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RADIOMETRIC MEASUREMENT OF TOTAL ALPHA AND BETA ACTIVITY OF RADIONUCLIDES IN DRINKING WATER

Rahkmonova Mohichehra
Toyloq olimpiya va paralimpiya sport turlariga tayyorlash markazi
fizika fani o‘qituvchisi

Abstract. *Ensuring the safety of drinking water is crucial for public health, particularly when it comes to the presence of radionuclides. Radionuclides are radioactive isotopes that emit radiation in the form of alpha and beta particles as they decay. These radionuclides may occur naturally or can result from human activities like nuclear power generation. Drinking water contaminated with excessive levels of radionuclides can pose serious health risks, including cancer and organ damage. Hence, measuring the total alpha and beta activity in drinking water is a key step in assessing its safety.*

Key words: *radiometric, alpha, beta, analysis.*

Alpha and Beta Activity of Radionuclides

- **Alpha particles** are heavy, positively charged particles consisting of two protons and two neutrons. Due to their larger mass and charge, alpha particles have limited penetration but can cause significant damage to living cells if ingested or inhaled.
- **Beta particles** are lighter, fast-moving electrons or positrons emitted from the radioactive decay of certain radionuclides. They have greater penetration power than alpha particles but less ionizing potential on a per-particle basis.

Both alpha and beta particles are hazardous when radionuclides are ingested through water, and measuring their total activity helps ensure that levels remain within regulatory limits.

Importance of Measuring Alpha and Beta Activity

Monitoring the total alpha and beta activity in drinking water helps to:

- Assess the radiological quality of water sources.
- Identify contamination and take necessary remediation actions.
- Ensure compliance with public health and environmental safety regulations.

Most countries have set regulatory limits for radionuclide activity in drinking water. For example, the World Health Organization (WHO) recommends that the total alpha activity should not exceed 0.5 Bq/L, and total beta activity should be below 1 Bq/L.

Methodology of Measuring Alpha and Beta Activity Using Radiometry

The radiometric measurement of alpha and beta activity is performed using specialized instruments called **radiometers**, which detect and quantify the emitted particles from a water sample. The typical process involves the following steps:

a) Sample Preparation

The first step is collecting and preparing the water sample for measurement:

- A specific volume of water (often several liters) is filtered to remove particulate matter, as radionuclides often adhere to suspended particles.
- The sample is then concentrated through evaporation or chemical treatment to increase the sensitivity of the measurements. This helps in detecting low concentrations of radionuclides that may otherwise be difficult to measure.

b) Radiometer Calibration

Before the actual measurement, the radiometer must be calibrated to ensure accurate readings:

- The radiometer is tested with standard reference sources of known alpha and beta activity to verify its response.
- Calibration accounts for background radiation (environmental radiation not originating from the sample) to prevent skewed results.

c) Radiometric Measurement

The prepared sample is placed into a detector within the radiometer, which is sensitive to both alpha and beta radiation. The process includes:

- **Alpha counting**: Alpha-sensitive detectors (like solid-state detectors) count the number of alpha particles emitted from the radionuclides in the sample. These detectors are designed to block beta particles to ensure that only alpha emissions are measured.
- **Beta counting**: After the alpha counting is completed, a different type of detector, often a gas proportional counter or liquid scintillation counter, is used to measure the beta radiation emitted by the radionuclides.

Measurements typically take several hours to ensure sufficient counts are recorded, especially when radionuclide concentrations are low.

d) Data Analysis

Once the counting is complete, the radiometer provides the activity of alpha and beta particles, usually in **Bq/L (becquerels per liter)**. The becquerel is the unit of radioactive decay and indicates one disintegration per second.

- The raw data are corrected for background radiation and converted into activity concentrations using the volume of the water sample and the efficiency of the detector.

e) Comparison to Regulatory Limits

The measured activity levels are compared to national or international safety standards (e.g., WHO guidelines) to determine if the water is safe for consumption. If the activity exceeds acceptable levels, further investigations or remediation processes are initiated.

Instrumentation and Techniques

There are several types of radiometric instruments used for measuring total alpha and beta activity in drinking water:

- **Gas Proportional Counters**: These instruments use gas-filled chambers to detect radiation. When an alpha or beta particle enters the chamber, it ionizes the gas, generating an electrical pulse that is counted.
- **Liquid Scintillation Counters**: In this technique, the sample is mixed with a scintillation fluid that emits light when hit by radiation. The light is detected by photomultiplier tubes, allowing for the detection of alpha and beta emissions.
- **Solid-State Detectors**: These are highly sensitive detectors, typically made of silicon, that directly detect the energy deposited by incoming alpha particles. They are often used for alpha measurements due to their ability to block beta particles.

Each technique has its advantages and is chosen based on the specific needs of the analysis, such as sensitivity requirements or the type of radionuclide present.

Challenges in Radiometric Measurement

While radiometric measurements are highly effective, they also present certain challenges:

- **Low Radionuclide Concentrations**: Drinking water typically contains very low levels of radionuclides, making detection difficult without proper sample preparation and highly sensitive instruments.

- **Interference from Natural Background Radiation**: Background radiation from cosmic rays and terrestrial sources can affect the accuracy of measurements, requiring careful calibration and background subtraction.
- **Distinguishing Between Alpha and Beta Radiation**: Some radiometers struggle to differentiate between alpha and beta particles, making it essential to use detectors that can isolate these particles effectively.

Health and Safety Standards

In addition to WHO guidelines, many countries have their own regulatory standards for radionuclides in drinking water. For example:

- The **U.S. Environmental Protection Agency (EPA)** limits the combined alpha particle activity in drinking water to 15 pCi/L (picoCuries per liter).
- **European Union (EU)** drinking water regulations mandate a maximum total alpha activity of 0.1 Bq/L and a beta activity limit of 1 Bq/L.

These limits ensure that any radiological exposure from drinking water remains within safe levels.

Conclusion

The radiometric measurement of total alpha and beta activity in drinking water is a crucial step in assessing the radiological safety of water supplies. By using specialized instruments like gas proportional counters, liquid scintillation counters, and solid-state detectors, it is possible to accurately measure the levels of radionuclides. These measurements help ensure that drinking water complies with regulatory limits and poses no significant health risks to the public.

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