Demonstration Testing of a System for the High Speed Monitoring of the Radioactive Concentration of Wastewater In Situ


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*** Nikkin Flux Inc.
Background of the R&D
Radioactive Land Contamination

Radiocesium ($^{134}\text{Cs} + ^{137}\text{Cs}$) Land Contamination Level Map (Dec. 28$^{th}$, 2012, data)

Source: The Ministry of Education, Culture, Sports, Science and Technology Japan
Radioactive Decontamination Work

Japanese government blockaded the radioactive contaminated area, and various decontamination works have been conducted.

Stripping work of contaminated soil and leaves

High-pressure water decontamination vehicle
In the decontamination work, wastewater containing radiocesium is generally treated using some sort of radiocesium-removal system in addition to a conventional wastewater treatment process. The treated wastewater is transferred to a temporary storage effluent tank.

Wastewater collection

Radioactive contaminated wastewater Treatment
Approximately 2 liters of the water is collected from the effluent tank and analyzed by a germanium semiconductor detector.

Sampling only a portion of treated water
Wastewater Treatment Flow

Decontamination Work

The treated water can be discharged to a public water area if the analytical results satisfy the regulations.

Wastewater collection

Radioactive contaminated wastewater Treatment

Effluent regulation

\[
\frac{134\text{Cs (Bq/l)}}{60} + \frac{137\text{Cs (Bq/l)}}{90} \leq 1
\]

Sampling only a portion of treated water

Marinelli type vessel (2l)

Analyzing
Needs in wastewater treatment plant

Decontamination Work

Wastewater collection

Radioactive contaminated wastewater Treatment

Effluent regulation

\[ \frac{^{134}\text{Cs}}{(\text{Bq/l})/60} + \frac{^{137}\text{Cs}}{(\text{Bq/l})/90} \leq 1 \]

In the decontamination working site, the measurement system of the total amount of wastewater was needed for the environmental safety.
Outline of Cesimoni-water®

Photo of Cesimoni-water®
**Cesimoni-water®**

### Top view
- **Cabin 1:** Analysis water (Wastewater)
- **Cabin 2:** Shielding water (Fresh water)

### Vertical cross section view
- Gamma Ray Detector
- Bottom Pump
- Analysis water Outlet

### Bird’s eye view
- Inlet
- Outlet
- Control Panel
- Top Pump

Dimensions:
- 2.6m x 2.7m x 2.2m
Cabin1 is the cylindrical shape with a capacity of 3.5 m³. The analysis water sample is poured into Cabin1 and then measured the radioactivity by the gamma ray detector centered in the water tank.

The cylindrical tank is equipped with a small inner cylinder and two submersible stirring pumps. Both pumps discharge the water into the space between the outer and inner cylinders, creating a swirl flow that efficiently circulates the suspended solids.
The gamma ray measurement takes 10 minutes and the overall operational time of a batch, including influent and effluent times, is 18 minutes.

Cabin2 with a capacity of 8 m$^3$ is consistently filled with fresh water as a shielding water for the external natural background radioactivity.
Gamma ray detection system

Gamma Ray Detector

- NaI(Tl) Scintillator
- PMT
- Stainless Case
- AMP
- High Voltage Power supply
- Logger
- Multi Channel Analyzer
- DC Power supply
- PC

Control Panel

Photo of Gamma ray detectors

Photo of Control panel
Measurement Tests of Radioactive Concentration
A water shield of approximately 1 m can reduce external radiation by more than 400-fold compared to an unshielded condition.
Radiopotassium ($^{40}$K) solution test

Potassium-40 accounts for 0.0117 % of natural potassium, and 1g-potassium has a radioactive concentration of 30.4 Bq.

The pulse height spectrum of the radiopotassium solution

The gamma ray counting rate for $^{40}$K was estimated by integrating the value of this range.
Several concentrations of KCl solutions were prepared and measured by the Cesimoni-water system.

<table>
<thead>
<tr>
<th>KCl solution concentration (g/l)</th>
<th>Theoretical radioactive concentration (Bq/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60</td>
<td>1</td>
</tr>
<tr>
<td>3.0</td>
<td>5</td>
</tr>
<tr>
<td>3.0</td>
<td>10</td>
</tr>
<tr>
<td>13.5</td>
<td>22.5</td>
</tr>
</tbody>
</table>

Both regression curves can be regarded as linear.
Artificial radiocesium solutions were prepared by diluting a radioactively contaminated dry sludge whose radioactive concentration had been preliminarily measured with a germanium semiconductor detector.

The pulse height spectrum of the radiocesium solution

The gamma ray counting rate for radiocesium was estimated by integrating the value of this range.
After the artificial radiocesium solution tests, a demonstration measurement test was conducted using actual wastewater collected from decontamination work. In the result, the Cesimoni-water system is also feasible for the radiocesium measurement of actual wastewater.
Conclusion

- Radiopotassium and radiocesium solutions were prepared and measured by the Cesimoni-water® system. The regression curves between the radioactive concentration of these solutions and the gamma ray counting rate can be regarded as linear.

- The Cesimoni-water® system is capable of measuring a low radioactive concentration of less than 1 Bq/l as the limit of detection at an operating rate of more than 10 m³/hour.

- The findings suggest that the Cesimoni-water® system is feasible for the radiocesium measurement and appears to be suitable for use as a continuous monitoring system for radioactive effluent water.
Application Image for Wastewater treatment plant

Continuous monitoring image by the alternate operation using 2 units of Cesimoni-water®

Treated water tank

Cesimoni-water A

Cesimoni-water B

Effluent pipe

Returned water pipe

Under Effluent regulation

Discharge into Public waters

Automatic diversion valve

Return to treatment plant

Exceed Effluent regulation

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Thank you for your attention

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