Chemical regeneration of catalytic filter beds used for the removal of iron, uranium and radium

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Introduction

The LIFE ALCHEMIA project (LIFE16 ENV/ES/000437) faces one of the current challenges in the treatment of water for human consumption, such as the presence of natural radioactivity.

This is an environmental problem that cannot be solved at source, since it is generated by the dilution of minerals rich in radioactive isotopes in groundwater, mainly by the Uranium (U), Radium (Ra) and Thorium (Th) decay series. Therefore, new systems capable of providing a sustainable elimination of radioactivity from the point of view of environmental and economic sustainability are needed.

The objective of the LIFE ALCHEMIA (LIFE16 ENV/ES/000437) project is to demonstrate the technical and economical viability of sustainable technologies using catalytic filter beds to remove the natural radioactivity in groundwater and thus be able to be used subsequently for urban uses, always ensuring compliance with the legislation in force. In order to accomplish the objectives of the project, the design and construction of four pilot plants have been carried out. Three of them have been installed in Alboloduy, Benizalón and Tahal, municipalities of Almeria (Spain) which currently use reverse osmosis, and another one in Viimsi (Estonia).

The concentration of radiosotopes of uranium and radium in groundwater are reduced through catalytic filter beds (zeolites coated with manganese oxide), accumulating with the operation of the pilot plants. Therefore, it is necessary to carry out chemical regenerations of the filter materials to avoid problems of radiological impact and to improve the operation of the pilot plant.

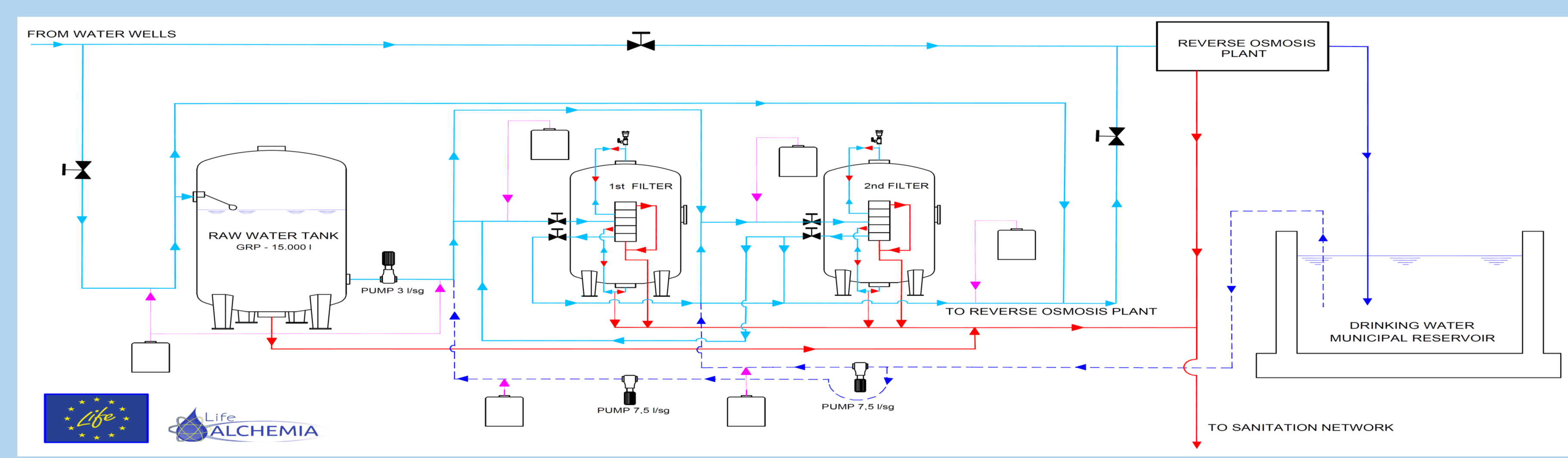

Figure 1. Alchemia pilot plants in Almeria province

Objective

The aim of this work is to study the reduction of radioactivity and the concentration of iron in the catalytic filters beds in the two tanks, for which a chemical regeneration with KCl is proposed in both tanks. The specific objectives are: i) reduce the concentration (Bq / kg) of the radioisotopes of U-235, U-238, Ra-226 and Ra-228, ii) reduce the concentration of iron (kg Fe / kg filled) and iii) improve the operation of the pilot plant.

Materials and methods and tests

Chemical regeneration (**Table 1**) was carried out in the two tanks of the Tahal pilot plant (1000 kg of filter material in each tank). In tank 1, 639.2 kg of KCl were added through 11 dosages of KCl solutions (0.125 and 0.25 kg/L) and backwashing (13 m^3 / h for 15 minutes) at the end of the dosages 9, 10 and 11. Regarding tank 2, the initial accumulated radioactivity in the beds was not as high as in tank 1 therefore 408 kg of KCl were added in 6 doses (0.125 and 0.25 kg/L) with countercurrent water washes (10 and 14 minutes with 13 and 23 m^3/h) after the dosages 5 and 6. The residence time of the dosages has been 90 minutes. In addition, gamma radiation was measured throughout the process in both tanks.

	Tank 1	Tank 2
Nº dosage	kg KCl	kg KCl
1	39	41,875
2	43	41,875
3	40	41,875
4	40	83,75
5	40	41,875
6	40	156
7	40	
8	40	
9	80	
10	80	
11	156	
Total dosage	640	408

Table 1. Dosages of KCl during the chemical regeneration

Image 1. Tank 1 during the chemical regeneration

Image 1.Gamma radiation measurement equipment

Results and conclusions

The results of the regeneration process in tank 1 (**Figure 2.A**) have been satisfactory, obtaining removals of 63% and 51% for Ra-226 and Ra-228 and 81% and 27% for U-234 and U-238, respectively. In this tank, gamma radiation was reduced to 0.66 (**Figure 2.B**). Respect to tank 2, the reduction percentages of Ra-228 and Ra-226 were 53% and 59%, respectively. Uranium radioisotopes do not show any reduction due to the very low starting values, very close to the original concentration in the filter materials.

Regarding the iron concentration removals, it has been measured in the filter materials, resulting good (52%) in tank 1 (**Figure 3.A**) and unsatisfactory in tank 2 (**Figure 3.B**) where the iron concentration is slightly increased. Finally, gamma radiation is reduced during regeneration. In tank 1 (**Figure 4.A.**) from 1.06 to 0.66 µS/h and in tank 2 (**Figure 4.B**) from 0.3 to 0.15 µS/h.

The chemical regeneration (KCl) applied filling materials composed of zeolites coated by manganese oxide, is an optimal maintenance process for the reduction of the radioisotopes of uranium and radio. It is an economical and simple process

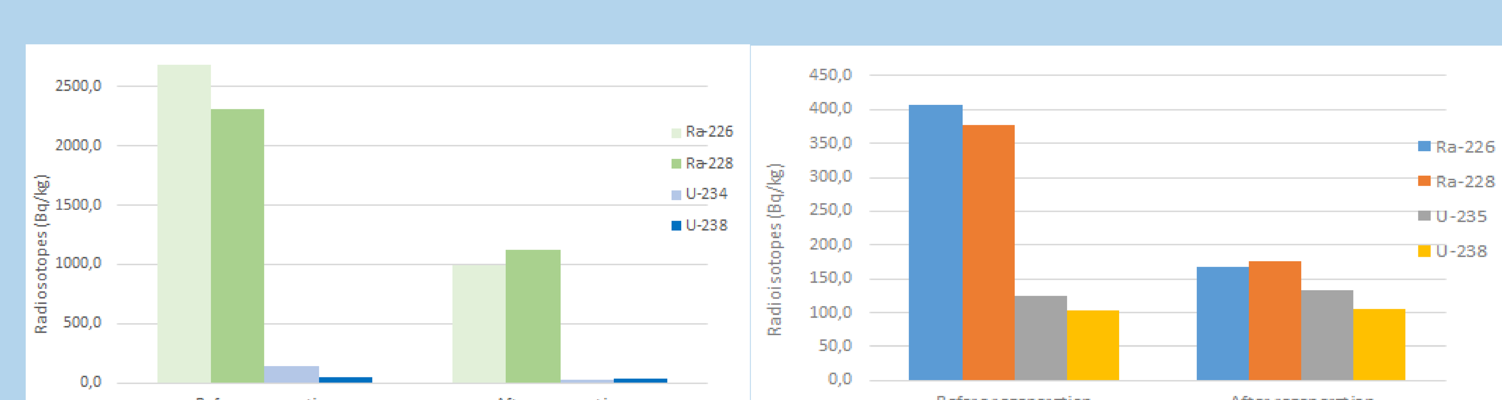

Figure 2. **C**oncentration of radiosotopes in tank 1 (**A**) and tank 2 (**B**) before and after the chemical regeneration process.

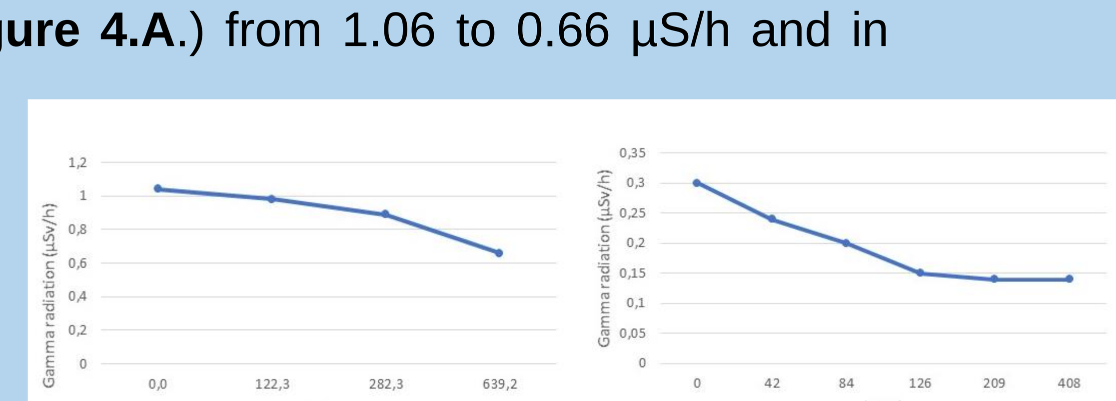

Figure 4. Gamma radiation in tank 1 (**A**) and in tank 2 (**B**)

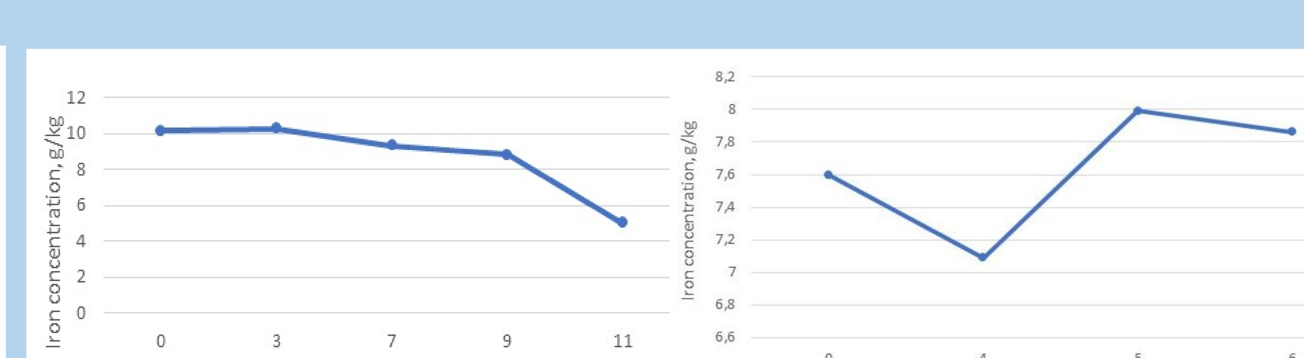

Figure 3. **Iron concentration** in tank 1 (**A**) and tank 2 (**B**) during the chemical regeneration process.

References: Goi A; Nilb N; Suurso S. et al. "Regeneration of filter materials contamined by naturally ocurring radiactive compounds in drinking wáter treatment plant", *Water process engineering* 2019, 30.
Acknowledgement: This study has been supported by the European Commission, European Project LIFE ALCHEMIA (LIFE16 ENV/ES/000437).