Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 5
Open Access

Determination Of Gross Alpha And Beta Radioactivity Levels And Corresponding Doses In Drinking Water Samples From The Southern Coastal Regions Of Tamil Nadu

R. T. Asher Nebin[1], A. Yardily[2]
[1]Research Scholar, Ph.D. Reg. No: 20213162031004, Department of Chemistry, Scott Christian College, Nagercoil, Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamil Nadu, India.
[2]A. Yardily, (Supervisor), Assistant Professor, Department of Chemistry, Scott Christian College, Nagercoil, Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamil Nadu, India.

Cite this paper as: R. T. Asher Nebin, A. Yardily (2024). Determination Of Gross Alpha And Beta Radioactivity Levels And Corresponding Doses In Drinking Water Samples From The Southern Coastal Regions Of Tamil Nadu. *Frontiers in Health Informatics*, *13 (5) 505-513*

Abstract
Exposure to radioactive substances found in drinking water can increase the risk of cancer and various health issues, including immune system problems, reproductive issues, and neurological effects. Radioactive substances can also alter DNA, potentially leading to genetic mutations. The water samples from three different natural background areas (Kanyakumari, Parangipettai and Kalpakkam) were collected and the gross α and β activity were counted using a dual channel gross alpha and beta counted. It was observed that the α activity in the drinking water samples from Kanyakumari zone, Parangipettai zone and Kalpakkam zone ranged from BDL to 0.93 Bq/L, BDL to 1.39 Bq/L and BDL to 0.93 Bq/L with an average of 0.29, 0.41 and 0.27 Bq/L respectively. The beta (β) activity in the drinking water samples collected from the three zones ranged from 0.59 to 34.31 Bq/L, BDL to 6.51 Bq/L and 0.59 to 9.46 Bq/L, with an average of 8.08, 2.1 and 4.86 Bq/L respectively. The annual α-effective dose through drinking water from Kanyakumari, Parangipettai, and Kalpakkam zones were ranged from BDL to 7×10^{-4} mSv/y, BDL to 1×10^{-3} mSv/y and BDL to 7.4×10^{-4} mSv/y respectively and the annual β-effective dose in the three zones ranged from 8×10^{-5} to 4×10^{-3} mSv/y, BDL - 9×10^{-4} mSv/y and 8×10^{-5} to 4×10^{-3} mSv/y respectively.
Keywords: gross alpha, gross beta, drinking water.

Introduction

Radioactivity in drinking water is due to natural or fallout contamination. The nuclear explosion, medical waste, nuclear reactor accidents etc. are the causes for man-made (induced) radioactivity in water. The natural radioactivity in drinking water may be due to the water passing through the rocks which contains primordial radionuclides. This study is focused on the Gross – alpha and Gross – beta radioactivity radio activity measurement in the drinking water from three different zones of Tamil Nadu with varying levels of natural radioactivity.

Gross alpha and Gross beta activity measurement is the measure of α and β emitting particles in the drinking water. These particles are introduced into the environment naturally, by humans, manually and by the deposition on ground and water from the atmosphere, then they get washed away by the water.

Gross - α activity in water is due to the bedrock in earth containing different levels of radioactive elements. Gross – α activity in water indicates the presence of radioactive substances, such as ^{224}Ra and ^{226}Ra.

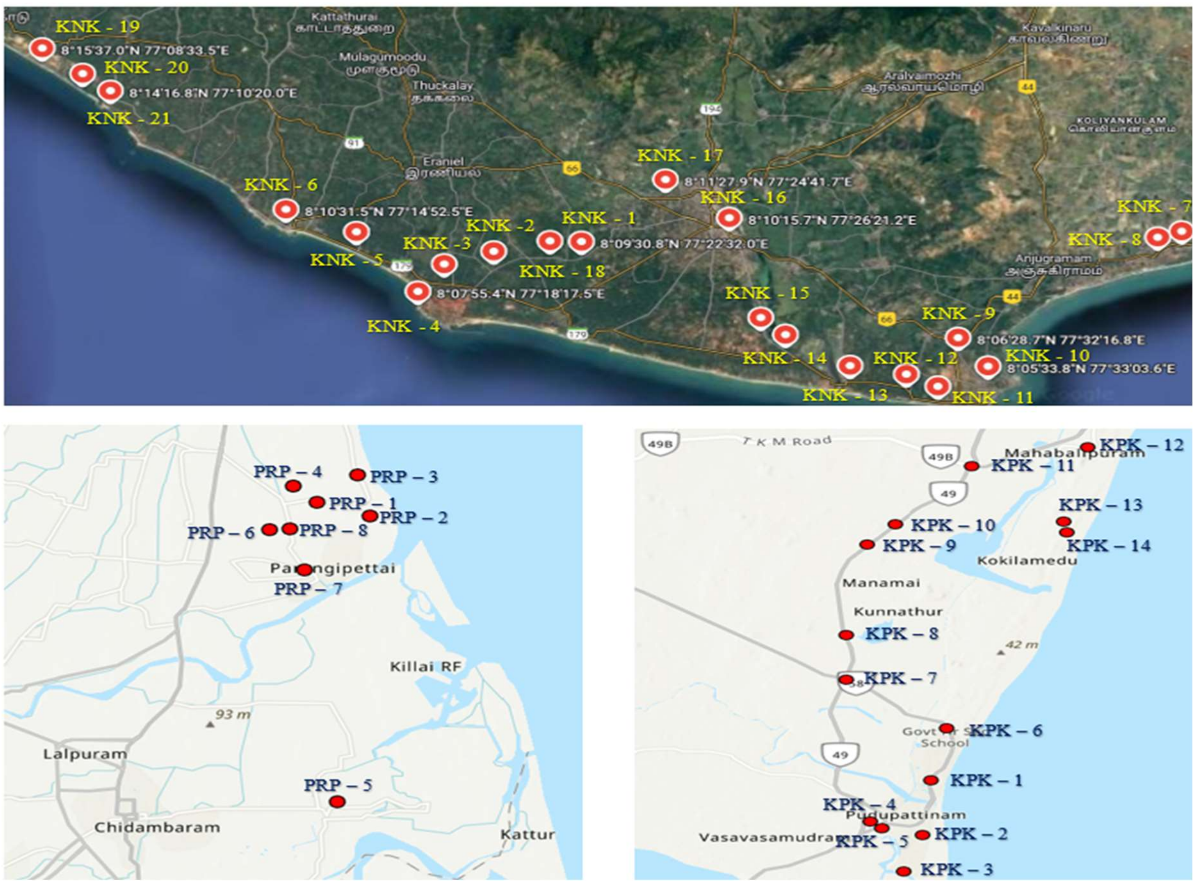
Gross - β activities in ground water is due to the long-lived radionuclides in ground water and ingrowth of β – emitting radionuclides, during holding times between collection of samples and laboratory measurement (Welch et al., 1995).

The Gross – α is not harmful when its contact is external. Intake of food material containing Gross – α activity is harmful. At elevated levels; radium increases the risk of bone cancer and uranium increases the risk of kidney damage. However, the α – particles cannot penetrate skin but it can damage the cornea of human eye. Generally, β – particles are not harmful as alpha particles, but some are capable of breaching skin. Gross – β particles cause burns on the skin.

Materials and Methods

The sampling locations with co-ordinates are given in tables 1,2, and 3 and fig.1. The water samples were collected from borewell pipes and open well, particularly the water which the people use for drinking purpose, in 50 ml plastic bottles. The samples were preserved by adding 1N con. HNO_3 to bring it to the pH level 2, as per the Environmental Protection Agency protocol. The samples were preserved in the particular container for at least 16 hours before carrying out the analysis. 20 ml of each sample was dried in a planchet using hot plate, the dissolved salts get deposited to the planchet. A dual channel alpha beta counter fig .2. was used to get the gross counts and the necessary calculations were carried out to find the activity and dose.

Figure.1. Sampling Locations.



KNK - Kanyakumari, PRP - Parangipettai, KPK - Kalpakkam

Figure.2. The dual channel alpha, beta counter used for counting

Calculations

Efficiency of the System

The efficiency of the system is calculated using the formula,

E% $= \frac{\text{CPM}}{\text{DPM}} \times 100$

Where,

E - Efficiency

CPM - Counts Per Minute

DPM - Disintegration Per Minute

The α and β efficiency calculated using this formula is 17.93% and 14.087% respectively

Minimum Detectable Activity (MDA)

The minimum detectable level can be calculated using the following formula,

MDA $= \left(\frac{2.7\,1 + 4.65 \times \sqrt{\text{B} \times \text{T}}}{\text{T} \times \text{E} \times \text{V}}\right)$

Where,

B - Background

T - Time

E - Efficiency

V - volume

The factor 2.71 is used to account for the uncertainty in the background count rate, representing the number of standard deviations corresponding to 95% confidence level and 4.65 is used to account for the variability in background count rate, representing twice the square root of the background count rate.

Activity Concentration

The gross alpha and gross beta activities were calculated using the formula,

(α, β) Activity (Bq/L) $= \frac{\text{Net Cps} \times 100 \times 1000}{\text{T} \times \text{E} \times \text{V}}$

Where,

Net CPS – Actual Counts Per Second – Background Counts Per Second.

T - Time in Seconds.

E - Efficiency (α, β).

V - Volume.

Ingested Activity (IA)

Annual activity due to ingestion is calculated using the formula,

IA = C × I_l × 365 Bq/y

Where,

IA - Ingested Activity

C – Activity Concentration

I_l - Liter of water intake in a day (2 L)

365 – number of days in a year

Effective Dose

For α and β effective dose is calculated using the following formula,

For **α, E** = (IA (Bq/y) × 1.1 × 10^{-9}(Sv/Bq)) × 1000 (mSv/y)

For **β, E =** (IA (Bq/y) × 1.9 × 10^{-10} (Sv/Bq)) × 1000 (mSv/y)

Where,

E – Effective dose

IA – Ingested activity

1.1 × 10^{-9} and 1.9 × 10^{-10} are the α and β coefficients, to convert activity concentration to dose (WHO, 2011) and 1000 is to convert Sv to mSv.

Results and Discussion:

The α and β activities in the drinking water samples collected from the three zones are given in tables, 1, 2 and 3.

Table: 1. The gross α and β activities in the drink water samples of Kanyakumari zone with sampling coordinates.

S/N	Latitude	longitude	Alpha activity (Bq/L)	Beta Activity (Bq/L)
1	8° 9' 30.78"	77° 22' 31.98"	BDL	5.32
2	8° 9' 12.3516"	77°20' 15.504"	0.46	2.36
3	8° 8' 47.7276"	77°18' 58.032"	BDL	17.7
4	8° 7' 55.3944"	77°18' 17.478"	BDL	4.73
5	8° 9' 49.14" N	77°16' 41.736"	0.46	8.28
6	8° 10' 31.512"	77°14' 52.512"	BDL	5.32
7	8° 9' 49.968"	77° 38' 4.056"	BDL	1.77
8	8° 9' 38.2968"	77°37'26.8392"	0.46	0.59
9	8° 6' 28.6884"	77°32'16.7676"	BDL	6.50
10	8° 5' 33.8316"	77° 33' 3.5892"	0.46	4.14
11	8° 4' 55.9812"	77°31'44.7492"	0.46	19.52
12	8° 5' 19.5324"	77° 30' 56.268"	0.46	4.73
13	8° 5' 34.9224"	77°29'29.0868"	BDL	1.77

14	8° 6' 33.57"	77°27'48.8592"	BDL	7.09
15	8° 7' 5.916"	77°27'10.7568"	0.929	3.54
16	8°10'15.7188"	77°26'21.1596"	0.929	11.83
17	8° 11' 27.888"	77° 24' 41.724"	0.46	3.55
18	8° 9' 31.212"	77° 21' 42.588"	BDL	5.32
19	8° 15' 36.972"	77° 8' 33.54"	0.46	15.97
20	8° 14' 48.768"	77° 9' 36.576"	0.46	34.31
21	8° 14' 16.764"	77° 10' 20.028"	BDL	5.32
		MDA	0	0.01

Table: 2 The gross α and β activities in the drinking water samples of Parangipettai zone with sampling coordinates.

S/N	**Latitude**	**Longitude**	**Alpha activity (Bq/L)**	**Beta activity (Bq/L)**
1	11°24'07.0"	79°45'21.7"	0.46	5.92
2	11°30'38.1"	79°45'55.6"	BDL	1.77
3	11°31'34.3"	79°45'43.2"	BDL	0.59
4	11°31'19.0"	79°44'34.7"	0.46	0.59
5	11°30'20.4"	79°44'31.7"	0.46	BDL
6	11°30'19.0"	79°44'10.0"	1.39	0.59
7	11°29'23.9"	79°44'47.0"	0.46	0.59
8	11°30'56.3"	79°44'59.5"	BDL	6.50
		MDA	0	0.01

Table :3. The gross α and β activities in the water samples of Kalpakkam zone along with sampling coordinates.

S/N	Latitude	Longitude	Alpha activity (Bq/L)	Beta activity (Bq/L)
1	12°31'02.1"	80°09'38.9"	BDL	0.21
2	12°30'00.8"	80°09'32.4"	0.46	9.46
3	12°29'19.9"	80°09'18.7"	BDL	4.73
4	12°30'16.4"	80°08'53.8"	0.46	8.87
5	12°30'08.6"	80°09'02.2"	BDL	6.50
6	12°32'00.2"	80°09'50.5"	BDL	1.18
7	12°32'55.0"	80°08'35.9"	0.46	3.54
8	12°33'44.9"	80°08'36.2"	BDL	5.91
9	12°35'25.9"	80°08'51.0"	0.46	5.32
10	12°35'48.4"	80°09'12.3"	BDL	6.50
11	12°36'53.5"	80°10'08.8"	BDL	1.77
12	12°37'15.0"	80°11'35.1"	BDL	0.59
13	12°35'51.6"	80°11'17.0"	0.92	4.73
14	12°35'39.4"	80°11'19.5"	0.92	6.50
		MDA	0	0.01

Table: 4. The ingested activity of gross α and its effective dose due to the waters of three zones KNK, PRP and KPK.

S/N	KNK		PRP		KPK	
	Ingested Activity (Bq/y)	Effective dose (mSv/y)	Ingested Activity (Bq/y)	Effective dose (mSv/y)	Ingested Activity (Bq/y)	Effective dose (mSv/y)
1.	BDL	BDL	339.28	3.7×10^{-4}	BDL	BDL
2.	339.28	3.7×10^{-4}	BDL	BDL	339.28	3.7×10^{-4}
3.	BDL	BDL	BDL	BDL	BDL	BDL
4.	BDL	BDL	339.28	3.7×10^{-4}	339.28	3.7×10^{-4}
5.	339.28	3.7×10^{-4}	339.28	3.7×10^{-4}	BDL	BDL
6.	BDL	BDL	1017.85	1.12×10^{-3}	BDL	BDL
7.	BDL	BDL	339.28	3.7×10^{-4}	339.28	3.7×10^{-4}
8.	339.28	3.7×10^{-4}	BDL	BDL	BDL	BDL
9.	BDL	BDL			339.28	3.7×10^{-4}
10.	339.28	3.7×10^{-4}			BDL	BDL
11.	339.28	3.7×10^{-4}			BDL	BDL
12.	339.28	3.7×10^{-4}			BDL	BDL
13.	BDL	BDL			678.56	7.5×10^{-4}
14.	BDL	BDL			678.56	7.5×10^{-4}

15.	678.56	7.5×10^{-4}				
16.	678.56	7.5×10^{-4}				
17.	339.28	0.00037				
18.	BDL	BDL				
19.	339.28	3.7×10^{-4}				
20.	339.28	3.7×10^{-4}				
21.	BDL	BDL				

Table: 5. The ingested activity of gross α and its effective dose due to the waters of three zones KNK, PRP and KPK.

S/N	**KNK**		**PRP**		**KPK**	
	Ingested Activity (Bq/y)	**Effective dose (mSv/y)**	**Ingested Activity (Bq/y)**	**Effective dose (mSv/y)**	**Ingested Activity (Bq/y)**	**Effective dose (mSv/y)**
1.	3886.56	7.4×10^{-4}	4318.40	8.2×10^{-4}	1727.36	3.3×10^{-4}
2.	1727.36	3.3×10^{-4}	1295.52	2.5×10^{-4}	6909.44	1.31×10^{-3}
3.	12955.21	2.46×10^{-3}	431.84	8×10^{-5}	3454.72	6.6×10^{-4}
4.	3454.72	6.6×10^{-4}	431.84	8×10^{-5}	6477.60	1.23×10^{-3}
5.	6045.76	1.15×10^{-3}	BDL	BDL	4750.24	9.0×10^{-4}
6.	3886.56	7.4×10^{-4}	431.84	8×10^{-5}	863.68	1.6×10^{-4}
7.	1295.52	2.5×10^{-4}	431.84	8×10^{-5}	2591.04	4.9×10^{-4}
8.	431.84	8×10^{-5}	4750.24	9.0×10^{-4}	4318.40	8.2×10^{-4}
9.	4750.24	9.0×10^{-4}			3886.56	7.4×10^{-4}
10.	3022.88	5.7×10^{-4}			4750.24	9.0×10^{-4}
11.	14250.73	2.71×10^{-3}			1295.52	2.5×10^{-4}
12.	3454.72	6.6×10^{-4}			431.84	8×10^{-5}
13.	1295.52	2.5×10^{-4}			3454.72	6.6×10^{-4}
14.	5182.08	9.8×10^{-4}			4750.24	9.0×10^{-4}
15.	2591.04	4.9×10^{-4}				
16.	8636.80	1.64×10^{-3}				
17.	2591.04	4.9×10^{-4}				
18.	3886.56	7.4×10^{-4}				
19.	11659.69	2.22×10^{-3}				
20.	25046.73	4.76×10^{-3}				
21.	3886.56	7.4×10^{-4}				

The α activity in the drinking water samples from Kanyakumari zone ranged from BDL to 0.93 Bq/L, with an average of 0.29 Bq/L, and the alpha activity in the drinking water collected from the Parangipettai zone ranged from BDL to 1.39 Bq/L with an average of 0.41 Bq/L. In Kalpakkam zone the activity ranged from BDL to 0.93 Bq/L with a mean of 0.27 Bq/L.
The beta (β) activity in the drinking water samples collected from Kanyakumari zone ranged from 0.59 to 34.31 Bq/L, with an average of 8.08 Bq/L. In Parangipettai it ranged from BDL to 6.51 Bq/L with a mean of 2.1 Bq/L. The activity in the Kalpakkam water samples ranged from 0.59 to 9.46 Bq/L, with an average of 4.86 Bq/L.

The average α activity from Parangipettai (PRP) zone was higher than the Kanyakumari zone (KNK) and Parangipettai (PRP) zones. The average β activity in Kanyakumari zone was higher than the other two zones. The average α activity from PRP zone was higher than KNK and KPK zones.

The gross α activity safe limit is 0.5, 1 and 0.2 Bq/L for drinking water, surface water and ground water respectively and for gross β activity the limits are 1, 2 and 0.5 Bq/L respectively (WHO, 2006). The gross α -activity is well within the safe range, but the gross β activity from Kanyakuamri and Kalpakkam exceeded the safe limit, however the safety level depends upon the source and type of radionuclide, also it depends upon the duration of exposure and individual sensitivity and health status. However, activity below 10 Bq/L is considered to be safe (IAEA. 2019).

The annual ingested activity (Bq/y) and effective dose (mSv/y) are presented in tables 4 and 5. The annual α effective dose through drinking water from Kanyakumari zone ranged from BDL to 7×10^{-4} mSv/y with an average of 2×10^{-4}mSv/y. The annual effective dose from Parangipettai sampling zone ranged from BDL to 1×10^{-3}mSv/y with an average of 3×10^{-4} mSv/y. The dose from Kalpakkam zone ranged from BDL to 7×10^{-4} mSv/y with a mean of 2×10^{-4} mSv/y.

The annual β effective dose through consumption of water from Kanyakumari zone ranged from 8×10^{-5} to 4.76×10^{-3} mSv/y, with an average of 1×10^{-3}mSv/y. The dose from Parangipettai zone varied between BDL and 9×10^{-4} mSv/y with an average of 2×10^{-4} mSv/y. The dose from Kalpakkam zone ranged from 8×10^{-5} to 1×10^{-3}mSv/y, with an average of 6×10^{-4} mSv/y.

The average annual α effective dose at Parangipettai zone was higher than KNK and KPK zones, whereas, the average annual β effective dose was higher in KNK zone and the PRP zone had the least dose.

Conclusion

The gross alpha and gross beta activity in drinking water samples from three different zones, Kanyakumari (KNK), Parangipettai(PRP) and Kalpakkam(KPK) of the East coast of Tamil Nadu with varying background natural radiation levels were measured and risk factors were estimated.

The α activity in the drinking water samples from Kanyakumari zone, Parangipettai zone and Kalpakkam zone were, ranged from BDL to 0.93 Bq/L, BDL to 1.39 Bq/L and BDL to 0.93 Bq/L respectively.

The beta (β) activity in the drinking water samples collected from Kanyakumari zone, Parangipettai zone, and Kalpakkam zone ranged from 0.59 to 34.31 Bq/L, BDL to 6.51 Bq/L and 0.59 to 9.46 Bq/L. The gross α and β gross activity in the drinking water samples were well within the safe range.

In this study the gross α – activity of Parangipettai zone was higher than Kanyakumari and Kalpakkam zones. The gross β activity of Kanyakumari zone was higher, than Parangipettai and Kalpakkam zones

The annual α-effective dose through drinking waters of Kanyakumari, Parangipettai, and Kalpakkam zones were ranged from BDL to 0.0007 mSv/y, BDL to 0.001 mSv/y and BDL to 0.0007 mSv/y respectively.

The annual β-effective dose by through consumption of water from Kanyakumari, Parangipettai and Kalpakkam zones ranged from 0.00008 to 0.00476 mSv/y, BDL - 0.0009 mSv/y and 0.00008 to 0.001 mSv/y respectively.

The safe limit for α and β effective doses are 0.1 mSv/y) and 0.5 mSv/y respectively (WHO, 2006). The effective doses in the present study are well within this safe limit.

References

1. Welch, A. H., Szabo, Z., Parkhurst, D. L., Van Metre, P. C., & Mullin, A. H. (1995). Gross-beta activity in ground water: natural sources and artifacts of sampling and laboratory analysis. Applied Geo Chemistry, 10(5), 491-503.
2. WHO 2011. Guidelines for Drinking-Water Quality. World Health Organization, Geneva
3. International Atomic Energy Agency (IAEA). (2019). Radiation Protection and Safety of Radiation Sources. GSR Part -3
4. WHO, Guidelines for drinking water quality: incorporating first addendum, recommendations, (3rded.),

chapter 9: radiological aspects. World Health Organization Geneva, 1 2006.