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# Determination of Natural and Artificial Radionuclides in Soil Samples of Habigonj District, Bangladesh

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**Abstract**
The specific activities of natural and artificial radionuclides in 22 soil samples collected from Habiganj district in Bangladesh, have been Studied and evaluated. Experimental results were obtained by using a High Purity Germanium (HPGe) Detector and the radioactive standard sources supplied by IAEA were used to determine the efficiency. The measuring time of all samples is 5000 seconds. It was found that, the soil specific activity ranges from 5.27733 ± 0.01534 - 18.8277 ± 0.0155 Bq/kg for Radium-226 ($^{226}$Ra), 7.1355 ± 0.00248 - 38.1423 ± 0.00338 Bq/kg for Thorium-232 ($^{232}$Th) and 93.140877±0.006196 - 392.62765±0.007421 Bq/kg for Potassium-40 ($^{40}$K), with mean values of 11.09224 ± 0.01090 Bq/kg, 21.98392 ±0.00293 Bq/kg and 227.96598± 0.00676 Bq/kg respectively. It was also found that there is no artificial radionuclide ($^{137}$Cs) in any kind of samples of Habiganj district. In order to evaluate the radiological hazard of the natural and artificial radioactivity, Radium equivalent activity ($Ra_{eq}$), gamma absorbed dose rate, The external hazard index ($H_{ex}$), annual effective dose rate for different soil samples were calculated 58.513 Bq/Kg, 27.99008 nGy/h, 0.162327, 33.17704 μSv respectively.
**Keywords:** Habiganj, HPGe detector; soil, Natural Radionuclides, Artificial Radionuclides, $^{40}$K, $^{137}$Cs, $^{226}$Ra, $^{232}$Th.

## 1. INTRODUCTION

Radiation is common phenomenon in our life but we are not concerned about this phenomenon. Radionuclides (radioactive element) can be divided into natural and artificial radionuclides. Radionuclides are present all over the world. We found various amount of radioactivity in all of the elements of our environment like air, soil, water, food, industrial materials etc. Although radionuclides are just a mare material of environment it reminds us the use in medical science, nuclear power plant, industry as well as the horrible day of Hiroshima & Nagasaki. Radiation may be artificial or natural, or radiation dose may be small or large, it creates some biological effects. For these reason the whole world has became aware of radionuclides and many splendid works has been done monitoring radioactivity. Geographical position & natural resources of Habiganj is in the favour of radioactivity, there is no such information about radioactivity in Habiganj is present due to lack of measurement. For this reason, concentration of radionuclides in 22 soil samples have been studied and evaluated.

## 2. MATERIALS AND METHODS

### 2.1. Description of study area

The district Habiganj is in the northeastern part of Bangladesh. Habiganj is located at 91°10'E-91°40'E longitude and at latitude 23°57'N-24°42'N. It is established as a district at 1 March 1984. It has 3 gas fields which are Habiganj, Bibiyana & Rashidpur gas field. Mineral sand is also found in Habiganj.The annual rainfall in this area is 3334 mm. Minimum and maximum temperature of Habiganj district varies from 13.6°C to 33.2°C. Rivers as well as streams and lakes are situated in Habiganj district. This district is vulnerable to both flood and drought.

### 2.2. Sampling and samples preparation

Soil samples were collected during 2011 from 22 locations in the municipal area of Habiganj district in the north east of Bangladesh. Samples were collected from a depth of 0 – 3 inch. Lands of slightly dry soil were chosen maintaining some criteria mentioned below:

1. The collection area should be undisturbed open terrain.
2. There should be very little or no runoff soil during heavy rain, particularly in rainy season.

After removing the stones and vegetation, all soil samples were dried up at room temperature, sieved, placed in the plastic 400 cm$^3$ containers and left for four weeks to reach radioactive equilibrium. Then the samples were weighted by a weighting balance supplied by Shanghai, Japan. Each soil sample weighted between 250 to 400gm is chosen for the experiment. Then all the samples were put into the cylindrical plastic pot of equal size, collected from local market. All the samples were then rested for at least 24 or 26 days. All samples were analyzed with gamma ray detector.

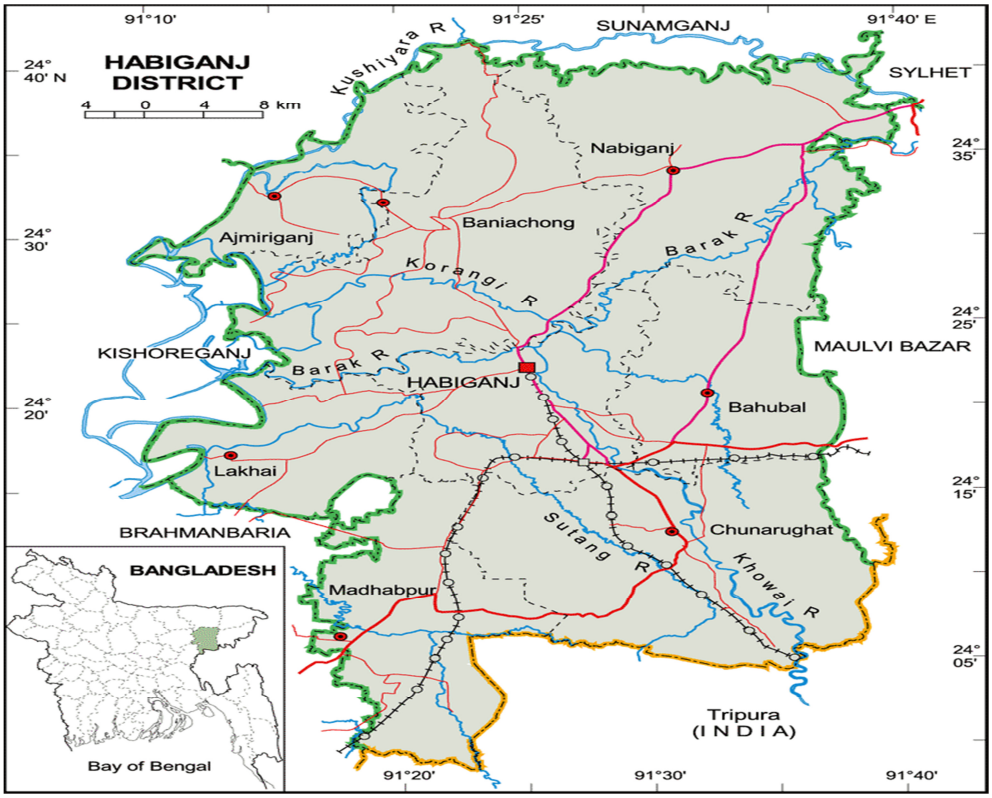


Fig.1. Map of Habigonj District,Bangladesh. This map indicates the location of the Upazilas studied. Retrieved from: https://www.google.com.bd/?gws_rd=cr,ssl&ei=-MXqVOSDG82i8AW684LYAQ#q=map+of+habiganj+district+bangladesh

**Table 1: Sample Codes and corresponding Locations of Habigonj District**

| Upazila | Sample Code | Specific Location |
|---|---|---|
| 1. Habiganj Sadar | HS1 | Nurpur Govt. Primary School |
| | HS2 | Sabaspur Govt. Primary School |
| | HS3 | Gonganagar High School |
| 2. Chunarughat | CS4 | Upozila Health Complex |
| | CS5 | Agrani High School |
| | CS6 | Ubahata Kudratia Madrasha |
| 3. Bahubal | BS7 | Mirpur Girls High School |
| | BS8 | Bahubal Food Godoun |
| | BS9 | Lamatoly Govt. Primary School |
| 4. Lakhai | LS10 | Kalaukh Sub Register Office |
| | LS11 | Puspomoy Govt. Primary School |
| | LS12 | Lakhil Food Godoun |
| 5. Azmirigonj | AS13 | Azmirigonj College |
| | AS14 | Jolshukha Ghat |
| 6. Baniachong | BS15 | Baniachong Adarsha High School |
| | BS16 | Adarsha Bazar Noukaghat |
| 7. Nobigonj | NS17 | Nobigonj Degree College |
| | NS18 | Nadampur Mirazabari Govt. Primary School |
| | NS19 | Nabigonj Adarsha Govt. Primary School |
| 8. Madhabpur | MS20 | Madhabpur Govt. Primary School |
| | MS21 | Saiduddin Degree College |
| | MS22 | Noagaon Regt. Private Primary School |

### 2.3. Experimental setup

Gamma spectroscopy system is applied to investigate soil samples. The spectrometry system consisted of a high

purity germanium (HPGe) detector, Pre-amplifier (supplied by Oxford instrument Inc. Nuclear measurement group, U.S.A), High voltage supplier (HV supply model ORTEC 459 ), Amplifier, MCA card memory containing a commercial software EMCAPLUS (silena) version 1.012 (supplied by silena, Germany). The contents of the memory after a measurement lasting 5000s can be displayed on a CRT screen of a monitor coupled with the PC. The digital recording of the content of each channel can be printed out through a printer (Model LQ-570+) supplied by EPSON,Japan. The resolution of the (HPGe) detector was found 2.80keV at FWHM of the 1332keV peak of $^{60}$Co. The shielding arrangement surrounding the detector was fabricated in the form of a circular cylinder having 21 inch in height using lead and steel. The top was covered by round movable steel and a lead plate. $^{226}$Ra activity of the samples was determined by the help of its daughters ($^{214}$Pb and $^{214}$Bi) and $^{232}$Th activity of the sample was determined by the help of its daughters ($^{228}$Ac). Average Radioactivity of different soil samples were determined and are given in Table 2. The activity of each radionuclide $^{214}$Pb, $^{214}$Bi, $^{228}$Ac,$^{40}$K and were then calculated using the following formula:

$$A = \frac{N \times 100 \times 1000}{P_\gamma \times \varepsilon \times W} \quad \text{..... (1)}$$

Where,
N=Net counts per second (c.p.s) = (sample c.p.s-back ground c.p.s)

P $\gamma$=Probability of radionuclide

$\varepsilon$= Efficiency in%.
W=Weight of the sample in kg.

**Table 2 : Average Radioactivity of different soil samples.**

| Upazila | Code | $^{214}$pb (295.21keV ) Bq/kg | $^{214}$pb (351.92keV ) Bq/kg | $^{214}$Bi (609.31keV ) Bq/kg | $^{214}$Bi (1120.07keV ) Bq/kg | $^{228}$Ac (911.07keV ) Bq/kg | $^{228}$Ac (969.1 1 keV) Bq/kg | $^{40}$K (1460. 8 keV) Bq/kg |
|---|---|---|---|---|---|---|---|---|
| 1. Habiganj Sadar | HS1 | 3.3728 ±0.000795 | 5.5063 ±0.002531 | 14.4078 ±0.00364 | 15.6495 ±0.038695 | 23.4884 ±0.003331 | 19.12920 ±0.0023956 | 227.96598 ±0.006765 |
| | HS2 | | | | | | | |
| | HS3 | | | | | | | |
| 2. Chunarugha t | CS4 | | | | | | | |
| | CS5 | | | | | | | |
| | CS6 | | | | | | | |
| 3. Bahubal | BS7 | | | | | | | |
| | BS8 | | | | | | | |
| | BS9 | | | | | | | |
| 4. Lakhai | LS10 | | | | | | | |
| | LS11 | | | | | | | |
| | LS12 | | | | | | | |
| 5. Azmirigonj | AS13 | | | | | | | |
| | AS14 | | | | | | | |
| 6. Baniachong | BS15 | | | | | | | |
| | BS16 | | | | | | | |
| 7. Nobigonj | NS17 | | | | | | | |
| | NS18 | | | | | | | |
| | NS19 | | | | | | | |
| 8. Madhabpur | MS2 0 | | | | | | | |
| | MS2 1 | | | | | | | |
| | MS2 2 | | | | | | | |

## 3. RADIATION HAZARD INDICES CALCULATION

The distribution of $^{226}$Ra, $^{232}$Th and $^{40}$K is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity ($Ra_{eq}$) in Bq/kg to compare the specific activity of materials containing different amounts of $^{226}$Ra, $^{232}$Th and $^{40}$K. It is calculated using the following relation (UNSCEAR, 2000):

$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.07C_K$ ..... (2)

where $C_{Ra}$, $C_{Th}$ and $C_K$ are the activity concentrations of $^{226}Ra$, $^{232}Th$ and $^{40}K$ in Bq/kg, respectively. While defining $Ra_{eq}$ activity according to Eq. (2), it has been assumed that 370 Bq/kg of $^{226}Ra$ or 259 Bq/ kg of $^{232}Th$ or 4810 Bq/kg of $^{40}K$ produce the same gamma dose rate.

The external gamma absorbed dose rate in the air at lm above ground level was calculated from the measured activities of $^{226}Ra$, $^{232}Th$ and $^{40}K$ in soil assuming that the other radionuclides, such as $^{137}Cs$, $^{90}Sr$ and the $^{235}U$ series can be neglected as they contribute very little to the total dose from environmental background. The calculations were performed according to the following equation (UNSCEAR, 2000) :

$D = 0.462C_{Ra} + 0.604C_{Th} + 0.042C_K$ ..... (3)

where $D$ is the dose rate in nGy/h and $C_{Ra}$, $C_{Th}$ and $C_K$ are the specific activities (Bq/kg) of $^{226}Ra$, $^{232}Th$ and $^{40}K$, respectively.

The external hazard index, $H_{ex}$, is defined as (UNSCEAR, 2000):

$H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_K / 4810$ ..... (4)

where $C_{Ra}$, $C_{Th}$ and $C_K$ are the specific activities (Bq/kg) of $^{226}Ra$, $^{232}Th$ and $^{40}K$, respectively. The value of this index must be less than unity in order to keep the radiation hazard insignificant. The maximum value of $H_{ex}$ equal to unity.

To estimate annual effective dose rates, the conversion coefficient from absorbed dose in air to effective dose ($0.7SvGy^{-1}$) and an outdoor occupancy factor (0.2) proposed by UNSCEAR, 2000 are used. Therefore, the annual effective dose rate ($mSvy^{-1}$) was calculated by the formula (UNSCEAR, 2000):

$D_{eff}(Sv) = D(nGy/h) \times (24 \times 365)(h) \times 0.7 \times 0.2$ ..... (5)

## 4. RESULTS & DISCUSSION

The results of the measurements for 22 soil samples collected at different locations in Habiganj District. It was found that, the soil specific activity ranges from 5.27733±0.01534 - 18.8277 ± 0.0155 Bq/kg for Radium-226 ($^{226}Ra$), 7.1355 ± 0.00248 - 38.1423 ± 0.00338 Bq/kg for Thorium-232($^{232}Th$) and 93.140877±0.006196 - 392.62765±0.007421 Bq/kg for Potassium-40 ($^{40}K$), with mean values of 11.09224 ± 0.01090 Bq/kg, 21.98392 ±0.00293 Bq/kg and 227.96598± 0.00676 Bq/kg respectively. We did not get artificial radionuclide ($^{137}Cs$) in any kind of samples of Habiganj district. Radium equivalent activity($Ra_{eq}$) , gamma absorbed dose rate , The external hazard index($H_{ex}$) , annual effective dose rate for different soil samples were 58.513 Bq/Kg , 27.99008 nGy/h , 0.162327 , 33.17704 µSv respectively.

**Table 3: Specific activities of radionuclides ($^{226}Ra$, $^{40}K$, $^{232}Th$) in soil samples at different locations in Habiganj District.**

| Location | Sample Code | Radioactivity of $^{226}$ Ra (Bq/kg) | Radioactivity of $^{232}$ Th (Bq/kg) | Radioactivity of $^{40}$K (Bq/kg) |
|---|---|---|---|---|
| 1. Habiganj Sadar | HS1 | 9.8328 ± 0.01564 | 22.5094 ± 0.00299 | 169.64205±0.006566 |
| | HS2 | 8.9118 ± 0.01193 | 24.6257 ± 0.00299 | 263.52309±0.006899 |
| | HS3 | 6.9669 ± 0.01524 | 17.9312 ± 0.00283 | 263.35077±0.006959 |
| 2. Chunarughat | CS4 | 14.1590±0.01562 | 16.9908 ± 0.003130 | 321.57677±0.007194 |
| | CS5 | 7.5424 ± 0.01532 | 7.1355 ± 0.00248 | 212.22427±0.006714 |
| | CS6 | 5.27733 ± 0.01534 | 13.2997 ± 0.00269 | 151.44345±0.006462 |
| 3. Bahubal | BS7 | 6.4477 ± 0.00273 | 13.7630 ±0.00261 | 241.56055±0.006696 |
| | BS8 | 8.7014±0.0154 | 17.2215 ± 0.00280 | 165.51562±0.006526 |
| | BS9 | 11.7445± 0.01546 | 14.1968 ± 0.00276 | 161.25088±0.006584 |
| 4. Lakhai | LS10 | 14.7151 ± 0.01230 | 34.8203 ± 0.00331 | 231.85590±0.006823 |
| | LS11 | 14.6966 ± 0.01160 | 34.3311 ± 0.00318 | 350.29827±0.007155 |
| | LS12 | 11.0815 ± 0.01204 | 21.8139 ± 0.00291 | 392.62765±0.007421 |
| 5. Azmirigonj | AS13 | 12.6522 ± 0.01221 | 38.1423 ± 0.00338 | 233.19610±0.006829 |
| | AS14 | 11.2385 ± 0.01215 | 27.8833 ± 0.00313 | 191.64967±0.006645 |
| 6. Baniachong | BS15 | 12.3629 ± 0.01224 | 32.8687 ± 0.00326 | 218.61234±0.006770 |
| | BS16 | 12.6117 ± 0.01234 | 30.3693 ±0.00317 | 93.140877±0.006196 |
| 7. Nobigonj | NS17 | 18.8277 ± 0.0155 | 19.2458 ± 0.00280 | 284.78372±0.006896 |
| | NS18 | 11.2548 ± 0.0156 | 21.2819 ± 0.00292 | 356.53950±0.007321 |
| | NS19 | 11.5474 ± 0.01201 | 16.4699 ± 0.00279 | 176.90739±0.006578 |
| 8. Madhabpur | MS20 | 14.7142 ± 0.0156 | 17.9699 ± 0.00289 | 250.70865±0.006870 |
| | MS21 | 10.5202 ±0.01205 | 20.2285 ±0.00286 | 154.43019±0.006437 |
| | MS22 | 8.8227 ± 0.01202 | 20.5478 ±0.00258 | 130.41407±0.006292 |
| **Average** | | 11.09224 ±0.01090 | 21.98392 ±0.00293 | 227.96598± 0.00676 |

**Table 4: Radium equivalent activity, gamma absorbed dose rate, annual effective dose and external hazard index for soil samples at different locations in Habiganj.**

| Location | Sample | Radium Equivalent Activity, $Ra_{eq}$(Bq/Kg) | Dose Rate, D (nGy/h) | External Hazard Index, $H_{ex}$ | Annual Effective Dose, $D_{eff}$ ($10^{-6}$ Sv) |
|---|---|---|---|---|---|
| 1. Habiganj Sadar | HS1 | 53.896 | 25.2634 | 0.148753 | 30.98303 |
| | HS2 | 62.573 | 30.05914 | 0.173952 | 36.86453 |
| | HS3 | 51.043 | 25.10988 | 0.142813 | 30.79476 |
| 2. Chunarughat | CS4 | 60.966 | 30.31013 | 0.170725 | 37.17234 |
| | CS5 | 32.601 | 16.70785 | 0.092057 | 20.49051 |
| | CS6 | 34.896 | 16.83177 | 0.097098 | 20.64248 |
| 3. Bahubal | BS7 | 43.038 | 21.43723 | 0.120786 | 26.29060 |
| | BS8 | 44.914 | 21.37349 | 0.12442 | 26.21245 |
| | BS9 | 43.333 | 20.77336 | 0.12008 | 25.47645 |
| 4. Lakhai | LS10 | 80.738 | 37.56779 | 0.222415 | 46.07314 |
| | LS11 | 88.310 | 42.23834 | 0.2451 | 51.8011 |
| | LS12 | 69.759 | 34.78561 | 0.195801 | 42.66107 |
| 5. Azmirigonj | AS13 | 83.519 | 38.6775 | 0.229944 | 47.43409 |
| | AS14 | 64.527 | 30.08299 | 0.177876 | 37.17234 |
| 6. Baniachong | BS15 | 74.668 | 34.74607 | 0.205769 | 20.49051 |
| | BS16 | 62.559 | 28.08158 | 0.170706 | 30.98303 |
| 7. Nobigonj | NS17 | 66.284 | 32.28378 | 0.1844 | 39.59283 |
| | NS18 | 66.645 | 33.02864 | 0.186713 | 40.50632 |
| | NS19 | 47.482 | 22.71283 | 0.131579 | 27.85501 |
| 8. Madhabpur | MS20 | 57.960 | 28.18154 | 0.161272 | 34.56184 |
| | MS21 | 50.257 | 23.56441 | 0.138641 | 28.89939 |
| | MS22 | 47.335 | 21.96435 | 0.130293 | 26.93708 |
| Average | | 58.513 | 27.99008 | 0.162327 | 33.17704 |

## 5. CONCLUSION

Habiganj district is one of the border districts of Bangladesh. Although it is important both geologically and from the view point of natural resources , information about radioactivity in Habiganj in present is still unavailable due to lack of measurement. For this reason, concentration of radionuclides in 22 soil samples have been studied and evaluated.

For soil samples radium equivalent activity ($Ra_{eq}$), gamma absorbed dose rate, The external hazard index (Hex) , annual effective dose rate were 58.513 Bq/Kg , 27.99008 nGy/h , 0.162327 , 33.17704 µSv respectively. The average value of gamma dose rate obtained in this study is less than to the world average 57 nGy/h. All values obtained for radium equivalent activity are less than 370 Bq/kg, which are acceptable for safe use OECD 1979.We did not get artificial radionuclide ($^{137}Cs$) in any kind of samples of Habiganj district.

This radioactivity monitoring study is significantly devoted to measure the effective dose to the environment where people live in. This type of study may be continued to establish a complete database of environmental radioactivity dissymmetry. This study may lead scientists or researchers to improve necessary safety measure.

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