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Activities of Uranium and Radium Radioisotopes in Sediment Samples and Their Impact on Soil Pollution in Lower Moulouya River (Morocco)

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Abstract

In this work, the results of analysis of the activities of the main uranium and radium radioisotopes (^{238}U, ^{234}U, ^{226}Ra and ^{228}Ra) are presented (mBq / kg) in 5 samples of sediment collected in the Moulouya River region. In addition, the values of the main physico-chemical parameters (pH, T° and CE) affect the mobility, transport and geochemistry of these radionuclides. These samples belong to 4 types of natural water sources (spring, rivers, lakes and dams). The activities of these radioisotopes are measured by gamma spectrometry. The purpose of these analyses is to evaluate the effect of mining sites on the radioactivity content and their impact on the sampling sites, and to know the average distribution of the activity concentrations of these radioelements in this watershed. The ultimate goal is to determine the possible links between this radioactive pollution and the geological, geographical and socio-economic environment.

Keywords: Natural Radioactivity, Sediment, Radioisotopes, Uranium, Radium, Moulouya River

1 Introduction

Water plays an important role in landscape transformation by displacing large amounts of soil in the form of sediments. The latter are removed by erosions, transported by hydrographic networks, and then deposited in lakes, rivers, and dams. Rivers carry millions of tons of sediment per year to the sea. The sediment cycle begins with the process of erosion by which particles or fragments are torn from rock materials under the action of mechanical, chemical and geochemical agents [1].

Anthropogenic erosion can occur much more rapidly like mining, agricultural and industrial activities. It is important to understand the role of each agent before studying sediment transport because any dislodged material is ready to be transported. When energy is no longer sufficient to move the sediments, they sink into ponds, lakes and water sources. Later, they accumulate new materials and they deposit them in the Plains and Deltas [1], [2]. Sediments are measured and classified according to their dynamic characteristics.

By studying the quantity, quality and characteristics of sediments in rivers, it is possible to determine the sources of pollution and assess the impact of pollutants on the aquatic environment. Water quality management must take into account the management of sediment because they play a very important role in the transport and fate of pollutants in the environment [3], [4], [5].

2 Sampling materials and methods

This sampling technique involves taking a sediment quantity of about 300 g from a well-localized site. This sediment quantity is enclosed in an unused white plastic bag, which is not contaminated. The sediment is thoroughly cleaned and purified from impurities, and it can be washed in some cases with distilled water. It is then placed in an oven at a temperature of between 100 °C and 120 °C for 12 hours so that it evaporates from the aqueous material [6], [7]. Next, the quantity of about 5 grams is weighed and sealed in a clean tube of suitable size for counting in a germanium well detector [4], [6], [7].

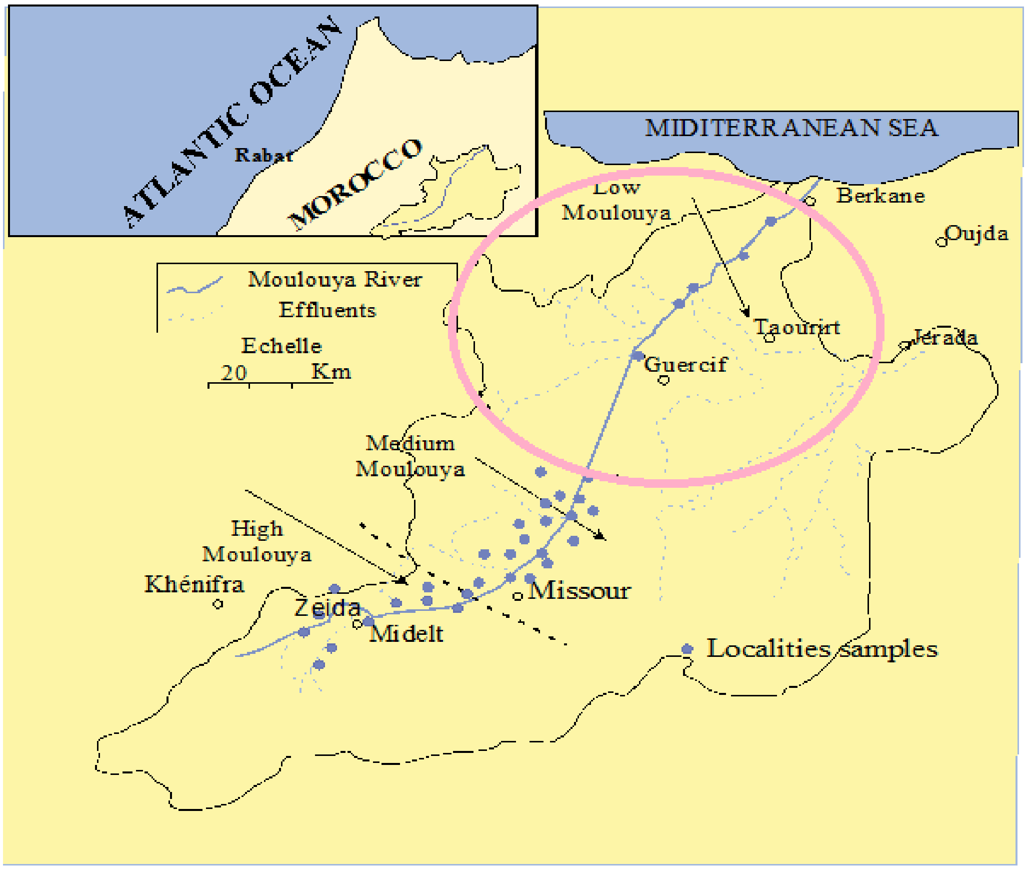

Figure1. Map of Morocco with sampling sites in the Low Moulouya River.

3 Results and Discussions

The results of the analyses of the sediment samples taken in the Lower Moulouya zone are shown in the table below.

Table 1: Activity and activity ratios of uranium and radium (mBq / kg) measured in sediment samples in Lower Moulouya River

Samples	localities	^{226}Ra	^{228}Ra	^{238}U	^{228}Th	^{228}Ra/^{226}Ra	^{228}Th/^{228}Ra	^{226}Ra/^{238}U
SDS1	Safsaf (Nador-Berkane)	18.0±4.1	16.5±1.6	17.1±4.4	17.0+0.7	0.92±0.23	1.03±0.10	1.05±0.36
SDS2	Moulouya River near Za River downstream Taourirt	---	---	---	---	---	---	---
SDS3	Moulouya River near Za River upstream of Taourirt	19.0±1.0	16.1±0.6	11.1±3.2	15.2±0.6	0.85±0.05	0.94±0.05	1.71±0.50

Table 1: (Continued): Activity and activity ratios of uranium and radium (mBq / kg) measured in sediment samples in Lower Moulouya River

SDS4	Za River upstream of Taourirt	17.0±1.0	16.0±1.3	14.1±3.2	15.1±0.6	0.94±0.09	0.94±0.08	1.20±0.28
SDS5	Moulouya River near Taourirt	15.0±1.0	12.0±1.3	8.5±2.9	12.3±0.5	0.80±0.10	1.03±0.12	1.76±0.61
SDS : Sites of the sediment sample **MTE :** trace metallic elements **pH**: Hydrogen potential **T°** : Temperature **CE:** electrical conductivity								

The activity (^{226}Ra) varies between a minimum value of (15±1) mBq/kg and a maximum value of (19±1) mBq/kg with an average of (17.25±1.00) mBq/kg. A (^{228}Ra) varies between a minimum value of (12.0±1.3) mBq/kg and a maximum value (16.5±1.6) mBq/kg with an average of (15.12±1.3) mBq/kg. Similarly, A(^{238}U) varies between a minimum value (8.5±2.9) mBq/kg and a maximum value (17.1±4.4) mBq/kg with an average of (12.7±3.2).

The ^{228}Th varies between a minimum activity value (12.3±0.5) mBq/kg and a maximum value (17.0±0.7) mBq/kg with an average of (14.9±0.4). The activity of (^{238}U) is lower than that of (^{228}Th). This is explained by the strong adsorption of thorium on the sediments as opposed to uranium which has a low sediment co-precipitation and a high mobility in the surface water sample and subsequently in the sediments [8], [9].

The ratio of activities (^{228}Ra/^{226}Ra) varies between (0.80±0.1) and (0.94±0.09) with an average of (0.88±0.05), which is always less than unity. This is due to the fact that ^{226}Ra comes from the most abundant ^{238}U in nature. On the other hand, ^{228}Ra is formed from thorium which is less abundant than uranium in the sedimentary matrix in nature. The ^{228}Th/^{228}Ra varies between (0.94±0.08) and (1.03±0.12) with an average of (0.99±0.04) that it can be equal to unity because the two isotopes come from the same parent thorium ^{234}Th).

However, the activity ratio (^{226}Ra/^{238}U) varies between (1.05±0.36) and (1.76±0.61) with an average of (1.43±0.46). This ratio is always greater than unity in the sediment samples because radium is less mobile than its father uranium, and is fixed in this type of sample [6], [7]. Activities and activity ratios measured across all sediment samples did not differ significantly from site to site.

For example, the SDS3 samples taken at Za River, located upstream of Moulouya River, and SDS4 sampled at Moulouya River downstream from Za River, present practically the same activities and the same activity ratios. This shows that the passage of water and consequently of the sediments by the affluent Za River towards the Moulouya River has no influence on the concentrations of uranium and radium [15]. This is due to the same nature of the soil crossed by the two rivers in this region. Moreover, Za River does not cross a mining region and does not pass by industrial facilities which could be responsible for any differences.

The activity of the ^{238}U (mBq / kg) shows a strong variation from a value (17.1±4.4) to a value (8.5±2.9) because uranium is less adsorbed on sediments than radium. This is explained by the fact that the site (SDS5) is farther away from Za River and close to an area rich in agricultural activity with respect to the site (SDS1). At the same time, during the floods, the trace metallic elements (MTE) are brought into the watercourses via the particles resuspended. The MTEs can pass into the dissolved phase after having undergone a change in physicochemical parameters, such as pH, dissolved O_2, Electrical Conductivity, Temperature, complex ions, carbonate ions, sulfate ions [10].

The histogram (Figure 1) below shows the mean distribution of the activities of the radioisotopes (mBq/kg) in the sediments of lower Moulouya. The content changes from one mineralized medium to another in the same type of source [11]. These traces of metal (MTE) are accompanied in their transport by trace metals toxic in dissolved or particulate forms [11].

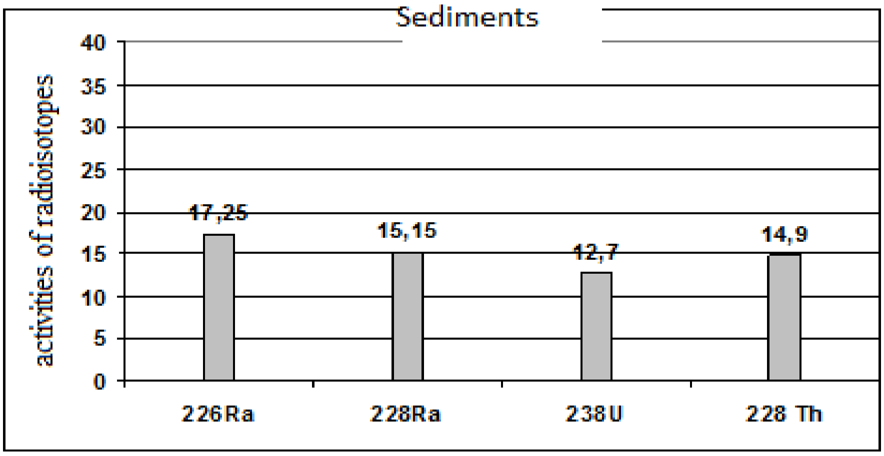

Figure 1: Distribution of mean values of activities of radioisotopes (radium, uranium and thorium) (mBq / kg) in sediment samples in Lower Moulouya

4 Conclusions

The lower Moulouya region is not very urbanized and industrialized. It has a poorly developed hydraulic network, and is subject to heavy sedimentation during the floods of Moulouya River and its tributaries. After clearing, the creation of a new interface between watercourses and the sediments left in place can make them a temporary and very important source of contamination of metal trace elements (MTEs) [15]. The fate of these MTEs in streams and subsequently in sediments during and after clearing has a great influence on the disturbance of physicochemical parameters. The variation of these parameters leads to contamination of neighboring soils by the leaching of these MTEs.

Thus, the latter can serve not only as a vector of pollutants during aquatic transport, but also as a storage and accumulation link of the main radionuclides in the bottoms of streams and in the aquatic environment by the sediment factor [11], [12]. This inert support of sediment consists of mineral and organic matter resulting from erosion phenomena of the Moulouya River and contributions of anthropic origin such as irrigation, fertilizers, and pesticides. Soils are the best integrators of water pollution. They can also tell us about the total burden of contamination of the surrounding environment. Therefore, sediments play a very important role in the geochemical cycle of trace metals [7], [12]. Toxic chemicals may bind to or be absorbed by sediment particles and transported and deposited in another site. The sediments retain the imprint of pollution until remobilization and transport [13]. Therefore, they are regarded as the best integrators of pollution in the environment. Variation in the concentrations of radioactive trace elements depends on several phenomena that may occur during the transport of sediments. The sampling lithology of the sample has a paramount effect on the variation of the concentrations. [6], [7], [9], [14].

The origin of each trace element, its geochemical behavior, and the sampling period play a very important role in the variation of the concentrations of these elements in the sediments. Sediments constitute a potential reservoir of pollutants. In conclusion, sediments present a major hazard on the environment due to the excessive accumulation of MTEs and the risk of release at the slightest change in environmental conditions in several physicochemical parameters. Extensive research on this compartment or exchange matrix of sediments must be carried out to better control the fate of trace metals and their impact on this area under study, which is Lower Moulouya River.

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