SURVEY OF GROSS ALPHA AND BETA RADIOACTIVITY IN WELL WATER FROM ZARIA AND ITS ENVIRONS

R. A. Onoja, T. C. Akpa*, S. P. Mallam and I. G. E. Ibeanu,
Health Physics and Radiation Biophysics Section,
Centre for Energy Research and Training , Ahmadu Bello University, Zaria, Nigeria.

(Submitted: 3 July, 2005; Accepted; 30 March, 2007)

Abstract

Thirty –two samples of well water were drawn at random from wells in and aound Zaria Township, Kaduna State. Two drops of concentrated nitric acid were added in two liters of the sampled water for preservation. The samples were later evaporated and counted for gross alpha and beta in an eight-channel-gas-filled proportional counter. Results show that the range of alpha activity in water in the area is 0.58-43.19 Bq/m³, with geometric mean, 6.35±0.45 Bq/m³. The range of beta activity is 3.58-622 Bq/m³ with geometric mean, 75.34±1.53 Bq/m³. Further statistical analyses of the data show that both alpha and beta activities are skewed towards low values and the contour analyses show three area of elevated activity for both alpha and beta. The overall results show that the alpha and beta activities do not necessarily come from the same source and their values are below the WHO practical screening level of radioactivity in drinking water.

Keywords: *Radioactivity, alpha, beta, drinking water*

Introduction

Gross alpha/beta particle activity is a measure of the total amount of natural radioactivity in a water sample attributable to the radioactive decay of alpha or beta emitting from natural decay series. Gross alpha and beta radiation measurement is not a nuclide specific measurement, but is used to create awareness of the level of contamination especially in drinking water. It is also recommended test of drinking water quality. The WHO limit for gross alpha activity in drinking water is 100 Bq/m^3 and 1000 Bq/m^3 for gross beta activity (WHO, 2003). Above these limits, specific radionuclide test is recommended as it is more important for later purification of the water if need be. There is a significant hazard in drinking water containing excess activity to both individuals and to a population, thus gross alpha and beta radiation measurement have been conducted in European countries as routine environmental radioactivity measurements. (CEC, 1982). In the United States of America, there also exists a legislative limit for gross alpha/beta activity in drinking water (USGS, 2000). In other countries and regions of the world, a lot of research efforts have been directed to this measurement.

In Nigeria, neither research nor legislation on the radiological quality of drinking water exists and this may be as a result of low level of development of the nuclear industry in the country. Gross alpha and beta radioactivity measurement involves the use of low-level background proportional counter system. This system is available in the Centre for Energy Research and Training, Zaria. The characterization of this system had been reported in our earlier communication (Akpa, *et al.*, 2004). In this paper we report the results of a survey of gross alpha and beta radioactivity in water from Zaria and environs. The aim is to compare the levels measured with values and limits applicable in other regions of the world.

*Corresponding author

Materials and Methods

Area of survey

The target area of this study is Zaria and Sabon-Gari Local Government Areas of Kaduna State, Nigeria. The area is bounded approximately by latitudes 11°02′S (11.03°S), 11°08′N (11.13°N) and longitudes 7°37′W (7.62°W) and 7°42′E (7.70°E) as is reported in the Nigerian geographical topo map number 102 NW. (NNS, 1965). Fig. 1 is an extraction map describing the research area. The area surveyed lies between 11.04 to 11.18°N and 7.63 to 7.77°E as is measured with a GPS. Zaria is estimated to have a population of over 1.5 million people. Most of the inhabitants live around the Zaria Township in rural settlements, which are well dispersed from each other. They draw their utility water from hand dug wells usually 7 – 10 m deep. The critical source of water for this study is the well water, because most of the people in these areas depend on well water for drinking, domestic activities, irrigation and animal husbandry.

Sampling procedure

The mapped area was arbitrarily divided into 16 grids of 2 cm x 1.6 cm representing an area of one square kilometer. Two settlements within each grid were chosen by simple random process making the total number of sampling points 32. Two litres of water was drawn from sample utility wells into a clean and dry plastic container. Two drops of acid were added to reduce biological actions. No further treatment was made outside the laboratory.

Sample preparation and counting

The acidified sample was evaporated in a beaker at temperature of 150°C. The residue was washed with distilled water and transferred into a counting pan of area 7.1cm^2 with the help of a robber policeman. The residue collected was left to dry in the counting planchet under ambient temperature. Samples were counted using a EURYSIS Proportional Counter Type IN20. The characteristics of the detector in terms of background count rate, detection limit and channel efficiencies were characterised and reported in an earlier communication (Akpa, *et al.*, 2004).

Data Analysis

The sample preparation efficiency was derived using the equation:

$$\varepsilon_s = \frac{(W_{b+s} - W_b) - (W_{b-s} - W_b)}{(W_{b+s} - W_b)} \qquad (1)$$

where W_{b+s} the weight of beaker and sample, W_b is the weight of beaker only, W_{b-s} weight of beaker after sample was recovered from it.

and the specific activity is:

$$Activity\ (\alpha,\beta) = \frac{Rate\ (\alpha,\beta) - Bgd\ (\alpha,\beta)}{Sample\ Efficiency \times Channel\ Efficieny \times Sample Volume} \left(Bq/m^3\right) \qquad (2)$$

Results and Discussion

Table 1 shows the gross alpha and beta radioactivity measured from well water in selected locations within Zaria town. The error quotes are standard deviation from repetition of measurements. Figure 2 is a graphical display of the alpha and beta activities according to locations. The graph shows that 41% of the positions measured showed elevated beta activity. The beta/alpha ratio ranges from 0.67 – 143.71 with a mean of 22.26. The pearson regression coefficient is 0.18 showing that there is no significant statistical relationship between the two set of activities. It is also possible to infer from this that the sources of alpha and beta are not necessarily the same. Table 2 shows a summary of data in Table 1, showing the statistical distribution of the data.

Table 1: Activity concentrations in sampled locations

S/N	Geographical Coordinate	Location	Activity Concentration (Bq/m^3)	
			Alpha	Beta
1	11.5°N,7.65°E	Catholic Church Premises, ABU, Zaria	5.23 ± 1.12	71.69 ± 8.05
2	11.13°N, 7.65°E	Tudun Sarki	0.58 ± 0.45	83.38 ± 7.30
3	11.11°N, 7.67°E	Ungwan Lumbayi	3.03 ± 0.67	74.45 ± 7.75
4	11.11°N, 7.66°E	Ungwan Rafi Magaji	8.04 ± 1.04	562.28 ± 14.92
5	11.09°N, 7.67°E	Kufaina	1.75 ± 0.52	31.46 ± 4.92
6	11.09°N, 7.65°E	Kufaina Karofi	0.92 ± 0.60	31.78 ± 5.07
7	11.10°N, 7.64°E	Sabon Gida	1.64 ± 0.52	70.35 ± 6.49
8	11.04°N, 7.64°E	Leprosy Centre Saye	0.81 ± 0.60	21.98 ± 5.59
9	11.06°N, 7.67°E	Ungwan Makada	17.00 ± 1.58	463.82 ± 3.76
10	11.04°N, 7.70°E	Ungwan Tunkare	36.42 ± 2.09	85.19 ± 5.31
11	11.04°N, 7.70°E	Kufan Gaya	5.13 ± 2.19	3.58 ± 3.31
12	11.05°N, 7.71°E	Kaura Zaria City	19.02 ± 1.36	147.61 ±5.23
13	11.06°N, 7.69°E	Fada Zaria City	5.18 ± 0.88	135.21 ± 5.31
14	11.09°N, 7.71°E	Tukur-Tukur	33.93 ± 2.06	115.41 ± 5.49
15	11.10°N, 7.72°E	Tudun-Jukur	37.12 ± 1.80	184.95 ± 5.17
16	11.08°N, 7.77°E	Tudun Wada	9.13 ± 1.12	11.06 ± 3.95
17	11.07°N, 7.76°E	Ungwan Madora (Dembo)	3.87 ± 0.82	44.84 ± 3.80
18	11.13°N, 7.76°E	Ungwan Malamai	7.13 ± 0.97	120.60 ± 5.67
19	11.15°N, 7.76°E	Ungwan Malam Danfulani	7.12 ± 1.04	35.39 ± 5.37
20	11.15°N, 7.74°E	Zabin Zaria	8.22 ± 0.89	155.59 ± 4.62
21	11.12°N, 7.72°E	Chikaji Industrial Estate	5.77 ± 0.89	34.66 ± 4.10
22	11.12°N, 7.73°E	Chikaji (BTC)	4.31 ± 0.75	86.14 ± 4.17
23	11.13°N, 7.74°E	Kings Road S/Gari	3.91 ± 0.75	336.46 ± 7.45
24	11.11°N, 7.73°E	S/Gari by Rex	43.19 ± 2.34	622.00 ± 10.96
25	11.13°N, 7.63°E	Gidan Ajiya	23.38 ± 1.56	140.95 ± 6.69
26	11.16°N, 7.64°E	L.E.A. Pri. School Samaru, Zaria	6.84 ± 0.93	46.52 ± 5.69
27	11.18°N, 7.68°E	Basawa	7.10 ± 0.99	256.00 ± 6.54
28	11.17°N, 7.72°E	Ungwan Barashi	21.92 ± 1.45	87.12 ± 4.75
29	11.16°N, 7.71°E	Tofu	6.15 ± 0.87	24.42 ± 3.22
30	11.14°N, 7.69°E	Panladan	5.79 ± 0.91	39.69 ± 3.92
31	11.08°N, 7.76°E	Dakache	17.49 ± 1.45	110.25 ± 4.90
32	11.06°N, 7.66°E	Hayin Danyaro	2.18 ± 0.64	42.55 ± 3.73

Table 2: Distribution of activity

Statistical Parameter	Value and Percentage of Measured Activity	
	Alpha	Beta
Minimum Activity (Bq/m^3)	0.58 Bq/m^3	3.58 Bq/m^3
<10 Bq/m^3	72%	3.12%
≥10<30 Bq/m^3	15.5%	9.38%
≥30<50 Bq/m^3	12.1%	28.12%
≥50<100 Bq/m^3	-	18.75%
≥100<200 Bq/m^3	-	25.00%
>200 Bq/m^3	-	15.63%
Maximum Activity Bq/m^3	43.19 Bq/m^3	622.00 Bq/m^3
Number of Samples	32	32
Geometric Mean Bq/m^3	6.35 Bq/m^3	75.35 Bq/m^3

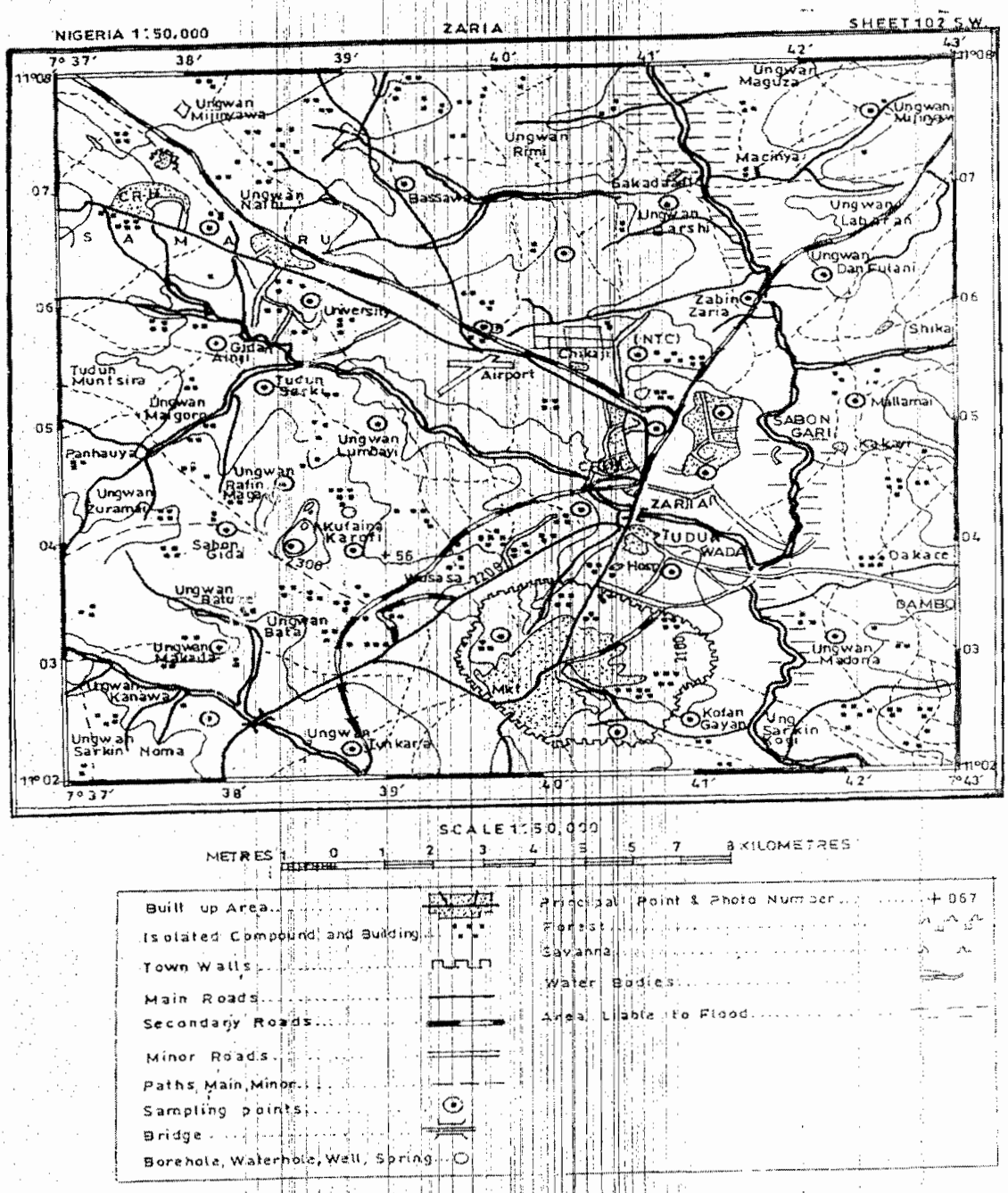

Fig. 1: Sketch of the surveyed area

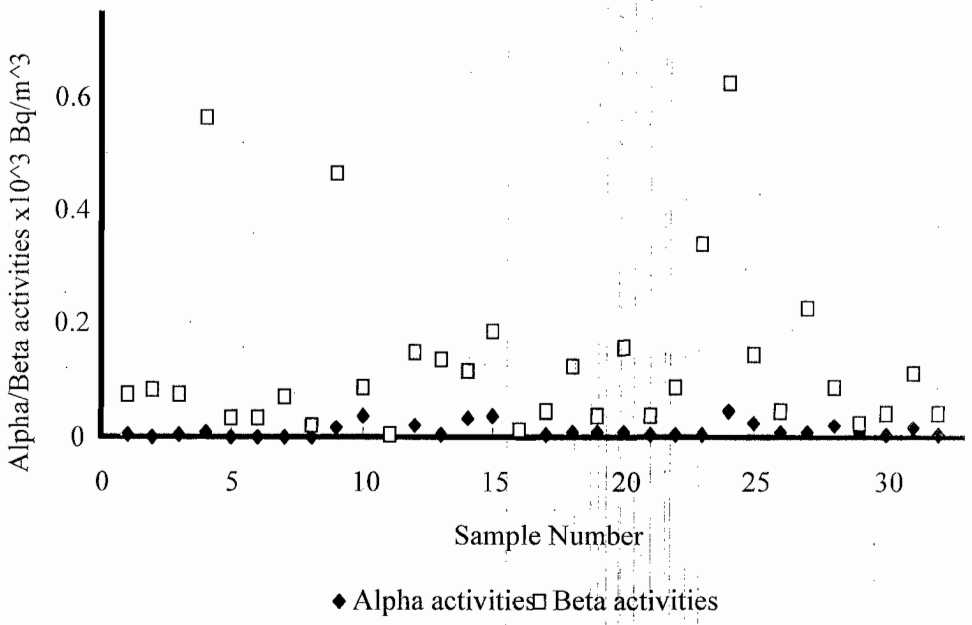

Fig. 2: Graph of gross alpha and beta activity against location number

Fig. 3 and 4 are frequency histograms of the data divided into 10 classes. From figure 3, it could be seen that the distribution of alpha activities is skewed to the left. This means that most of the areas have low alpha activity. The regression curve is log-normally distributed with a =21.23±7.51 representing the maximum theoretical frequency of the distribution. The standard deviation, σ = 0.30±0.08 and the population mean, μ = 1.45±0.04. From figure 4, it could be seen that the distribution of beta activities is skewed to the left. This means that most of the areas have low beta activity. Similarly, the regression curve is a log-normally distributed with a = 13.44±1.03, standard deviation, σ = 0.61± 0.10 and the population mean, μ = 1.18±0.14.

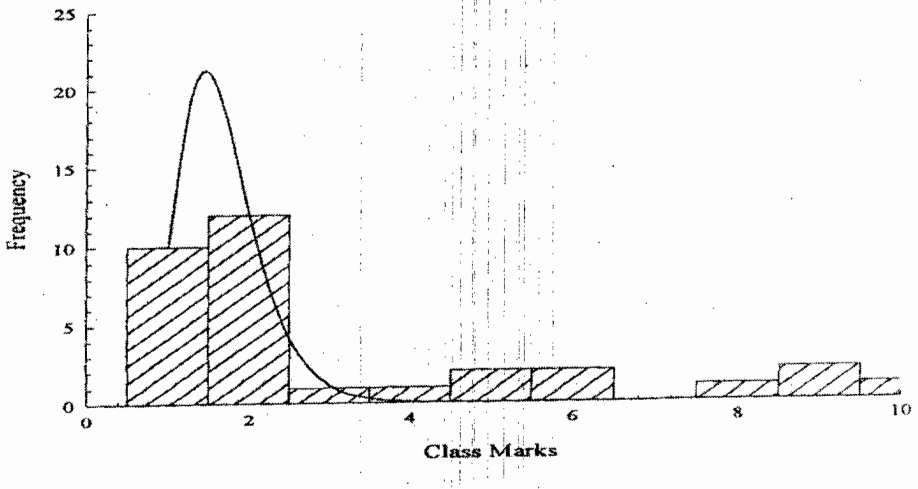

Fig. 3: Histogram of gross alpha activity distribution

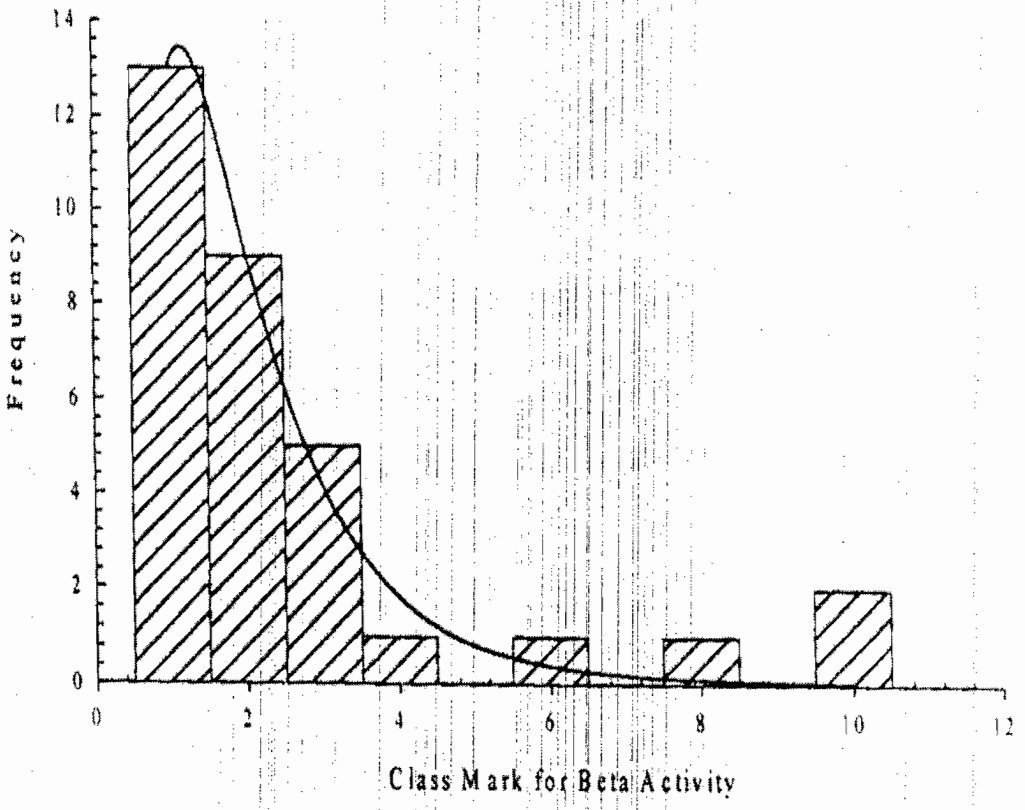

Fig. 4: Histogram of gross beta activity

Figure 5 and 6 are contour graphs that show the density distribution of gross alpha and beta activities respectively. The figures in the contour map represent the activity x10^{1}Bq/m^3. The contour map, fig 5 shows that the areas bounded by longitude 11.095°-11.105°, latitude 7.70°-7.75°; has elevated alpha activities of 30 Bq/m^3 and above. This is a narrow stretch bounded by Tudun-Jukur and Tukur-Tukur towards the west and Sabon Gari by Rex towards the east. A second area includes Ungwan Tunkare bounded by longitude 11.040°-11.045° and latitude 7.66°-7.67°. The other high alpha activity areas (15-20Bq/m^3) bounded by longitude 11.12°-11.15°, latitude 7.62°-7.65° the areas are Gida Ajiya and Ungwan Makada by the west of the sample area. Another area bounded by longitude 11.04°-11.07°, latitude 7.62°-7.72° (Kaura, Zaria City and Dakache). The other areas are said to be of low alpha activity.

Fig. 6. shows that the area covered by longitude 11.090° - 11.115°, latitude 7.10 – 7.76° has elevated activity of 200 Bq/m^3 and above. This is followed by area bounded by longitude 11.100 – 11.125°, latitude 7.650 – 7.685. These areas include Sabon Gari by Rex, Ungwan Makada, through Sabon-Gari (Kings Road) Basawa, up to Ungwan Rafin Magagi. Other areas have low beta activity.

Summary and Conclusion

The counter was used to determine gross alpha and beta activity in well water samples taken from Zaria area. Alpha activity was found to be in the range 0.58-43.19Bq/m^3 with geometric mean value of 6.35 Bq/m^3 and beta activity range to be from 3.58-622.00 Bq/m^3 with geometry mean value of 75.35Bq/m^3.

Statistical analysis of the result show that measured activities were positively skewed with the highest frequency at low activity

values. This means that majority of the area have low activity with few pocket of elevated activity. Areas of higher activity were also determined using the contour plot. The areas of elevated alpha activity include Sabon Gari by Rex, Tudun-Jukur, Unguwan Makada, Unguwan Tunkare, Gida Ajiya, Kaura and Dakache. Areas of elevated beta activity include Sabon Gari by Rex, Unguwan Makada, Kings Road, Basawa and Unguwan Rafin Magaji. This area covers the Zaria industries.

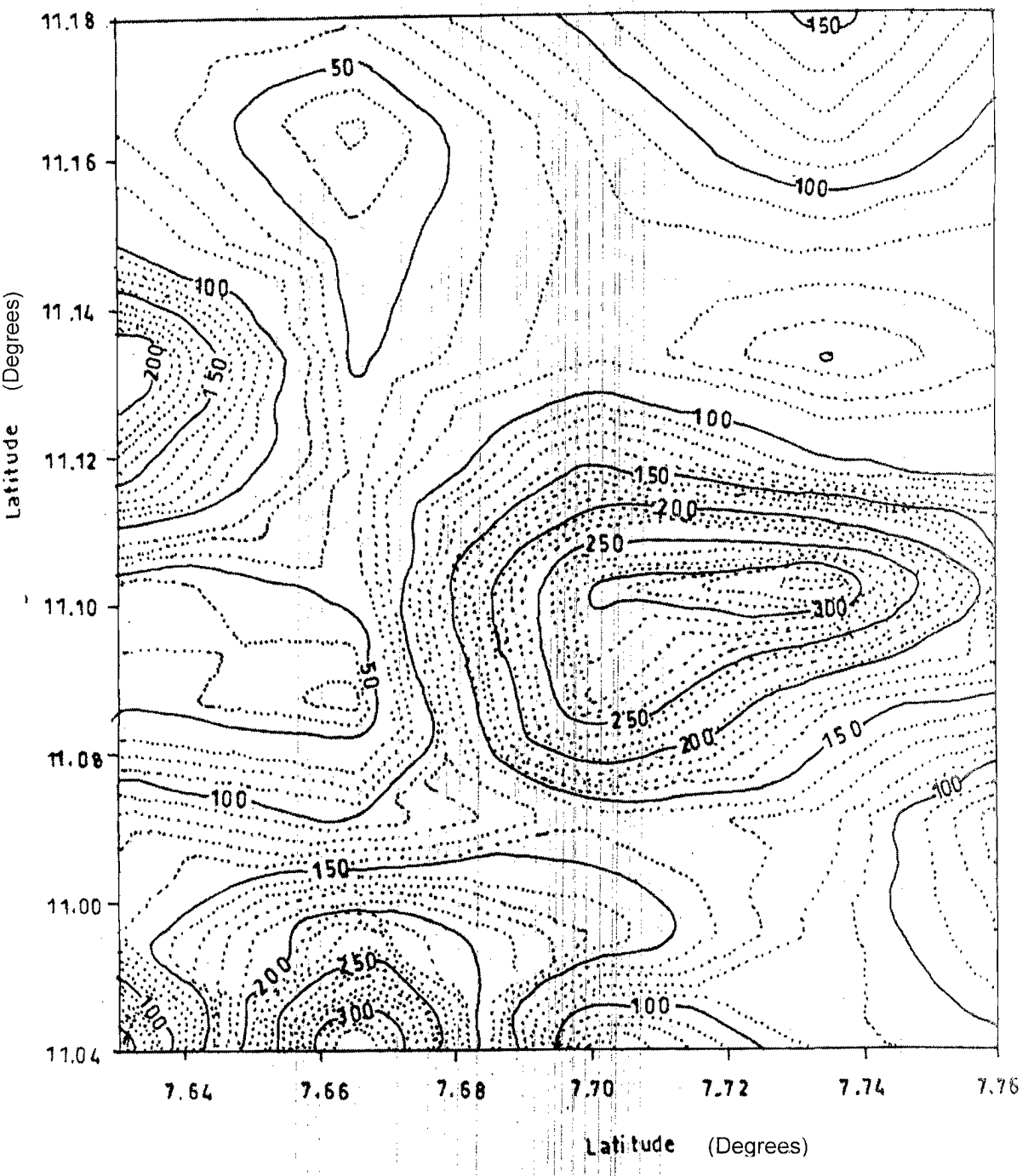

Fig. 5: Contour sketch gross alpha activity

United State Geological Survey (2002): Naturally Occurring Radionuclides in the Ground Water of South Eastern Pennsylvania. USGS Fact Sheet 012-00, April 2000, pp8

World Health Organization (2003): Radiological Quality of Drinking-Water, WHO Guidelines for Drinking Water Quality Volume No.3, pp 18.