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^{137}Cs and ^{210}Po Concentrations and Determination of Transfer Factors From Soil to Plant in Izmit Bay

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ABSTRACT

Kocaeli province that has a front place in Turkey for the industrial facilities has encountered a high level of environmentpollution caused by not taking precautions which is much higherthan average value of Turkey, and there is not enough information about the portion of radioactive pollution. For this purpose, soil (20 cm), moss, and lichen samples have been taken from three different regions at mountainous, lakeside, and settling areas of Izmit Bay. The datarelated to radionuclides of ^{137}Cs and ^{210}Po in these organisms in Izmit Bay are not available so far.

In this study, therefore, the activity levels of radionuclides of ^{137}Cs ($t_{1/2}$ = 30.17 years) and ^{210}Po ($t_{1/2}$ = 138 days) have been measured in soil and some bioindicators (lichens and mosses) by using gamma and alpha counting systems, respectively. Additionally, transfer factors of ^{137}Cs have been calculated. The obtained results will be reference information for future studies and the sake of precaution againstpossible radiation contamination.

Keywords: *^{137}Cs, ^{210}Po, lichens and muscis, gamma spectrometric, alpha spectrometric, environmental radiation*

INTRODUCTION

Humans come under radiation from nuclear accidents, experiments etc. Radioisotopes produced as a result of surface and underground nuclear tests affect many countries in the 1960's as a results of rainfall. Following the Chernobyl nuclear accident, the radionuclides were deposited on the marine and terrestrial environment of Turkey and other countries as wet and/or dry fallout. After the accident at the Chernobyl nuclear power plant, weather, rainwater, fish, such as fruit and vegetables, soil were measured.

Water soluble radionuclides were absorbed by the leaf surfaces of plants (1). Additionally, plants absorb radionuclides in the soil through from the roots (2). Separation of these two mechanisms, which is absorbing from leaf surface and soil from the roots, is difficult. Additionally it is significant, both in soil that had been absorbed to determine the level of radionuclides in plants and necessary to create models and scenarios in terms of radiation safety. In particular,our country will make sense in case of the introduction of the nuclear power plant. Moss and lichen have been used commonly as monitoring organism of fallout radionuclides such as ^{137}Cs.

Lichens and mosses have been widely used for monitoring organisms for radioactive and chemical pollution both qualitatively and quantitatively. Living of hundreds of years and very slow growth rate of lichens and mosses, as well as the inclusion of large structural surface area leads to high levels of radionuclides or metal accumulation. Mosses have a specific surface area 10 times larger than those of herbaceous plants (3). ^{137}Cs and ^{210}Po radionuclides can be absorbed by plants from the soil and enter the food chain in the way.

Radionuclides contamination of the food chain on the people by the radiation source is a continuous effect.After the Chernobyl nuclear accident, especially ^{134}Cs and ^{137}Cs were determined in the lichen and moss samples in Turkey. ^{137}Cs natural loss rate in samples of lichens and mosses was also detected (4-6).

^{210}Po returns to the earth as dry fallout or washed out in rain. Especially, thecoal-fired power plants are one of the major sources of increased natural radioactivity in the atmosphere. Previously, ^{137}Cs and ^{210}Po activity measurements related to lichen and moss samples are not available in the literature, in Izmit Bay. Additionally, ^{137}Cs activity measurements releated to sand and soil samples are available in the literature.

The aim of this study in the content of using ^{137}Cs and ^{210}Po values in these bioindicator organisms, is to contribute to the radiation map of our country.

METHODS

Study Site

In Turkey, after the Chernobyl accident as it is in many countries, sediments were contaminated with radionuclides in different proportions. In order to see these effects in Izmit Bay area, 13 samples were collected from 7 stations: Hereke, Derince, Umuttepe, Kartepe, Eşme Bahçecik, Karamürsel, (Fig.1).

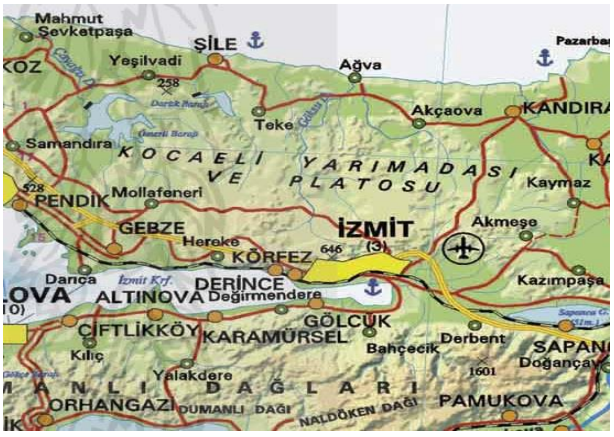

Figure 1. Location of the collected samples on the map

Soil, lichen and moss sampling

Soil samples were taken from 0-20 cm depth from the ground surface. Sampling is performed with the aid of a plastic pipe with a diameter of 8 cm and a length of 20 cm. Sample preparation procedures were carried out from the laboratuary of Çekmece Nuclear Research and Training Center (ÇNAEM).

Lichens were collected from Bahçecik, Kartepe, Hereke statations by hand from the roots. Moss were scraped with the clean spatula from soil surface where Bahçecik, Hereke, Kartepe, Umuttepe. Collected samples were placed and kept in labeled clean bags.

The soil samples were ground, crushed to fine grain size of about 100 mesh and sieved to homogenize them and remove big size. The samples were then dried at 80°C for 8 h to ensure that moisture is completely removed. Plant samples were dried for 8h at 80°C in an oven to obtain a constant dry weight. The samples were powdered and charred to get homogenize samples. Then each sample was weighted and prepared for the counting (Table 1).

Table 1. The masses of dry liclen, moss and soil samples (g)

Sapling stations	Sampling type	Sampling mass (g)
Kartepe	Soil	122.20
Eşme	Soil	114.70
Hereke	Moss	7.70
Kartepe	Moss	16.10
Kartepe	Lichen	12.70
Bahçecik	Lichen	9.50
Bahçecik	Soil	75.80
Bahçecik	Moss	6.80
Hereke	Soil	83.80
Derince	Soil	96.30
Umuttepe	Soil	60.20
Umuttepe	Moss	32.40
Karamürsel	Soil	98.80

^{137}Cs and ^{210}Pomeasurements

The gamma-ray activities were measured using HPGe (ORTEC GWL-190-15)computer-controlled detectors having 150 % relative efficiency. The detector was shielded with 10-cm-thick lead layer to reduce the background due to the cosmic rays and the radiation near by the systemORTEC Alpha spectrometer models and related analyzes were performed using the surface barrier silicon detectors (BU-019-300-AS brand).

This feature provides the count of eight samples simultaneously. Full energy peak efficiencies were determined using Standard Reference Material (IAEA-156) for the lichen and the moss samples prepared by International Atomic Energy Agency. Decay corrections were performed to the sampling date. The activity concentrations of 137Cs and 210Po were determined using 662 keV and 530 keV gamma-ray lines, respectively.

Calculation of activitiy concentrations

For 137Cs measurements, the following classical formula:

$$A(Bq/kg) = \frac{C'_{Ni}}{r_{Bi}.m.L_i.\varepsilon_E}$$

Where: A= specific activity (Bq/kg), C'_{Ni}= net count, r_{Bj}= branching ratio, m = dry mass, and ε_E= efficiency was used to determine the specific activities in the samples of soil, moss, and lichens.

Similarly, for ^{210}Po specific activity measurements, the following formula:

$$A = \frac{(C_{210} - C_{BG})\text{x}A(Po_{209})}{(C_{210} - C_{BG})\text{x}m}$$

Where: A = specific activitiy (Bq/kg), C_{BG}= bacground count, m = mass of sample (kg), and $A(Po_{210})$ = activity of tracer (Bq) was used.

Calculation of transfer factor

Transfer factor (*TF*) is the ratio of activity in the soil (A_S) and activity in the plant (A_P). Therefore, transfer factor indicates the passage from the soil the plant. The *TF* values were calculated according to the equation (International Union of Radioecologists, 1994):

$$TF = \frac{A_B(B_q/kg)}{A_T(B_q/kg)}$$

RESULTS AND DISCUSSION

In this study, we have studied and researched collecting 16 different samples from 7 stations between December 2006 to March 2007 in İzmit Bay. ^{137}Cs consantration on soil surface samples (20 cm) were collected form Hereke, Derince, Umuttepe, Eşme, Kartepe, Bahçecik. Lichens samples were collected from Kartepe and Bahçecik. Mosses samples were collected from Hereke, Umuttepe, Kartepe, Bahçecik. The obtained results for ^{137}Cs and ^{210}Po activity concentrations in soil, moss, and lichen samples have been listed in Table 2 and Table 3.

Table 2. The obtained ^{137}Cs activity concentrations in soil, moss, and lichen samples.

Sampling stations	Sampling type	Photo peak area	Counting time (s)	Activity (Bq/kg)
Kartepe	Soil	459	80000	1.41±0.17
Eşme	Soil	3022	80000	10.07±0.30
Hereke	Moss	126	85000	3.18±1.43
Kartepe	Moss	8590	80000	209.6±4.4
Kartepe	Lichen	502	250000	3.99±0.46
Bahçecik	Lichen	3664	85000	3.31±1.06
Bahçecik	Soil	4221	160000	27.56±1.42
Bahçecik	Moss	823	160000	<mda*
Hereke	Soil	2616	80000	12.23±0.43
Derince	Soil	1475	160000	17.3±3.30
Umuttepe	Soil	4689	88000	21.61±1.68
Umuttepe	Moss	4544	150000	21.30±0.74
Karamürsel	Soil	897	88000	1.71±*0.16*

Transfer factors of ^{137}Cs from soil to moss have been calculated for Hereke, Kartepe, and Umuttepe stations as 0.26 ± 0.12, 148.3 ± 26.7, and 9.86 ± 7.68, respectively. Also, transfer factors of ^{137}Cs from soil to lichen have been calculated for Bahçecik and Kartepe stations as 0.12 ± 0.07 and 2.83 ± 0.46.

Transfer factors of ^{210}Po from soil to moss calculated for Hereke and Kartepe stations are found as 5.31±1 and 14.71±2 while transfer factors of ^{210}Po from soil to lichen calculated for Bahçecik and Kartepe stations are found as 0.18±1 and 11.40±3.

We found that the maximum value was 27.6 ± 1.4 Bq/kg (Bahçecik) while the mininum value was 1.41 ± 0.17 Bq/kg (Kartepe). Transfer factors from soil to mosses ranged between 0.26 ± 0.12 and 148.3 ± 26.7, and those from soil to lichens were between 0.12 ± 0.07 and 2.83 ± 0.46.

As for the work done before in Izmit Bay, we can not give information about the reduction and increament in the amount of radiation in the environment. Current values have been found by this study and will help us to take measures in the case of a possible contamination event.

Table 3. The obtained ^{210}Po activity concentrations in soil, moss, and lichen samples.

Sampling stations	Sampling type	Photo Peak area	Counting time (s)	Activity (Bq/kg)
Kartepe	Soil	13	13552	7±3
Eşme	Soil	295	38084	68±6
Hereke	Moss	719	13564	271±16
Kartepe	Moss	654	48102	103±6
Kartepe	LİKEN	164	13554	91±8
Bahçecik	LİKEN	383	36601	93±7
Bahçecik	Soil	1338	13516	506±27
Bahçecik	Moss	67	13544	43±6
Hereke	Soil	80	13550	51±7
Derince	Soil	88	13567	57±7
Umuttepe	Soil	56	13561	36±5
Kartepe	Soil	13	13552	7±3
Eşme	Soil	295	38084	68±6

Conflict of Interest Disclosure

The authors declare no conflicts of interest.

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