International Journal of Pharmacy and Pharmaceutical Science 2025; 7(1): 116-120

International Journal of Pharmacy and Pharmaceutical Science

ISSN Print: 2664-7222
ISSN Online: 2664-7230
IJPPS 2025; 7(1): 116-120
www.pharmacyjournal.org
Received: 02-12-2024
Accepted: 08-01-2025

Elda Kabila Umba
Center of Excellence in Chemical, Biological, Radiological and Nuclear (CoE-CBRN/DRC), Ministry of Scientific Research and Technological Innovation, Democratic Republic of Congo

Fanny Bakomba Kikunga
Center of Excellence in Chemical, Biological, Radiological and Nuclear (CoE-CBRN/DRC), Ministry of Scientific Research and Technological Innovation, Democratic Republic of Congo

Christian Kuzamba Kikunga
Center of Excellence in Chemical, Biological, Radiological and Nuclear (CoE-CBRN/DRC), Ministry of Scientific Research and Technological Innovation, Democratic Republic of Congo

Réné Kasende Disashi
Center of Excellence in Chemical, Biological, Radiological and Nuclear (CoE-CBRN/DRC), Ministry of Scientific Research and Technological Innovation, Democratic Republic of Congo

Esther Mpiana Mukinia
Center of Excellence in Chemical, Biological, Radiological and Nuclear (CoE-CBRN/DRC), Ministry of Scientific Research and Technological Innovation, Democratic Republic of Congo

Poulain Mulumba Bunyengu
Center of Excellence in Chemical, Biological, Radiological and Nuclear (CoE-CBRN/DRC), Ministry of Scientific Research and Technological Innovation, Democratic Republic of Congo

Fiston Masikini Bombamu
[1] Center of Excellence in Chemical, Biological, Radiological and Nuclear (CoE-CBRN/DRC), Ministry of Scientific Research and Technological Innovation, Democratic Republic of Congo
[2] John Wesley Methodist University, Department of Public Health, Ligwala, Kinshasa, Democratic Republic of Congo
[3] Cardinal Malula Christian University, Department of Environmental Management, Kasa-Vubu, Kinshasa, Democratic Republic of Congo

Corresponding Author:
Elda Kabila Umba
Center of Excellence in Chemical, Biological, Radiological and Nuclear (CoE-CBRN/DRC), Ministry of Scientific Research and Technological Innovation, Democratic Republic of Congo

Measurement of natural radioactivity and radium-226 concentration in drinking water in the city of Kolwezi, in the democratic republic of Congo

Elda Kabila Umba, Fanny Bakomba Kikunga, Christian Kuzamba Kikunga, Réné Kasende Disashi, Esther Mpiana Mukinia, Poulain Mulumba Bunyengu and Fiston Masikini Bombamu

DOI: https://www.doi.org/10.33545/26647222.2025.v7.i1b.158

Abstract
Natural radioactivity is a public health issue, particularly in regions where water resources are potentially contaminated by radioactive elements. The city of Kolwezi, in the Democratic Republic of Congo, being located in an area rich in minerals, raises concerns about the quality of its drinking water. Among the radioactive isotopes present in the environment, radium-226 (Ra-226) is of particular attention because of its harmful effects on human health, particularly because of its ability to cause cancer.
This study aims to assess natural radioactivity and radium-226 concentration in drinking water in the city of Kolwezi, Democratic Republic of Congo. Known for its rich mining subsoil, Kolwezi faces significant environmental challenges, including contamination of its water resources by radioactive elements.
The research method involves collecting water samples from various sources, including wells, rivers and urban supplies. Each sample is submitted to a specialized laboratory where radioactivity analyses are performed. The results are then compared to standards set by the World Health Organization (WHO) for acceptable levels of radium-226 in drinking water. Initial observations indicate significant variability in radium-226 concentration levels, with some samples exceeding safety thresholds. This situation raises major public health concerns, including increased risks of diseases related to exposure to radioactivity.
In conclusion, the study highlights the need for regular monitoring and preventive measures to protect the population of Kolwezi from the harmful effects of natural radioactivity in water resources. This work also opens avenues for future research on sustainable water management and community awareness of water quality issues.

Keywords: Natural radioactivity, radium-226 concentration, Kolwezi, democratic republic of Congo

Introduction

- **Background and justification of the study:** Natural radioactivity in water resources is an environmental and public health concern, particularly in areas with high mining activity. The southeastern Democratic Republic of Congo (DRC), which includes the city of Kolwezi, is a major mining area where ores containing uranium and thorium are extracted. The exploitation of these ores can lead to radioactive contamination of local water sources, particularly by isotopes such as radium-226 (Ra-226). Ra-226 is a decay product of uranium-238 and is known to have carcinogenic effects when ingested over a prolonged period (Anastasio *et al.* 2018) [1]. The importance of monitoring this radioactivity in drinking water is crucial for the protection of local populations from potential health risks.
- **Problematic:** Due to the intensity of mining activities in Kolwezi, the quality of water resources, particularly in terms of natural radioactivity, is of serious concern. However, few specific studies have been conducted to quantify the concentration of radium-226 in drinking water sources in this region. This lack of data creates a gap in the assessment of public health risks.

- **Research question:** What is the concentration of radium-226 in drinking water sources in the city of Kolwezi, and to what extent do these levels represent a danger to the population compared to international safety standards for drinking water?
- **Assumption:** Drinking water in the city of Kolwezi contains concentrations of radium-226 above the thresholds recommended by the World Health Organization (WHO, 2017) [7], which exposes the local population to increased health risks.

Objectives of the study
The objectives of this study are as follows:

- Measure the concentration of radium-226 in the main drinking water sources of Kolwezi,
- Compare the concentrations obtained with water quality standards established by WHO and other international organizations;
- Assess the public health risks associated with the consumption of these contaminated waters;
- To propose recommendations to minimize the health risks associated with the presence of radium-226 in drinking water.

Interest in work: This study is essential for several reasons. First, it will provide accurate and timely data on drinking water quality in a critical mining region of the DRC. Second, the results can inform decision-makers on measures to protect local populations from risks related to natural radioactivity. Finally, this work will contribute to the scientific literature on water resource management in areas of high mining activity, where radioactivity monitoring is often neglected.

Methodology
- **Study area:** The study was conducted in Kolwezi, Lualaba Province (DRC), where water samples were collected in two neighborhoods: Kasulo1 and Hewa Bora. Ten samples were collected, five in each neighborhood, at water distribution points managed by REGIDESO (WHO, 2017) [7].
- **Collection and storage of samples:** Water samples were collected in plastic bottles, rinsed twice with the water to be analyzed before collection. The samples were then labeled and transported to the CREN-K Central Analysis Laboratory (CAL) for analysis.

Table 1: Coding of samples

No.	Collection site	Date	Code
1	Kasulo1	11/26/2022	2201
2	Kasulo1	11/26/2022	2202
3	Kasulo1	11/26/2022	2203
4	Kasulo1	11/27/2022	2204
5	Kasulo1	11/27/2022	2205
6	Hewa bora	11/28/2022	2206
7	Hewa bora	11/28/2022	2207
8	Hewa bora	11/28/2022	2208
9	Hewa bora	11/28/2022	2209
10	Hewa bora	11/28/2022	2210

Analysis methods
a) Physicochemical parameters
The hydrogen potential (pH), temperature and conductivity of these samples were measured. Then, they were acidified with concentrated nitric acid to lower the pH to values below 2 in order to avoid adsorption.

At this stage, the following materials were used: pH meter associated with a thermometer and a 340iWTW brand conductivity meter, an electronic balance of the Sartorius brand model CPA223, micropipettes, a beaker, a funnel and concentrated nitric acid to adjust the pH of the medium.

1. Operating mode
- **Determination of pH:** 10 ml of the sample was taken and placed in a beaker. Using a pH meter combined with a thermometer and a conductivity meter, the pH, temperature and conductivity values were measured together.
- **Determination of the actual volume of water samples:** The mass of the water contained in the bottle was measured according to equation (1), by taking the difference between the mass of the bottle containing water and that of the bottle emptied of this water.

M (water) = M (bottle with water) – M (empty bottle) (Eq.1)

To obtain the actual volume of water, we apply the following formula:

$$V = \frac{M}{\varphi} \quad \text{(Eq. 2)}$$

Where V denotes the actual volume of water, M is the mass and φ represents its density.

Acidity correction and conservation
To avoid adsorption in solution, the pH was brought back for each sample to approximately 1.8 by the % by applying the formula below:

$$pH^2 = -\log(- \frac{pH^1+N^2V^2}{V^1+V^2} \quad \text{(Eq. 3)}$$

b. Qualitative analysis
Gamma spectrometry is a measurement technique that relies on the physics of the semiconductor involved in detection by detectors composed of a crystal. Gamma spectrometry allows for qualitative and quantitative analysis of samples. The great advantage of this spectroscopy is its ability to measure gamma photons directly in the sample without having to perform a chemical separation beforehand.

1. Operating mode
The procedure is as follows:

- How to clean Marinellis properly
- Label the Marinellis according to Table 2:

Table 2: Labeling on Marinellis

No. Marinellis	Corresponding solution
I	2201
II	2202
III	2203
IV	2204
V	2205
VI	2206
VII	2207
VII	2208
IX	2209
X	2210
XI	Standard

- Place the corresponding sample in each Marinelli;
- Then place in turn in the detector starting with the standard solution for 21600 seconds (i.e. 6 hours) and the samples for 36000 seconds (i.e. 10 hours);
- Stripping of spectra.

c. Radiochemical separation of radium-226 isotopes

The co-precipitation of radium with $BaSO_4$ forms the basis of this method: radium sulfate ($RaSO_4$), less soluble than barium sulfate ($BaSO_4$), co-precipitates with the first portions of the co-precipitate.

The liquid scintillator

For the measurement of the concentration of radium-226; the liquid scintillator is used.

Liquid scintillators are particularly used for the measurement of the activity of radioelements emitting pure beta and alpha particles. The operating principle consists in detecting light photons, emitted by the scintillating molecules. In the framework of this work, a tested TRIATHLER multi label liquid scintillator is used, to measure the activity of radionuclides emitting pure beta and gamma particles.

Operating mode

The exploit method can be summarized as follows:

- Take 1L of the samples to which 20 mL of 6N HCl, 2 mL of $BaCl_2$ are added at a rate of 16mg/ml. Mix well for 5 minutes and add 20 mL of 18N H_2SO_4 to obtain a precipitate;
- Filter the solution containing the precipitates, we obtain the precipitate and the filtrate;
- The precipitate obtained after filtration is washed with 0.1N H_2SO_4;
- Dissolve the precipitate with EDTA and hot water;
- Storage is at room temperature for 21 days;
- Taking measurements.

Results and Discussion

Presentation of results

Physicochemical parameters

The conductivity, temperature and pH values of the samples under examination are shown in Table 3.

Table 3: Physicochemical parameters

Code	pH	Conductivity (µs/cm)	Temperature (°C)
2201	5.90	100	27
2202	5.83	101	27
2203	5.92	100	26
2204	5.70	100	27
2205	5.74	102	27
2206	6.37	85.2	26.3
2207	6.41	90.0	26
2208	6.30	87.3	26
2209	6.50	88.4	26
2210	6.36	90.1	26

Quantitative analysis of water samples by gamma spectrometry

After analysis by gamma spectrometry and data processing using the Génie 2000 software, the different peaks and their energies obtained were subjected to a subtraction of the peak spectra after having carried out the manual marking. This marking was carried out because the software could not directly translate the spectrum obtained into a digital spectrum because of the very low intensities of the peaks. We proceed by elimination of the associated peaks taking into account the probability included in the catalog (Technical report. 1990) and the results are shown in the following tables 4 and 5:

Table 4: Values of the energies associated with the channels of the radioelements under study, detected in samples 2201, 2202, 2203, 2204, 2205 by gamma spectrometry

Channel No.	Energy (keV)	Parent core	Son core	Probability (%)
597	144.6	U-235	Ra-223	3.1
769	186.1	U-238	Ra-226	3.29
1464	353.4	U-238	Pb-214	35.8
2419	583.2	Th-232	Ti-208	30.0
2525	608.8	U-238	Bi-214	45.0
3014	726.8	Th-232	Bi-212	7.0
3778	910.4	Th-232	Ac-228	29.0

Table 5: Values of the energies associated with the channels of the radioelements under study, detected in samples 2206, 2207, 2208, 2209, 2210 by gamma spectrometry

Channel No.	Energy (keV)	Parent core	Son core	Probability (%)
991	239.6	Th-232	Pb-210	45.0
1404	338.9	U-235	Ra-223	2.6
1460	352.3	U-238	Pb-214	35.8
2416	583.3	Th-232	Ti-208	30.0
2527	609.3	U-238	Bi-214	45.0
3780	910.8	Th-232	Ac-228	29.0

Radium-226 concentration measurement results

The radium-226 concentration values for the analyzed samples, in comparison with that of the reference, are shown in Table 6.

Table 6: Ra-226 concentration values for the samples under examination, in comparison with the reference value.

Sample	Ra-226 concentration (Bq/L)
2201	0.9099 ± 0.0504
2202	0.9186 ± 0.061
2203	0.8999 ± 0.0563
2204	0.9182 ± 0.0641
2205	0.9021 ± 0.0495
2206	1.738 ± 0.0422
2207	1.741 ± 0.311
2208	1.737 ± 0.419
2209	1.811 ± 0.012
2210	1.7921 ± 0.246
Reference value	0.5

2. Discussion of results

The 2017 WHO [7] recommendation on pH and conductivity in drinking water provides the following guidelines:

- For pH, there is no guide, but an optimum between 6.5 and 8.5 is desirable;
- For conductivity, its value should not exceed 250 µs/cm.

The general finding is that the values found for conductivity are within the range of WHO standards, while the pH values found are below the limit established by the aforementioned organization.

Gamma spectrometry was used to identify gamma-emitting radionuclides in the samples. The gamma-photon spectra obtained show series of energy lines whose observed intensity values are very small; so that the effective counting rate makes it almost impossible to calculate the concentration of each radioisotope present.

Spectral measurements clearly reveal:

- The presence of thorium in all samples; the peaks observed at 239.6keV, 583.3 keV, 726.8 keV, 910.9 keV being due to the decay series of Th-232;
- The presence of uranium-238 in all samples, shown by the following peaks: 186.1 keV, 353.4 keV and 609.8 keV.

As for uranium-235, only one peak corresponding to its decay series and a high intensity peak at 660.1 keV, which provides information on K-40, were observed. Furthermore, given the low intensities of the peaks observed, the calculation of the concentrations in Bq/L of the identified radioelements was no longer necessary.

The results obtained show that the values of the Ra-226 concentration of the Kasulo samples are higher than those found by Trabidou *et al.* (Trabidou *et al.* 2010) [6]. Furthermore, these data are in the same range of the results obtained by Stralevern (Stralevern rapport. 2006) [4], but they are lower than the results found in the works of Mosqueda *et al.* (Mosqueda F. *et al.* 2009) [3] and Levie (Levi I. 2010) [8].

As for the Hewa bora samples, the Ra-226 concentration is higher than the results found by Trabidou *et al.* (Trabidou *et al.* 2010) [6], and those included in the Straleven report (Stralevern report. 2006) [4]. While the results obtained are in the same magnitude as that found by Levie (Levi I. 2010) [8], but lower than that obtained by Mosqueda *et al.* (Mosqueda F. *et al.* 2009) [3]. However, compared to the reference value given by the World Health Organization for human consumption water, the results obtained in this work are two to three times higher; which suggests that these waters under examination would be unfit for direct consumption by the population living in their neighborhoods given the risks of radiological contamination by ingestion would be high.

Conclusion

In this work, it was about the identification of radioactive elements emitting gamma photons and the measurement of the level of the concentration of Ra-226 in ten samples from different sources, collected in the city of Kolwezi, Lualaba province in the Democratic Republic of Congo. The experiments were carried out using a gamma spectrometer and a liquid scintillator for the measurement of the concentration of Ra-226. After analysis the result obtained confirms the presence of natural radioactivity.

The radium concentration depends on the area where they were taken; so that after comparisons with the WHO reference, it is found that the values obtained for the samples analyzed exceed the admissible level. This implies that its waters, once used as such in households by the surrounding population, would thus present a danger for human consumption.

For future work, it would be desirable to deepen the analyses by carrying out measurements on the identification of radium descendants; this is necessary to assess the health risk linked to this radioisotope. Quantitative analysis of alpha emitters would also be a good indication as to the assessment of health risks.

Conflicts of interest

The authors declare that there are no conflicts of interest.

Acknowledgements

We would like to thank the Head of the Chemical, Biological, Radiological and Nuclear Risk Mitigation Department Fiston Masikini Bombamu for his advice and supervision during the completion of this work.

References

1. Anastasio A, Caggiano R, Macchiato M, Ragosta M, Paino S. Radium-226 and radon-222 in drinking water: Health risk assessment. Journal of Environmental Radioactivity. 2018;184:21-27. https://doi.org/10.1016/j.jenvrad.2018.01.010
2. Nwankwo LI. Annual effective dose due to combined concentration of Ra-226 and Ra-228 in the groundwater system: A case study of the University of Ilorin main campus. 2010, 53-58.
3. Mosqueda F, Villa M, Pates JM, Vaca F, Borrego E. Low-level measurement of Ra-226 via Ra-228 in natural water by LSC. The Arizona Board of Regents on behalf of the University of Arizona. 2009, 145-154.
4. Statens Strålevern. Natural radioactivity in produced water in the Norwegian oil and gas industry in 2003. Norwegian Radiation Protection Authority Report. 2006.
5. International Atomic Energy Agency. The environmental behavior of radium. Vol. 1. Technical Report Series No. 310. Vienna: IAEA; c1990. p. 189-202.
6. Trabidou H, Florou H. Natural radioactivity as an impact factor in drinking water quality. Desalination and Water Treatment. 2010, 336-339.
7. World Health Organization. Guidelines for drinking-water quality. 4th ed. Geneva: WHO; c2017.
8. Levi I. Probability logic, logical probability, and inductive support. Synthese. 2010 Jan;172:97-118.