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Monitoring of radionuclide concentrations in marine algae, mussel and sediment samples from the Turkish marine environment during the period of 2001-2009

2001-2009 yılları arasında, Türkiye'nin denizel ortamında bulunan denizel alg, midye ve sediment örneklerinde radyoaktivite konsantrasyonları

Sayhan Topçuoğlu[1], Halim Aytekin Ergül[2], Murat Belivermiş[1] and Önder Kılıç[1]

[1]Istanbul University, Faculty of Science, Radiobiology Section of Biology Department, 34134 Vezneciler, Istanbul, Turkey.
[2]Kocaeli University, Faculty of Art and Science, Department of Biology, Izmit, Turkey.

Abstract

The anthropogenic and natural radionuclide concentrations were reviewed in marine algae, mussel and sediment samples were collected from Turkish marine environment in 2001 to 2009. The results showed that, the concentration of ^{137}Cs activity gradually decreased in tested all the samples than previous results. On the other hand, the natural radionuclide concentrations are slight increased during this time.

Key words: Radionuclide, biota, sediment, Turkish marine environment.

Introduction

It is well known that establishing marine environmental quality threshold for coastal management demanded for all contaminants monitoring.

***Corresponding author:** sayhantopcuoglu@yahoo.com

The measurements of the contaminants in seawater are often technically difficulty and costly. For this reason, the use of the marine algae and mussel samples preferred that are widely distributed in the coastal zone and sedentary way of life. At the same time, marine sediment samples are also important for controlling direct and indirect waste releases a considerable amount of the anthropogenic radionuclides (especially ^{137}Cs) entered in Turkish marine environment after Chernobyl accident (Topcuoğlu et al. 2001, 2003). Of late, the natural radionuclide concentrations in Turkish marine environment are gradually increasing from the fossil fuel, phosphate industry and use of fertilizers (Topcuoğlu 2000).

A study was published on monitoring of radioactivity concentrations in marine algae from the Turkish Black Sea coast and Bosphorus during the period of 1984-2001 (Topcuoğlu 2005). The results of the previous study showed that the Chernobyl radionuclides levels in fish, mussel and sea snail samples were not higher than the macrolagae samples especially one year after accident. At the same time, the results also showed that the maximum concentrations of natural radionuclide (^{235}U and ^{232}Th) in macroalgae are significantly higher than the organism and sediment samples. However, the natural radionuclide concentrations of ^{210}Po, ^{210}Pb and ^{40}K in macroalgae samples are found within the range of cited values in literature.

This review presents the concentration of an anthropogenic (^{137}Cs) and some natural (^{238}U, ^{232}Th and ^{40}K) radionuclides in marine algae, mussel and sediment samples collected from different stations in Turkish marine environment. At the same time, the some unpublished results on the level of the radionuclides are also given in marine algae samples collected from different Turkish marine environment.

The results for ^{137}Cs and natural radionuclide concentrations in marine algae of the Turkish marine environment are given in Table 1. The results showed that ^{137}Cs concentrations in the tested algae samples at the Mediterranean and Aegean coast were found as quite low level in 2004 when compared with the Black Sea algae collected as similar time.

Table 1. Radionuclide concentrations in marine algae at the Turkish marine environment (Bq kg^{-1} dry weight) (Unpublished data)

Station/region and species	Collection Date	^{137}Cs	^{238}U	^{232}Th	^{40}K
İskenderun-Arsuz *Jania rubens*	2.12.2004	0.71±0.07	3.77±3.52	Nd	14.50±1.53
Adana-Yumurtalık *Padina pavonia*	2.12.2004	0.33±0.13	8.88±1.95	2.44±1.66	19.91±2.34
Alanya *Cystoseita sp.*	1.12.2004	0.51±0.12	10.20±1.10	3.71±0.50	23.30±2.30
Fethiye-Ölüdeniz *Jania rubens*	30.11.2004	0.95±0.09	2.42±0.97	Nd	16.77±2.10
Ordu-Ünye *Cyctoseira barbata*	30.08.2004	2.41±0.44	11.34±3.01	6.17±2.86	435.7±97.6

Nd= Not detected

The ^{137}Cs levels in mussels from the Black Sea were found to be high concentrations than Mediterranean and Aegean transplanted mussel samples (Table 2). However, the ^{137}Cs and ^{40}K activity levels in Çanakkale mussel samples are generally higher than Black Sea mussel samples collected in 2003. In generally, the size of the mussel selected between 5-7 cm, except Çanakkale mussel samples. The size of the Çanakkale mussel samples ranged between 10-12 cm. For this reason, activity concentrations in the Çanakkale samples are different than other tested mussels.

The radionuclide concentrations in sediment samples are given in Table 3. The highest ^{137}Cs level was found in Rize station and the results showed that the ^{137}Cs activity contents significantly increased with the decrease of the grain size. Similar trend are also found for natural radionuclides.

The ^{137}Cs, ^{238}U, ^{232}Th and ^{40}K contents in the sediment trap material are shown in Table 4. The high ^{137}Cs activity concentrations determined during Autumn 2003. The vertical flux of tested all radionuclides can be calculate by multiplied mass flux and activity of the radionuclide in the settling particle. The maximum flux rate of the ^{137}Cs was found to be 2.81 ± 0.56 $Bq\cdot m^{-2}\cdot d^{-1}$ during 24 Sep-30 Oct in 2003. The results also showed that small seasonal variation in the radionuclide concentration and flux rate are found in the sediment trap material.

Table 2. Radionuclide concentrations in mussels (*Mytilus galloprovincialis)* collected in 2001-2009 (Topcuoğlu et al. 2001, Thébault et al. 2008, Önder et al. 2010).

Station/region	Collection date	^{137}Cs	^{238}U	^{232}Th	^{40}K
Bosphorus-R.Feneri	13.06.2002	1.63±0.73	5.91±2.56	3.94±0.73	b.d.l.
	16.10.2002	2.08±0.78	3.70±1.80	2.32±0.78	280.1±69.3
	29.01.2003	3.93±0.67	2.99±1.46	b.d.l.	223.3±38.6
Black Sea-Kilyos	13.06.2002	1.92±1.06	3.31±2.08	b.d.l.	66.5±25.2
	16.10.2002	3.16±0.74	4.59±2.24	2.30±0.78	161.8±29.7
Black Sea-İğneada	27.08.2002	3.20±0.75	b.d.l.	b.d.l.	103.1±32.4
Black Sea-Rize	22.05.2002	1.39±0.70	6.12±2.54	3.06±0.99	357.2±35.7
Black Sea-Yomra	02.03.2003	1.84±0.90	15.60±2.93	b.d.l.	251.8±40.2
Black Sea-Sinop	20.11.2002	1.60±1.40	9.27±2.70	b.d.l.	60.4±10.9
Black Sea-Ünye	21.11.2002	2.22±1.06	3.62±2.19	b.d.l.	51.7±20.1
Bosphorus-R.Feneri	04.06.2003	2.91±0.64	3.36±1.91	b.d.l.	231.1±45.2
Black Sea-Kilyos	04.04.2003	2.70±0.02	b.d.l.	2.61±0.66	331.1±45.2
Bosphorus-R.Feneri	06.05.2004	3.53±0.45	5.95±1.31	b.d.l.	241.2±43.2
Black Sea-Rize	07.07.2004	2.28±0.21	8.12±2.54	2.06±0.88	307.5±37.5
Black Sea-Yomra	07.07.2004	2.33±0.25	7.98±1.98	b.d.l.	287.4±42.9
Black Sea-Ünye	15.08.2004	1.98±1.46	2.63±1.21	b.d.l.	70.4±19.1

[1]Transplanted mussel and values are expressed in Bq kg^{-1} wet weight, b.d.l.= below detection limit

Table 2. continued

Station/region	Collection date	^{137}Cs	^{238}U	^{232}Th	^{40}K
Bosphorus-R.Feneri	27.09.2005	2.41±0.41	b.d.l.	b.d.l.	112.2±33.3
Black Sea-Yomra	16.08.2005	2.41±0.52	8.97±2.32	b.d.l.	175.3±53.7
Black Sea-Ünye	14.07.2005	1.13±0.67	3.36±1.33	b.d.l.	56.5±12.2
Black Sea-Sinop	15.07.2005	0.96±0.74	12.65±3.47	b d.l.	77.6±25.6
Marmara Sea Menekşe	07.05.2001	2.19±0.86	3.39±1.64	b.d.l.	380±46.5
Marmara Sea-Gemlik	16.09.2004	1.31±0.76	2.98±1.66	b.d.l.	218.7±35.7
Marmara Sea-Çanakkale	24.06.2003	4.01±0.93	-	-	1036.3±78.9
	30.10.2003	3.11±0.72	-	-	989.3±89.2
Mediterranean Sea-Antalya[1]	30.11.2004	0.03±0.01	1.54±2.34	0.08±0.03	1.55±0.15
Mediterranean Sea-Botaş[1]	02.12.2004	0.06±0.02	1.02±0.27	b.d.l.	9.18±1.91
Mediterranean Sea-Akkuyu[1]	01.12.2004	0.030±0.014	0.78±0.08	b.d.l.	1.53±0.17
Aegean Sea-Fethiye Bay[1]	30.11.2004	0.020±0.011	0.05±0.01	b.d.l.	1.48±0.77
Bosphoerus-R.Kavağı	2008-2009	1.20±0.25	b.d.l.	1.40±0.08	304.0±16.0
Bosphorus- Tarabya	2008-2009	1.31±0.26	0.90±0.09	1.90±0.10	310.0±16.0
Golden Horn-Balat	2008-2009	1.05±0.23	b.d.l.	0.80±0.06	348.0±18.0

[1]Transplanted mussel and values are expressed in Bq kg^{-1} wet weight, b.d.l.= below detection limit

Table 3. Radioactivity concentrations (in Bq kg^{-1} dry weight) in the bottom sediment samples collected from Turkish marine environment (Topcuoğlu et al. 2003, 2004, Ergül et al. 2006, Kılıç et al. 2010).

Station/region	Particle size	Collection	137Cs	238U	232Th	40K
Black Sea-Rize	>250	6.2001	85±12	44±12	< 7	460±186
	<250	6.2001	85±11	100±30	69±21	221±172
	<63	6.2001	159±70	543±139	363±284	2783±696
Black Sea-Pazar	<250	10.1998	51±7	37±11	<7	235±116
Black Sea-Yomra	<250	Autumn 2003	83±17	<13	53±40	964±299
Black Sea- Ünye	<500	7.2001	22±7	39±21	47±16	686±128
Bosphorus-R.Kavağı	>63	2008-2009	27.50±1.40	11.6±0.7	12.0±0.7	630±52
	<63	2008-2009	46.0±2.6	10.8±0.7	14.8±0.7	630±33
Bosphorus-Tarabya	>63	2008-2009	1.81±0.83	7.9±0.4	10.7±0.6	344±17
	<63	2008-2009	35.7±2.3	20.5±1.2	25.2±1.2	403±26
Golden Horn-Balat	<63	2008-2009	40.5±2.2	16.5±0.6	22.0±0.9	346±16
Aegean Sea-Fethiye Bay	<63	30.11.2004	7.0±0.7	16.1±1.5	5.8±06	198±15
Mediterranean Sea-	<63	30.11.2004	7.7±08	12.3±1.2	19.8±1.9	438±41
Mediterranean Sea-	<63	01.12.2004	1.7±0.2	19.8±1.9	22.1±2.0	320±16
Mediterranean Sea-Botaş	<63	02.12.2004	3.2±0.4	12.0±1.2	9.6±1.1	284±26
Mediterranean Sea-Arsüz	<63	02.12.2004	0.22±0.05	2.3±0.2	1.5±0.2	256±25

Table 4. Radioactivity concentrations (in dry weight) in settling particles and mass fluxes trough 40 m depth in the eastern Turkish Black Sea coast (Ergül et al. 2006).

Sampling period	Mass	^{137}Cs	^{238}U	^{232}Th	^{40}K
5-20 July 2002	25.92	0.10±0.2			
24 Sep-31 Oct 2003	56.36		<0.01	0.04±	
20 Jun-20 Feb 2003	9.39		0.37±0.1		
15 Apr-9 May 2003	13.55		<0.01		

Conclusion

The use of marine algae, mussel and bottom samples could conveniently be taken monitoring of radionuclide contamination of coastal marine environment. Moreover, sediment trap studies are the tool of choice for investigating concentrations and fluxes of substances in sinking particulate material.

The results in the organism and sediment samples showed that a strong inverse relationship between the concentrations of ^{137}Cs measured in the samples and the distance of their sampling stations from the Chernobyl Nuclear Power Plant. At the same time, the sediment trap study demonstrated that radionuclide concentrations in the settling material and vertical flux rate in the eastern Black Sea coastal waters are variable and are likely dependent upon seasonal changes.

Özet

Bu çalışmada, yapay ve doğal radyonüklidlerin konsantrasyonları denizel alg, midye ve sediment örneklerinde bir derleme olarak verilmektedir. Örnekler 2001 ile 2009 tarihleri arasında Türkiye'nin denizel ortamlarından alınmıştır. ^{137}Cs aktivitesi test edilen tüm örneklerde önceki bulgulara göre bir azalma göstermiştir. Buna karşılık bu süreç içinde az da olsa doğal radyonüklid düzeylerinde bir artış olmuştur.

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