RADIONUCLIDE DETERMINATION IN BOTTOM SEDIMENT OF THE PINHEIROS RIVER-SAO PAULO

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Abstract.

Radionuclide contents were determined in bottom sediment of the Pinheiros river, at west metropolitan area of the Sao Paulo city. The Instituto de Pesquisas Energeticas e Nucleares (IPEN) has continuously discharged low level radioactive effluents into the Pinheiros river, giving rise to radionuclides association with riverbed sediment; the major contributors to the effluent release source term have been Unat, ^{60}Co, and ^{137}Cs. The results showed that the activity of natural radionuclides and activity of ^{137}Cs found in the sediment was close to the expected background, not allowing a clear discrimination of the IPEN's contribution. The ^{60}Co was the only other artificial radionuclide detected, with concentrations ranging from 0.20 Bq/kg to 0.85 Bq/kg dry, at some points of the river.

1. Introduction.

This paper describes the determination of radionuclides concentration in the bottom sediment of Pinheiros river, which drains the area of the Instituto de Pesquisas Energéticas e Nucleares (IPEN), at west metropolitan area of the São Paulo city.

The aim of this study is to evaluate the level of accumulation of radioactive sediment along the Pinheiros river, due to the radioactive liquid effluents released from IPEN, and to provide data to the study of dispersion of radionuclides released to the river.

The continuous release of low level radioactive liquid effluent to the Pinheiros river was begun soon after the establishment of the IPEN in 1957. Such releases are controlled and limited in accordance with the discharge limits adopted at IPEN(1). In the last 5 years the total cummulative quantity of radionuclides discharged in the river has not exceeded $8.3x10^9$ Bq(2); the major contributors for this activity were the Unat ($2.7x10^9$ Bq), ^{60}Co ($1.9x10^9$ Bq) and ^{137}Cs ($4.8x10^8$ Bq). The IPEN's effluent enters Pinheiros river at a point located 7 km downstream from the junction with Tiete river.

The Pinheiros river is an artificial unlined channel extending 26.2 km from the Tietê river to the Billings reservoir (Figure 1). At the present, its water quality is degraded to such an extent that the water can not be consumed and aquatic life is no more available.

The tributary streams are sources of a large quantity of solid materials that reduces its flow capacity. To prevent flooding in rainy days, periodic dredging is carried out at critical points, and the excess bed load is deposited in specific places along the river bank. Since the dredged sediment could become a potential source of radiation exposure to man, radionuclide contents was monitored in the bottom sediment along the river and at two dredged sediment deposit sites.

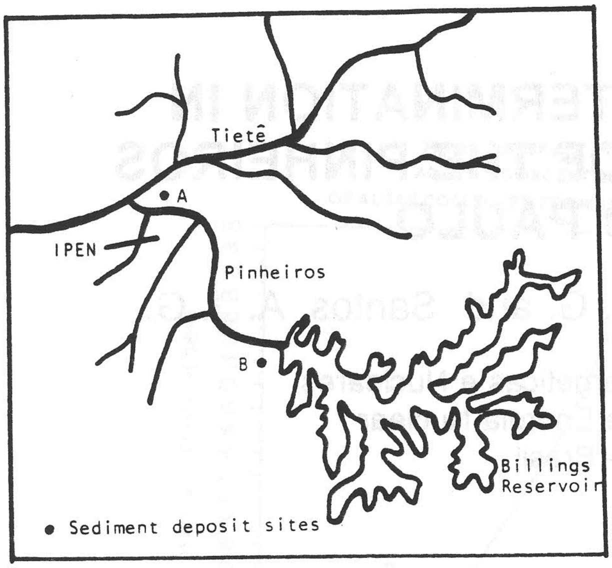

Figure 1. Draining basin of IPEN.

2. Sampling and Measurement Procedures.

In the summer of 1992, bottom sediment was collected in a cooperative programme with the Instituto de Pesquisas Tecnologicas do Estado de São Paulo (IPT).

The river was divided in 47 sampling sections, extending from the junction with the TietÛ river downstream to the Billings reservoir, each of them measuring about 500 meters. Only one snapshot sample was collected at each sampling section, alternately at left hand, center and right hand of the river. Also, 4 samples were collected from two sediment deposit sites, at 0 to 2 meters soil deep.

The bottom sediment were sampled by a manual dredger, mounted on a motorized boat. It was collected, at each section, about 5 to 10 kg of sediment, from its superficial layer.

The collected sediment was dried, calcinated and analyzed for determination of ^{238}U and high energy gamma emitters contents. ^{238}U was measured by thermal neutron activation analysis; high energy gamma emitters were measured by a 20% relative efficiency coaxial HPGe detector, in a 850 cm^3 Marinelli beaker, for a counting time of 100.000 seconds.

3. Results.

Results of the radionuclide determination at each one of the 47 sections of the river, and at 4 points of the sediment deposit site A and B (Figure 1), are presented in Table 1. The distance indicated in the first column of the Table 1 was measured from the junction with the Tiete river, downstream to the Billings reservoir.

The results show that radionuclide concentration in the bottom sediment of the Pinheiros river lies within the expected range for natural radionuclides, not allowing any clear correlation with the IPEN's discharge into this river. For artificial radionuclides, the ^{60}Co and ^{137}Cs were the only two radionuclides detected, at levels ranging from 0.20 Bq/kg to 0.85 Bq/kg dry for ^{60}Co and from 0.30 Bq/kg to 0.98 Bq/kg dry for ^{137}Cs, at some sections of the river.

It can be seen that there is no observable trend of radionuclides accumulation at any location downstream the discharge point. This is due to the relatively small quantity of radionuclides released to the river, and also to the continuous input of solid materials carried by tributary streams, causing the periodic dredging of the major sediment accumulation points along the river.

4. Conclusions.

From the above results one can conclude that the contribution of the IPEN's discharges to enhance the radionuclide concentration in the bottom sediment of the Pinheiros river is very small. Also, these results show that the radioactive liquid efluent emission from IPEN is being properly controled.

5. Acknowledgments.

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6. References.

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Table 1. Radionuclide concentration in the bottom sediment of the Pinheiros river (in Bq/kg).
Distance is given in meters (L = left hand; C = center; R = right hand)

Distance	U-238	Ra-226	Ra-228	Th-228	Be-7	K-40	Co-60	Cs-137
1000L	48.2±7.2	30.7±0.6	48.1±1.5	45.4±1.3	10.4±0.5	309.7±4.6	0.38±0.06	<0.28
2000R	ND	79.4±3.5	117.5±4.4	107.4±4.5	<41.5	490.0±8.2	<0.91	1.3±0.2
2500R	ND	66.3±1.0	98.8±1.6	95.4±1.0	6.8±0.1	422.2±5.9	<0.39	0.33±0.05
3000C	71.2±10.7	56.9±0.8	110.6±2.4	100.2±2.5	35.1±1.2	391.3±5.8	0.85±0.07	<0.44
3500C	ND	52.4±0.6	85.7±2.1	77.4±3.5	16.6±1.4	432.2±6.4	<0.37	0.47±0.06
4000R	74.9±11.2	66.0±1.6	109.2±2.4	106.5±1.5	22.2±0.6	386.5±6.8	0.30±0.07	0.31±0.03
4500C	ND	58.2±1.2	84.5±2.1	75.9±3.0	9.9±0.7	342.3±4.8	0.34±0.28	0.34±0.05
5000L	90.3±13.5	76.2±1.7	86.3±2.1	79.1±1.0	61.0±2.0	378.0±5.3	<0.50	0.46±0.06
5500C	ND	85.1±1.9	121.1±1.5	120.7±3.6	5.9±0.5	317.3±4.7	<0.32	<0.22
6000C	ND	28.8±1.6	42.3±3.7	38.3±5.2	<94.2	321.8±15.8	<0.67	<0.56
6500R	ND	70.6±1.1	83.0±2.2	76.1±3.2	64.5±1.6	379.5±5.0	<0.30	0.32±0.09
7000C	95.2±14.3	63.3±4.4	77.5±1.0	74.1±1.7	8.3±1.0	309.6±7.3	<0.22	<0.23
7500L	ND	68.4±1.5	81.7±1.8	79.3±2.0	<4.0	339.9±5.4	<0.38	<0.25
8000C	ND	72.3±1.0	81.1±2.1	76.5±1.5	9.9±0.4	350.1±6.0	<0.28	<0.29
8500R	ND	78.7±1.2	79.5±2.1	76.8±1.9	43.2±1.6	375.1±6.0	<0.30	<0.40
9000C	ND	64.2±1.2	78.4±1.4	70.9±2.1	15.7±0.5	378.0±4.4	<0.32	<0.30
9500L	ND	52.5±1.2	91.4±1.8	89.3±2.2	11.2±0.2	306.9±4.0	0.29±0.09	<0.27
10000C	79.1±11.9	69.4±1.0	97.6±1.6	86.5±2.6	41.8±0.7	362.5±9.5	0.43±0.04	0.32±0.06
10500R	ND	54.1±1.0	82.4±2.0	73.5±1.7	17.9±0.6	309.0±4.5	<0.47	0.31±0.06
11000C	70.9±10.6	71.5±1.4	110.6±2.4	90.1±1.7	22.7±0.7	394.2±6.8	<0.44	0.44±0.06
11500L	ND	82.1±1.6	102.0±2.0	100.6±3.3	9.5±0.8	361.4±1.9	<0.50	0.30±0.07
12000C	96.5±14.5	90.8±1.7	126.6±1.7	103.7±4.5	39.4±1.6	379.6±7.5	0.60±0.06	0.54±0.06
12500R	ND	61.9±1.2	82.6±1.6	77.8±4.3	21.1±1.8	358.8±5.4	<0.50	<0.30
13000C	66.7±10.0	61.6±1.1	85.9±1.5	74.0±1.8	15.4±1.2	376.2±6.0	<0.45	0.39±0.08
13500L	ND	71.7±1.4	103.4±2.4	96.7±3.4	21.7±1.6	447.8±4.5	<0.34	0.44±0.07
14000C	87.2±13.1	67.7±1.3	87.7±2.2	84.0±1.4	3.8±1.3	421.2±6.1	<0.48	<0.49
14500R	ND	82.8±1.2	112.9±2.3	107.3±2.2	5.6±0.2	408.2±6.2	<0.29	0.45±0.08
15000C	102.5±15.4	78.8±0.9	113.2±2.5	93.0±1.8	48.0±1.0	403.3±6.5	0.66±0.37	0.42±0.10
16000C	ND	33.3±0.7	54.6±1.4	51.9±1.2	3.8±0.7	232.6±4.7	<0.20	<0.43
16500R	ND	74.9±1.2	93.1±2.4	92.3±2.3	12.4±0.5	277.4±1.6	<0.30	<0.45
17000C	85.9±12.9	78.8±1.6	107.2±2.4	94.5±4.6	15.7±0.8	399.7±6.0	0.41±0.08	0.38±0.07
17500C	ND	25.6±0.8	31.6±1.1	30.0±1.0	<5.1	181.8±2.7	<0.23	<0.30
18000L	ND	127.9±2.4	169.7±2.6	170.3±5.0	8.4±1.2	244.4±6.1	<0.38	0.57±0.08
18500C	ND	98.4±2.2	109.3±2.5	97.6±3.3	80.2±3.7	342.9±5.9	<0.32	0.42±0.07
19000R	107.6±16.1	81.5±1.6	89.3±2.2	85.6±3.0	21.1±1.6	299.2±4.7	<0.46	<0.44
19500C	ND	80.3±1.4	107.3±2.5	95.1±2.6	19.4±0.5	350.1±6.1	0.28±0.06	0.58±0.09
21000C	ND	75.6±1.5	108.8±2.0	103.1±1.8	8.0±0.9	253.1±6.1	0.20±0.06	<0.26
21500R	ND	80.7±1.4	103.3±2.7	95.6±2.6	8.8±1.9	324.5±18.1	<0.63	0.57±0.11
22500L	ND	80.3±1.6	100.0±2.3	95.5±3.5	7.3±1.7	374.1±6.6	<0.38	0.59±0.06
23000R	ND	87.6±4.9	128.8±3.3	107.8±3.2	25.6±6.9	391.7±6.5	<0.49	0.35±0.08
23500C	ND	83.4±1.9	97.2±2.4	95.2±3.9	11.9±1.4	382.1±4.1	<0.30	0.35±0.06
24000L	100.2±15.0	90.7±4.6	138.3±6.9	112.6±7.3	<99.4	497.7±5.6	<1.1	<0.96
A1	ND	46.5±1.1	64.4±1.7	62.1±1.6	<18.9	381.4±4.3	<0.25	<0.38
A2	77.4±11.6	71.8±2.3	109.3±6.0	99.3±5.3	<88.0	543.1±7.4	<1.4	<0.85
B1	ND	39.8±2.4	55.8±3.7	52.1±2.4	<76.6	256.3±7.1	<0.62	<0.56
B2	ND	101.8±4.5	133.7±3.4	123.4±3.7	<51.6	432.2±8.3	<0.90	0.98±0.11

ND = Not Determined