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^{210}Po radioactivity measurements from mussels in the coastal sites of Dakar region (Senegal)

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Abstract

This work aim to assess the ^{210}Po radiation in the coastline by analyzing the radioactivity of the ^{210}Po incorporated in the mussels (Mytilus Galloprovincialis) whose consumption is part of the eating habits of riparian populations.Mussels samples have been collected from 15 different sites of Dakar (Senegal) coast. The results of ^{210}Po activity concentrations of 10 mussel samples (P1 to P10) around the Iles Madeleines (touristic islands) located at 3 km from the Dakar coast were found to vary between (44.68±13.25) Bq.kg^{-1} dry weight and (156.07±15.93) Bq.kg^{-1} dry weight giving a mean value of (123.74±14.10)Bq.kg^{-1}. From 5 others coastal sites (P11 to P15) which are wether under freshwater discharges or under strong influence of domestic and industrial discharges, the radioactivity concentrations are more high with a mean value of (177.03±14.24)Bq.kg^{-1}.

Keywords: Mytilus Galloprovincialis, ^{210}Po, Dakar region coast

1-Introduction

Polonium-210 (^{210}Po) is a product of uranium-238, a naturally occurring radionuclide present in trace amounts in the environment, along with ^{222}Rn and ^{210}Pb. It is the most abundant of the 29 isotopes of polonium, with a half-life of 138.4 days. Its specific activity is very high: 1.66.10^{14} Bq per gram of ^{210}Po. It emits 99.999% of alpha particles with energy equal to 5.304 MeV and 0.001%. gamma radiation of energy equal to 0.80 MeV, and transforms into stable lead (^{206}Pb).

^{210}Po is the most radiotoxic radionuclide in the ^{238}U decay chain. It is concentrated in soft tissues, such as muscles, liver and others (Stewartet al., 2008). The radioactive ^{222}Rn precursor to polonium is responsible for its permanent presence in the atmosphere (aerosols). Its concentration in air is of the order of 50 mBq/m^3 (IRSN, 2006) but may vary depending on the local importance of radon exhalation and the presence of industrial activities promoting its emission (mining activities, phosphate industry, etc.).

In the marine environment, ^{210}Po is largely generated by the decay of ^{210}Pb deposited from the atmosphere. A small amount of ^{210}Po in seawater comes from the atmospheric deposition of polonium itself. After ^{210}Po and ^{210}Pb enter the marine environment, they are subjected to different biogeochemical reactions (dissolution, hydrolysis, complexation, sorption/desorption, coprecipitation and speciation) (Stricht and Kirchmann, 2001).

^{210}Po is easily attached to particle surfaces but also to living organisms where it is associated with proteins and may potentially enter the cytoplasm of cells. ^{210}Po is the primary natural source of internal

irradiation of marine organisms (Cherry and Shannon, 1974; Carvalho, 1988; Brown et al., 2004). It is known that ^{210}Po is transferred along marine food chains, with ingestion being the main route of absorption. It is also responsible for a large proportion of the doses received by humans as a result of the consumption of seafood and could account for up to 80% of the collective dose received by a population consuming marine organisms (Aarkrog et al., 1997;Pollard et al., 1998).

The mussels are distributed widely on the coasts of almost Cape Verde (Dakar region) and their collection is easy. They are sedentary and have the ability to filter and therefore accumulate highly contaminants which explains their use as a bio indicator in monitoring pollution of coastal sites with heavy metals and radionuclides (Ugur et al., 2002, Strok and Smodis, 2011). These properties make it an excellent tool for assessing marine pollution.

The objective of this paper is to make a preliminary assessment of the level of concentration of polonium on the coasts of the Dakar region using mussels that are heavily consumed by riparian populations and later an assessment of annual effective doses will be done.

2. Material and Methods

2.1Study area

The main study area is the island called îles Madeleines (Fig.1) where 10 mussel samples (P01 to P10) have been collected. At around 3.5km (Notes Africaines ,1968) in front of Soumbedioune the iles Madeleines represent a tourist site.It is one of the smallest marine parks in the world. This mixed space consists of a few uninhabited volcanic rocky islets with a turbulent relief and an oceanic space very rich in marine species including mussels (Mitulis) (Notes Africaines No 120, 1968). On its 500000m2 (including 150000 m2 of land) many plant and animal species compete for a corner of tranquility in this sanctuary so close to the hustle and bustle of dakar.

Thousands of seabirds have made it their resting place and breeding ground and are therefore covered with a substantial layer of white guano. Protected since 1949, it is in 1976 that it is offered the status of national park ((Notes Africaines No 120, 1968). Average precipitation of 3.4 mm makes February the driest month. In August, precipitation is the largest of the year with an average of 177.4 mm. In September, the average temperature is 27.6°C. September is therefore the warmest month of the year. February is the coldest month of the year. The average temperature is 20.6°C at this time.

10 mussel samples (P01 to P10) have been collected. The other 5 samples (Fig. 2) are collected respectively to Cap Manuel, Soumbédioune , Ngor, Port et Zone industrielle (P11 to P15) all these zones are characterized by the intensive fish activity and also by tourist activities.

Mussels were collected during August 2019 as indicated in Fig.1. Sampling locations are placed in coastal water areas (Port et Zone industrielle (P11 to P15) that are under significant influence of domestic and industrial wastes from Dakar city and the surrounding industries.

The Soumbedioune and Ngor sites are placed of landing fisheries products and according to the its geographical position Soumbedioune site receive a numerous water discharges from the western channel called Canal IV.

All Locations from P1 to P15 are placed in areas with significant area with possible anthropogenic influence.

The sampling sites are subjected to liquid effluents due to domestic products transported by the open channel called canal4 and by the hospitals located on the coasts (Cap Manuel).

This study area is touristical site but also the major one for the collection of mussels dedicated to the consumption of the coastal population.

It is clearly indicated that sample P6 originate from the smallest island as the reference sample in the chekh-in of the radioactivity homogeneity

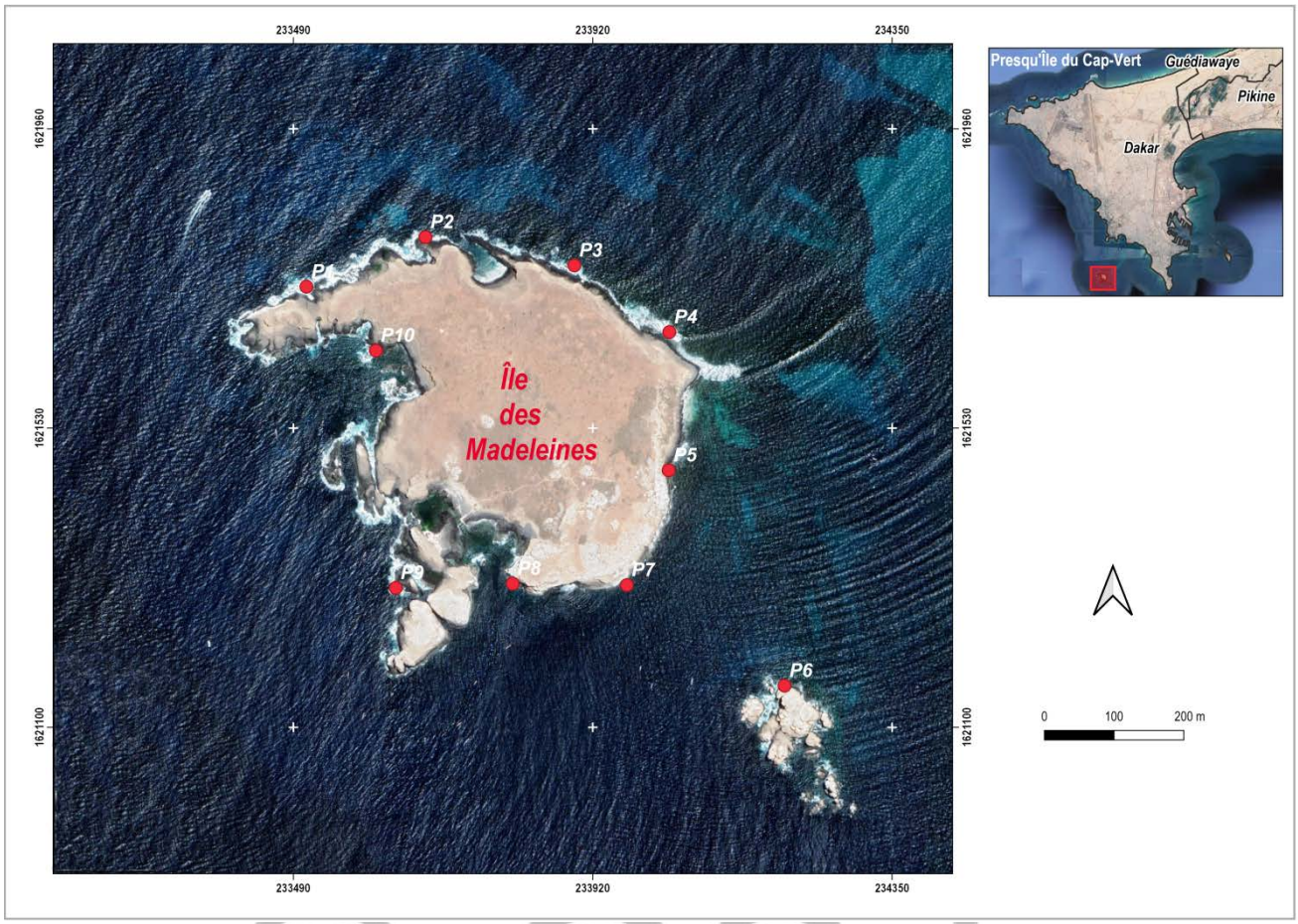

Figure1: Sampling area (Iles Madeleines) and sampling stations.

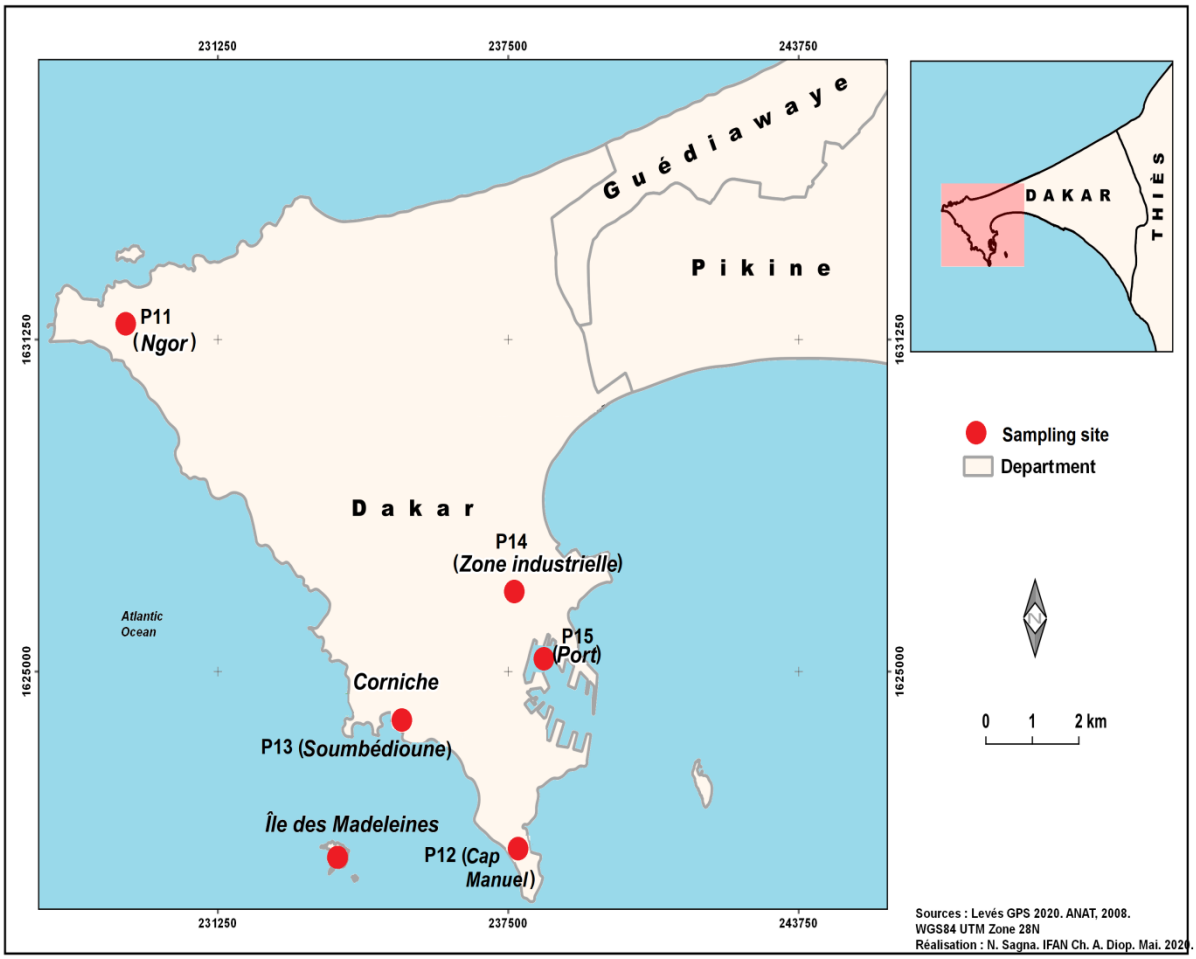

Figure2: Coastal sampling locations.

Table1: Geographical coordinates of sampling locations

Location	Sample identification	Longitude	Latitude	Habit
Iles Madeleines	P01	14°39'21,35"	17°28'27,35"	Breeding site
Iles Madeleines	P02	14°39'23,86"	17°28'21,77"	Breeding site
Iles Madeleines	P03	14°39'23,31"	17°28'16,90"	Breeding site
Iles Madeleines	P04	14°39'19,09"	17°28'9,78"	Breeding site
Iles Madeleines	P05	14°39'13,29"	17°28'9,81"	Breeding site
Iles Madeleines	P06	14°39'2,89"	17°28'3,98"	Breeding site
Iles Madeleines	P07	14°39'7,97"	17°28'11,99"	Breeding site
Iles Madeleines	P08	14°39'7,84"	17°28'17,14"	Breeding site
Iles Madeleines	P09	14°39'7,58"	17°28'22,58"	Breeding site
Iles Madeleines	P10	14°39'18,56"	17°28'23,93"	Breeding site
Ngor	P11	14°39'12,43"	17°30'48,98"	Pier
Cap manuel	P12	14°39'9.57"N	17°26'4.98"W	Breeding site
Soumbédioune	P13	14°39'14,55"	17°27'31,09"	Pier
Zone industrielle	P14	14°39'15,43"	17°26'8,34"	Breeding site
Port autonome	P15	14°39'15,63"	17°25'48,87"	Pier

2.2. Sampling

Mussels (Mytilus Galloprovincialis) were collected during August 2019 as indicated on the Iles Madeleines sites and on the coastal sites of Dakar region as indicated in Fig.1 and Fg.2. Sampling locations and dates are shown in Table2. Samples were stored in cold storage boxes and transported to the laboratory. Samples were washed with distilled water to remove any material attached to the surface. The edible tissue, skin, and internal organs of shellfish were separated as much as possible before being pooled, freeze-dried, and homogenized.. Samples were weighted twice: wet weight immediately after separation and dry weight after freeze drying,homogenization, and oven drying.

2.3 Determination of ^{210}Po activity concentration

^{209}Po was used as an internal tracer for determination of ^{210}Po radiochemical recovery. A working solution was prepared from a standard solution provided by the IAEA (International Atomic Energy Agency).The mother source is Ecker and Ziegler (SRS 109278).The dilution of ^{209}Po have been done in CNESTEN (Morocco) on july 2018 with HCL 2M to give an activity of A= 188 ±4Bq.kg^{-1} (k=2).The reference date is 18 April 2018.

All other chemicals and reagents used in the radiochemical procedures were of analytical grade. The samples were dried at 80^{o}C (to prevent polonium losses) to constant weight, homogenized. Between 0.5g to 1g of dried mussel sample was weighted in a glass beaker (250mL).A few mL (8-10mL) of concentrated HNO_3 were added in order to digest the sample, after which 300µL of ^{209}Po tracer solution (~ 0.075Bq) have been added.

The beaker was covered with a watchglass and left overnight. Afterwards the watchglass was rinsed with a few drops of concentrated HNO3 and removed. 1 mL of H_2O_2 was added drop by drop and the solution was evaporated at 90^{o}C till dryness. Then 6mL of HNO3 and 1mL H_2O_2 was added into the sample and evaporated till dryness, the procedure was repeated three times.

To remove all the remaining HNO_3, 2mL of concentrated HCl were added to the dried residue and evaporated to incipient dryness. The mentioned procedure was repeated three times.

The dry digested sample residue was dissolved in 1mL of concentrated HCl, diluted with deionized water to 100 mL and filtered if necessary. 0.5 g of ascorbic acid was added to the solution to reduce Fe^{3+} and prevent copulating of iron and interfering elements.

The spontaneous deposition of polonium on a 19 mm diameter silverdisk was carried out at 90^{o}C for 4 h. A silver disk, covered onone side, was fixed in a holder and immersed in the gently wiped with cotton brush, soaked with ethanol. Overall the chemical recovery is around 43.47% on average and the reability of the QC/QA method have been done doing the repetability of the measurements.

The disk was dried in air and subsequently counted on alpha spectrometerfor activity concentration determination and recovery calculation (Benedik and Vrecˇek, 2001).

An alpha spectrometer (Alpha Ensemble, ORTEC, USA), with8 counting chambers are used. The series detectors used have a thin (500Å) contact which is ion-implanted into the silicon surface. The maximum detectors active area is 3000 mm^2 and approximately 28% efficiencyfor a 20 mmdiameter disk.

The calibration of the detectors wasmade with a standard radionuclide source, containing a mixture of ^{239}Pu and ^{241}Am. The standard is certificate by Czech Metrology Institute (Regional Branch Prague, Radiova), the certificate number is 1035-SE-40708-15 and the serial number is 220115-1132138.Data acquisition analysis was performed by aMaestro (multichannel analyzer) application software. The counting time varied from 1 to5 days, depending on the radionuclide activities in the samples. Radiochemicalrecovery was determined by ^{209}Po activity measurementand the final result of ^{210}Po activity concentration was correctedat the sampling date.

3. Results and Discussions

Table 2: The activity concentrations of ^{210}Po with combined standard uncertainties (k = 2) in mussels (Mytilus Galloprovincialis) for each sampling place.

Sample identification	Sampling date	Fresh weight/ Dry weight	Activity (^{210}Po) (Bq kg^{-1} Dry weight) mean ± Sd
P01	15-08-2019	3.9	44.68±13.25
P02	15-08-2019	4.3	80.60 ± 12.82
P03	15-08-2019	3.6	107.44± 14.66
P04	15-08-2019	4.5	133.59±18.40
P05	15-08-2019	3.8	138.43±11.81
P06	15-08-2019	3.7	140.80±12.30
P07	15-08-2019	3.9	142.4±10.3
P08	15-08-2019	3.9	146.7±13.83
P09	15-08-2019	4.05	156.07±15.93
P10	15-08-2019	4.4	146.72±17.77
P11	16-08-2019	4.2	163.95±19.25
P12	16-08-2019	4.3	166.20±10.1
P13	16-08-2019	4.04	177.07±16.31
P14	16-08-2019	3.9	187.20±10.3
P15	16-08-2019	3.36	190.73±15.25

Although it is well known that the species M. Galloprovincialis accumulate radionuclides effectively and present a successful biomonitor organism for estimation of ^{210}Po levels in marine environment,comparable information for this species are scarce at present in the coastal part of Senegal. Only some limited studies in mussels at this coast have been undertaken for the determination of trace elements concentration (Ndiaye B. and al ; Issa Diagne et al.).

Considering the fact that the Senegalese coastline of Senegal stretches 700km and corresponds to the maritime facade of six administrative regions. The Senegalese coastline is made up of diverse and rich ecosystems but is threatened by the combination of natural action exacerbated by climate change and the effects of anthropogenic pressure: high economic and demographic concentration.The marine and coastal environment is today threatened by industrial and domestic pollution that manifests itself acutely on the state of the different ecosystems.If the anarchic occupation of the coast and erosion are often cited, as well as the salt invasion, we also note the lack of health of the coastline with the question of all kinds of waste that pollute the end up in the coastal as well as the fact that seafood is the main diet in the region**,** total annual effective dose assessment for the population consuming mussels in everyday diet is necessary.

3.1. Determination of ^{210}Po in mussels from the study areas

In general, the results obtained (**Table 2**), the concentrations of Po in the Dakar region sites show a variation between the different sampling sites. This may be due to the influence of environmental

parameters including: temperature, pH, salinity, nature of the site, the degree of pollution, the nature of the bio-indicator used..Then the arithmetical mean of ^{210}Po radioactivity concentrations determined in M. Galloprovincialisis is (123.74±14.10)Bq.kg^{-1} dry weight, in Iles Madeleines (**Fig.1**) and is in range from (44.68±13.25) Bq.kg^{-1} dry weight to (158.72±17.77) Bq.kg^{-1} dry weight (P01 to P10). A part from the first two low radioactivity values P1 and P2, the activity values are almost uniform around Madeleines Island (107.44±14.66Bqkg$^{-1)}$ dry weight to (146.72 ±17.77Bq. kg^{-1}) dry weight and vary around an average value 139.02Bq kg$^{-1.}$ This can be explained by the fact that the dimensions of the island are small (15 hectares) therefore a low dispersion of radioactivity can be noted. Relatively close to the coast at 3.6km west of Dakar (Notes Africaines, 1968.), the island is less subject to domestic and industrial dumping and sea fluctuations.

The highest activities were measured in the samples originating from the 5 others sites; Soumbédioune site (P11), Ngor site (P12), Cap manuel site (P13), Zone industrielle site (P14); Port autonome site (P15)
The radioactivity varies from 163.95±19.25 (Bq kg-1) dry weight to 190.73±15.25 (Bq kg-1) dry weight, these results are higher than those obtained around the Madeleines Islands. These differences can be explained by the differences in environmental conditions suggested by Ndiaye et al. 2015.

Samples collected from the Ngor (P11.) and Soumbedioune (P13) sites had a radioactivity of 163.95 ±19.25 (Bq kg^{-1}) dry weight and 166.20±10.1 (Bq kg-1) dry weight, respectively. The two sites have the distinction of being next to the pumping stations (Ngor pak put) and (Soumbédioune) of wastewater. The radioactivity values can be explained by the fact that the mussels growing on the floating dock of the Dakar coast are exposed to large variations of tides several times a day so the waters can have a different composition of food based on mussels. It is therefore reasonable to say that anthropogenic activities are responsible for the contribution of polonium in mussels with a relatively high level on these two sites in the Dakar region.

The Cap Manuel (P12) has a radioactivity of 177.07± 16.31 (Bq kg-1) dry weight and the industrial zone (P14) with a radioactivity of 187.20± 10.3 (Bq kg-1) dry weight, these values are raised compared to the values obtained on the docks.. Cape Manuel is one of the most polluted sites of Dakar by the discharge of medical waste, the site being close to the hospitals (Dantec Hospital and Main Hospital). The industrial zone is a group of industries established since the Indepandences and is the subject of major industrial discharges. The port of Dakar (P15) with a radioactivity of 190.73± 15.25 (Bq kg-1) dry weight is the site with the highest radioactivity. The site is very active with frequent shipment of oil.It is also a starting point of several pipelines that supply various oil companies of Dakar. Moreover a pumping station whose outlet is called Canal Hann-Fann is installed in order to concentrates and discharges heavy metals and ^{210}Po in mussels confirming the contribution of antropogenic radioactivity.

In general, all these values remain low if we rely on literature data the mass activity of ^{210}Po in mussels vary from 80 to 1200 Bq.kg-1 dry weight (Bustamante et al., 2002; Germain et al., 1995-a; Mc Donald et al., 1996; Ryan et al., 1997; Stepnowski and Skwarzec, 2000; Wildgust et al., 1998).

4. Conclusion

The preliminary results obtained in this study showed that ^{210}Po levels in mussels collected in the coastal sites of the Dakar region are found in the range from (44.68±13.25) Bq kg^{-1} dry weight to (158.72±17.77) Bq kg^{-1} dry weight for the Madeleines Island. These low activities concentration of ^{210}Po were measured in the breeding areas (Madeleines Island) which are not under strong influence of domestic and industrial discharges.

The activity concentrations of ^{210}Po in the 5 others coastal sites (Ngor ,Soumbedioune , Cap Manuel, Zone Industrielle, Port Autonome) are between (146.72±17.77) Bq kg^{-1} and (190.73±15.25) Bq kg^{-1}. These activity concentrations of ^{210}Po are relatively high which shows that the sites are under strong influence of domestic and industrial discharges from the coast.
In perspective a more exhaustive sampling will be done for a comparison with some sites of the neighboring coasts but also a assessment of a total annual effective dose for the population consuming mussels.

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5. References

Aarkorg A, Baxter MS, Bettencourt AO, Bojanowski R, Bologa A, Charmasson S, Cunha I, Delfanti R, Duran E, Holm E, Jeffree R, Livingston HD, Mahapanyawong S, Nies H, Osvath I, Pingyu L, Povinec PP, Sanchez A, Smith JN et Swift D (1997). A comparaison of Doses from 137Cs and 210Po in Marine Food, a major international study. J Environ Radioactiv, 34(1): 69-90

Benedik, L., Vrec ˇek, P., 2001. Determination of ^{210}Pb and ^{210}Po in environmental samples. Acta Chim. Slov. 48, 199–213.

Bustamante P, Germain P, Leclerc G et Miramand P (2002). Concentration and distribution of 210Po in the tissues of the scallop Chlamys varia and the mussel Mytilus edulis from the coasts of Charente-Maritime (France). Mar Pollut Bull, 44: 997-1002.

Carvalho, F.P., 1988. Po-210 in marine organisms , a wide range of natural radiation–dose domains. Radiat. Prot. Dosim. 24, 113–117.

Cherry, R.D., Shannon, L.V., 1974. Alpha radioactivity of marine organisms. Atom. Energy Rev. 12, 3–45.

Diagne I, Ndiaye M, Ndiaye B, Diop A , Thiom M, 2013. Evaluation de la contamination métallique des moules Mytilus gallo provincialis et des sédiments marins au niveau des côtes de la région de Dakar (Sénégal). Int. J. Biol. Chem. Sci. 7(2): 872-883, April 2013

IAEA/QA/34. IAEA Analytical Quality in Nuclear Applications Series N0 34

IAEA, 2003. International basic safety standards for protection against ionizing radiations and for the safety of radiation sources. Safety Series No. 115, IAEA, Vienna.

Germain P, Leclerc G, et Simon S (1995-a). Transfer of polonium-210 into Mytilus Edulis (L.) and Fucus vesiculosus (L.) from the baie de Seine (Channel coast of France). Sci Total Environ, 164: 109-123.

Mc Donald P, Baxter MS et Scott EM (1996). Technological Enhancement of Natural Radionuclides in the Marine Environment. J Environ Radioactiv, 32(1-2): 67-90.

Ndiaye B. and al Ndiaye, B., Ndiaye, M., Pérez-Cid, B. and Diop, A. (2015) Distribution of Inorganic and Total Mercury in Marine Sediments from Two Coastal Areas Delimited by Atlantic Ocean: Galician Rias (NW Spain) and Coast of Dakar (Senegal). Asian Jou rnal of Chemistry , 27, 2707-2711. https://doi.org/10.14233/ajchem.2015.18869

Notes Africaines , 1968. L'îles au serpents. Bulletin de l'IFAN,Université Cheikh Anta Diop N 120, Page 87-108

Pollard, D., Ryan, T.P., Dowdall, A., 1998. The dose to Irish seafood consumers from Po-210. Radiat. Prot. Dosim. 75, 139–142.

Rozmaric M, Rogic M, Benedik L, Štrok M, Barišic D, Astrid Gojmerac Ivšic ,´ c aRudjer Boskovic ,Ivsic A.G. , 2012.. ^{210}Po and ^{210}Pb activity concentrations in Mytilus galloprovincialis from Croatian Adriatic coast with the related dose assessment to the coastal population.Chemosphere 87 (2012) 1295-1300

Ryan TP, Dowdall AM, Mc Garry AT, Pollard D et Cunningham JD (1999). 210Po in Mytilus edulis in the Irish marine environment. J Environ Radioactiv, 43(3): 325-342.

Stepnowski P et Skwarzec B (2000). A comparison of 210Po accumulation in molluscs from the southern Baltic, the coast of Spitsbergen and Sasek Wielki Lake in Poland. J Environ Radioactiv, 49(2): 201-208.

Wilgust MA, McDonald P et White KN (1998). Temporal changes of 210Po in temperate coastal waters. Sci Total Environ, 214(1): 1-10.