

First radionuclide survey in marine environment off the Mauritius coast: levels and distribution of naturally occurring radionuclides and ¹³⁷Cs in seawater, sediments and biota

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1. Introduction

- ◆ A significant lack of data on radionuclides for the South Western Indian Ocean, in particular the island of Mauritius
- ◆ The objectives of this study were to:
 - a)determine the background level of selected natural radionuclides from uranium and thorium series and anthropogenic ¹³⁷Cs in different marine compartments at established sites around Mauritius; and
 - b)estimate the annual committed effective dose from the intake of ²¹⁰Po through ingestion of fish and oysters for adults in Mauritius
- ◆ This study also established a new radio-ecological reference database for the marine environment of Mauritius

3. Methodology

- ◆ Seawater, marine sediment and biota (algae, sea cucumber and fish) samples were collected at five sites around Mauritius island, namely Baie du Tombeau, Riambel, Trou d’Eau Douce, Melville and Grand Baie (Fig 1)
- ◆ Oyster samples were collected at Melville and Trou d’Eau Douce only due to their limited availability around the island
- ◆ Physico-chemical parameters of the seawater, namely dissolved oxygen, nitrate, phosphate, chemical oxygen demand, pH, temperature and salinity, at the sampling sites were determined
- ◆ The sediment and biota samples were dried at 90°C for 24 h and freeze dried afterwards
- ◆ Gamma-ray spectrometry was performed to determine the massic activities of gamma-emitting radionuclides, specifically those in the ²³⁸U, ²³⁵U and ²³²Th decay series, ⁴⁰K and ¹³⁷Cs in biota and sediment samples
- ◆ Polonium-210 and uranium isotopes were determined by alpha-particle spectrometry
- ◆ Sediment-Water Distribution Coefficients (K_{ds}) for ²¹⁰Po and uranium isotopes were calculated
- ◆ The annual effective doses from ²¹⁰Po obtained through consumption of fish and oysters were calculated

2. Study Area - Mauritius Island

- ◆ Located on the Mascarene Plateau in the Western Indian Ocean region
- ◆ 1864.8 km² land area with a coastline of approximately 330 km comprising both sandy and rocky shores, and shallow lagoons with 240.4 km² of coral reefs
- ◆ Very unique coastal bed formed mainly from biogenic carbonate origin, namely corals, molluscs and foraminiferans (Daby, 2006)
- ◆ Very few or no data on radionuclides distribution and behaviour available for this type of environment worldwide
- ◆ Fish and other seafood form a key part of the Mauritian diet with a per capita fish consumption of around 29 kg (Statistics Mauritius, 2018)
- ◆ Artificial radionuclides was expected to be detected at very low levels as a result of the global fallout including a fallout of plutonium from the failure of the SNAP 9A satellite in the Indian Ocean (Raaf *et al.*, 2017)



Fig 1: Map of Mauritius island with location of sampling sites (Source Google Earth)

4. Results

Table 1: Massic activity of ²¹⁰Po and U isotopes (²³⁴U, ²³⁵U and ²³⁸U) and activity ratios of ²¹⁰Po/²³⁸U and ²³⁴U/²³⁸U in seawater samples

Sites	Massic activity mBq/kg				Activity ratio	
	Po-210	U-238	U-235	U-234	²¹⁰ Po/ ²³⁸ U	²³⁴ U/ ²³⁸ U
Grand Baie	0.6±0.1	41.5±10	<5.7	42.8±10.2	0.015±0.004	1.0±0.4
Baie du Tombeau	2.0±0.2	40.6±1.5	2.6±0.2	46.1±1.7	0.050±0.003	1.1±0.1
Riambel	1.2±0.1	41.9±1.5	1.7±0.2	50.6±1.7	0.027±0.002	1.2±0.1
Trou d'Eau Douce	2.1±0.1	49.7±2.2	2.8±0.3	52.1±2.3	0.042±0.003	1.0±0.1
Melville	0.40±0.04	47.9±1.8	2.4±0.2	53.7±2	0.009±0.001	1.1±0.1

Table 2: Massic activities of radionuclides in sediment at the sampling sites

Sites	Activity Bq/kg dry weight										
	⁴⁰ K	²²⁸ Th	²²⁸ Ra	²²⁶ Ra	¹³⁷ Cs	⁷ Be	²¹⁰ Po	²¹⁰ Pb	²³⁸ U	²³⁵ U	²³⁴ U
Grand Baie	35.6±2.3	1.3±0.1	0.9±0.2	1.4 ±0.1	BDL	8.9±2.9	7.7±0.4	5.67±1.1	11.5±0.4	0.5±0.1	14.1±0.5
Baie du Tombeau	10.6±0.9	0.7±0.1	<0.47	1.3±0.1	BDL	BDL	5.3±0.4	4.78±1	37.1±1.2	1.3±0.1	40.6±1.3
Riambel	95.1±5.3	7.9±0.3	5.7±0.3	4.8±0.2	0.4±0.04	BDL	6.8±0.3	5.2±0.9	15.6±0.5	0.6±0.1	18.6±0.7
Trou d'Eau Douce	67.1±3.3	3.4±0.1	2.3±0.1	2±0.04	0.1±0.01	BDL	7.52±0.4	5±0.04	5.4±0.3	0.3±0.1	6.3±0.3
Melville	21.7±1.4	0.9±0.1	0.3±0.1	1.9 ±0.1	0.1±0.03	BDL	12.7±0.7	10.5±1.1	33.6±1.1	1.7±0.2	39.2±1.3

Table 3: Sediment-water distribution coefficients (K_{ds}) for ²¹⁰Po and U isotopes.

Sites	Sediment-Water Distribution Coefficients (K _{ds})			
	²¹⁰ Po	²³⁴ U	²³⁵ U	²³⁸ U
Grand Baie	12.8x10 ³	3.3x10 ²	-	2.8x10 ²
Baie du Tombeau	2.7x10 ³	8.8x10 ²	5x10 ²	9.1x10 ²
Riambel	5.7x10 ³	3.7x10 ²	3.5x10 ²	3.7x10 ²
Trou d'Eau Douce	3.5x10 ³	1.2x10 ²	1.1x10 ²	1.1x10 ²
Melville	31.8x10 ³	7.3x10 ²	7.1x10 ²	7.0x10 ²

5. Conclusion

- ◆ Calculated K_{ds} for ²¹⁰Po and U isotopes were lower than the reported average worldwide and the marine sediments were found poor in ⁴⁰K (10 to 95 Bq/kg) due to their biogenic carbonate composition
- ◆ Macro-algae samples readily bio-accumulated ⁴⁰K and also displayed the highest levels of ²¹⁰Pb (48.1±42 Bq/kg)
- ◆ High levels of ²¹⁰Po were observed in oyster *Saccostrea* sp samples collected at the two sites
- ◆ Annual effective doses from ²¹⁰Po obtained through consumption of fish and oysters were below the annual effective dose due to natural radiation sources.

Table 4: Annual Effective Dose of ²¹⁰Po for adults from the consumption of fish and oysters in Mauritius

Sites	Annual Effective Dose (mSv/year)	
	Fish	Oysters
Grand Baie	0.31	-
Baie du Tombeau	0.25	-
Riambel	0.30	-
Trou d'Eau Douce	2.19	0.05
Melville	0.19	0.03

Table 5: Massic activities of ⁴⁰K, ²¹⁰Po, ²¹⁰Pb and U isotopes in biota samples

Sites	Species Name	D:W	Activity Bq/kg dry weight						
			⁴⁰ K	²¹⁰ Po	²¹⁰ Pb	²³⁸ U	²³⁵ U	²³⁴ U	
			Macro-algae						
Grand Baie	<i>Sargassum</i> sp	0.18	1680±90	73.3±3.5	16.2±1.5	14.1±0.5	0.8±0.1	15.0±0.5	
Baie du Tombeau	<i>Codium</i> sp	0.12	6330±380	43.0±3.0	17.4±2.2	8.5±0.3	0.5±0.1	10.0±0.3	
Riambel	<i>Gracilaria</i> sp	0.14	4040±240	118.8±6.6	40.1±4.1	10.2±0.5	1.0±0.1	11.5±0.6	
Trou d'Eau Douce	<i>Codium</i> sp	0.07	2500±150	108.8±6.7	48.1±42	3.5±0.2	0.3±0.04	4.4±0.2	
Melville	<i>Sargassum</i> sp	0.13	1940±100	50.9±2.7	7.35±1	12.6±0.4	0.6±0.1	15.0±0.5	
			Sea Cucumber						
Grand Baie	<i>Thelonata</i> sp	0.1	216±11	66.6±2.7	6.96±0.7	6.1±0.2	0.5±0.1	7.3±0.3	
Baie du Tombeau	<i>Holothuria</i> sp	0.12	258±16	91.2±3.1	3.73±0.8	27.6±1.3	1.1±0.1	32.8±1.5	
Riambel	<i>Holothuria</i> sp	0.11	208±11	167.0±7.5	5.04±0.6	12.8±1.3	0.5±0.1	14.7±0.5	
Trou d'Eau Douce	<i>Holothuria</i> sp	0.1	240±9	89.9±4.7	33.8±10.5	18.2±0.8	1.0±0.1	20.7±0.8	
Melville	<i>Holothuria</i> sp	0.14	342±18	39.0±1.2	<2.8	28.5±1.2	1.1±0.1	32.6±1.4	
			Oyster						
Trou d'Eau Douce	<i>Saccostrea</i> sp	0.12	241±9	372.6±12.0	<16.5	11.1±0.4	0.24±0.1	12.5±0.4	
Melville	<i>Saccostrea</i> sp	0.16	352±19	177.7±6.7	<282	5.19±0.3	0.5±0.1	6.7±0.4	
			Fish						
Grand Baie	<i>Lethrinus</i> sp	0.3	490±17	29.1±1.3	<7.2	<0.1	<0.1	<0.1	
Baie du Tombeau	<i>Siganus</i> sp	0.25	558±20	28.5±1.0	<10.6	<0.2	<0.1	<0.1	
Riambel	<i>Scarus</i> sp	0.24	664±24	35.3±1.3	<14.4	0.4±0.04	0.2±0.02	0.6±0.1	
Trou d'Eau Douce	<i>Mulloidichthys</i> sp	0.32	518±24	193.6±5.5	<41.7	0.5±0.1	0.4±0.1	0.6±0.1	
Melville	<i>Lethrinus</i> sp	0.26	448±23	21.0±0.8	11.3±4.2	<0.1	<0.1	<0.1	

6. References

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