Detecting Radium Isotopes in Submarine Groundwater Discharge

Rashaun J. Davis

Introduction

Submarine groundwater discharge (SGD) is the flow of water from coastal aquifers into oceans (Hyung-Mi Cho, Guebuem Kim, 2016). Precipitation seeps through the ground into the underground freshwater picking up different elements and minerals along the way. Fresh SGD has been used as a resource for a long time, we distinguish five categories: drinking, hygiene, agriculture, fishing/diving, and spiritual use (N. Moosdorf, T. Oehler, 2017). SGD is an important process between groundwater and seawater, it is widely recognized as a significant pathway of material such as nutrients, metals, carbon and rare earth elements into coastal waters (Xuejing Wang Hailong Li, Chunmiao Zheng, Jinzhong Yang, Yan Zhang, Meng Zhang, Zhanhui Qi, Kai Xiao, Xiaolang Zhang, 2018). Radium is a radioactive element that can be found naturally in nature commonly found at low levels in natural systems such as lacustrine or marine sediments (Arnaud Mangeret, Jean-Louis Reyss, Marina Seder-Colomina, Lucie Stetten, Guillaume Morin, Antoine Thouvenot, Marc Souhaut, Pieter van Beek, 2020), it is also a byproduct of Uranium. Uranium extraction activities put off high levels of hazardous byproducts such as waste rocks, mill tailings, and can also impact lands, river and lake sediments, which can result in the radioactive nuclides such as 226Ra (Arnaud Mangeret, Jean-Louis Reyss, Marina Seder-Colomina, Lucie Stetten, Guillaume Morin, Antoine Thouvenot, Marc Souhaut, Pieter van Beek, 2020). Radium isotopes (228Ra and 226Ra) are excellent tracers of SGD (Hyung-Mi Cho, Guebuem Kim, 2016).The method of using Radium isotopes in SGD studies is based on the fact that Radium is largely particle-bound in fresh water but desorbs from particles in contact with salt water. Therefore, it is very useful when it comes to SGD studies where the subsurface mixing of fresh and salt water occurs (Moore, 2006).

Material and Methods

One study was conducted at the site of the lake Saint-Clément. The lake was created in 1931 electricity generation, the lake was located about 20 km downstream from the former Uranium mining site of Bois-Noirs-Limouzat (Arnaud Mangeret, Jean-Louis Reyss, Marina Seder-Colomina, Lucie Stetten, Guillaume Morin, Antoine Thouvenot, Marc Souhaut, Pieter van Beek, 2020). Lake sediments cores were sampled within PVC liners using a 90 mm diameter Uwitec hand corer (Arnaud Mangeret, Jean-Louis Reyss, Marina Seder-Colomina, Lucie Stetten, Guillaume Morin, Antoine Thouvenot, Marc Souhaut, Pieter van Beek, 2020). Sediment cores were collected at a location about 100 m upstream from the dame in October 2015 and in May 2016

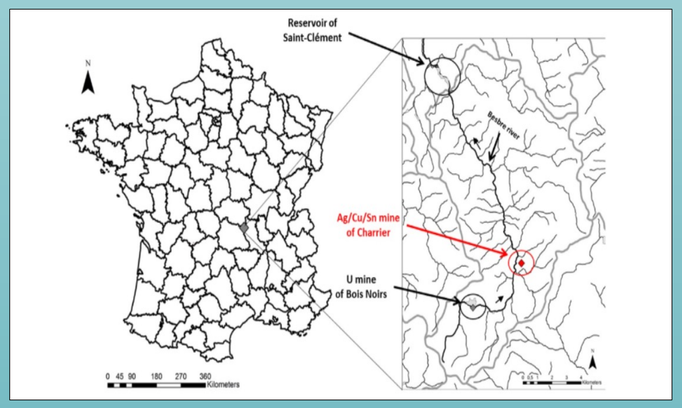

Figure 1: Map of the of Saint-Clément (Allier, France) and the core sampling station from the French hydrographic network database. The of Saint-Clément is supplied by the river Besbre (Arnaud Mangeret, Jean-Louis Reyss, Marina Seder-Colomina, Lucie Stetten, Guillaume Morin, Antoine Thouvenot, Marc Souhaut, Pieter van Beek, 2020)

Dr. W. Hitt and his colleagues from the department of nuclear engineering, Kahalifa University of Science, Abu Dhabi, United Arab conducted an experiment that showed a strong correlation environmental conditions (temperature) and the decay rate. This paper describes the setup of a series of counting experiments commissioned for addressing these criticisms (George W.Hitt, Braden Goddard, Alexander A.Solodova, Dorian Bridi, A.F.Isakovic, Reyad El-Khazali, Ayman Abulail, 2015). Six detector systems (four different types) measuring six different isotopes (Carbon-14 (14C), Maganese-54 (54Mn), Cobalt-60 (60Co), Strontium-90(90Sr),Thalium-204 (204Tl), 226Ra) have been continuously collecting source activity synchronously with environmental data for a period of one month (April 2014) (George W.Hitt, Braden Goddard, Alexander A.Solodova, Dorian Bridi, A.F.Isakovic, Reyad El-Khazali, Ayman Abulail, 2015).

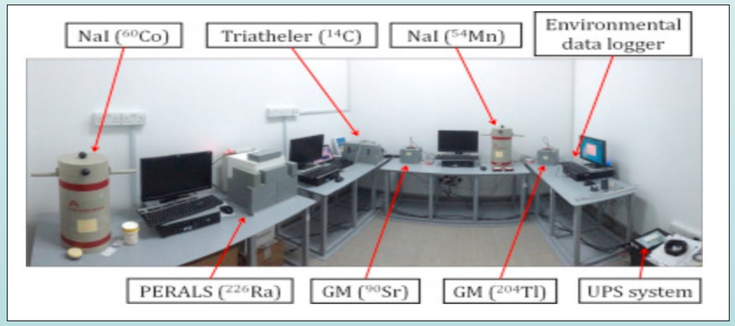

Figure 2: Laboratory setup highlight important experimental equipment. (George W.Hitt, Braden Goddard, Alexander A.Solodova, Dorian Bridi, A.F.Isakovic, Reyad El-Khazali, Ayman Abulail, 2015)

Results

Detailed protocols of selective chemical extraction of radium in sediments.

Reagent	Solid/ Liquid Ratio	Experimental conditions	Radium fraction extracted
1M $Mg(NO_3)_2$	1: 20	2h at ambient temperature	Loosely and ionically bound Ra
0.27M $C_6H_5Na_3O_7$, $2H_2O$ 0.1M $NaHCO_3$ 2 g $Na_2S_2O_4$	2 : 75	40 min at 80 °C	Ra sorbed and coprecipitated with amorphous/poorly ordered and well crystallised iron oxides
0.02M HNO_3 (1) + 30% H_2O_2; further 30% H_2O_2 (2)	1: 20	1 => 2 h at 85 °C 2=> 3 h at 85 °C	Radium associated with organic matter

Figure 1: (Arnaud Mangeret, Jean-Louis Reyss, Marina Seder-Colomina, Lucie Stetten, Guillaume Morin, Antoine Thouvenot, Marc Souhaut, Pieter van Beek, 2020)

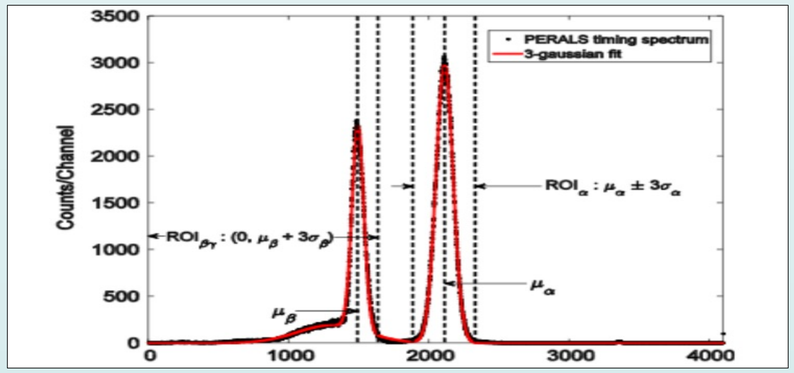

Figure 4: An example timing spectrum of the PERALS detector system for a single 30 min measurement. Counts from ^{226}Ra plus daughters' source are shown in black with the 3-Guassian fit show in red (George W.Hitt, Braden Goddard, Alexander A.Solodova, Dorian Bridi, A.F.Isakovic, Reyad El-Khazali, Ayman Abulail, 2015).

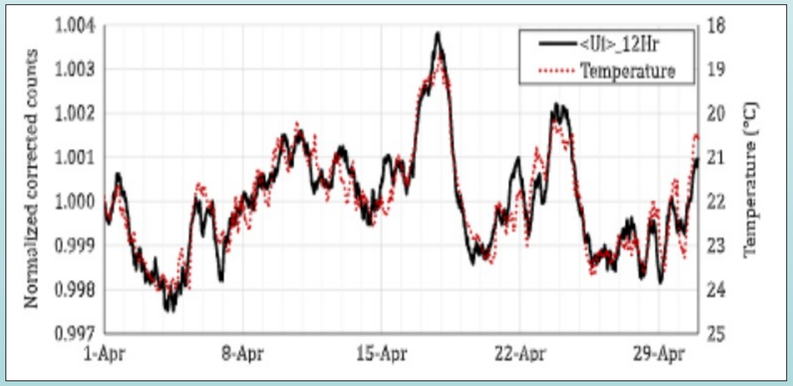

Figure 5; The 12-h moving average of the measured counts from the PERALS alpha ROI after normalizing (black line). The counting room temperature is plotted, with decreasing temperature axis, alongside (red dotted line), showing a clear negative correlation (George W.Hitt, Braden Goddard, Alexander A.Solodova, Dorian Bridi, A.F.Isakovic, Reyad El-Khazali, Ayman Abulail, 2015).

Conclusions

Ra isotopes are excellent tracer of SGD (Hyung-Mi Cho, Guebuem Kim, 2016), and the four isotopes (223Ra,224Ra, 226Ra, and 228Ra) can be found in the SGD, although 226Ra and 228Ra are better known tracers due to their long-lived nature. From Dr. W. Hitt and his colleagues work at Khalifa University We see in Figure 5. that there is a noticeable correlation between environmental conditions (temperature) and the rate at which counts are detected. So, one may say that the Radium isotopes decay rate (at least that we can detect) in SGD fluctuates with temperature as did the 226Ra and its 210Pb daughter.

Acknowledgments: *Advisor, Dr. Monica Gray mgray@coastal.edu*