IAEA Review of Safety Related Aspects of Handling ALPS Treated Water at TEPCO's Fukushima Daiichi Nuclear Power Station

"Additional Measures" for Independent Sampling and Analysis Related to Discharges of ALPS Treated Water – Preliminary Additional Measure, October 2024

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1. INTRODUCTION

The main objective of "Additional Measures" for Independent Sampling and Analysis Related to Discharges of ALPS Treated Water (hereafter referred to as "Additional Measures") is to further increase transparency by facilitating the wider participation of stakeholder countries, through the IAEA's Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA[1]) network [1] member laboratories, in independent sampling and analysis related to discharges of ALPS treated water under the framework of the IAEA.

The IAEA and Japan concurred in September 2024, to implement additional measures under the framework of the IAEA. The Agency confirms that this agreement builds upon its existing sampling and monitoring activities in compliance with the IAEA statutory functions.

Therefore, the Additional Measures outlined herein are intended to be a key component of the ongoing IAEA programme and will be executed under the authority of the IAEA. The scope of the Additional Measures encompasses the following activities:

a) **Source Monitoring (Post-ALPS Treatment, Pre-Dilution)**: This involves independent sampling and analysis of ALPS treated water sourced from the measurement and confirmation facility, specifically the tanks where the water is stored, homogenized, and tested prior to release.

b) **Monitoring at Discharge Vertical Shaft/Seawater Pipe Header (Post-Dilution)**: This comprises independent sampling and analysis of the diluted ALPS treated water.

c) **Marine Environmental Monitoring (Post-Discharge)**: This includes independent sampling and analysis of seawater and fishery products.

In October 2024, the IAEA initiated the first practical steps toward implementing the Additional Measures through marine sampling undertaken near the Fukushima Daiichi Nuclear Power Station (FDNPS). This preliminary additional measure was aimed at establishing the concept and processes associated with the Additional Measures, while leveraging the presence of IAEA staff from the Marine Environment Laboratories in Monaco and international experts from members laboratories of the ALMERA network who were present in Japan for a mission to collect samples for an IAEA interlaboratory comparison (ILC) related to the ALPS treated water discharge.

This report presents the results of subsequent analyses for radionuclides activity concentrations conducted in laboratories in Japan, at the IAEA in Monaco and from the ALMERA Network in China, the Republic of Korea and Switzerland. Additionally, it includes the results of an intercomparison of these measurement results which was carried out by the IAEA according to international best practice for proficiency testing [2].

[1] ALMERA is a network comprising more than 200 member laboratories globally. It provides a platform for maintaining and developing capability on the determination of radionuclides in air, water, soil, sediment and vegetation that can be used for both routine and environmental emergency monitoring in the IAEA Member States.

2. PARTICIPATING LABORATORIES

The participating laboratories – 4 from Japan; three from the ALMERA network and the IAEA – are presented in Table 1.

TABLE 1. LABORATORIES PARTICIPATING IN PRELIMINARY ADDITIONAL MEASURE OCTOBER 2024

Identifier	Participant
IAEA	IAEA Marine Environment Laboratories, Monaco
JCAC	Japan Chemical Analysis Center, Chiba, Japan
KANSO	KANSO TECHNOS Co. Ltd., Osaka, Japan
KEEA	Kyushu Environmental Evaluation Association, Fukuoka, Japan
KINS	Korea Institute of Nuclear Safety, Daejeon, Republic of Korea
MERI	Marine Ecology Research Institute, Chiba, Japan
SPIEZ	Spiez Laboratory (Labor Spiez), Switzerland
TIO	Third Institute of Oceanography, Ministry of Natural Resources, Xiamen, China

3. SAMPLE COLLECTION AND PRETREATMENT

Surface seawater samples were collected on 15 October 2024 by boat from monitoring location M-103 as defined in Japan's Comprehensive Radiation Monitoring Plan [3]. M-103 is located at latitude and longitude 37.445 and 141.047 respectively and is located approximately 3 km northeast of FDNPS.

Each participating laboratory was provided with a seawater sample comprised of:

- For analysis for ^{90}Sr and ^{137}Cs, 60 L of seawater in three 20 L cubitainers, acidified to pH 1–2 with concentrated HCl.
- For analysis for tritium, 2L of seawater in a 2L plastic bottle.

To take the samples, a 400 L plastic container with four valves was first filled with seawater. The 20 L and 2 L sample containers were filled, one at a time, from one of the valves. The experts from the ALMERA member laboratories took the opportunity to fill the containers that would subsequently be shipped to their laboratories for analysis if they wished. In all other cases the sample containers were filled by Japanese contractors. The 400 L container was refilled as necessary to facilitate provision of the required sample volume to all participating laboratories. For each sample, the fill sequence, valve number and recipient laboratory were recorded to facilitate the traceability of each sample container.

Concentrated HCl was added to the 20 L cubitainers after unloading from the boat. The samples were then checked and boxed. The samples were shipped to all participating laboratories in October and November 2024 for analysis.

FIG. 1. Hands-on sampling by an expert from the Republic of Korea, observed by an IAEA staff member.

FIG. 2 Experts from ALMERA member laboratories in China, the Republic of Korea and Switzerland and the IAEA check samples after landing at port.

4. ANALYSES

Participating laboratories were requested to analyse the samples for activity concentrations of ^{3}H, ^{90}Sr and ^{137}Cs using an appropriate analytical method. A reporting form and target detection limits were provided by the IAEA. Participating laboratories were requested to submit a single measurement result for each radionuclide analysed, comprised of an activity concentration, standard combined uncertainty (k=1) and detection limit. They were asked to report activity concentrations for a common reference time of 15 October 2024 12:00 UTC.

5. STATISTICAL EVALUATION OF THE RESULTS

The IAEA compiled and evaluated the results submitted by all participating laboratories. For each radionuclide a comparison reference value x_{ref} was determined as a power-moderated mean of the combined results [4]:

$$x_{ref} = \sum_{i=1}^{N} w_i x_i$$

where x_i is the value reported by the laboratory i, N is the number of results reported and w_i is a normalized weighting factor.

Then, a ζ (zeta) score was calculated for each laboratory as follows.

$$\zeta = \frac{d_i}{u(d_i)}$$

where $d_i = x_i - x_{ref}$, the difference between the value reported by the laboratory x_i and the reference value x_{ref}, and $u(d_i)$ is the standard uncertainty associated with d_i.

Following the current ISO standard for statistical methods for use in proficiency testing [5], for zeta scores between -3 and 3, the corresponding result was evaluated as agreeing with the reference value at a 99.7% confidence level and for zeta scores greater than 3 or less than -3 the reported result was evaluated as not agreeing at a 99.7% confidence level.

6. RESULTS

The results submitted by the participating laboratories and associated consensus reference values are presented in Table 2 and Figures 3 - 5. The uncertainties quoted are combined standard uncertainties, i.e. with a coverage factor of $k = 1$. Table 3 contains the zeta scores.

TABLE 2. ACTIVITY CONCENTRATIONS (Bq L^{-1}) IN SEAWATER SAMPLES

Nuclide	IAEA	JCAC	KANSO	KEEA	KINS	MERI	SPIEZ	TIO	Reference
^{3}H	0.111 ± 0.015	0.135 ± 0.015	0.15 ± 0.01	-	0.226 ± 0.065	0.120 ± 0.018	<1.3	0.24 ± 0.03	0.154 ± 0.022
^{90}Sr	0.001139 ± 0.000069	0.00080 ± 0.00013	0.00091 ± 0.00017	0.00083 ± 0.00016	0.000564 ± 0.000087	-	0.00125 ± 0.00025	0.00084 ± 0.00009	0.000885 ± 0.000085
^{137}Cs	0.01024 ± 0.00053	0.0106 ± 0.00064	-	0.0103 ± 0.0005	0.00966 ± 0.00048	0.011 ± 0.001	0.0111 ± 0.0011	0.0138 ± 0.0007	0.01090 ± 0.00052

TABLE 3. ZETA SCORES FOR ACTIVITY CONCENTRATION OF RADIONUCLIDES IN SEAWATER SAMPLES

Nuclide	IAEA	JCAC	KANSO	KEEA	KINS	MERI	SPIEZ	TIO
^{3}H	-1.8	-0.8	-0.2	-	1.1	-1.4	DL	2.6
^{90}Sr	2.5	-0.6	0.1	-0.3	-2.9	-	1.5	-0.4
^{137}Cs	-1.0	-0.4	-	-0.9	-1.9	0.1	0.2	**3.7**

Note: DL: As a value less than the detection limit was submitted, no evaluation was performed.

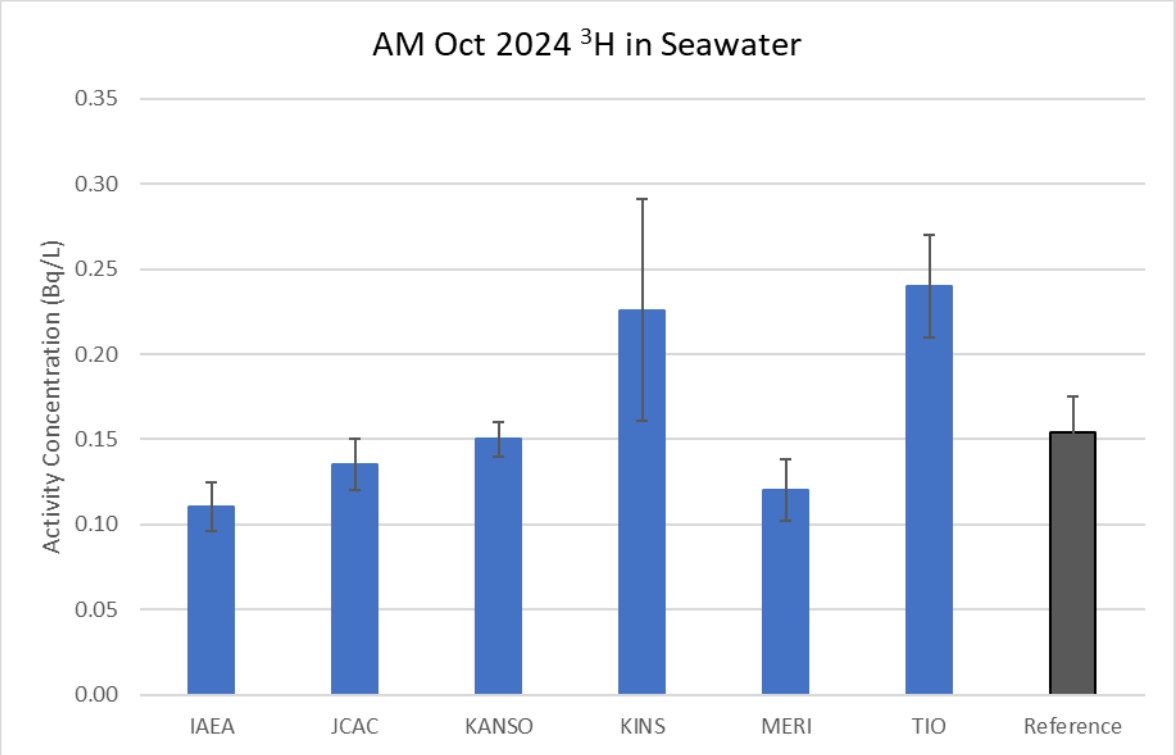

FIG. 3. Additional Measures – AM
Activity concentrations of ^{3}H.

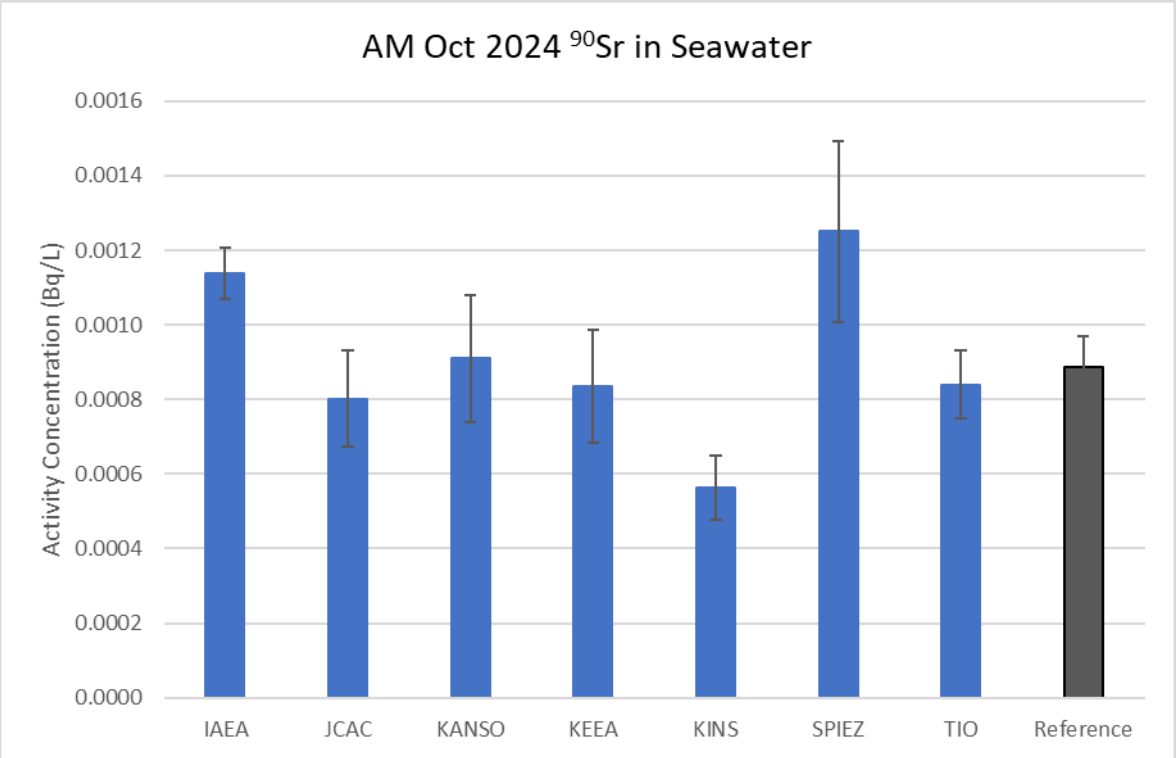

FIG. 4. Additional Measures – AM
Activity concentrations of ^{90}Sr.

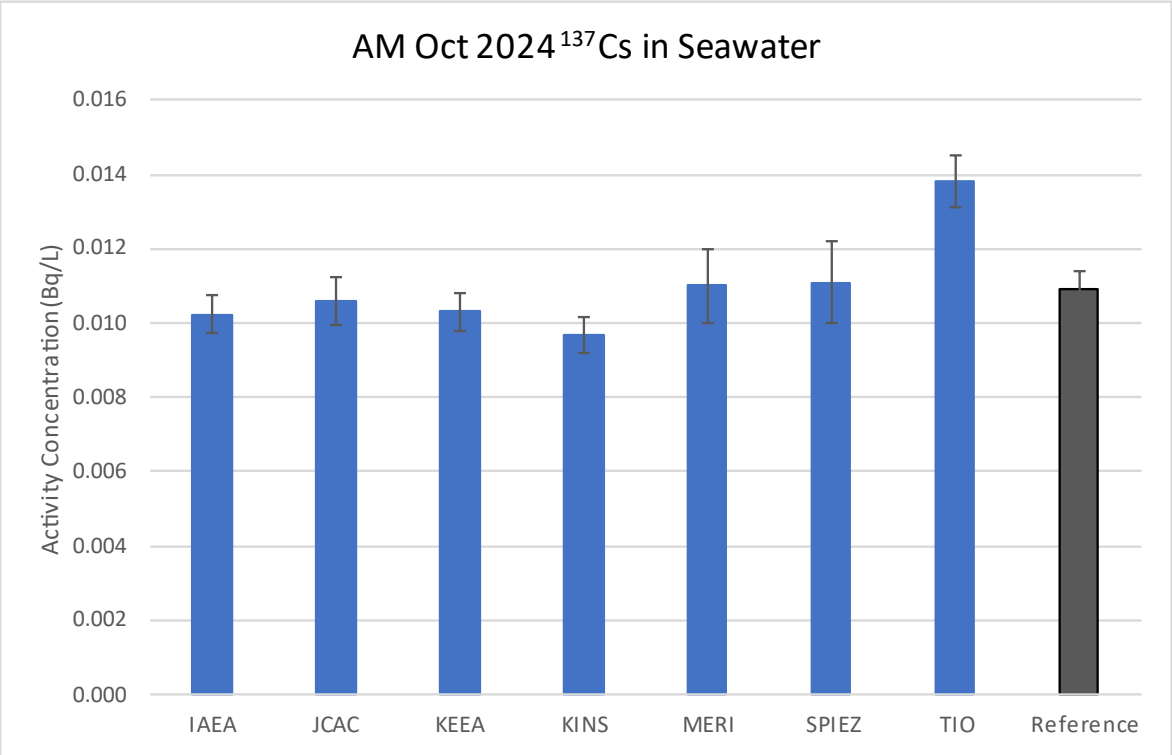

FIG. 5. Additional Measures – AM Activity concentrations of ^{137}Cs.

7. CONCLUSION

The results of this additional measure indicate that the majority of the results submitted are comparable to the corresponding consensus reference values. The single exception was the ^{137}Cs activity concentration reported by TIO which was reported to be statistically significantly higher than the reference value at a 99.7% confidence level. It is important to note that the magnitude of this deviation is modest and detectable primarily due to the rigorous statistical criteria applied in this analysis. Minor discrepancies of this nature are occasionally observed in laboratory performance evaluations. While further investigation by the reporting laboratory is recommended to identify any potential sources of variance, this deviation does not materially affect confidence in the laboratory's technical competence for performing such measurements in practical applications.

More generally, the results reported by the laboratories participating in this preliminary additional measure are consistent with the conclusions of the IAEA Comprehensive Report on the Safety Review of the ALPS-Treated Water at the Fukushima Daiichi Nuclear Power Station [6] that was released in July 2023 stating that the IAEA found that the discharges as planned would have a negligible radiological impact to people and the environment.

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