



MEASUREMENT OF ^{90}Sr CONCENTRATION IN SOIL SAMPLES OF JHANGAR VALLEY IN EASTERN SALT RANGE OF PUNJAB, PAKISTAN

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A study is being carried out with the collaboration of University of Peshawar for the detection and measurement of radioactive pollution level in Eastern Salt Range of Pakistan. In the present work soil samples were collected from ploughing fields of the Jhangar valley of Eastern Salt Range, to determine the geographical distribution of ^{90}Sr in the area. The samples were collected from 6-12 cm depth from the surface. The activity of ^{90}Sr was determined via its daughter nuclide ^{90}Y after radiochemical separation from the soil samples. The radiochemical separation of ^{90}Y was carried out from its soluble matrix constituents using Tributyl Phosphate (TBP) followed by removal of interfering radionuclides by using sodium carbonate. The activity of ^{90}Y in aqueous solution was measured by cerenkov counting on a liquid scintillation counting system model 4530 having sample capacity of 300 vials with multi-microprocessor. The activity of ^{90}Sr in Jhangar valley varied below MDA to 2.52 Bq kg^{-1} with an estimated mean value of 0.49 Bq kg^{-1} , which is lower than some other regions of the world.

Keywords : Eastern salt range, Jhangar valley, ^{90}Sr , TBP, Soil samples, Liquid scintillation counter

1. Introduction

^{90}Sr is a radioactive isotope of strontium that is produced as a fission product of uranium. It is a low energy beta emitter with a physical half-life of 28.8 years. In the environment it is accompanied by its decay product, ^{90}Y , also a beta emitter [1].

The radioactive isotopes of strontium are exclusively of anthropogenic origin, which have reached the natural environment in large quantity after atmospheric nuclear weapon tests and large-scale nuclear accidents like Chernobyl. Apart from the isotope of cesium and plutonium, these isotopes rank among the most dangerous radioisotopes-pollution sources in the human environment [2].

The ^{90}Sr is readily incorporated into the biosphere as a result of chemical properties it share with calcium, an essential element for most organisms including human beings. Thus metabolically, strontium is an analog of calcium and is rapidly absorbed from the gastrointestinal tract or the lung into the bloodstream and is subsequently deposited in bone [3,4]. Retention in the bone is long-term, with yearly loss of the

existing burden in adults of 7.5 % from cortical bone and 30% from trabecular bone [5].

Soil is a valuable environmental monitoring medium because it can accumulate contaminants from air emissions as well as re-suspended materials. Thus soil sampling and subsequent analysis evaluates long-term contamination trend and monitor environmental radionuclides inventories. Moreover, the determination of ^{137}Cs and ^{90}Sr in soil is of great importance owing to the fact that plant roots are one way of incorporation into the trophic chain [6]. Also ^{137}Cs activity is important for soil erosion studies. The main practical difficulty regarding calcareous soil samples will be the existence of large disparity between the amounts of both elements. The selection of radiochemical procedure for separation is another difficult task. In our study radiochemical separation was carried out by solvent extraction method followed by cerenkove counting on a liquid scintillation counter.

Present study was undertaken within the framework of our countrywide radiological environmental monitoring programme [7-12] with

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the collaboration of other research institutes of the country. The results of gamma emitting radionuclides including naturally occurring and ^{137}Cs have already been published for the area under study [13]. Soil samples from Jhangar valley of Eastern Salt Range were collected between longitude $73^{\circ} 00'$ to $73^{\circ} 15'$ E and latitude $32^{\circ} 40'$ to $33^{\circ} 00'$ N. The samples were analysed for their ^{90}Sr content and the results were compared with reported values for some other regions of the world.

2. Experimental Procedures

2.1. Sample collection and pretreatment

The soil samples were collected from various locations of Jhangar valley. Each soil sample was a composite of three plugs, from the depth of 6-12 cm and collected within 10 m of one another. The soil samples were cataloged and dried for several days at room temperature. After that, these samples were homogenized by mechanical treatment and passed through a 2 mm mesh sieve. After drying at 110°C in an oven the samples were ashed at 500°C till the complete destruction of organic matter [14]. Then the samples were properly labeled and packed in plastic containers.

2.2. Radiochemical separation

Five gm. of a dried and carbon free soil sample was leached in HNO_3 along with strontium Sr^{+2} Carrier by heating for 2-3 hours. This was followed by an extraction of leached solution with tributyl phosphate (TBP). Stripping of yttrium from TBP to aqueous phase was carried out. Then the solution was neutralized with NaOH and pH adjusted from 8 to 8.3 using ammonium hydroxide solution, to obtain hydroxide of yttrium. To avoid the precipitation of thorium hydroxide, the precipitate was dissolved in nitric acid and precipitated again with sodium carbonate. The precipitate was dissolved in nitric acid and oxalic acid was added. The pH was adjusted again from 1.7 to 1.9 using ammonium oxide. The solution was heated on water bath and filtered on glass fiber filter. The precipitates were dried at 110°C to calculate the yield. The precipitates were re-dissolved in HCl for counting [14].

2.3. Measurement of radioactivity

Before starting the measurement of samples containing ^{90}Y , efficiency of Liquid Scintillation Counting System was measured by taking standard strontium solution in a polyethylene vial followed by cerenkov counting using energy

windows of 0-32 keV in liquid scintillation analyser. The measurements were carried out in duplicate and efficiency was calculated by the relation $(\text{cpm/dpm}) \times 100\%$. The efficiency of the system was found to be 60%. The contribution of ^{90}Sr to the efficiency was assumed to be negligible. 20 ml solution of each sample was taken in a vial alongwith a blank sample in a similar vial for ^{90}Y counting. The liquid scintillation counting system model 4530 having sample capacity of 300 vials with multi-microprocessor and efficiency of 60% for ^{90}Sr was used for counting. The samples were counted for 100 min. by selecting window 0-32 keV. The lower limit of detection (LLD) was calculated using the expression [14].

$$\text{LLD} = [2.71 + 4.66\sqrt{B}] / [t.\epsilon.\text{Yield}]$$

Where B is the background counts, t is the counting time in seconds and ϵ is the detector efficiency.

The activity (A) of ^{90}Sr in the sample at the time of analysis was calculated using the formula [14];

$$A(\text{Bq/kg}) = \frac{(i_s - i_{\text{BG}})e^{-\lambda t}}{60.\epsilon.\eta.m}$$

Where

i_s = total count rate of sample (cpm)

i_{BG} = back ground count rate (cpm)

ϵ = counting efficiency

η = chemical recovery

t = decay time

λ = decay constant

m = mass of the sample in kg

The standard deviation (SD) was calculated by using the formula.

$$\text{SD} = \frac{\sqrt{\text{CPM (sample) / T} \times \text{CPM (background) / T}}}{\text{Detector-efficiency} \times m \times 60} \times e^{\lambda t}$$

Where

T = counting time

t = decay time

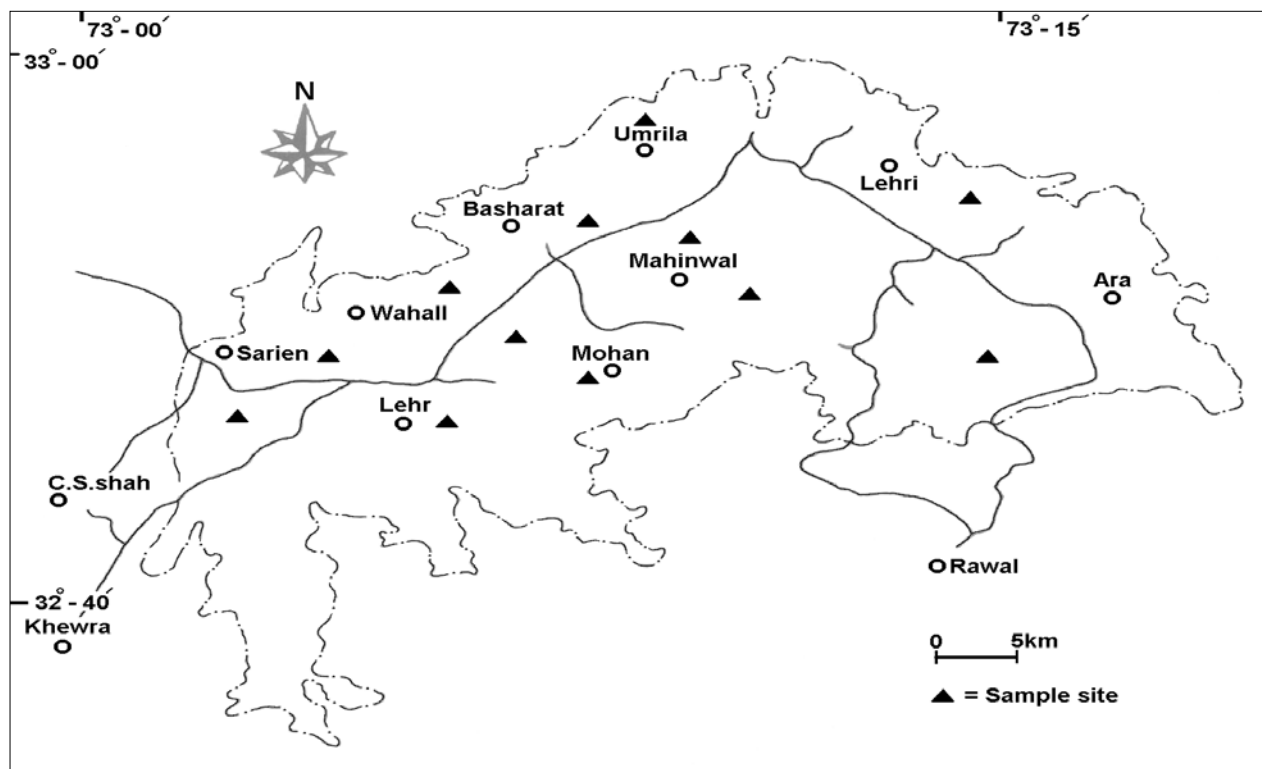


Figure 1. Map of Jhangar valley showing major localities and sampling sites.

3. Results and Discussion

Jhangar valley and its tributaries are a part of Eastern Salt Range of Punjab Province of Pakistan and are located in Tehsil Choa Saidu Shah, district Chakwal. The whole valley is located between longitude $73^{\circ} 00'$ to $73^{\circ} 15'$ E and latitude $32^{\circ} 40'$ to $33^{\circ} 00'$ N. The maximum elevation of the area is 1123.5 m above mean sea level and low hills run from the centre to the end of the valley. The location map of the valley is shown in figure 1.

A total of 40 soil samples were analysed and the results are given in table 1. The table shows that concentration of ^{90}Sr varies from <MDA (less than minimum detectable activity) to 2.52 Bq kg^{-1} with an estimated mean value of 0.49 Bq kg^{-1} . An estimated value, in the presence of <MDA is normally calculated by taking the average of the weighted mean of the detectable data and the mean MDA value of the undetectable data [15].

A comparison of ^{90}Sr concentration in soil samples with reported values of other regions of the world is also made in the present study and the results are shown in table 2. The table shows that

^{90}Sr contents in the soils of Spain and Germany are greater than those of the present study in Pakistan (Eastern Salt Range), while the soil samples from Ukraine showed very high activity of ^{90}Sr . This enhanced level of ^{90}Sr in Ukrainian soils is mainly attributed to Chernobyl nuclear reactor accident of April 1986. On the other hand concentration of ^{90}Sr , measured in three different sites from Hanford (USA), is also higher than that for Pakistan (Eastern Salt Range). This may be due to the Hanford releases as well as from atmospheric fallout. The comparison of the present study site shows slightly higher deposition of ^{90}Sr in CHASNUPP site as compared to Jhangar valley of Eastern Salt Range. As there is no strontium producing facility in the area under study, therefore the presence of ^{90}Sr in this area is entirely attributed to atmospheric nuclear testing and to Chernobyl nuclear reactor accident. From table 2, it is obvious that there is no clear-cut pattern of ^{90}Sr distribution for different regions of the world. This non-uniform geological distribution of ^{90}Sr may be due to various factors including surface run-off as well as its transport and vertical migration to deep inside the soil.

Table 1. Concentration of ^{90}Sr in soil samples from Jhangar Valley in Eastern Salt Range of Punjab, Pakistan.

Sample Description	^{90}Sr (Bq kg $^{-1}$)	Sample Description	^{90}Sr (Bq kg $^{-1}$)
Soil-1	< 0.04	Soil-22	1.12 ± 0.20
Soil-2	2.28 ± 0.29	Soil-23	1.53 ± 0.22
Soil-3	< 0.04	Soil-24	< 0.04
Soil-4	< 0.04	Soil-25	1.81 ± 0.20
Soil-5	2.52 ± 0.20	Soil-26	< 0.04
Soil-6	2.34 ± 0.28	Soil-27	< 0.04
Soil-7	< 0.04	Soil-28	< 0.04
Soil-8	< 0.04	Soil-29	< 0.04
Soil-9	1.78 ± 0.20	Soil-30	1.23 ± 0.21
Soil-10	< 0.04	Soil-31	< 0.04
Soil-11	< 0.04	Soil-32	< 0.04
Soil-12	2.12 ± 0.23	Soil-33	1.64 ± 0.20
Soil-13	< 0.04	Soil-34	< 0.04
Soil-14	1.35 ± 0.21	Soil-35	< 0.04
Soil-15	< 0.04	Soil-36	< 0.04
Soil-16	< 0.04	Soil-37	< 0.04
Soil-17	< 0.04	Soil-38	< 0.04
Soil-18	< 0.04	Soil-39	< 0.04
Soil-19	< 0.04	Soil-40	< 0.04
Soil-20	< 0.04		
Soil-21	< 0.04		

Estimated Average = 0.49 ± 0.2 Bq kg $^{-1}$

4. Conclusions

The presence of ^{90}Sr concentration in the soil samples of Jhangar valley of Eastern Salt Range of Pakistan indicates that this region has also received small inventories of this radionuclide from fallout activity due to nuclear weapon testing in the past and/or nuclear reactor accident such as

Chernobyl. This study has been initiated for the first time and no background data is available for the surveyed area. Thus a base line data for ^{90}Sr concentration in soil has been established for the area under study, which will be helpful in any radiological/nuclear emergency. Moreover, the data will also be useful for the determination of transfer factors of this radionuclide/ root uptake

Table 2. Comparison of ^{90}Sr concentration with reported values

S. No.	Region	No. of Samples	Depth (cm)	^{90}Sr (Bq kg ⁻¹)	Reference
1.	Spain (Island of Majorca)	10	5	4.4 ± 0.2	[16]
2.	USA (Hanford, on-site)	15	2.54	5.5 ± 0.08	[17]
3.	USA (Hanford, perimeter)	4	2.54	2.8 ± 0.04	[17]
4.	USA (Hanford, distant)	1	2.54	3.5 ± 0.02	[17]
5.	Ukrain (Korosten)	5	1-10	34.1 ± 2.8	[18]
6.	Germany	2	1-10	2.8 ± 1.05	[19]
7.	Pakistan (CHASNUPP site)	2	5 cm	1.54 ± 0.4	[20]
8.	Pakistan (Eastern Salt Range)	40	6-12	0.49 ± 0.2	Present study

studies for plants. This study may also be useful for the assessment of overall radiation exposure (due to natural and man-made sources) of human, flora and fauna.

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