Natural and Artificial Radioactivity in Drinking Water in Málaga, Spain.

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INTRODUCTION

Water has a vast importance for numerous human activities, so that securing supplies of drinking water of a standard quality is becoming more and more difficult. The measurement of radioactivity in drinking water permits us to determine the exposure of the population to radiation from the habitual consumption of water. The occurrence of radionuclides in drinking water gives rise to internal exposure of humans, directly on the decay of radionuclides taken into the body through ingestion and inhalation and indirectly when they are incorporated as part of the food-chain The measurement of radioactivity in drinking water permits us to determine the exposure of population to radiation from the habitual consumption of water. An intensive study of the water supply in the city of Malaga during 2002-2010 has been carried out in order to determine the gross alpha activities, gross beta activities and natural and artificial radionuclides present in drinking water. A data base on natural and artificial radioactivity in water was produced. The results indicated that a high percentage of the water sample contains a total gross alpha and beta less than 0.10 Bq/l and 1 Bq/l respectively. The main objectives were: 1) to analyses gross alpha and gross beta activities and to know the statistical distributions. 2) to study the levels of natural and artificial radionuclides 3) to determine a possible mathematical correlation between the radionuclides and several factors.

MATERIALS AND METHODS

The sample point was situated in the Faculty of Science of University of Malaga (4º 28′ 80″ W; 36º 43′ 40″ N) (see Fig. 1). The climate in Malaga is warm, temperate with hot summers and little rain (550 mm is the mean annual precipitation height). The geological structure of Malaga is characterized by predominantly sedimentary rock (carbonated and detritical) which has a low concentration of radioactive elements.

The analytical procedure used for determine the gross alpha activity level was coprecipitation method with a volume of 500 cm^3 of sample water. The level of gross alpha activity is measured by a solid SZn(Ag) scintillation counter.

The beta activity is measured with a gas flow proportional counter of the low-background multiple detector type with four sample detectors (Camberra HT-1000) with a precipitate obtained by evaporation until nearly dry of a maximum volume of sample water of 150 cm^3.

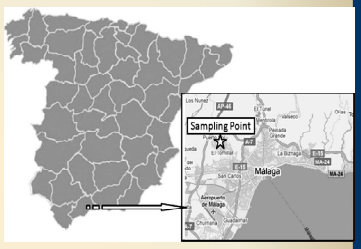


FIG. 1. *The map of sampling location.*

An analysis has also been carried out of radioisotopes by gamma spectrometry using an intrinsic germanium coaxial detector made be CANBERRA with an relative efficiency about 30% to the efficiency of a 3"x3" NaI(Tl) at 25 cm distance. Samples were counted for 48 h to achieve a higher precision. Owing to the low activity level of most samples, for quality control instrumental and reagent blanks were measured frequently. Furthermore, for quality control for gamma-spectrometric analysis we participated in international and national intercomparison analyses

RESULTS I

Table 1 shows the estimates of the arithmetic mean (AM), geometric mean (GM), standard deviation (SD), dispersion factor of geometric mean (DF), maximum, minimum as well as the percentage of samples with concentration below the minimum detectable (%). These values are given in Bqm^{-3} for gross-alpha and gross-beta activities.

TABLE 1. *Statistical parameters of different measurements*

	Date	AM	SD	GM	DF	Maximum	Minimum	%
Gross-α	108	16.53	11.70	12.97	2.08	74.7	1.51	0
Gross-β	108	97.06	57.83	80.99	1.87	301	14.2	7.4

During the sampling period activity measurements were made with gamma spectroscopy for the natural and artificial. The average activity during the sampling periods corresponding to the natural radioisotopes is below the normal level of environmental radioactivity. Only three natural radionuclides have been detected with a frequency of 4.6% (^{40}K), 1.8% (^{214}Pb), 7.4 % (^{214}Bi).

RESULTS II

Fig.2 shows that the assumption of a log-normal distribution is justified. Assuming these types of distribution, the GM for the gross-alpha and gross-beta activities should be used to characterize average values.

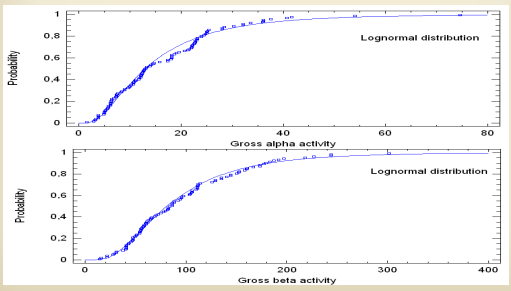
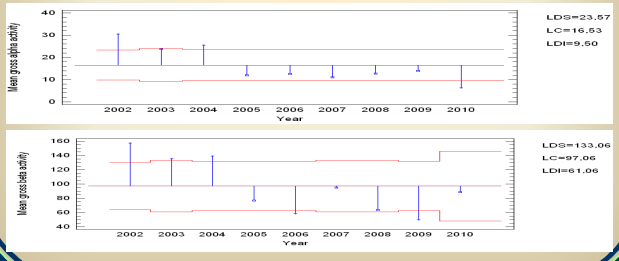


FIG. 2. *Normal probability plot*

RESULTS III

Fig. 3 shows the same behavior in gross alpha and gross beta activities. In 2005 there was a change in the behavior of alpha and beta activities. This year, marked by a severe drought (about 240 mm) comes into operation Desalination plant aimed at improving water quality in the city of Malaga, the procedure using reverse osmosis to treat brackish water. Thanks to this work, and improve water quality characteristics of the population served has been possible to increase supply capacity by allowing use of water resources that were previously under-utilized due to its high salt concentration. The variation of gross-alpha and gross-beta activities in the rest of the years can't be explained by wet and dry deposition. The gross-alpha and gross-beta activities in drinking water do not show correlation with bulk deposition

FIG. 3. *Analysis of means (ANOM) of gross-alpha and gross-beta activities.*



CONCLUSIONS

- The results indicated that a 100% of the water sample contains a total gross alpha and beta less than 0.10 Bq/l and 1 Bq/l respectively being fit for human consumption.
- Gross-alpha and gross-beta activities in drinking water do not show correlation with bulk deposition so we can't find a mathematical correlation between radionuclides activities and meteorological factors.
- The gamma-emitting radioisotopes found were ^{40}K, ^{214}Pb, ^{214}Bi with very low frequency.

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