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RADIOMETRIC PARAMETERS IN FRESHWATER SAMPLES OF CENTRO EXPERIMENTAL ARAMAR (CTMSP/BRAZIL)

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ABSTRACT

Experimental results are described obtained with gamma spectrometry, alpha and beta gross counts, liquid scintillation and fluorometry techniques for the measurement of background radiation in surface water samples, collected in Centro Experimental Aramar and surroundings, from 1988 to 2009. The estimated average background radiation concentrations in water samples in this region are low, related to the Low Level Detection limits of the techniques, and indicates good water quality parameters, and low interference in the environment in Centro Experimental Aramar and region.

Keywords: Water samples; Water quality parameters; Gamma spectrometry; Environmental protection

1. INTRODUCTION

As modern civilizations strive aggressively to increase their high standards of living in industrialized countries, they drain resources from the entire globe and prejudice the environment in a frequently irreversible way [1,2,3]. In this world increasingly stressed by our activities, political decisions made every day either add to or lessen the stress. At present, in Brazil, there is a framework of institutions and laws that governs the degree industry is permitted to affect the environment. These laws and their enforcement, although imperfect, have had a generally good effect in the direction of protecting and improving the conditions of the environment [4].

The Centro Tecnologico da Marinha (CTMSP) is a military research organisation, located in São Paulo city (Brazil), whose objectives are to set up nuclear and energy systems for Brazilian naval Ship propulsion. These projects are being developed in Centro Experimental

Aramar, situated at Ipero city (100 km from São Paulo).The investigation of background radiation concentrations in water samples of the Centro Experimental Aramar and region are of great significance because an industrial nuclear research programme is being assembled in this centre[5]. Therefore, surface water samples from environmental stations have been collected and analysed systematically, since 1988(2^{nd} semester), by using gamma spectrometry, alpha and beta gross counts, liquid scintillation and fluorometry techniques [6,7] and several other techniques for water chemical parameters analysis [8]. The main objective is to assess the water quality parameters and verify the possible interference in the environment. The measurements were performed in addition to the Environmental Monitoring Programme, carried out by the radioecological laboratory in this region [9].

This study provides a reference level for the purposes of water quality parameters analysis and comparative monitoring, specifically, knowledge of radioactive concentrations and water chemical parameters is a basic task in determining the quality parameters, background levels, transfer, dosimetry and environmental conditions implications.

2. MATERIALS AND METHODS

The Environmental Monitoring Program has been conducted by the Radiation Protection and Environmental Control Department (CTMSP) and is being systematically carried out in this center and region (this region corresponds to an area defined by a 10 km radius circle) by collecting and analyzing soils, fish, grass, water, milk, harvest and air samples in 124 environmental stations, since 1988[6,7,9]. Surface water samples are collected in 11 environmental stations, distributed on Ipanema river (five sample points: 1,2,3,4,8), Sorocaba river (four sample points : 5,6,7,9) and in Ferro stream (two sample points: 13,15), located in the vicinity of this nuclear research center,as can be seen in figure 1. The UTM (Universal Transverse Mercator) location coordinates of the environmental stations for water sampling are:
a)Ipanema river:(1){234738E,7406988N}2){235051E,7409710N}(3){235179E,7409948N}(4){235290E,7412106N};(8){238303E,7403542N}
b)Sorocaba river:(5){236449E,7413912N}(6){232708E,7413615N}(7){225895E,7415869N}(9){242876E,7406164N},
c)Ferro stream: (13){232597E,7411083N} (15){231720E,7409390N}. The sample preparation methodologies are described in references [9,10]. The frequency of the collected and analyzed samples has been not the same along the years, caused by technical conditions, but in general it was monthly [9] .

The gamma spectrometry, alpha and beta gross counts, liquid scintillation and fluorometry measurements are well known techniques employed for several kinds of analyses [8,9]. Gamma spectrometry were performed by using a 65 cm^3 Ge intrinsic detector with a relative efficiency of 25% and a resolution of 1.9 keV (FWHM) for the 1332 keV peak of ^{60}Co. This detector was coupled to a 4096 multichannel which was connected to a microcomputer. Spectra were analyzed using the software Maestro – Egg Ortec. The energy efficiency curve was obtained using a set of gamma ray reference sources. The ^{238}U natural series activity was

estimated from de 351.9 keV and 609.3 keV gamma lines of ^{214}Pb and ^{214}Bi, respectively. The ^{232}Th natural series activity was estimated from the ^{228}Ac emission at 911.1 keV. The samples were sealed and the measurements were made one month later to ensure equilibrium between the isotopes and its daughters [11]. The gamma spectrometry system calibration has been periodically checked by participating in a National Intercomparison Program (PNI) for water sample analysis , conducted by Secondary Standard Dosimetry Laboratory (IRD / CNEN/BRAZIL) [12].

Fluorometry analysis methodology was made by using a digital fluorometry detector model 5015 and the methodology of analysis is described in reference [8].

Tritium counting was performed with a Beckmann (model LS-5801) liquid scintillation spectrometer, using polyethylene vials containing 10 ml of Ultima Gold XR (scintillation) and 1 ml of the distillated sample. The samples were counted during 100 minutes. The counting regions were selected by taking into account the quench level of the samples. Previously tritium spectrum was calibrated using Beckman / Spectrum Analysis software calibration, by measuring a set of ^{3}H standards ((761 ± 5%) dps : activity in 01/02/1991) with different levels of quenching (called #H number). The reproducibility counting efficiency is 1 % [13].

Alpha and Beta gross counts were performed in a Berthold LB-770-2 low level counter, containing ten proportional gas detectors. The efficiencies previously determined were 13 % for alpha counting and 34 % for beta counting , by using calibrated ^{230}Th alpha source and ^{90}Sr beta source .

3. RESULTS AND DISCUSSION

The low level detection limits (LLD) of the gamma spectrometry technique are shown in table1. The values are related to the ^{214}Pb (^{238}U-serie) and ^{228}Ac (^{232}Th-serie) limits detection. These values are variables, because the software and the preparing methodology changed along the years [9]. Nowadays, the ^{214}Pb concentrations are lower than 0.20 Bq/l and the ^{228}Ac concentrations are lower than 0.30 Bq/l in the water samples. The ^{214}Pb and ^{228}Ac concentrations obtained in all the samples were LLD values. Those values are in good accordance with the data obtained in the pre-operational conditions[7], indicating a low natural radioactivity in Centro Experimental Aramar and region [13]. The paper published in reference [14] states a contrasting situation: the values of ^{238}U and ^{232}Th concentrations in water rivers nearby uranium mines obtained were enhanced in comparison with concentrations measured in other rivers , indicating an increase of natural radioactivity.

The LLD value for tritium measurement by using the liquid scintillation technique is 14.8 Bq/l [13]. Tritium activities (Bq/l) in fourteen surface water samples were measured in the period from 1990 to 1999 and the results obtained provided an estimate average of (25.9 ± 2.1) Bq/l. The results published in reference [15] indicates tritium activities levels between 0.6 Bq/l (LLD value), and 3.6 Bq/l in rivers of different origin. In spite of this, both values are compatible with the tritium limit concentration in drinking water of 740 Bq/l. established by E.P.A (U.S.A)[16] and 100 Bq/l for waters intended for human consumption[15],

indicating a low natural tritium radioactivity in Centro Experimental Aramar and region [13]. Uranium concentrations results obtained by fluorometry analysis in all samples were LLD values , in agreement with the data obtained in the pre-operational conditions[7], and the data obtained in a similar environmental monitoring programme[17]. These LLD values are also shown in table1 and are variable, because the software and the preparing methodology changed along the years [5].

The LLD values for alpha and beta total counts monitored in these samples are shown in table 1. Alpha and beta results obtained in the majority of the samples analysed were LLD values (more than 95 %). By analyzing the complementary results (5 %) the maximum and average values obtained were, respectively: 0.30 Bq/l and 0.20 Bq/l for alpha counts and 0.80 Bq/l and 0.40 Bq/l for beta counts. The results published in reference[18] indicates alpha activity between 0.06 and 0.13 Bq/l and beta activity between 0.14 Bq/l and 0.36 Bq/l in surface water around a proposed uranium mining site, and the results of alpha activity in water published in reference[19], indicates a value of 0.05 Bq/l. Also, the limits established by E.P.A (U.S.A) [8] indicates that if the average annual concentrations is less than 0.56 Bq/l (15 pCi/l) for alpha gross counts and less than 1.85 Bq/l (50 pCi/l) for beta gross no further analysis are required. By taking into account these limits, the alpha and beta radioactive contaminants in the water samples must be not identified.

TABLE 1. Low Level Detection limits (LLD) used in surface water analysis in all environmental samples

Year	^{214}Pb	^{228}Ac	U	Alpha counts	Beta counts
1988 *	0.27	0.48	0.025	0.13	0.10
1989-1991	0.37	0.48	0.13	0.13	0.10
1992-1995	0.40	0.50	0.13	0.13	0.10
1996-1998	0.20	0.30	0.13	0.13	0.10
1999-2009	0.20	0.30	0.005	0.13	0.10

OBSERVATIONS:

a) by gamma spectrometry technique (^{214}Pb and ^{228}Ac concentrations in Bq/l) ;

b) fluorometry technique (U concentrations in Bq/l units);

c) by using alpha and beta gross counts technique (alpha and beta concentrations in Bq/l) ;

* values were obtained in the pre-operational conditions [7].

4. CONCLUSIONS

The assessment realized in eleven environmental sample points located at Centro Experimental Aramar and region. by taking into account the radioactive parameters in water samples collected and measured in the period from 1988 to 2009. indicates accordance mainly with pre-operational values and governmental limits. and we conclude that practically there are no changes in the water quality radioactive parameters in that sampling points analysed.

REFERENCES

1. Daily . G. C. and Ehrlich. P. R. , Population. sustainability. and Earth`s carrying capacity. *BioScience* **42** (10). 761-771, (1992).

2. Baer. W. , A economia brasileira**.** 4.ed. São Paulo: *Nobel.* 331-361, (1995).

3. Vitousek. P. M.; Mooney. H.A.; Lubchenco. J.and Melillo. J.M., Human domination of Earth´s ecosystems**.** *Science* **277**. 494-499, (1997).

4. Costanza. R., Three general policies archieve sustainability. In: Jansson. A.; Hammer. M.; Folk. C.; Costanza. R. (Eds.) *Investing in Natural Capital*. Washington: Island Press, (1994).

5. CTMSP – available in : < http:// www.mar.mil.br/ctmsp > Acessed in (2009) .

6. IAEA . , Objectives and Design of Environmental Monitoring Programmes for Radioactive Contaminants. *Safety Series 41 (Viena IAEA*),(1975*)* .

7. Hiromoto.G.; Jacomino,V.;Venturini L.; Moreira S.; Gordon,S.; Duarte,C.; Pecequilo,B. and Mazzili,B., Programa de Monitoração Ambiental da Usina de Enriquecimento de Uranio Almirante Alvaro Alberto.*(Instituto de Pesquisas Energeticas e Nucleares- IPEN). Pub.233***,** (1988*).*

8. APHA, Standard Methods for Examination of water and wastewater. 19th ed. *W*ashington DC: *APHA* .Edited by A.D.Eaton. L.S. Clesceri and A.E.Greenberg, (1995).

9. CTMSP- Centro Experimental Aramar, Programa de Monitoração Ambiental -PMA– proceedings of the Symposium “Nuclear Energy and the Environment “ – American Nuclear society/latin american section . held in Rio de Janeiro. from 27 june to 01 july . 1993. **3** . pp 45-52, (1993) .

10. CETESB, Guia de coleta e preservação de amostras de água. São Paulo: *CETESB,*150p, (1988) .

11. Moraes.M.A.P.V.and Daltro.T., Environmental gamma radiation and natural radioactivity in soils in Centro Experimental Aramar and Region. *Radiation Protection Dosimetry* **87**(3). 207-211, (2000).

12. Tauhata.L.;Vianna.M.E. and Faria.R.Q., The Brazilian National Intercomparison Program (PNI/ IRD/ CNEN) evaluation of 15 years of data . *Journal of Environmental Radioactivity* **86**(3). 289-390, (2006) .

13. Moraes . M.A.P.V. and Sartoratto. M., Tritium concentration analysis in environmental water samples of centro nuclear Aramar (CTMSP-Brazil). *Radiation Measurements* **35**. 333-337, (2002).

14. Carvalho .F.; Oliveira .J. and Batista . F., Radionuclides from past uranium mining in rivers of Portugal . *Journal of Environmental Radioactivity* **98** (3) . 298-314, (2007).

15. Palomo .M.; Penalver.A.;Aguilar.C. And Borrul.F., Tritium activity levels in environmental water samples from different origin . *App. Rad. Isot* **65** (9), 1048-1056, (2007) .

16. EPA, U S Environmental Protection Agency - Tentative reference Method for tritium concentrations analysis, (1975).

17. Melo.P.; Souza.E. and Peres.S, Development of an environmental monitoring program for IRD. CNEN . *2005 International Nuclear Atlantic Conference (INAC 2005) held in Santos. S.P. Brazil. from august 28 to september 2*(2005).

18. *Kha*. S.; Kenka. S. and Vdtripathi.R., Radiological assessment of surface water quality around proposed uranium mining site in india . *Journal of Environmental Radioactivity – in press*, (2009*).*

19. Zikocaky. L., Alpha radioactivity in drinking water in Quebec. Canadá . *Journal of Environmental Radioactivity* **88** *(* 3 *)* . 306-309, (2006).

20. CONAMA -Conselho Nacional Do Meio Ambiente , Resolução No 20: “Classificação de Águas Doces. Salobras e Salinas do Território Nacional”. Junho de (1986).

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