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Natural Radioactivity Levels In Drinking Water of Dwellers Near East Coast of Odisha and Andhra Pradesh

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ABSTRACT

Drinking water from nearer to East coast fetched between Andhra Pradesh(AP) and Odisha collected from hand pumps and wells were analysed for gross alpha, gross beta and ^{226}Ra concentration using Alpha and Beta counting systems. The gross alpha, gross beta activity and ^{226}Ra activities ranging from 2mBq.l^{-1} to 80 mBq.l^{-1}, <30mBq.l^{-1} to 342 ± 31 mBq.l^{-1} and 0.005 ± 0.001 mBq.l^{-1} to 8 ± 1 mBq.l^{-1} with a mean activities 6 ± 1 mBq.l^{-1}, 44 ± 5 mBq.l^{-1} and 0.614 ± 0.05 mBq.l^{-1}in Odisha. The gross alpha, gross beta activity and ^{226}Ra activities ranging from <2mBq.l^{-1}to 9 ± 2 mBq.l^{-1}, <30 mBq.l^{-1} to 198 ± 30 mBq.l^{-1}and 0.5 ± 0.04 Bq.l^{-1} to 1.6 ± 0.24 mBql^{-1}with a mean activities 5 ± 1 mBq.l^{-1}, 342 ± 31 mBq.l^{-1} and 1 ± 0.08 mBq.l^{-1} in Andhra Pradesh(AP). The ingested effective dose due to Ra-226 were measured using consumption factor of adult in the study area and the values are found within the range even though overall annual effective dose also below the World Health Organization(WHO)reference dose level of 100 µSv.y^{-1}. The results show that consumption of groundwater may not pose any radiological health hazard to the public

KEYWORDS: Radioactivityconcentration, Gross alpha, Gross beta,Groundwater, Annual effective dose

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INTRODUCTION

Internal exposure of humans can be occurred through ingestion and inhalation due to ionizing radiation of radionuclides which were entered into the body from food and water. Small amount of radiation can damage internal organs and may pose a serious health risk. These radionuclides deliver radiation dose to the public, once they are ingested. Radiation levels are not same as compare before place to place and depend on the occurrence and distribution of radionuclides in earth's crust[1].

In case of water, it can change with respective their geochemical structure and geographical nature of the sources[2]such as soil and rocks, environment can contaminate through leaching and mobility of these radionuclides in earth crust. Naturally occurring radionuclides dissolve in water[3]such as Uranium and Thorium series daughter particles due to their chemical properties from solid by precipitation as a result of natural process [4].Occurrence of these radionuclides in water can control by other factors such as hydro-geological conditions and geochemistry[5]. Hence generally water has naturally occurring radionuclides which emits alpha and beta particles are also responsible for total dose received by humans.^{226}Ra is the second source of natural radioactivity in drinking water which effects bones and its absorbance in blood streams. The concentration of uranium influences the ^{226}Ra activity and it is the parent particle of radon which may effects the health greatly. Hence the monitoring of drinking water is useful for identifying and trends f0r the radionuclide content.

The southern part of the Odisha state and the Northern part of the AP is the study area has different geological structure with rocks of Eastern Ghats releasing heavy minerals carried into sea through rivers, wind and tidal waves which are settled in beach[6]. The coast has largest and richest deposit like Rutile, Zircon and Monazite along East Coast of India. The study area includes total 77 km region of East coast nearly comprises Chatrapur, Odisha and Sompeta, AP and sampling locations were identified within a distance between 1-10 km from the coast.The area was covered 31locations of Odisha and 25 locations in AP, it includes coastal villages as showed in figure 1.

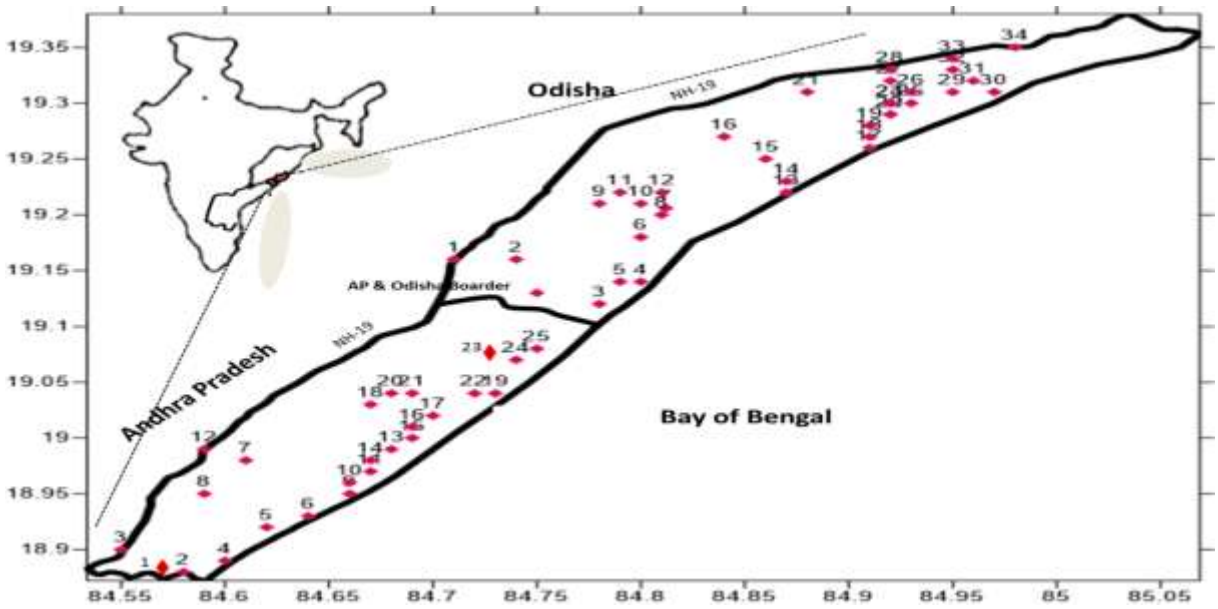

Figure 1: Selected locations of study area between Odisha and Andhra Pradesh

The present study aimed to assess the natural radioactivity levels in water sources and the estimation of annual effective dose due to intake since it represents dose received by the population due to intake. An attempt is made to study, environmental Radiation levels in dwelling near East coast of AP and Odisha compared with other parts in World.

MATERIALS AND METHODOLOGY

The Water Samples were collected from aquatic environment include mainly drinking water samples from bore wells and surface water samples as per the International Atomic Energy Agency(IAEA) protocol. These include tube well water, supply water, open well and river waters. Each 10 L water Sample were collected in pvc carboys and Physicochemical parameters (TDS and pH) were determined onsite using electronic probes and a portable multi-parameter instrument. Sample have been acidified through adding 3 N nitric acid to bring pH value 2 immediatelyin order to keep radionuclides in watermedium and to avoid adsorption on the container's wall.

The process of measuring gross alpha and gross beta is a better way and shortest way to estimate total dose in the form of alpha and beta radioactivity in the water. This process has convenience and can be used for daily monitoring rather to measure the concentration of individual radionuclide. Alpha counting system(Make: Electronic Enterprises Pvt. Ltd., Model: PNC-Alpha, S.No-1416) and Beta counting system (Make: Electronic Enterprises Pvt. Ltd., Model: PNC-1G, S.No-1409) were used for gross alpha and gross beta activity measurements in different water samples.The detectors were calibratedfor α and β energies using by ^{241}Am and ^{90}Sr-^{90}Y standard sources respectively. Backgroundsof each detector were determined by counting empty steel planchet for alpha and Aluminum planchet for beta. Gross alpha and beta of each water sample was

prepared depending on their TDS(Total dissolved salt) and analyzed as per Indian standards IS19194 Part I & II.If TDS of the sample lessthan 100mg.l^{-1}, sample was counted directly through evaporating at 70°C temperatureof 150 ml volumeon planchet or used radio chemical separation method in case of TDS greater than 100mg.l^{-1}. The residue in the vessel was scraped and placed on a planchet and counted for each samples.

Table 1: Gross alpha, gross beta, ^{226}Ra concentration and annual effective dose from the digestion of ^{226}Ra concentration values of water in Odisha

S. No	Location	Latitude North	Longitude East	Gross alpha activity (mBq.l^{-1})	Gross beta activity (mBq.l^{-1})	Ra-226 activity (mBq.l^{-1})	Annual dose due to ingestion of Ra-226 (μSv.y^{-1})
1	Girisola	19^0 09'48"	84^0 42'45"	4 ± 0.4	*BDL	1.5 ± 0.11	0.31
2	Chatipadar	19^0 10'32"	84^0 42'10"	9 ± 0.9	134 ± 11	0.03 ± 0.01	0.01
3	Sonapur	19^0 09'49"	84^0 42'43"	4 ± 0.4	BDL	1.2 ± 0.1	0.25
4	RamayyaPatnam	19^0 14'32"	84^0 52'34"	6 ± 0.3	245 ± 13	0.05 ± 0.01	0.01
5	Chandanabad	19^0 13'34"	83^0 43'52"	3 ± 0.3	198 ± 20	0.05 ± 0.01	0.01
6	Dhepanaupada	19^0 10'13"	84^0 48'52"	4 ± 0.2	31 ± 3	1.5 ± 0.11	0.31
7	Indrakhi	19^0 12'32"	84^0 49'45"	5 ± 0.5	BDL	1.5 ± 0.14	0.31
8	Tulu	19^0 13'08"	84^0 48'03"	6 ± 0.6	BDL	0.75 ± 0.08	0.15
9	Sasanpadar	19^0 13'27"	84^0 47'29"	6 ± 0.5	BDL	1.4 ± 0.13	0.29
10	Gunupur	19^0 13'45"	84^0 48'49"	4 ± 0.4	BDL	1.1 ± 0.1	0.22
11	Padmapur	19^0 06'52"	84^0 30'58"	8 ± 0.7	BDL	1.5 ± 0.12	0.31
12	Terapentho	19^0 13'39"	84^0 46'10"	5 ± 0.3	BDL	2.1 ± 0.21	0.43
13	New Golabandha	19^0 11'31"	84^0 43'41"	6 ± 0.3	BDL	0.9 ± 0.09	0.18
14	Gounju	19^0 17'26"	84^0 50'18"	4 ± 0.4	38 ± 4	0.1 ± 0.01	0.02
15	Gopalpur	19^0 15'54"	84^0 52'20"	2 ± 0.2	259 ± 13	3.5 ± 0.32	0.72
16	Haripur	19^0 15'10"	84^0 55'35"	5 ± 0.3	80 ± 8	1.2 ± 0.11	0.25
17	Upulaputi	19^0 03'25"	84^0 29'59"	8 ± 0.6	220 ± 18	3 ± 0.24	0.61
18	Kalipalli	19^0 18'44"	84^0 55'32"	5 ± 0.3	BDL	1 ± 0.1	0.20
19	Mandiapalli	19^0 07'41"	84^0 40'14"	7 ± 0.7	BDL	0.005 ± 0.01	0.01
20	Basanaputti	19^0 18'18"	84^0 55'56"	4 ± 0.3	BDL	1.5 ± 0.15	0.31
21	Badaputi	19^0 18'10"	84^0 56'25"	7 ± 0.7	133 ± 12	0.3 ± 0.03	0.06
22	P.Lakshmipur	19^0 18'22"	84^0 55'13"	2 ± 0.2	56 ± 6	1.1 ± 0.09	0.22
23	Lakshmipur	19^0 39'45"	84^0 24'21"	8 ± 0.4	35 ± 4	1 ± 0.1	0.20
24	Bhaginapeta	19^0 19'10"	84^0 56'34"	7 ± 0.7	67 ± 7	0.87 ± 0.05	0.18
25	S.Payakapada	19^0 54'47"	83^0 30'10"	2 ± 0.2	BDL	0.83 ± 0.09	0.17
26	Chamakhandi	19^0 20'18"	84^0 55'58"	7 ± 0.7	133 ± 14	0.2 ± 0.02	0.04
27	Mattikhalo	19^0 18'47"	84^0 56'57"	80 ± 4	78 ± 7	0.3 ± 0.03	0.06
28	Arjyapalli	19^0 09'37"	84^0 58'35"	7 ± 0.5	BDL	1.6 ± 0.16	0.33
29	Chandrapada	19^0 19'47"	84^0 57'00"	4 ± 0.4	106 ± 8	1.2 ± 0.1	0.25
30	Mayapatna	19^0 20'16"	84^0 56'51"	4 ± 0.2	342 ± 31	0.9 ± 0.09	0.18
31	Chatrapur	19^0 21'00"	84^0 58'48"	5 ± 0.3	189 ± 16	0.7 ± 0.06	0.14
	Minimum			2 ± 0.2	BDL	0.005 ± 0.01	0.01
	Maximum			80 ± 4	342 ± 31	3.5 ± 0.32	0.72
	GM			6 ± 1	44 ± 5	0.61 ± 0.07	0.12
	SD			14 ± 1	91 ± 8	0.81 ± 0.08	0.17

*Below Detectable Limit(BDL)

Estimation of ^{226}Rain water samples are also done using radiochemical separation method as suggested standard protocol BARC/HSEG/PROTOCOL/TECDOC-001.Four liters of water samples

were filtered through what man / Millipore filters (< 0.7µm pore size) and evaporated to dryness and evaporated again after adding 5 to 10 ml of 4N concentrated nitric acid to dissolve the residue to bring the sample in nitrate form. The residue is dissolve in water and 2.5 mg of Ba carrier and 200 mg lead carrier were added. Sulfates were precipitated with 1:1 sulfuric acid and centrifuged to discardthe supernate. Dissolve the sulfate in 10% ammonical EDTA solution while keeping it on a water bath. Glacial acetic acid was added and only barium sulfate was precipitated. The $BaSO_4$precipitate was transferred on steel planchette and dried under an infrared lamp. ^{226}Ra activity was done by counting of sample followed by ZnS(Ag) alpha counting system. The gross alpha, gross beta and ^{226}Ra activities were measured in water samples are showed in tables 1 and 2 in two different regions.

Table 2: Gross alpha, gross beta, ^{226}Ra concentration and annual effective dose from the digestion of ^{226}Ra concentration values of water in Andhrapradesh

S.No	Location	Latitude North (DDM)	Longitude East (DDM)	Gross alpha activity ($mBq.l^{-1}$)	Gross beta activity ($mBq.l^{-1}$)	Ra-226 activity ($mBq.l^{-1}$)	Annual dose due to ingestion of Ra-226 ($\mu Sv.y^{-1}$)
1	Mulapalam	18^0 53'10"	84^0 34'38"	7 ± 0.35	BDL	1.1 ± 0.08	0.22
2	Baruva	18^0 53'05"	84^0 35'01"	4 ± 1.2	35 ± 3.5	1.4 ± 0.13	0.29
3	Kurlam	18^0 54'06"	84^0 33'08"	6 ± 0.9	BDL	1 ± 0.15	0.20
4	Baruvapeta	18^0 56'34"	84^0 35'05"	4 ± 0.2	BDL	0.79 ± 0.04	0.16
5	Gollagandi	18^0 55'22"	84^0 37'18"	5 ± 0.25	26 ± 1.3	0.8 ± 0.08	0.16
6	Rushikudda	18^0 56'28"	84^0 38'24"	6 ± 0.42	BDL	1.4 ± 0.21	0.29
7	Kuttuma	18^0 56'04"	84^0 36'49"	7 ± 0.63	BDL	1.34 ± 0.07	0.27
8	Sompeta	18^0 56'44"	84^0 34'56"	2 ± 0.2	BDL	1.27 ± 0.06	0.26
9	Manikyapuram	18^0 57'06"	84^0 37'52"	2 ± 0.16	BDL	0.82 ± 0.04	0.17
10	Balliputtuga	18^0 58'38"	84^0 39'17"	4 ± 0.28	BDL	0.97 ± 0.05	0.20
11	Kusumpuram	18^0 58'01"	84^0 38'44"	6 ± 0.72	BDL	1.18 ± 0.08	0.24
12	Kanchili	18^0 58'51"	84^0 34'55"	8 ± 0.48	BDL	1.2 ± 0.11	0.25
13	Borivanka	18^0 58'59"	84^0 40'01"	5 ± 0.35	BDL	1.6 ± 0.24	0.33
14	Varakha	18^0 59'15"	84^0 39'06"	6 ± 0.9	BDL	1.5 ± 0.11	0.31
15	Bejjiputtuga	18^0 59'18"	84^0 40'23"	BDL	31 ± 2.8	1.3 ± 0.12	0.27
16	Jagathi	18^0 59'56"	84^0 41'04"	6 ± 0.84	BDL	1.12 ± 0.11	0.23
17	Kaviti	19^0 00'33"	84^0 41'18"	4 ± 0.28	BDL	0.67 ± 0.05	0.14
18	Putiyadala	19^0 01'42"	84^0 42'17"	5 ± 0.4	133 ± 6.6	0.87 ± 0.04	0.18
19	Kapasakuddi	19^0 01'17"	84^0 43'13"	8 ± 0.72	198 ± 19.8	1.1 ± 0.11	0.22
20	Rajapuram	19^0 02'36"	84^0 40'01"	6 ± 0.42	BDL	1.3 ± 0.07	0.27
21	Chandiputtuga	19^0 02'57"	84^0 40'54"	3 ± 0.45	BDL	1.6 ± 0.16	0.33
22	Nelavanka	19^0 02'21"	84^0 43'20"	7 ± 0.84	BDL	1.2 ± 0.18	0.25
23	Baliyaputtuga	18^0 58'29"	84^0 34'19"	5 ± 0.8	67 ± 4.7	0.9 ± 0.05	0.18
24	Kesapuram	19^0 04'17"	84^0 42'26"	9 ± 1.62	BDL	1 ± 0.05	0.20
25	Burjapadu	19^0 03'24"	84^0 43'38"	9 ± 0.18	BDL	1.1 ± 0.08	0.22
	Minimum			BDL	BDL	0.67 ± 0.04	0.14
	Maximum			9 ± 3	198 ± 30	1.6 ± 0.24	0.33
	GM			5 ± 1	11 ± 1	1.11 ± 0.09	0.23
	SD			2 ± 0.12	45 ± 1.62	0.25 ± 0.05	0.23

Minimum Detectable Activity(MDA) of Alpha = 2 $mBq.l^{-1}$
Minimum Detectable Activity (MDA) of beta = 30mBq.l-1

RESULTS AND DISCUSSION

From table 1, the gross alpha, gross beta activity and ^{226}Ra activitiesranging from 2 ± 0.1 mBq.l^{-1} to 80 ± 8 mBq.l^{-1}, BDL(<30mBq.l^{-1}) to 342 ± 31 mBq.l^{-1}and 0.005 ± 0.001 mBq.l^{-1} to 8 ± 1 mBq.l^{-1}with a mean activities 6 ± 1 mBq.l^{-1}, 44 ± 5 mBq.l^{-1} and 0.614 ± 0.05 mBq.l^{-1}in Odisha. From table 2, the gross alpha, gross beta activity and ^{226}Ra activities ranging from BDL(<2mBq.l^{-1})to9 ± 2 mBq.l^{-1}, BDL(<30mBq.l^{-1})to 198 ± 30 mBq.l^{-1}and 0.5 ± 0.04 Bq.l^{-1} to 1.6 ± 0.24 mBql^{-1}with a mean activities 5 ± 1 mBq.l^{-1}, 342 ± 31 mBq.l^{-1} and 1 ± 0.08 mBq.l^{-1} in Andhra Pradesh. The resultant values were compared with other regional values as given in table 3 and are comparable.

Table 3:Comparison of gross alpha, beta and ^{226}Ra activity concentrations found in drinking waters with regulations andliterature value

Region	Gross alpha activity (mBq.l^{-1})	Gross beta activity (mBq.l^{-1})	^{226}Ra activity (mBq.l^{-1})
WHO[3]	500	1000	1000
Tunisia[8]	48 - 94	45 - 430	2.0 - 67.0
Sudan[9]	--	--	8.5 - 16.5
Iran (Guilan)[10]	12 -115	23 - 332	--
Turkey (Siirt)[11]	50 - 5640	60 - 2760	--
Bangladesh (Dhaka)[12]	0.73 - 0.96	65.54 - 77.29	--
Nigeria[13]	7-80	120 -980	--
India(Odisha)[14]	--	--	0.2- 5.7
India(Odisha)-Present study	2 - 80	<30 - 342	0.005- 8
India(AP)- Present study	<2 - 9	<30 -198	0.5 -1.6

Resultant values of gross alpha, gross beta and ^{226}Ra activity concentrationswere showed in figure 2 & 3.

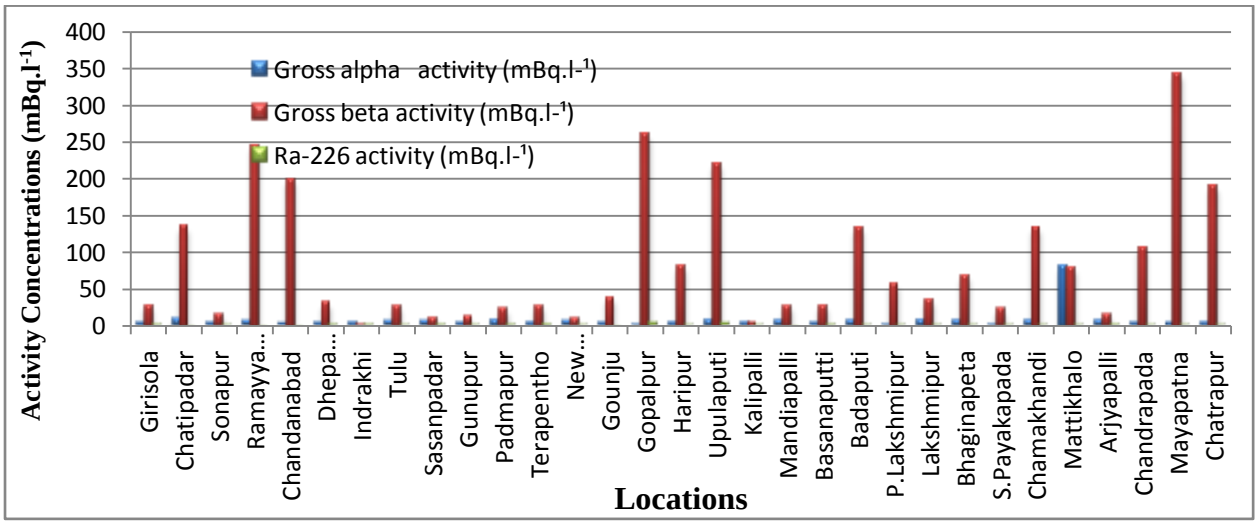

Figure2: Gross alpha, gross beta and Ra-226 activity concentrations indrinking wateratOdisha

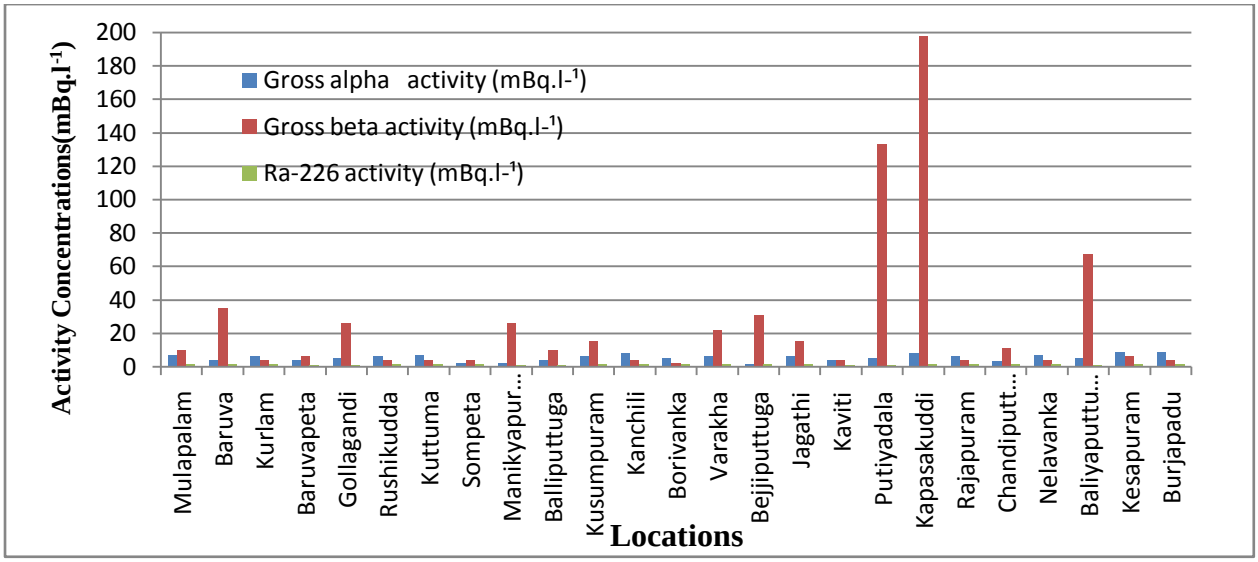

Figure3: Gross alpha, gross beta and Ra-226 activity concentrations indrinking water atAndhrapradesh

CONCLUSIONS

Internal exposure due to gross-α, gross-β and ^{226}Ra radionuclide in water were measured in Odisha and Andhra Pradesh and observed to be below the recommended guidelines valuesfor drinking water quality by WHO(2008)500 mBq.l^{-1}, 1000 mBq.l^{-1} and 1000mBq.l^{-1}. World Health Organization and ICRP has suggested a dose limit of 100 µSv.y^{-1}and 1000 µSv.y^{-1}due to ingestion of ^{226}Ra in water and resulted mean values are within the limit. Hence, it can be concluded that the radioactivity levels of drinking water in the study area are much below the recommended limits and considered as safe for drinking.

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