electrical machinery equipment manufacturing	120	68	57%	3.1	2	1	13
3100	Transport equipment manufacturing	77	38	49%	3.9	2	1	17
Total		786	473	60%	4.8	3	1	56

Figure 1 shows the breakdown of the estimation techniques used for reported releases and transfers for 25 substances with a relatively large number of valid responses and total of all responses (substances). The results showed that most of the reported releases to public water bodies, soil, and on-site landfill and transfers to sewage treatment were estimated as ‘zero,’ for most of the substances. The releases and transfers to these media are reported as zero for the majority of the reported data

for the entire country of Japan and the surveyed prefectures. Our survey results revealed that they were deemed zero when reporting rather than being zero as the result of estimations using techniques based on mass balance or direct monitoring. The majority of responses as to the reason why the releases and transfers were reported as zero were that in the process of handling the target substances there is no discharge to rivers, soil, and sewage systems, or no landfill of waste at the facility site. This suggests that most of the reported release and transfer data for these media generally reflects the actual situation.

Conversely, a relatively large proportion of releases to air were reported as 'zero' for metals and their compounds and were estimated by using mass balance and emission factors techniques for organic compounds. Although a slightly different trend was seen depending on substances, it was found that different estimation techniques were used at different facilities even for the same substances. Moreover, the estimation techniques used to estimate the transfers to waste treatment showed no obvious trend by substance group, and even looking at individual substances, different estimation techniques were used by different facilities. These results reflects the fact that different estimation techniques are selected by facilities according to the situation of the usage of target substances, processes and equipment, and available information, even when the substance is the same. However, it is not clear in each of these cases whether each facility uses appropriate estimation techniques according to the actual situation, including the release/transfer ratio, release concentration, and release fluctuations, as summarised in Table 1. Given this, the next section discusses how reliable the reported release and transfer data are as information indicating the actual values of environmental emissions and transfers from the facilities by summarising whether appropriate estimation techniques were used according to the situation of each facility an substance based on the summary in Table 1. It should be noted that the discussion below covers releases to air and transfers to waste treatment, for which we had many responses for estimation techniques other than 'set at zero'.



(Fig. 1. Estimation techniques used to estimate the PRTR-reported releases and transfers)

3.3 Degree to which the PRTR-reported releases and transfers reflect the actual values of releases and transfers for each estimation technique

Based on the questionnaire survey results, this section discusses the degree to which the reported releases and transfers reflect the actual environmental releases and transfers from facilities for each estimation technique. Here, we discuss the results for three techniques: mass balance, direct monitoring, and emission factors, and the engineering calculation, which was used only at a few

facilities responded that they compute using this technique, is excluded from the discussion.

3.3.1 Mass balance

As summarised in Table 1, the reported release and transfer data estimated using mass balance technique may deviate from the actual release and transfer in cases where the release/transfer ratio is small. Because mass balance estimates releases and transfers by subtracting the other releases/transfers from the amount of substances handled, the error in the estimated other releases/transfers directly becomes the error in the estimated release or transfer to a target medium. Figure 2 shows an example of how the error in the estimated release or transfer to the target medium changes according to the release/transfer ratio. This figure shows the estimated value of the release and transfer relative to the release/transfer ratio of the target medium. The solid line shows the true value of the release and transfer to a target medium when the amount of handled substances is 100 tons. In contrast, the dashed lines show the value of release and transfer to the target medium estimated using the mass balance when the estimated other releases/transfers, which are subtracted from the amount of substances handled, have an error of ±5% or ±10% as examples.

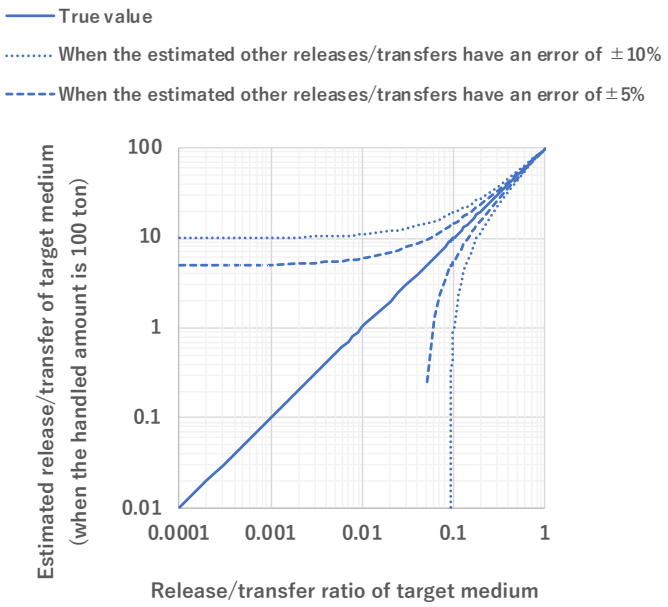


Fig. 2. Examples of estimate accuracy in reported releases and transfers estimated using mass balance

The influence of the errors in the estimated other releases/transfers becomes greater as the

release/transfer ratio of the target medium becomes smaller. For example, as can be seen from Figure 2, when the estimated other releases/ transfers, which are subtracted from the amount of substances handled have the error of ±10%, the range of the release/transfer ratio for which the estimated release or transfer to the target medium deviates from the true value by one order of magnitude or more is approximately 0.01 (1%) or less on the positive side and approximately 0.1 (10%) or less on the negative side. It is quite possible that the other releases/transfers estimated by other estimation techniques, such as direct monitoring or emission factors, contained an error of ±10%; thus, at least in cases where the release/transfer ratio of the target medium is 0.01 (1%) or less, the estimated releases and transfers may deviate from the actual releases and transfers by one order of magnitude or greater.

Figure 3 shows the percentages of the reported release and transfer data estimated using mass balance for different release/transfer ratio magnitudes for releases to air and transfers to waste treatment. The figure summarizes the data for all substances for which we received responses. The release/transfer ratio was calculated for each substance and medium from the published reported releases and transfers and the amount handled answered in the questionnaire survey. The calculated release/transfer ratio in some cases exceeded 1, that is, the reported releases and transfers exceeded the amount handled, but in most of these cases, the ratio exceeded 1 only slightly and these results could be attributed to errors when estimating the reported releases and transfers or the amount handled which was answered in the questionnaire survey.

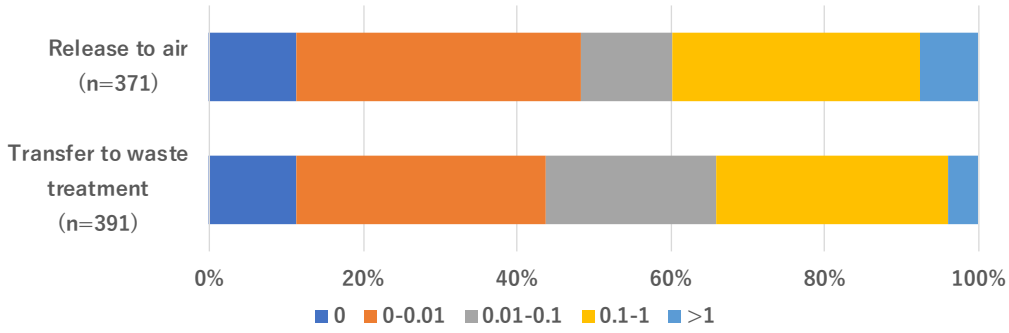


Fig. 3. Release/transfer ratio for reported release and transfer data estimated using mass balance (n is the number of reported release and transfer data for which a valid response was received)

Among the reported release and transfer data estimated using the mass balance technique that we received responses in our survey, cases with a release/transfer ratio 0.01 or less (where 1% or less of the amount handled is released or transferred) accounted for 50% for releases to air and 45% for transfers to waste treatment. Reported data of the release to air and the transfer to waste treatment estimated using mass balance technique accounted for 24% and 25%, respectively, of all valid responses in total of all substances (Fig. 1), suggesting that just more than 10% of reported data of all responses may deviate from the actual releases or transfers by more than one order of magnitude. The results for five substances (ethylbenzene, xylene, styrene, 1,2,4-trimethylbenzene, and toluene), for which a relatively large number of responses were received, indicated that such reported release and transfer data, which may deviate from the actual releases and transfers by more than one order of magnitude, occupied 1%–44% and 5%–34% of the total reported releases to air and transfers to waste treatment, respectively, that were estimated using mass balance technique by the responding facilities. These corresponded to 1%–6% and 1%–9% of total reported release and transfer amount at the responding facilities, suggesting that even if the release/transfer ratio is small, the influence of errors in the estimation on the total release and transfer amounts may not be negligible depending on the substance.

Note that in some cases, the releases to air are estimated by multiplying the amount transferred to the exhaust gas treatment system calculated by the mass balance technique by the removal rate of the substances in the exhaust gas treatment. Even if the release/transfer ratio is small, calculating the release to air using mass balance technique may be appropriate when the removal rate is large, such as close to 100%. Although our survey could not obtain sufficient data to consider this, it should be noted that some of the data may not have large errors in the estimated values, depending on the magnitude of the removal rate in the exhaust gas treatment.

3.3.2 Direct monitoring

From the summary in Table 1, when estimating the releases and transfers using direct monitoring, the degree to which they reflect the actual situation relies on the level of the concentration of the target substance in emissions and its fluctuations. Monitoring at an appropriate frequency is particularly necessary when the concentration of the target substance in flue gas or waste fluctuates greatly.

Our survey results showed that the reported data of the release to air and the transfer to waste treatment estimated using direct monitoring accounted for 6% and 10%, respectively, of all valid responses (Fig. 1). Looking at the monitoring frequency for those responses, once or twice a year accounted for 91% and 73%, respectively, of the all valid responses for air (discharged gas) and waste (Fig. 4). Meanwhile, 15% of the all valid responses for waste was accounted for by 12 times a year (once a month on an average) or more or every time when they have the waste disposed of by waste disposer.

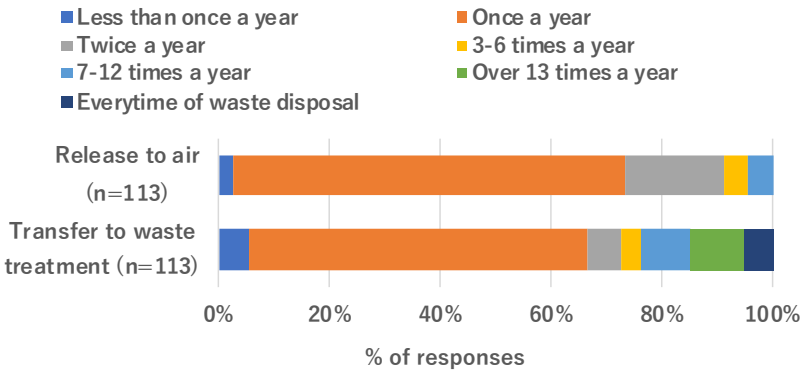


Fig. 4. Monitoring frequency for reported releases and transfers estimated using direct monitoring (n is the number of reported release and transfer data for which a valid response was received)

With regard to fluctuation in the concentration of the target substances, 'mostly constant' accounted for 36% and 49% of the valid responses for air (discharged gas) and waste, respectively. If this response reflects the actual situation at the responding facilities, it suggests that the reported releases and transfers reflect the actual releases and transfers to a certain degree in these cases, even with a monitoring frequency of once or twice a year. As reported releases and transfers estimated using direct monitoring accounted for about 10% of the entire valid responses, 4%–5% of the total data of reported release and transfer from the responding facilities fall into this case.

On the other hand, the responses of 'fluctuation is unknown because direct monitoring is conducted once a year' and 'may fluctuate in the range of five or ten times or more' accounted for 40%–50% and 4%–5%, respectively, of the total valid responses. This suggests that approximately 5%–6% of the total reported release and transfer data may deviate from the actual releases and transfers with direct monitoring about once or twice a year. The results for hydrogen fluoride and its

water-soluble salts, for which a relatively large number of responses were received on the reported release and transfer data estimated using direct monitoring, indicated that such reported data accounted for 39% and 89% of the total reported releases to air and transfers to waste treatment estimated using direct monitoring by the responding facilities, and these corresponded to 38% and 50%, respectively, of total reported releases and transfers at the responding facilities.

Moreover, according to the survey results, reported releases and transfers were estimated using only direct monitoring values for the single relevant year in most cases (approximately 95% and 80% of all valid responses for releases to air and transfers to waste treatment, respectively). However, if no significant changes were made to the equipment and raw materials, etc. in the process of handling the target substances , the releases and transfers estimated based on direct monitoring values from multiple years would produce values closer to the actual situation in which the effects of concentration fluctuations have been averaged out. In light of this, it may also useful for a third party to check for fluctuations in the reported release and transfer data of a certain facility from year to year and to use the average value of those years if the fluctuation is large among years, when using reported release and transfer data from an individual facility.

3.3.3 Emission factors

From the summary in Table 1, when estimating the reported releases and transfers using emission factors , the degree to which they reflect the actual situation relies on whether the reporting facility uses emission factors that suit to the situations of handling the target substances at the facility.

Reported release and transfer data estimated using emission factors for the releases to air and transfers to waste treatment accounted for 22% and 28%, respectively, of all valid responses (Fig. 1). Of these, approximately 57% and 69% for releases to air and transfers to waste treatment, respectively, were estimated using emission factors set based on past monitoring values (corresponding to 13% and 19% of the total reported release and transfer data of the responding facilities). The fact that they are based on direct monitoring at the individual facility suggests that the reported releases and transfers in these cases reflect the actual situation of releases and transfers at the individual facilities. As with the cases estimated using direct monitoring, the reported releases and transfers may deviate from the actual releases and transfers depending on fluctuations in the concentration of target substances in emissions and the number and representativeness of the

monitored values; therefore, further understanding of the actual conditions regarding this point is required.

On the other hand, among the reported release and transfer data estimated using emission factors, 43% for releases to air and 31% for transfers to waste treatment (each corresponding to 9% of the total reported release and transfer data in the responses received) were estimated using emission factors from the literature. As mentioned in 3.1, if the situation concerning handling and releases of the target substances, equipment and processes, etc. assumed in the calculations of emission factors in the literature are significantly different from the situation at the facility, the releases and transfers estimated using those emission factors may greatly deviate from the actual releases and transfers at the facility. Such release and transfer data are not necessarily reliable as data reflecting the actual releases and transfers unless this point is confirmed. In the reported release and transfer data for each of the five substances (ethylbenzene, xylene, styrene, 1,2,4-trimethylbenzene, and toluene), for which a relatively large number of responses regarding methods based on emission factors were received, such data occupied 24%–95% and 1%–49% of the total reported release and transfer data estimated using emission factors by the responding facilities for releases to air and transfers to waste treatment, respectively. These corresponded to 9%–37% and 1%–30% of total reported releases and transfers at the responding facilities.

As for the sources of emission factors, for both releases to air and transfers to waste treatment, 50%–60% were from national or industry association guidelines or manuals, approximately 10% were from safety data sheets (SDS) and waste data sheets (WDS), and approximately 30% were unknown. Although release and transfer data estimated using emission factors is not a large percentage of the total reported data (a few percent), given that emission factors from guidelines and manuals are used in many of the cases, it is important to thoroughly investigate their validity and their applicability to each facility. To do this, it may be useful, for example, to investigate the representativeness of the emission factors their applicability to the individual facility by understanding the differences in emission factors among facilities by collecting and organising direct monitoring data obtained by facilities. It is also necessary to examine the validity of emission factors with unknown sources.

Moreover, as shown in Table 1, emission factors need to be reviewed accordingly when the situation concerning release and transfer changes substantially or guidelines and manuals of industry

associations etc. are updated, to ensure that the estimated releases and transfers appropriately reflect the actual releases and transfers. However, the survey results from this study showed that over 80% of respondents did not review emission factors regularly, regardless of whether they were using past monitoring values or values from the literature. If the equipment and processes, etc. for handling the target substances and the situation concerning release and transfer have not changed substantially, there is no need to review the emission factors, but the results shows that in many cases, such review and check has not been conducted and it is necessary to investigate the validity of the used emission factors by understanding whether the situation concerning release and transfer has changed.

4. Conclusion

This study discussed the reliability of the reported release and transfer data of Japanese PRTR based on a survey of used estimation techniques for the estimation. The characteristics of each estimation technique regarding the degree to which the estimated releases and transfers reflect the actual environmental releases and transfers were summarized based on notes in the Government Manual and the OECD technical document. Then, the estimation techniques used for estimating reported releases and transfers were investigated through a questionnaire survey to reporting facilities and discussed how much reported release and transfer data can be relied upon as information indicating environmental releases and transfers in light of the above summary in terms of whether the estimation techniques in use are appropriate.

The results showed that releases to air and off-site transfers (to waste treatment) were estimated using a variety of techniques depending on the facility, even for the same substance. On the other hand, most of the reported releases to public water bodies, soil, and on-site landfill and transfers to sewage treatment were reported as zero as no releases or transfers were expected. Approximately half of the reported data of releases to air and transfers to waste treatment estimated using mass balance (over 10% of the total reported data from the responding facilities) showed a ratio of the 0.01 or less (1% or less) of the amount of substances handled, suggesting that the reported data may deviate from the actual releases or transfers by one order of magnitude or more. Approximately half of the reported releases to air and transfer to waste treatment estimated using direct monitoring (approximately 5%–6% of the total reported data) may deviate from the actual releases and transfers

by one order of magnitude or more because the monitoring values for the estimation may not be representativeness considering the fluctuations in emission concentration or it was unclear whether the monitoring values reflect the actual situation because the fluctuations in the emission concentrations were unknown. Approximately 30%–40% of the reported release to air and transfer to waste treatment estimated using emission factors (approximately 10% of the total reported data) were estimated using emission factors from the national or industrial associations guidelines or manuals, or unknown sources; their reliability appeared to depend on the representativeness of the emission factors or their applicability to the individual facility.

Based on the results, it was considered that the PRTR-reported release and transfer data include a certain number of data that may not necessarily be reliable as information indicating the actual releases and transfers because appropriate estimation techniques are not being used or the validity of the supporting data has not been confirmed. This must be noted when using the reported release and transfer data as it is not possible to confirmed whether appropriate estimation techniques or supporting data were used from reported or published information in the current Japanese PRTR regime. Moreover, it is suggested that obtaining and accumulating data that better reflect the actual situation also requires improvement of the national and industrial associations guidelines and manuals to include clearer indications of recommended estimation techniques and the inspection and review of emission and other factors.

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