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GAMMA RADIATIONS IN SURFACE AND GROUNDWATERS OF THE RUGIA ISLAND

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Abstract

Water samples containing sea-water, river water, reservoir water, drinking water and groundwater were examined by means of gamma ray spectral analysis. Only gamma emitters in ^{228}U, ^{232}Th and ^{40}K series were detected. No fission products were detected with specific activity exceeding 1,0 Bq/kg. The present data could be a base line for future monitoring of radioactivity released from nuclear plants. The variation of specific activities detected may be related to geological differences and the effect of plants.

INTRODUCTION

Water radioactivity originates from natural and artificial sources. Natural or background radioactivity in water generally comes from primordial radioactive elements dissolved in it. The activity level is also affected by artificial sources of radioactivity that include fission products, neutron activation products, and industrial pollutants. Operation of seven nuclear power plants in northern Germany requires that attention should be given for developing techniques to assess possible resultant radioactive contamination of environment. It is thus, necessary to establish baselines for type and amount of radionuclides present for monitoring any possible radioactive release from nuclear power plant.

The majority of the gamma emitters present in water are ^{40}K and daughter ^{238}U and ^{232}Th nuclides, which are soluble through geochemical processes. The level of radioactivity in water strongly depends on the chemical solubility of heavy isotopes in water, the volume - to - contact area ratio, and the duration time. Groundwaters generally contain large amount of nuclides of the uranium and thorium series because of their large contact area. On the other hand, reservoir water have lower activity because of its extremely large volume - to - contact area ratio. Sea-waters are rich in ^{40}K because of a considerable amount of natural potassium in the form of KCl in the ocean.

This project was part of the environmental radiation measurements in Rugia Island conducted by the University of Szczecin and Technical University of Szczecin. Together with soil (Janukowicz, 1998; Lau et al. 1987), rock, plants and food data (Włodek and Grzybowska 1971; Rosik-Dulewska and Dulewski 1989), the present findings can be used in establishing the expected normal range of radionuclide concentrations in the study area.

MATERIAL AND METHODS

Thirty-four water samples, divided into five groups, were collected from various sites Rugia Island in the spring and summer of 1997-1998. Thirteen samples were sea-water, representing the radioactive pollutant deposited in territorial waters from natural and artificial sources. Seven samples ware taken from rivers and waterways discharging into the Baltic Sea. Five samples were collected from reservoirs and lakes, representing untreated drinking water. Four samples originated from tap water, representing untreated drinking water. Five samples of groundwater were also taken. The age of water in these groups was very different. Sea-water might have been present for some months, while river water might have been present only for days before flowing into reservoirs or sea.

The samples were kept in standard $1dm^3$ wide-neck screw-top polythene bottles. Each sample was weighed and analysed with a gamma-ray spectrometer with HPGe detector with a fixed geometry factor in a lead chamber. Energy and efficiency calibrations of the spectrometer were carried out using standard sources in bottles identical to those that held samples. Minimum limits for nuclides detectable with spectrometer based on background measurements are listed in Table 1.

Table 1.

Minimum detectable level for nuclides analysed

Radionuclide	Minimum detectable level (Bq)
^{228}Ac	0,3
^{212}Pb	0,1
^{212}Bi	0,3
^{208}Tl	0,1
^{226}Ra	0,8
^{214}Pb	0,1
^{214}Bi	0,1
^{40}K	3,9

RESULTS

In all the samples only ^{40}K and radionuclides of two natural series, ^{238}U and ^{232}Th, have been observed. No ^{137}Cs or any fission products ware detected with specific activity above 1,0 Bq/kg in any water sample. The range and mean activity for all water groups is listed in Table 2 and 3.

Table 2

Range of determined radionuclide concentration (Bq/kg) for five water groups and mean counting uncertainty of each radionuclide

Water group	^{228}Ac	^{212}Pb	^{212}Bi	^{208}Th	^{226}Ra	^{214}Pb	^{214}Bi	^{40}K
Sea	*-2,2	*-4,7	*-3,3	*-0,8	*-3,5	*-1,6	*-1,4	*-39,2
River	*-1,5	*-59,8	*-31,2	*-19,2	*-2,8	*-0,2	*-1,9	*-7,7
Reservoir	*-2,4	*-11,9	*-9,1	*-3,7	*-9,5	*-1,1	*-0,9	*-10,8
Tap	*-*	*-0,4	*-*	*-*	*-*	*-2,7	*-3,6	*-12,4
Groundwater	0,7-1,8	*-0,5	*-2,5	*-0,3	*-3,1	0,4-32,8	*-33,6	*-21,7
Mean counting uncertainty (in %)	28	21	25	27	27	22	28	2,7

*Indicates a value below minimum detectable level

Table 3

Mean radionuclide concentration (Bq/kg) for five water group

Water group	^{228}Ac	^{212}Pb	^{212}Bi	^{208}Th	^{226}Ra	^{214}Pb	^{214}Bi	^{40}K
Sea	0,6	0,5	0,6	0,1	0,4	0,2	0,6	14,5
River	0,8	9,2	5,0	2,9	0,6	*	0,7	3,3
Reservoir	0,6	1,2	1,7	0,5	2,5	0,2	0,2	1,4
Tap	*	0,2	*	*	*	0,9	1,1	6,4
Groundwater	1,4	0,2	1,3	0,1	1,3	11,1	11,3	8,0

*Indicates a value below minimum detectable level

DISCUSSION

The concentration of ^{40}K is high in sea-waters but low in freshwater samples. The concentration of ^{40}K in reservoirs situated in the southern part of Rugia Island is higher than that in other reservoirs. The difference may be due to higher ^{40}K content in soil in the southern part of Rugia Island. In general surface waters collected in the northern part of the study area sedimentary rocks are of negligible ^{40}K concentration. In areas with intrusive igneous rocks, water samples usually show a ^{40}K activity.

The reservoir-water group, except for reservoirs in Rugia Island, has higher ^{226}Ra concentration than water of other groups. This is due to radionuclides of the uranium series, rich in the water-collecting zone, being dissolved in reservoir water.

Groundwater have the highest concentration of ^{214}Pb and ^{214}Bi. It is because of largest volume - to - contact area ratio with soil. Together with the low activity of ^{226}Ra measured, it is suggested that ^{214}Pb and ^{214}Bi might have originated from ^{222}Rn

escaping from bedrock soil and being trapped by water. The radon content in groundwater in urban areas is worth future investigation as it may produce health hazards.

Surface water samples have accosted the same activities in ^{232}Th series throughout the region except for one place called Jasmund National Park. It is interesting to note that significantly higher concentration of ^{212}Pb, ^{212}Bi and ^{208}Tl in ^{232}Th series has been found in river water at this location, with specific activities attaining 59,8 Bq/kg, 31,2 Bq/kg and 19,2 Bq/kg, respectively. However, specific activity of ^{228}Ac in the same water river is below 0,32 Bq/kg. It seems that much ^{228}Th or ^{224}Ra have been dissolved in this river water, but not ^{228}Ac. It is unlikely that high concentration of ^{212}Pb originates from ^{220}Rn leaking out from the river bed, as the lifetime of ^{220}Rn is too short. The specific activity of ^{226}Ra has also been found to be high in that river. It amounted to 2,78 Bq/kg. It is possible that plant exertion near the river enhances the water solubility of radium.

Higher ^{226}Ra concentration has been detected in reservoir water than in river and groundwaters. Its low concentration in river water may be due to its young age (a few days) in comparison with reservoir waters (a few months). However, a higher concentration of ^{228}Ra in reservoir waters than in groundwater needs some future investigations. Again, the biological activity of plants in the surface soil is likely to increase solubility of radium.

The tap water in urban areas has negligible radioactivity, which implies a very good filtering system water supply (Janukowicz, 1999; Włodek and Grzybowska 1971). The activity level in water supplied in rural areas, though in detectable concentrations, is very low and safe for drinking.

CONCLUSIONS

Only gamma emitters in ^{238}U, ^{232}Th and ^{40}K series were detected in 34 water samples collected from various sites in the Rugia Island. No fission products were detected with specific activity above 1,0 Bq/kg. This could be a baseline for future monitoring of radioactivity released from nuclear power plants.

Variation of radionuclide concentrations was water and a likely effect of plants. The greater part of the activity level of gamma emitters found in drinking water in urban areas is below detectable limits quoted in Table 1.

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ŹRÓDŁA PROMIENIOWANIA GAMMA W WODACH POWIERZCHNIOWYCH I GRUNTOWYCH RUGII

Streszczenie

Próbki wody, zawierające wodę morską, rzeczną, pitną (wodę ze zbiorników, z jezior oraz z kranów) oraz podziemną zostały zbadane metodą analizy spektralnej przy pomocy promieniowania gamma. W badanych próbkach wody pochodzących z wyspy Rugia wykryto tylko źródła promieniowania gamma w szeregach ^{238}U, ^{232}Th i ^{40}K. Nie znaleziono produktów rozszczepienia o aktywności właściwej powyżej 1,0 Bq/kg. Otrzymane wyniki badań mogą stanowić podstawę do monitorowania w przyszłości radioaktywności środowiska wodnego okolic ujścia Odry i Zatoki Pomorskiej, spowodowanej zanieczyszczeniami oraz działalnością elektrowni jądrowych znajdujących się na terenie Północnych Niemiec.

W badanych próbkach wody stwierdzono wahania aktywności właściwych promieniowania gamma co może być związane z różnicami geologicznymi oraz wpływem roślinności badanego obszaru.