Radon and Thoron Concentration measurement of Ground Water in Kufa City by using RAD7 detector

*Ali,A.Al-Hamadwi **Abdulhussan,A.Al.Bayati. ***Asia,H.Al.Mashhadani

* University of Kufa /Collage of Science / Department of Physics . ** University of Baghdad /Collage of Science / Department of Physics *** University of Baghdad /Collage of Science / Department of Physics

Abstract

Radon (^{222}Rn) and Thoron (^{220}Rn) concentration in the groundwater samples and their annual effective dose exposure were measured in the Kufa city - Iraq. it is measured by Durridge RAD-7 radon-in-air monitor, RAD-H2O new technique with closed loop aeration concept. Study was identified on the map at the city of Kufa, by GIS.

It is found that Radon and Thoron concentration in 20 groundwater samples of studied area. The range is between (0.267- 5.662), (0-0.07486)Bq L^{-1} respectively, the EPA's maximum contaminant level (MCL) of 11.1 Bq L-1 . Also, obtain this study independent of groundwater physical and chemical properties such as (PH and EC) on the radon concentration. The total annual effective dose resulting from radon in groundwater of studied samples were significantly lower than the UNSCEAR and WHO recommended limit for members of the public of 1 mSv $.y^{-1}$.

قياس تركيز الرادون والثورون للمياه الجوفية في منطقة الكوفة باستخدام كاشف RAD7

***علي عبد ابوجاسم الحميداوي**
جامعة الكوفة كلية العلوم
قسم الفيزياء

*** عبد الحسين عبد الأمير البياتي**
جامعة بغداد كلية العلوم
قسم الفيزياء

***اسيا حميد المشهداني.**
جامعة بغداد كلية العلوم
قسم الفيزياء

الخلاصة

تم قياس تراكيز الرادون والثورون في نماذج من المياه الجوفية ومعدل الجرعة السنوية الفعالة في مدينة الكوفة في العراق حيث قيست تراكيز الرادون والثورون باستخدام تقنية جديدة تسمى Durridge RAD-7 في الماء ذات الحلقة المغلقة .تم تحديد نقاط الدراسة على خارطة مدينة الكوفة باستخدام برنامج GIS .

ووجد ان مدى قياس تراكيز الرادون والثورون ل 20 نموذج للمياه الجوفية للمساحة المدروسة يتراوح بين (0.267-) 5.662 و (0-0.07486) $Bq.L^{-1}$على التوالي اذ ان اعلى مستوى للتلوث لمنظمة EPA's هو $Bq.L^{-1}$ 11.1 كذلك أظهرت الدراسة عدم اعتماد الخصائص الفيزيائية والكيميائية مثل (PH and EC) للمياه الجوفية على تركيز الرادون.

ان نتائج الجرعة السنوية الفعالة من الرادون في المياه الجوفية للنماذج المدروسة اقل من القيم المسموح بها لمنظمتي UNSCEARوWHO وهو $1 mSv .y^{-1}$.

1-Introduction

^{222}Rn's lifetime is considered long relative to the other isotopes. This is of significance, since radon is formed in the ground or building materials [1] and has significantly more time to diffuse through the material into the indoor environment in buildings or the outdoor atmosphere. The radon formed relatively close to the earth's surface can diffuse through the soil or be driven by pressure gradients [2].

In many countries, radon is the second most important cause of lung cancer after smoking. The proportion of lung cancers attributable to radon is estimated to range from 3 to 14%. Significant health effects have been seen in uranium miners who are exposed to high levels of radon. However, studies in Europe, North America and China have confirmed that lower concentrations of radon – such as those found in homes – also confer health risks and contribute substantially to the occurrence of lung cancers worldwide [3 -5]. The risk of lung cancer increases by 16% per 100 Bq/m3 increase in radon concentration. The dose-response relation is linear – i.e. the risk of lung cancer increases proportionally with increasing radon exposure. Radon is much more likely to cause lung cancer in people who smoke.

There are some scientists modernly using RAD7 detector to measure radon and thoron concentrations in air, soil, gas and water. R.K. Somashekar et al. in (2010)[6] studied the distribution of radon (^{222}Rn) activity concentration in groundwater samples and their annual effective dose exposure in the Varahi and Markandeya command areas. Radon measurement was made using Durridge RAD-7 radon-in-air monitor, using RAD H2O technique with closed loop aeration concept. K.Badhan et al. in(2010) [7] studied the methods to measure radon in ground water using RAD7 and assessed in door radon using LR-115 type II plastic track detectors of average dose in the environs of NITJ , Punjab , India. And Yanliang Tan and Detao Xiao in (2011) [8] used RAD7 detector for Measuring the Radon Exhalation Rate from the medium Surface . The common calculation method for deriving the exhalation rate as based on an assumption that the radon concentrations in the detector's internal cell and that in accumulation chamber are equal with sufficient accumulation time.

2-Study area

In this study 20 regions was taken as fair distribution in Kufa city .The locations are determined pointed by using (GIS) as shown in Fig.(1) which its obtain the map sits of Kufa city draw by using GPS technical. Table (1) shows the sites of measurement in Kufa .

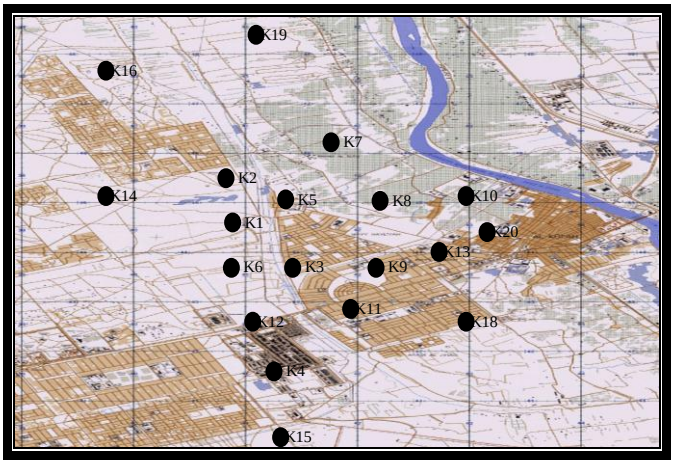

Figure (1) Map of sits of Kufa area

Table (1) Sites of measurements in Kufa area for taking samples

name	Symbol	Coordinates
Al. Mutanabi	K1	$44^0 22' 53.662'' E$, $32^0 1' 48.533'' N$
Al.Askary	K2	$44^0 22' 52.701'' E$, $32^0 2' 7.472'' N$
Al.Shorta	K3	$44^0 23' 21.377'' E$, $32^0 1' 40.2'' N$
Tamoz	K4	$44^0 23' 19.438'' E$, $32^0 1' 2.182'' N$
Al.Jameah	K5	$44^0 23' 21.377'' E$, $32^0 1' 40.2'' N$
Kinda	K6	$44^0 23' 21.377'' E$, $32^0 1' 40.2'' N$
Al.Jemeah	K7	$44^0 23' 32.435'' E$, $32^0 1' 16.483'' N$
Al.Jamhoria	K8	$44^0 23' 57.168'' E$, $32^0 1' 59.881'' N$
Al.Moallem een	K9	$44^0 23' 37.175'' E$, $32^0 1' 47.986'' N$
Al.Sarria	K10	$44^0 24' 10.902'' E$, $32^0 2' 16.906'' N$
Methamalta mmar	K11	$44^0 23' 38.578'' E$, $32^0 1' 18.738'' N$
Al.Saha	K12	$44^0 23' 17.486'' E$, $32^0 1' 18.365'' N$
Al.Rashadia h	K13	$44^0 24' 12.41'' E$, $32^0 1' 57.693'' N$
Al.Asatetha h	K14	$44^0 21' 51.843'' E$, $32^0 2' 30.579'' N$
Al.Shoarah	K15	$44^0 23' 26.618'' E$, $32^0 0' 48.767'' N$
Messan 1	K16	$44^0 21' 32.478'' E$, $32^0 3' 16.807'' N$
Meassan 2	K17	$44^0 22' 2.231'' E$, $32^0 3' 15.717'' N$
Al.Forat	K18	$44^0 24' 38.225'' E$, $32^0 2' 150.766'' N$
Alwatalfahal	K19	$44^0 22' 59.216'' E$, $32^0 3' 17.863'' N$
Al.Jedada	K20	$44^0 24' 21.563'' E$, $32^0 2' 25.565'' N$

3-Sampling and assays

Water samples were taken from the environs of Kufa city. Radon concentrations in these samples were measured with RAD7 an electric radon detector connected to RAD-H2O accessory (Durridge Co,USA, 2010) for a period of one month . Figure (3) shows the schematic diagram of RADH2O .In the setup ,the RAD7 detector was used for measuring radon in water by connecting it with a bubbling kit which enables to degas radon from a water sample into the air in a closed loop. A sample of water was taken in a radon – tight reagent bottle of 250 mL capacity connected in a close circuit with a zinc sulphide coated detection chamber which act as scintillator to detect alpha activity and a glass bulb containing calcium to absorb the moisture , Air was then circulated in a close circuit for a period of 5-10 min until the radon was uniformly mixed with the air and the resulting alpha activity was recorded and it directly gives the radon concentration . Also the PH and EC of water samples were measured using electric PH meter.

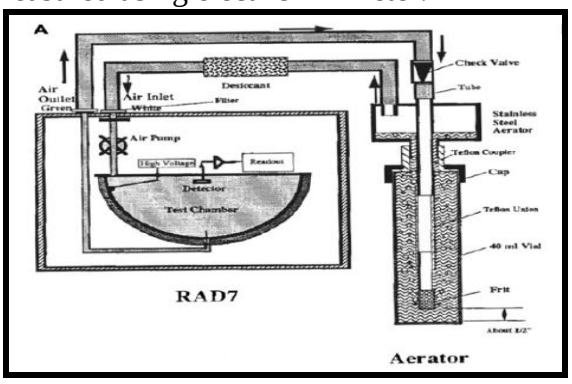

Fig. 3. Schematic representation of the RAD 7 instrument for measuring radon in water [9]

4-Result and discussion

. Table (2) was shown the results of thoron (^{220}Rn) concentration in kufa area for unit of mean concentrations (Bq.m^{-3}). Table (3) was shown the results of radon (^{222}Rn) concentration for unit (Bq.m$^{-3)}$ and annual effective dose (for unit mS.y^{-1}) of ground water in kufa city .From the results obtained , All sampling sites in Table (2) and Figure (4) does not detect the concentration of thoron except for some sites which are (K8 , K10 , K15 and K17) the rate of change focus between the highest value at the position icon (K17) is (276.9968 Bq.m^{-31}) and the lowest value at (K8) is (273.9998 Bq.m^{-1}).

From Table (3) and Figure (5) the location sample (K2) (Al.Askary) had highest radon concentration of each location samples in Kufa city for Ground water which had mean value (5662.5 Bq.m^{-3}), and location sample (K15) (Al.Shorah) had lowest radon concentration of each location samples in Kufa area for Ground water which had mean value (263.5 Bq.m^{-3}).

From the spectrum that shown in figures (6) and (7) for higher and lower of location in of Kufa city can be noted the relation between the count rate and the energy which consist of Radon daughters in A(^{218}po) , B(^{214}po) and Thoron daughters D(^{216}po) , E(^{212}po).

The annual effective dose, HE, due to the inhalation of radon, resulting from the radon concentration in domestic water, was calculated according to the following expression UNSCEAR (B), 2000 [10]:

$$H_E = C_{Rn-w} R_{a-w} EqT 9nSv(Bqhm^3)^{-1} \text{.....(1)}$$

where CRn_w is the average radon concentration in water, in Bq/m^3, Ra_w is the air–water concentration ratio (=10^{-4}), Eq is the equilibrium factor between indoor radon and its progeny (=0.4), T is the exposure time to this concentration, in hours (assumed to be equal to 7000 h per year), and 9 nSv (Bq h m^{-3})$^{-1}$ is the dose conversion factor.

Also from the Table (3) , showed the highest value of the annual effective dose in sample (K2) was 0.014289885 mSv.y^{-1} ,but the less value of the annual effective dose in sample (K15) was 0.000664969 mSv.y^{-1} . All results of the annual dose effective for ^{222}Rn of ground water in Al-Kufa city were smaller than the normal limits of world (1) msv.y^{-1} [11].Results of the average activity concentration of ^{222}Rn and ^{220}Rn of ground water in Al-Kufa city were smaller than the accordable limit as reported in USEPA [12]. The allowed maximum concentrations level for ^{222}Rn in water is 11 KBq.m^{-3} .The activity concentration ^{222}Rn (in Bq.L^{-1}) of ground water samples in the present study as compared with other studies for different location were shown in Table (4) some values obtained in the present study were lower than the international values , while others were higher. The reason for vibration in radon

concentration could be a function of geological structure of the area, depth of the water source and also differences in the climate . Others have reported that the geological structure of an area is a predominant factor for high radon concentration and climate is also an important factor[13].

Table (2) The activity concentration of (^{220}Rn) in (Bq.m^{-3}) of ground water sample in kufa city

No.	Location Sample	Mean of Concentration Thoron (Bq.m^{-3})
1	K1	------
2	K2	------
3	K3	------
4	K4	------
5	K5	------
6	K6	------
7	K7	------
8	K8	273.9998
9	K9	------
10	K10	276.02
11	K11	------
12	K12	------
13	K13	------
14	K14	------
15	K15	275.9978
16	K16	------
17	K17	276.9968
18	K18	------
19	K19	------
20	K20	------

Table (4) Concentration ranges of dissolved radon from recent studies that included ground water and springs.

Site	Range (Bq.L^{-1})	Ref.
Lebanon (many locations)	0.46–49.6	[14]
Jordan (many locations)	2.8–116	[15]
Tassili, Southeast Algeria	0.67–21.25	[16]
Eastern Doon Valley, outer Himalaya	20–95	[17]
Northern Venezuela	0.1–576	[18]
Sudety Mountains, South Western Poland	1.7–376	[19]
Cyprus (many locations)	0.1–5	[20]
Bavaria, Germany Median	3–50 Max: 16–1220	[21]
Midgonia Basin, Greece	Below DL-161	[22]
Punjab , India	69.189-209.459	[7]
Kufa city of Iraq	0.267-5.662	This Study

Table (3) The activity concentration of (^{222}Rn) in (Bq.m^{-3}) of ground water sample in kufa city.

No.	Location Sample	Run of Radon Concentration (Bq.m^{-3})				Mean of Concentration Radon (Bq.m^{-3})	The Annual Effective Dose (msv.y^{-1})
		1	2	3	4		
	K1	2410	2850	3560	3990	3202.5±707.17159	0.008081829
2	K2	5970	5850	5270	5560	5662.5±313.19589	0.014289885
3	K3	707	785	770	742	751±34.322004	0.001895224
4	K4	825	870	854	827	844±21.802140	0.002129918
5	K5	1880	1854	1570	1721	1756.3±142.36	0.004467678
6	K6	283	285	285	242	273.75±21.1876536	0.000690836
7	K7	1130	1285	1570	1570	1388.75±218.64640	0.00350465
8	K8	1420	1285	1154	1254	1278.25±109.79488	0.003225792
9	K9	290	242	285	250	266.75±24.267605	0.00067317
10	K10	1980	1850	1570	997	1599.25±436.42744	0.004035867
11	K11	2156	2990	2990	2850	2746.5±399.16036	0.006931067
12	K12	1790	1850	1712	1712	1766±66.992536	0.004456678
13	K13	1425	1280	1420	1140	1316.25±135.36216	0.003321689
14	K14	1850	1997	1710	1420	1744.25±245.88395	0.004401789
15	K15	285	285	242	242	263.5±24.826061	0.000664969
16	K16	1130	1140	1280	1710	1315±272.09067	0.003318534
17	K17	3990	4300	4300	4300	4222.5±155	0.010655901
18	K18	725	712	770	785	748±35.014282	0.001887653
19	K19	842	854	712	770	794.5±66.340033	0.002005
20	K20	300	325	290	304	304.75±14.728091	0.000769067

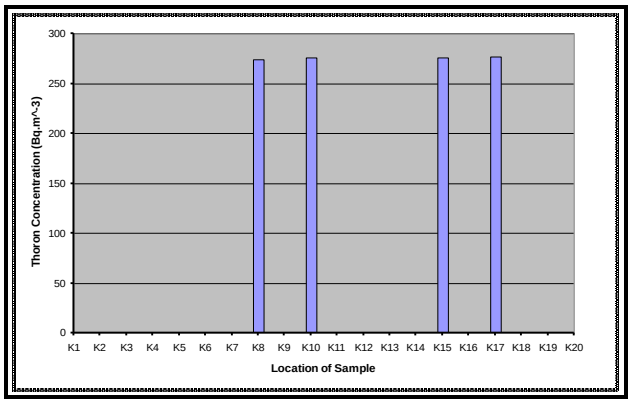

Figure (4) Thoron Concentration of Ground Water in Kufa city.

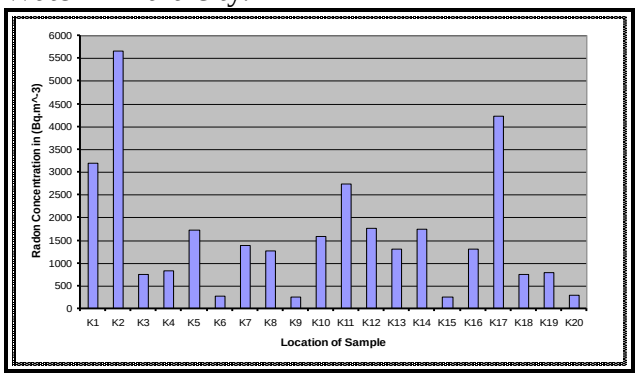

Figure (5) Radon Concentration of Ground Water in Kufa city

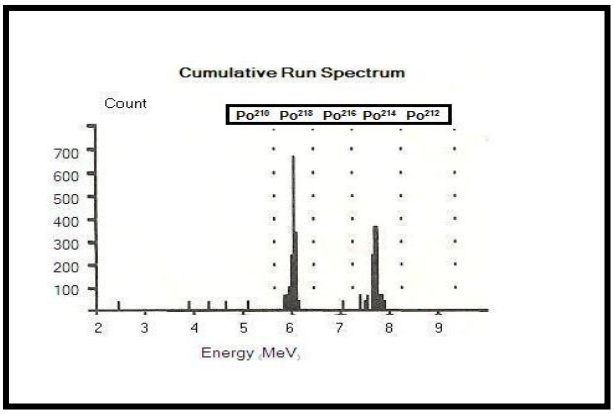

Fig.(6) alpha energy spectrum of location Sample(K2)

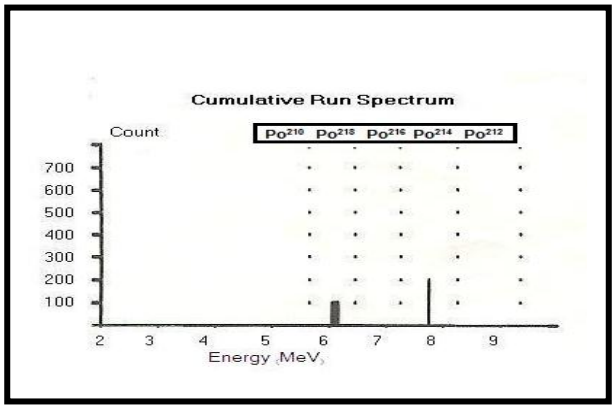

Fig. (7) alpha energy spectrum of location Sample(K15)

5-Conclusion :

The discussion of the result , which are obtained from this study leads to the following conclusion :

1. Radionuclide (^{222}Rn) ,which emits alpha ray and from uranium decay chain (^{238}U) was measured for samples of ground water at depth over (3m) to all the of regions the study. The maximum concentration of ^{222}Rn in Kufa city at the location sample (K2) was (5662.5 Bq.m^{-3}) and the minimum concentration of ^{222}Rn at the location sample (K15) was (263.5 Bq.m^{-3}) .
2. Radionuclide (^{220}Rn) ,which emits alpha ray and from thorium decay chain (^{232}Th) was measured for samples of ground water at depth over (3m) to all the of regions the study. The maximum concentration of ^{220}Rn in Kufa city at the location sample (K17) was (276.9968 Bq.m^{-3}) and the minimum concentration of ^{220}Rn for some of the region has neally zero value .
3. The Radon concentration of Ground water is independent on the values of PH and EC.
4. The allowed maximum concentration level in ground water which (11 KBq.m^{-3}) proposed by USEPA, therefore all results that its obtained in this study are less than the allowed maximum concentration level .
5. The united nations scientific committee on the effects of atomic radiation (UNSER) have suggested a value of radon concentration in water for human conception between (4 – 40) Bq.m^{-3} [7],then some propels were used ground water as drink water is very dangers.
6. The annual effective dose for ground water is less than of the allowed maximum concentration level in ground water.

References :

[1] A.V. Nero, "Radon and its decay products in indoor air": An overview. Editors W. Nazaroff and A. Nero, John Wiley and Sons, Inc., P. 1 – 53, (1988).

[2] C.Samuelsson, , H.Petterson, "Exhalation of ^{222}Rn from porous materials". Radiation Protection Dosimetry, Vol. 7, No.1 – 4, P.95 – 100, (1984).

[3] C. Lubin , "Adjusting Lung Cancer Risks for Temporal and Spatial Variations in Radon Concentration in Dwellings in Gansu Province" Radiat. Res; Vol.163 ,P.571-579 , (2005).

[4] D.Krewski, "Residential Radon and Risk of Lung Cancer: A Combined Analysis of 7 North American Case-Control Studies ", Epidemiology; Vol.16, P.137-145, (2005).

[5] S.Darby, " Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies", BMJ; Vol.330 , P.223-227,(2005).

[6] R. K Somashekar,. And P. Ravikumar, '" Radon concentration in groundwater of Varahi and Markandeya river basins, Karnataka State, India ", J. of radioanalytical and nuclear chemistry, Vol. 285 ,No.2,P. 343-351 ,(2010).

[7] K.Badhan , R.Mehra and R.G.Sonkwade .," measurement of radon in ground water using RAD7 and assessment of average annual dose in the environs of NITJ , Punjab , India' , Indian Journal of pure & applied physics ,Vol.48 , P.508-511,(2010).

[8] Y.Tan and D. Xiao , IEEE Transaction on nuclear science, Vol. 58, No. 1, P.209-213, (2011).

[9] Durridge Company Inc., Reference Manual version 6.0.1, RAD7™ Electronic Radon Detector ,(2010).

[10] UNSCEAR (B), Sources and Effects of Ionizing Radiation, Annex B: Exposures from Natural Radiation Sources. United Nation Scientific Committee on the Effect of Atomic Radiation, UNSCEAR 2000, New York, USA.

[11] UNSCEAR , Sources, effects and risks of ionizing radiation.
United Nations, New York, pp 1–35,(2000)

[12] Connecticut Department of Public Health Environmental Health Section Radon Program , Report , (2010).

[13]J.Vaupotic , I.Kobal and J.Planinic ,J. Radioanalyt Nucl. Chem., Vol.238 , P.61 ,(1998).

[14] S.M. Abdallah , R.R.Habib,R.Nuwayhid, M.Chatila and G.Katul., "Radon measurements in well and spring water in Lebanon" Radiation Measurements ,Vol. 42 ,P. 298 – 303, ,(2007)

[15] A.T. Al-Kazwini, and M.A. Hasan, ' Radon concentration in Jordanian drinking water and hot springs", J. Radiol. Prot., Vol. 23, P.439–448,(2003)

[16] Amrani, D., Cherouati, D.E., Cherchali, M.E.H.,"Groundwater radon measurements in Algeria", J. Environ. Radioact., Vol. 51,P. 173–180, ,(2000).

[17] Choubey, V.M., Bartarya, S.K., Ramoula, R.C., "Radon in groundwater of eastern Doon valley Outer Himalaya.", Radiat. Meas. Vol.36,P. 401–405 ,(2003).

[18] A.Horvath, "Radon concentration in hot springs waters in northern Venezuela.", J. Environ. Radioact.,Vol. 47,P.127–133 ,(2000)

[19] Kozlowska, B., Hetman, A., Dorda, J., Zipper, W.,"Radon enriched spring waters in the south of poland ",Radiat.phys.Chem.Vol.61,P.677-678.
,(2001)

[20] I.Sarrou and I. Pashalidis,"Radon levels in Cyprus." , J. Environ. Radioact. Vol.68, P.269–277 ,(2003).

[21] Trautmannsheimer, M., Schindlmeier, W., Hubel, K.,"Radon exposure levels of the staff in the drinking water supply facilities in Bavaria", Germany. Int. Congr. Ser. ,Vol.1225, P.81–86 ,(2002)

[22] Zouridakis, N., Ochsenkuhn, K.M., Savidou, A.,"Determination of uranium and radon in potable water samples.", J.Environ ,Radoact , Vol.61, P.225-23,(2002).