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Investigation of Cs-137 in the environmental soil segments of the Peshawar and Nowshera districts of Khyber Pakhtunkhwa, Pakistan

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► ***Original article***

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ABSTRACT

Background: Radioactive contamination in soil arises due to various activities of human being, such as nuclear energy generation, use of radioisotopes in industrial applications, science, technology, medicine and release of radiation in nuclear weapon tests. ***Materials and Methods***: The two districts (Peshawar and Nowshera) of Khyber Pakhtunkhwa, Pakistan were selected for the study of anthropogenic Cs-137 assessment. A total of 102 soil samples were collected from different locations of these two districts of Khyber Pakhtunkhwa. ***Results:*** The activity concentration of Cs-137 was determined by gamma ray spectrometry using a high purity germanium detector coupled with a PC. The highest values for Peshawar and Nowshera found were 44.1 ± 4.6 Bq/kg and 27.9 ± 4.3 Bq/kg, respectively. ***Conclusion:*** The presence of Cs-137 shows that the areas under study have gained some fallout, however, the activity concentrations of Cs-137 found in the surveyed area were nominal and do not pose any potential health hazard to human beings.

Keywords: Cs-137, soil, radioactivity, Peshawar, Nowshera, gamma spectroscopy.

INTRODUCTION

Human beings are exposed to the natural as well as artificial radioactivity. A numbers of biological effects are induced by ionizing radiation, from cell death to mutations and carcinogenesis [(1)]. The natural radioactivity mainly arises from primordial radio nuclides, such as K-40, U-235 and Ra-226. Whereas the anthropogenic radioactivity arises from the human activities, such as generation of electricity, nuclear medicine, nuclear weapon tests etc. [(2)]. The radioactivity gained much more importance to the general public due to the recent Japan nuclear reactor accident and Chernobyl accident in Russia [(3)]. The most important fallout radioactive containment is Sr-90 and Cs-137, because of their long half-life, very high toxicity and relatively high uptake by bio-systems [(4)].

Cs-137 is the most abundant fission product with half-life of more than 30 years. It is distributed globally through the upper atmosphere. The other physical parameters which are important to play a role is its solubility in water [(5)]. Therefore, it is very important to analyze the Cs-137 concentration in the environmental soil segments. Another major source of Cs-137 is ground level nuclear weapon tests. It also enters into the environment through the routine activities of nuclear power generation stations, radioactivity fuel reprocessing plants and waste disposal sites [(4)].

The Cs-137 can enter the food chain directly by the deposition on the exposed crops or by its solubility in water through uptake of the root system. The isotopes of Cesium behave like potassium and they are widely distributed in the tissues of plants and animals. However,

the soil chemistry and the retention in upper surface soil profile play a significant role [6]. A number of scientists, researchers and monitoring bodies are involved in the study of radioactivity level from natural sources and in particular with anthropogenic fission product Cs -137 [7]. The overall damages from the Chernobyl and Japan nuclear reactor are presented for future reference [8].

Various researchers of the world have determined radioactive contamination in different environmental samples such as soil, air water and vegetable etc. [9-10]. The present study is a part of our ongoing research work [11-13], in which various building materials, environmental samples (soil, air and water) and food items have been analyzed for natural radioactivity. In the present work a comprehensive study of Cs-137 activity concentration in the soil samples collected from two districts (Peshawar and Nowshera) of Khyber Pakhtunkhwa, Pakistan was carried out. Results were compared with other areas of Pakistan and also with the available data in the literature for other countries of the world.

MATERIALS AND METHODS

Collection and preparation of samples

The soil samples were collected from the two districts (Peshawar (PS1 to PS42) and Nowshera (NS1 to NS60)) as shown in figures 1a and 1b. The samples were taken up from 10 -12 cm depth and the soil from three different places was combined to make a single sample. The samples were collected from the fields in labelled plastic bags. In the laboratory, the samples were spread on plastic sheets and dried at room temperature for several days to avoid any loss of radionuclides. After this, the samples were homogenized by mechanical treatment and passed through 2 mm mesh sieve. The aliquot of samples were properly labelled, place of collection was noted down and packed in selected plastics containers.

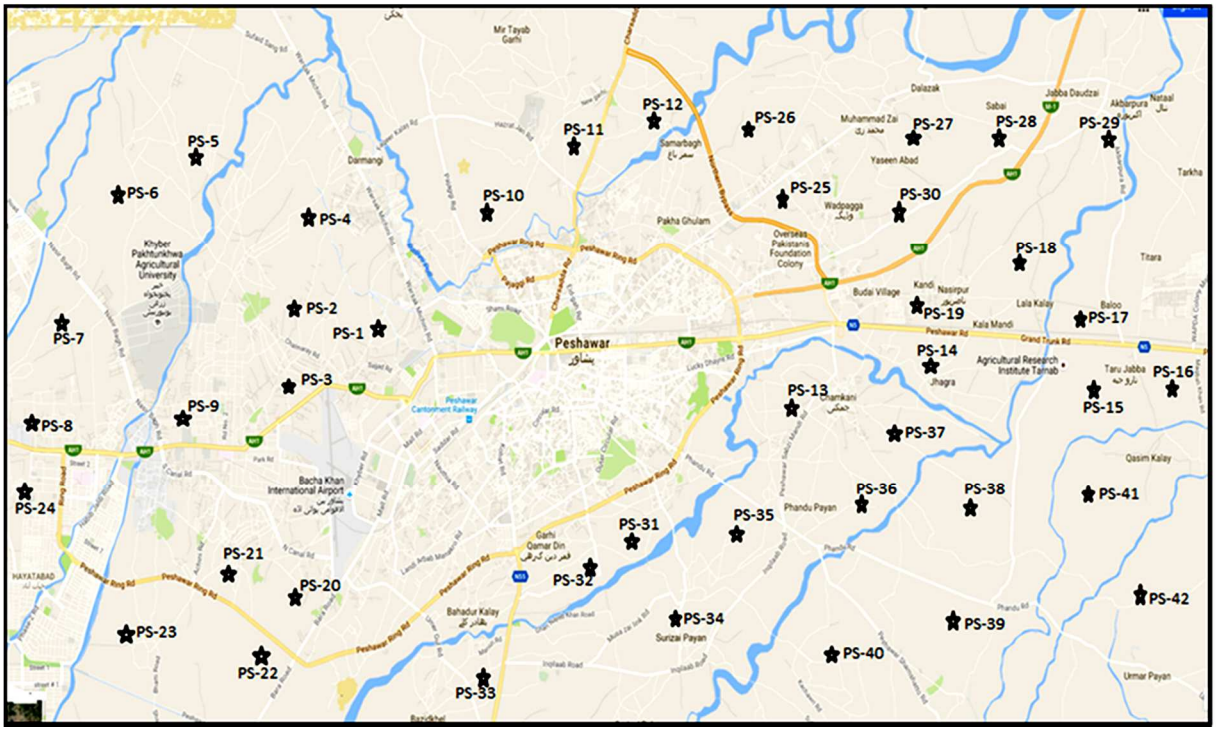

Figure 1a. Map of Peshawar area and location of sampling sites (PS1 to PS42).

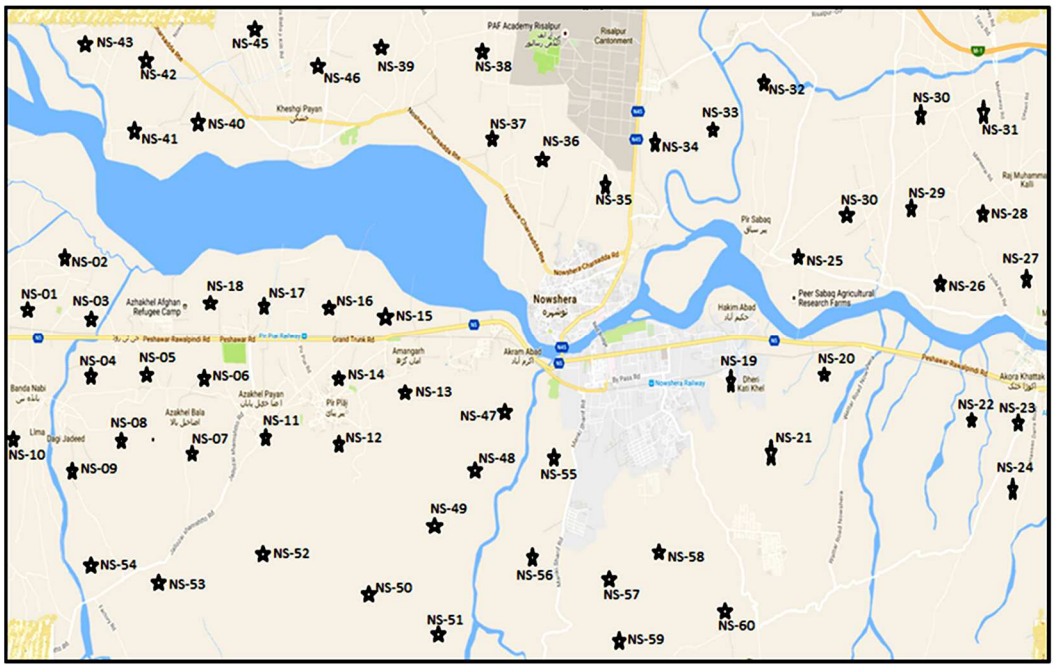

Figure 1b. Map of Nowshera area and location of sampling sites (NS1 to NS60).

Gamma ray spectroscopy

High purity germanium (HPGe) detector (Model GC 3020 Canberra, USA) with 8192 channels, coupled with a computer based multichannel analyzer acquisition board (Accuspec-A, Canberra) was used for measurement of radioactivity. The system was calibrated with International Atomic Energy Agency (IAEA,Vienna, Austria) standard references material IAEA-375 soil, for gamma ray activity determination in soil samples. The relative efficiency of the detector was 30% and its resolution for full energy peak of 1332.5 keV gamma ray of Co-60 was 2 keV. The results were analysed by Genie-2000 software (Canberra, USA). The measurement time for each sample was 65000 seconds. Background signals were also recorded periodically and subtracted from each result.

The activity concentration of radionuclides was calculated by using the following equation [11];

$$AC\ (Bq/sample) = (CS - CB)/(t \times E\gamma \times P\gamma)$$

where CS is the counts per second (cps) for soil sample, CB the cps for background, $E\gamma$ and $P\gamma$ the detection efficiency and emission probability of γ -ray and t the counting time.

RESULTS AND DISCUSSION

Measurements of Cs-137 radionuclide in soil samples were conducted for two districts (Peshawar and Nowshera) of Khyber Pakhtunkhwa, Pakistan. The activity concentration of Cs-137 in the soil samples of the selected area measured by direct gamma ray spectrometry is given in tables 1 and 2. The results are reported in Bq kg^{-1} for soil samples on dry weight basis. For the Peshawar District, the activity concentration of Cs-137 ranged from 9.5 ± 3.1 to 44.1 ± 4.6 Bq kg^{-1} as given in table 1. However, the activity concentration of Cs-137 ranged from 4.6 ± 3.2 to 27.9 ± 4.3 Bq kg^{-1} for Nowshera district as given in table 2.

As it is clear from the results that the concentration of Cs-137 of the various soil samples is not uniform but vary from sample to sample. Various factors may be responsible for this variation. Although these differences are not important keeping in view the large geological and geographic variations, which are mainly resulted from the soil characteristic and different metrological factors. Especially the rain at the time of deposition play important role in facilitating the deposition of Cs-137. Similarly the diffusion, sorption-desorption, plant uptake

by the root system or plant or animal originated mechanical changes also affect the Cs-137 level in soil. Topography of the area also plays important role in the accumulation of Cs-137 in soil. These above mentioned factors may be responsible for the different concentrations of Cs-137 in the soil of study areas.

Table 1. Activity concentration of Cs-137 in soil samples of Peshawar district.

Sample code	Cs-137 (Bq/kg)	Sample code	Cs-137 (Bq/kg)	Sample code	Cs-137 (Bq/kg)	Sample code	Cs-137 (Bq/kg)
PS-1	3.6 ± 14.0	**PS-12**	4.8±27.9	**PS-23**	3.8±22.2	**PS-34**	4.0±10.0
PS-2	3.5 ± 13.3	**PS-13**	BDL	**PS -24**	3.8±12.4	**PS-35**	3.9±17.1
PS-3	3.9 ± 23.1	**PS-14**	3.7±14.4	**PS -25**	4.1±24.9	**PS-36**	4.0±12.7
PS-4	3.7±18.7	**PS-15**	4.1±22.4	**PS -26**	3.9±16.6	**PS-37**	4.0±12.5
PS-5	4.2±19.7	**PS-16**	3.9±15.1	**PS -27**	4.2±20.9	**PS-38**	3.1±9.5
PS-6	4.1±21.8	**PS-17**	3.1±9.81	**PS -28**	3.6±19.9	**PS-39**	4.2±16.2
PS-7	4.6±44.1	**PS-18**	4.2±21.7	**PS -29**	4.0±19.2	**PS-40**	3.8±18.4
PS-8	4.1±35.5	**PS-19**	4.3±14.2	**PS -30**	4.0±15.6	**PS-41**	3.5±24.7
PS-9	4.0±18.5	**PS-20**	3.9±18.0	**PS -31**	3.4±9.6	**PS-42**	3.9±15.8
PS-10	4.3±24.5	**PS-21**	4.2±27.2	**PS -32**	BDL		
PS-11	4.8±27.9	**PS-22**	4.5±27.4	**PS-33**	4.1±9.1		

BDL = Below Detection Limit
PS = Peshawar Soil

Table 2. Activity concentration of Cs-137 in soil samples of Nowshera district.

Sample code	Cs-137 (Bq/kg)	Sample code	Cs-137 (Bq/kg)	Sample code	Cs-137 (Bq/kg)
NS-01	3.5±16.1	**NS-21**	3.4±15.1	**NS-41**	4.3±14.7
NS-02	3.5±15.8	**NS-22**	3.9±19.4	**NS-42**	4.0±13.9
NS-03	3.9±22.1	**NS-23**	3.6±20.6	**NS-43**	3.6±9.2
NS-04	3.4±12.9	**NS-24**	3.8±27.8	**NS-44**	4.4±22.5
NS-05	3.4±10.9	**NS-25**	3.2±11.1	**NS-45**	3.9±20.3
NS-06	3.7±21.8	**NS-26**	3.4±11.8	**NS-46**	4.6±34.0
NS-07	3.8±20.8	**NS-27**	3.4±24.6	**NS-47**	<BDL
NS-08	3.0±16.5	**NS-28**	3.5±22.4	**NS-48**	4.3±22.8
NS-9	3.6±21.5	**NS-29**	3.7±10.1	**NS-49**	3.5±16.4
NS-10	3.3±12.9	**NS-30**	3.5±24.7	**NS-50**	BDL
NS-11	3.5±17.2	**NS-31**	2.6±9.8	**NS-51**	4.2±17.3
NS-12	3.2±8.68	**NS-32**	3.6±21.4	**NS-52**	3.5±20.2
NS-13	3.2±16.2	**NS-33**	3.5±23.3	**NS-53**	3.9±16.8
NS-14	3.2±7.0	**NS-34**	3.2±4.6	**NS-54**	BDL
NS-15	3.7±15.6	**NS-35**	3.1±26.8	**NS-55**	4.0±20.2
NS-16	3.5±8.9	**NS-36**	3.7±18.5	**NS-56**	3.8±16.6
NS-17	BDL	**NS-37**	3.6±20.8	**NS-57**	4.0±18.5
NS-18	4.1±25.5	**NS-38**	3.8±21.2	**NS-58**	BDL
NS-19	3.3±26.4	**NS-39**	2.8±7.6	**NS-59**	4.2±22.6
NS-20	BDL	**NS-40**	4.3±27.9	**NS-60**	4.2±21.6

BDL = Below Detection Limit
NS = Nowshera Soil

The comparison of the Cs-137 data for Peshawar and Nowshera districts of KPK, Pakistan with the reported data, such as Kohistan [12] and Jhangar valley [13] of Pakistan, Mirpur Azad Kashmir, Pakistan [14] and also with the countries in the rest of the world show that the data of studied areas is not alarming (table 3). When comparing the results of present study with the different areas of the country such as Kohistan and Jhangar valley of Pakistan, we found that Jhangar valley has nearly same value of miximum activity concentration of Cs-137 as the Peshawar and Nowshera area, while Kohistan and Mirpur Azad Kashmir, Pakistan have smaller activity concentration of Cs-137 than the Peshawar and Nowshera area. Similarly, If we compare the results with different countries of the world, for example Syria [15] has higher values of activity concentration of Cs-137 than Peshawar and Nowshera. On the otherhand, Tehran (Iran) [16] and İkizdere Valley (Turkey) [17] have lower values than our studied area. The data reported for Louisiana (USA) [18] and Vojvodina (Serbia) [19] were close to our reported values. Similarly, if we compare our finding of Cs-137 concentration with Leningrad Region (Russia) [20], it is consistent that this area has very high density of Cs-137 deposition as a result of Chenobyl accident.

Table 3. Comparison of Cs-137 activity in the soil of Peshawar and Nowshera areas with data reported for other areas of Pakistan and other countries of the world.

Location	Minimum (Bq/kg)	Maximum (Bq/kg)	Average(Bq/kg)	Reference
Kohistan, Pakistan	7.06	14.9	9.5	(12)
Jhangar Valley, Pakistan	1.3	46.8	13.39	(13)
Mirpur, Azad Kashmir, Pakistan	0.076	2.94	1.39	(14)
Tehran (Iran)	0.29	28.82	11.30	(15)
Syria	1.2	143	37.17	(16)
İkizdere Valley, Turkey	3.83	6.45	5.25	[17)
Louisiana (USA)	5	58	-	(18]
Vojvodina, Serbia	5.7	55	-	(19)
Leningrad Region (Russia)	29	5320	467	(20)
Peshawar and Nowshera (Pakistan)	**4.6**	**44.1**	-	Present study

CONCLUSION

The results of the present study showed that an anthropogenic radionuclide Cs-137 was present in detectable amount in all soil samples. The highest activity concentrations of Cs-137 in the Peshawar soil (PS-7) and Nowshera soil (NS-40) samples were found 44.1 ± 4.6 and 27.9 ± 4.3 Bq kg^{-1}, respectively. The presence of Cs-137 shows that the areas under study have gained some fallout, however, the activity concentrations of Cs-137 found in the surveyed area were nominal and do not pose any potential health hazard to human beings. This data may also provide a guideline for future measurement and assessment of radionuclides in the case of any radiological emergency.

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Conflicts of interest*: *Declared none.

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