^{210}Po in epiphytic lichens of peninsular India

There are about 13,500 lichen species inhabiting the earth[1]. They extend from the tropics to the polar regions in a variety of habitats such as tree barks, leaves, bare rock surfaces, cooled lava flows, desert sands and tundra soils. Lichens are suitable bio-monitors due to their sensitivity to pollutants[2]. ^{210}Po activities in plants have been correlated with the presence of radon sources in the surroundings[3]. Several factors influence the metal level in lichens. These include the prevailing wind direction, vertical mixing of air, air currents and season[4,5].

The external sources of natural radiation include cosmic rays and primordial radionuclides (^{238}U and ^{232}Th), and their decay products. ^{210}Po belongs to the natural uranium-238 series and possesses a physical half-life of 138 days[6]. The main source of ^{210}Po entering the atmosphere is ^{222}Rn, a daughter product of ^{226}Ra, which continuously escapes from the surface of the earth. ^{222}Rn decays to ^{210}Pb and ^{210}Po, which attach themselves to atmospheric particulates and are transported back to the earth's surface[7,8]. Alpha particles (5.3 MeV) emitted from ^{210}Po can disrupt cell structures, fragment nuclei, damage DNA and cause cell death[9]. Thus the presence of ^{210}Po in the atmosphere should be viewed with health concern. No literature is available on the polonium levels in lichens of Kanyakumari coast, which is considered to be a high background radiation area. In the present study, an attempt has been made to assess the ^{210}Po activity in epiphytic lichens in select locations.

The sampling locations for the present study extended from Vallavila (8°16′54.01″N, 77°6′52.57″E) to Ambalapathy (8°5′40.24″N, 77°27′35.81″E) along the southwest coast of Kanyakumari District (Figure 1). Lichen samples were collected from 19 sampling locations (Table 1) and all these locations were marked with the help of a Global Positioning System (GPS; Garmin – GPS 12). Samples were mostly collected from coconut trees within a height of 2–13 ft. Morphometric data such as length (thallus holdfast to tip) and width of the thallus were recorded to the nearest 0.1 cm. The sample, after being measured for wet weight, was dried in a hot-air oven to constant weight. Four grams of the dried sample was taken for ^{210}Po estimation. The samples were acid-digested and ^{210}Po was plated in a hanging silver disc with the help of a magnetic stirrer with thermostat in 0.5 N HCl medium. The ^{210}Po activity of the lichen samples was measured using the Nucleonix Radiation Counting System (RC 605A)[10]. The ^{210}Po in the samples is reported in Becquerel per kilogram (Bq kg^{-1}). The external dose due to gamma rays was measured with the help of a hand-held survey meter (Nucleonix®-UR705) and the annual effective dose (AED) was calculated and reported in milli Sievert per year (mSv yr^{-1}) using the formula: AED = Total dose in nano Gray/hour (nGy/h) $\times 24 \times 365.25 \times 0.7 \times 0.2 \times 10^{-6}$ mSv yr^{-1}, where total dose in nGy/h is the survey meter reading in micro Roentgen/hour (μR/h) multiplied by a factor of 9 (where 9 is the μR/h to nGy/h conversion factor): 24 is the number of hours in a day; 365.25 is the number of days in a year; 0.7 is the Gy to Sv conversion factor; 0.2 is the outdoor occupancy factor and 10^{-6} is the nSv to mSv conversion.

The strength among the variables such as ^{210}Po activity, ambient gamma activity and morphometry was estimated using Karl–Pearson's product moment correlation coefficient.

The length of lichen thallus among the sampling locations ranged from 1 to 18.5 cm and the width from 0.1 to 1.2 cm. The maximum-sized lichen was observed in the sampling location Rajakamangalam Thurai and the minimum in Vallavila (Table 1). The activity of ^{210}Po in the lichen samples varied from 23.21 ± 5.77 to 67.33 ± 8.8 Bq kg^{-1} dry wt, with a mean of 36.47 ± 13.38 Bq kg^{-1} dry wt. Lichens from Manavalakurichi, where the Indian Rare Earths Limited is located, recorded the highest ^{210}Po activity and the lowest activity was recorded from Paruthikadavu. AED ranged from 0.17 to 4.0 mSv, with a mean of 1.17 mSv. The highest AED was recorded at Manavalakurichi II and the lowest at Chinnathurai. No significant correlation was noted between gamma dose, lichen size and lichen polonium activity. There was only a weak relationship ($r = 0.16$, $P > 0.05$) between the size of the lichen thallus (length) and lichen ^{210}Po activity. Polonium activity was not found to change with the size of the thallus. Thus, it can be inferred that ^{210}Po accumulation is not influenced by the size of the lichen, but by some other parameters. The ambient gamma doses in all the sampling stations were also related with the lichen polonium activity. A weak relationship ($r = 0.16$, $P > 0.05$) was observed between gamma dose and ^{210}Po activity. This was done to prove the fact that in high background areas, high emanation of ^{222}Rn is possible and subsequently high ^{210}Po in

Figure 1. Map showing the study area and sampling locations (courtesy: Google Earth).

Table 1. ^{210}Po activity in lichens, annual effective dose and thallus morphometry

Sampling location	Sampling coordinates (GPS reading)	^{210}Po activity in lichen samples (Bq kg^{-1} dry wt)	Annual effective dose (mSv)	Thallus length (cm)		Thallus width (cm)	
				Range	Mean	Range	Mean
Vallavila	8°16′54.01″N; 77°6′52.57″E	23.83 ± 5.52	0.25	1–4.5	1.78	0.1–0.4	0.2
Kirathoor	8°16′47.9″N; 77°7′47.37″E	30.8 ± 5.54	0.77	1.4–7.9	2.25	0.1–0.4	0.17
Chinnathurai	8°16′4.73″N; 77°7′52.46″E	41.27 ± 7.19	0.17	1.6–11.5	3.84	0.1–1	0.33
Paruthikadavu	8°15′58.32″N; 77°9′45.33″E	23.21 ± 5.77	0.56	2–8.6	3.96	0.1–0.5	0.22
Keezhkulam	8°13′28.98″N; 77°11′17.25″E	24.56 ± 5.68	2.49	1.7–11.8	5.32	0.1–0.5	0.3
Melmidalam	8°12′27.31″N; 77°12′31.56″E	35.97 ± 6.74	1.98	1.5–6.9	3.38	0.1–0.4	0.19
Colachel	8°10′28.08″N; 77°15′13.47″E	38.68 ± 6.79	0.78	1.4–8.3	3.43	0.1–0.2	0.17
Mondaikaud	8°9′33.11″N; 77°17′3.23″E	25.44 ± 6.16	2.58	2–9.1	3.81	0.1–0.6	0.22
Periakulam	8°10′25.33″N; 77°18′15.69″E	41.09 ± 7.01	0.36	1.5–8.7	3.8	0.1–0.3	0.14
Manavalakurichi II	8°9′6.77″N; 77°19′56.89″E	23.74 ± 6.33	2.67	1.8–11	4.16	0.1–1.3	0.33
Manavalakurichi I	8°9′13.05″N; 77°17′39.16″E	67.33 ± 8.80	4.00	1.7–9.9	5.14	0.1–0.4	0.24
Muttom	8°7′59.52″N; 77°19′5.15″E	51.91 ± 7.86	0.85	1.8–10.7	4.78	0.1–1	0.35
Vellamodi	8°8′28.14″N; 77°19′57.90″E	33.37 ± 6.68	0.52	1.9–8.6	4.02	0.1–0.8	0.3
Santhapuram	8°9′29.52″N; 77°21′51.14″E	24.46 ± 6.38	0.60	1.7–9.3	4.57	0.1–1	0.32
Rajakamangalam Thurai	8°7′5.81″N; 77°22′30.84″E	64.92 ± 9.07	0.92	2.5–18.5	5.17	0.1–1.1	0.25
Melakrishnanputhoor	8°6′39.58″N; 77°25′25.15″E	47.05 ± 7.98	0.36	2–8.9	3.8	0.1–1	0.38
Sankuthurai	8°6′5.27″N; 77°25′31.50″E	27.42 ± 6.75	1.39	3.5–10.8	7.85	0.5–1.2	0.8
Ambalapathy	8°5′40.24″N; 77°27′35.81″E	36.88 ± 7.26	0.75	3.8–10.1	7.42	0.3–1.2	0.64
Nagercoil	8°10′17.2″N; 77°26′21.2″E	30.97 ± 7.16	0.30	–	–	–	–

lichens can be obtained[3]. The absence of a significant positive relationship between gamma dose and ^{210}Po activity ($r = 0.16$, $P > 0.05$) also suggests that low air ^{210}Po levels could be attributed to the low soil uranium, as thorium deposits are high in the study area[11]. In the sampling locations Keezhkulam, Mondaikaud, Manavalakurichi I and Manavalakurichi II, the AED due to ambient gamma activity (external) crossed the world average of 2.4 mSv yr^{-1} (doses from all sources of natural radioactivity)[12]. It can be assumed that the air ^{210}Po levels would vary among the 19 sampling locations and that the intake of ^{210}Po due to respiration by humans can be high in a few sampling locations, as reflected by the lichen polonium levels. Apart from the soil ^{222}Rn emanation, the accumulation of ^{210}Po by lichens may be affected by other parameters such as wind, rainfall, humidity and other competing ions which are not considered in this study[13]. This study paves the way for future studies to assess the risk of air ^{210}Po levels to humans and to find other parameters that affect the accumulation of this radionuclide in lichens.

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