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Health Risk Assessment of Natural Occurring Radionuclides in Shore Sediment Collected from Ovambo Beach, Walvis Bay, Namibia

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INTRODUCTION

Overview of the Erongo region

- The Erongo region is a popular holiday destination in Namibia
- Major beaches in the coastline
  - Henties bay
  - Swakopmund
  - Walvis bay

Introduction Cont.

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- Over the years, the coastline of the Erongo Region of Namibia has experience an increase of industrial establishment,

❖ tourism,
❖ transport
❖ urbanization for socio-economic purposes.

- The region is also home to six active uranium mines, where commercial exploration of uranium is been taking place for export purposes.

Onjefu SA, Taole SH, Kgabi NA, Charles G, Owen PLM, Johann A (2017): Occupancy factor model for exposure to natural radionuclide along the coastline of Erongo region, Namibia. Journal of Geoscience and Environmental Protection, 4, 117-126.

Onjefu SA, Taole SH, Kgabi NA, Charles G, Johann A (2017): Assessment of natural radionuclide distribution in shore sediment sample from the North Dune beach Henties Bay, Namibia. Journal of Radiation Research and Applied Sciences, 10, 301-306.

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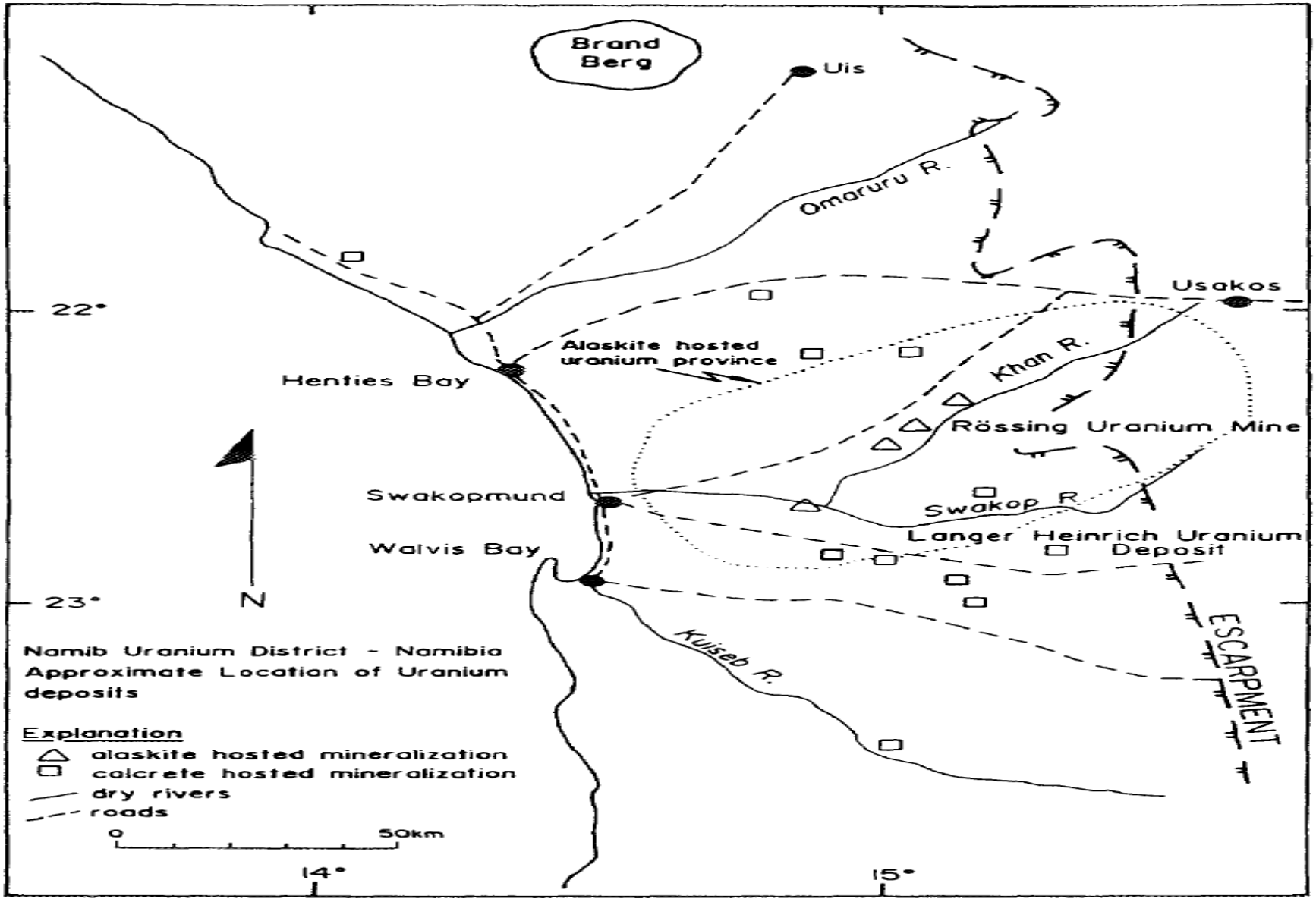
Erongo Region and Uranium mines



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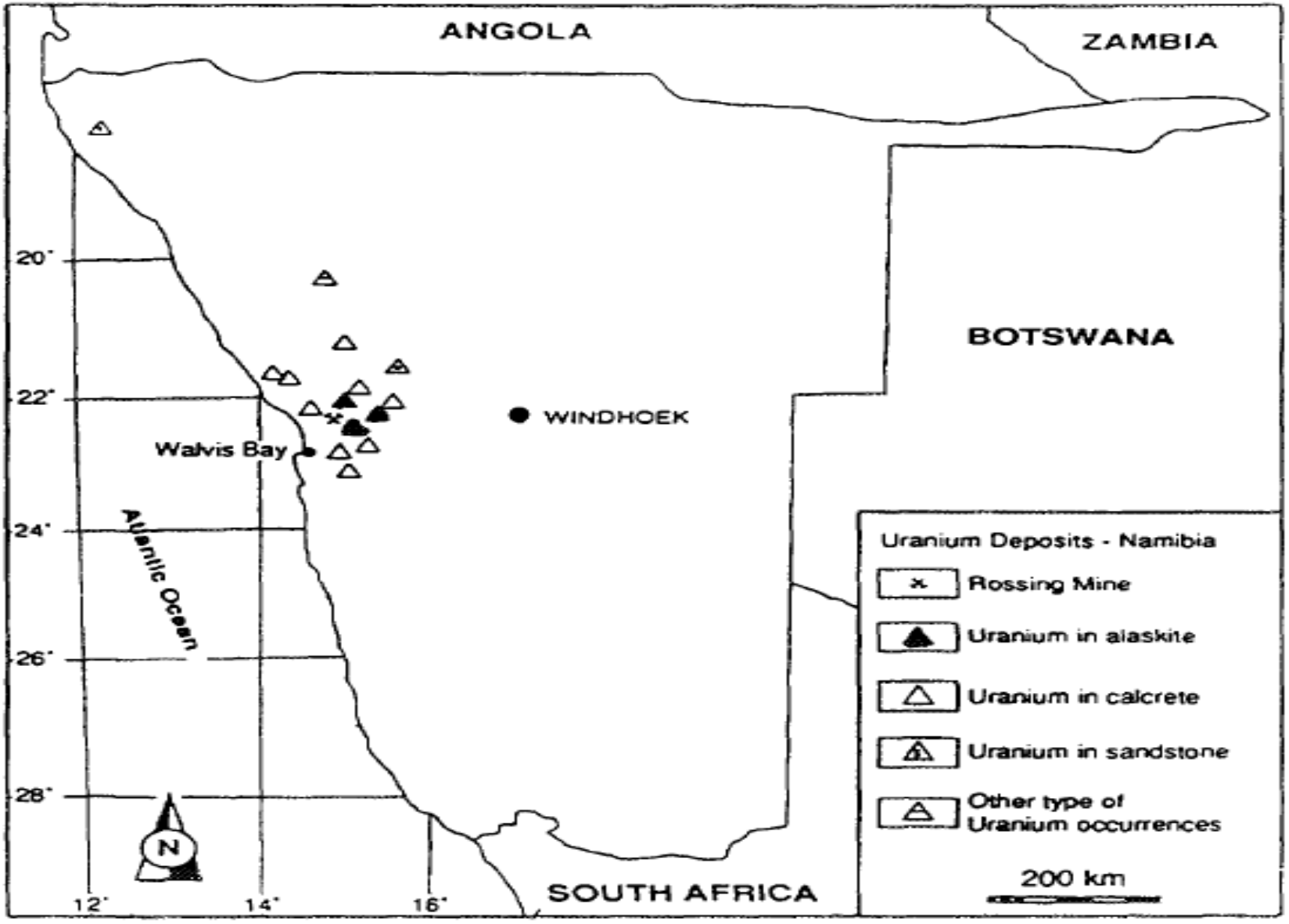
Erongo Region and Uranium mines



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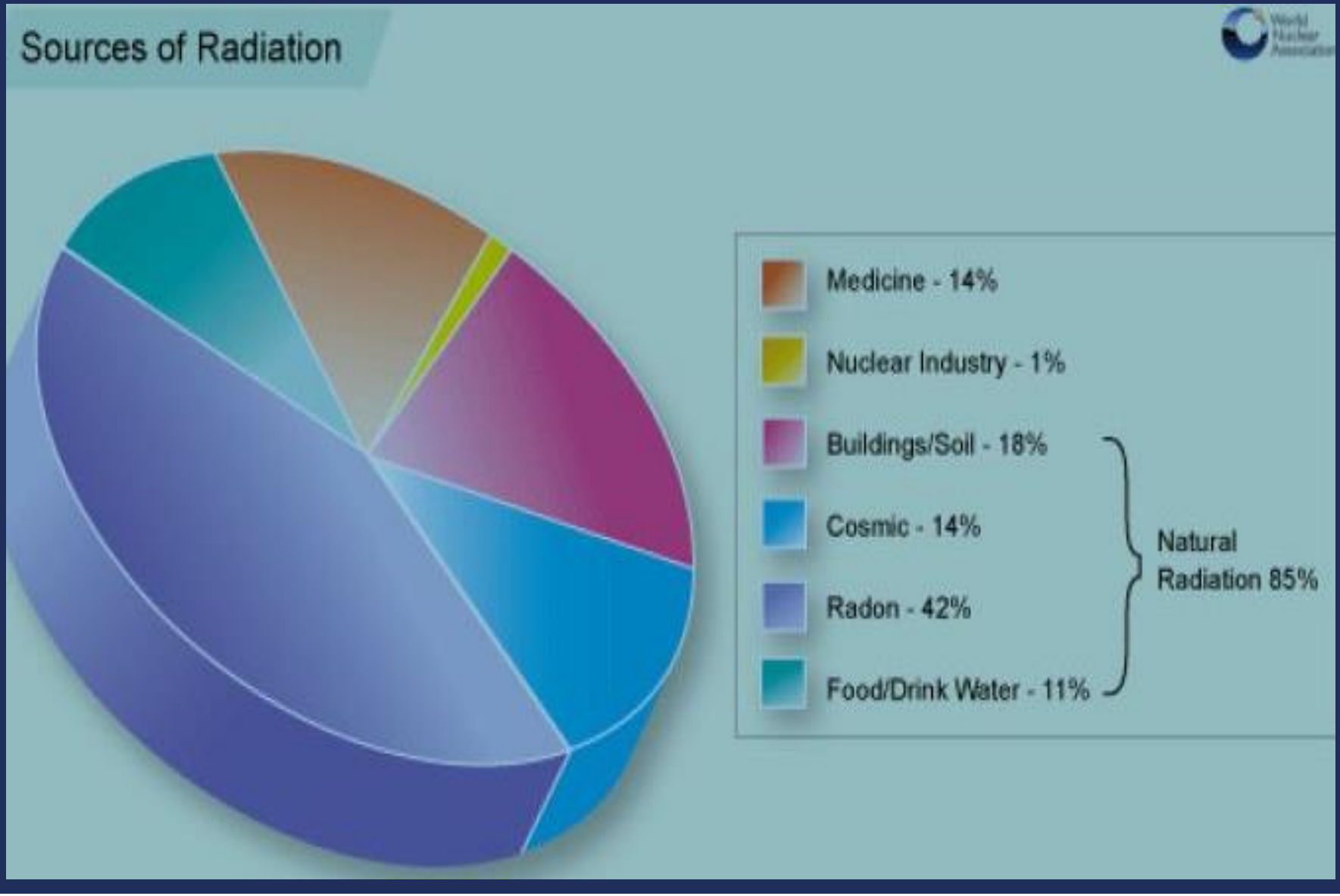
Human sources of radiation



What do we measure?

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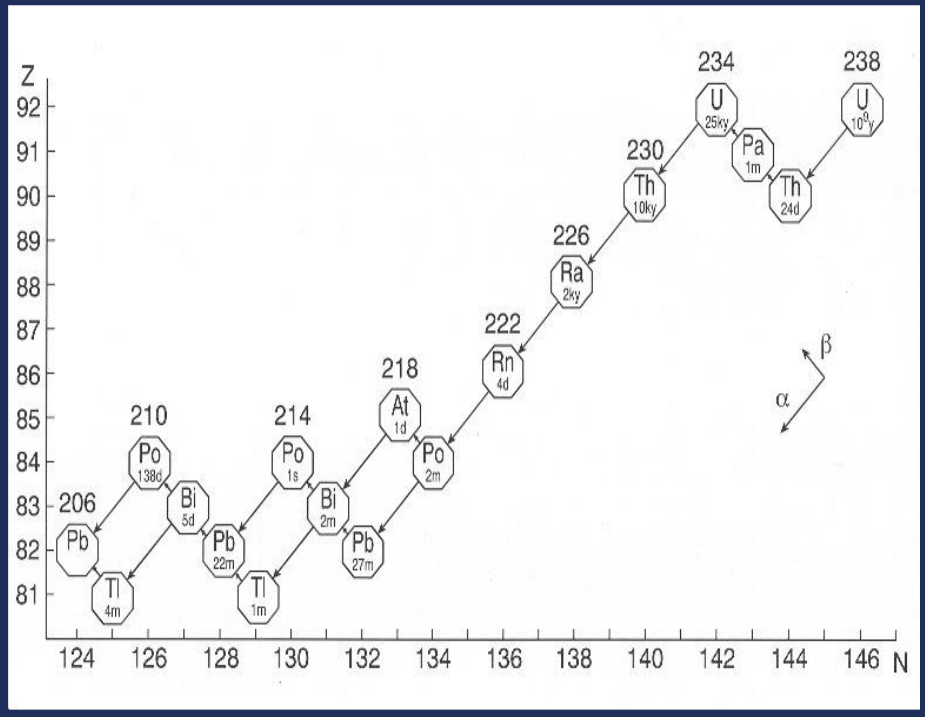

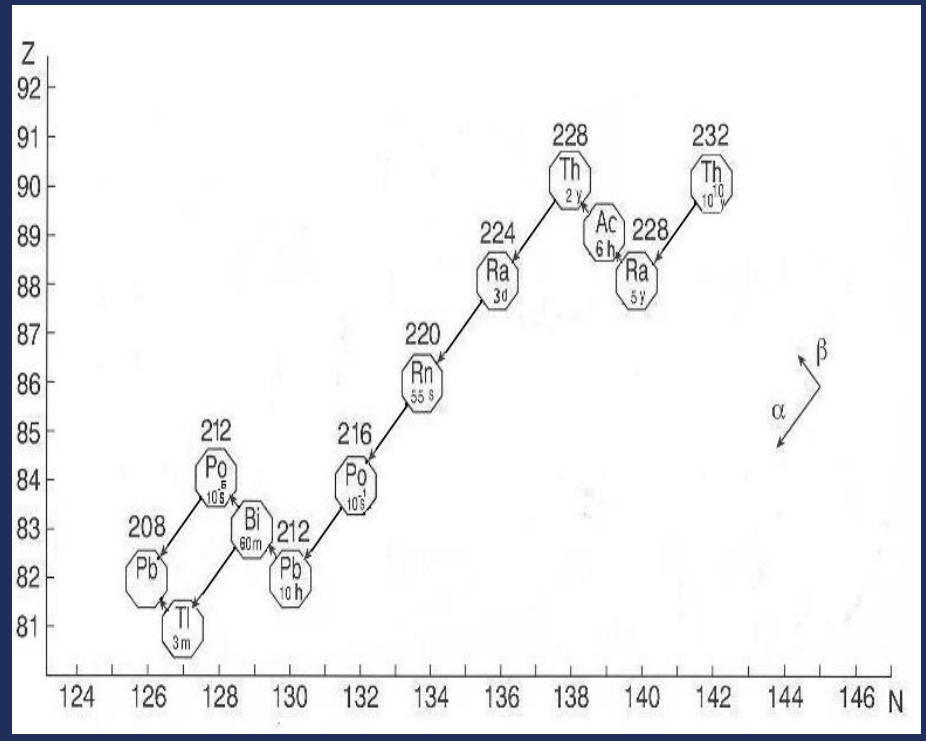

- **U-238**

Th-232

What do we measure?

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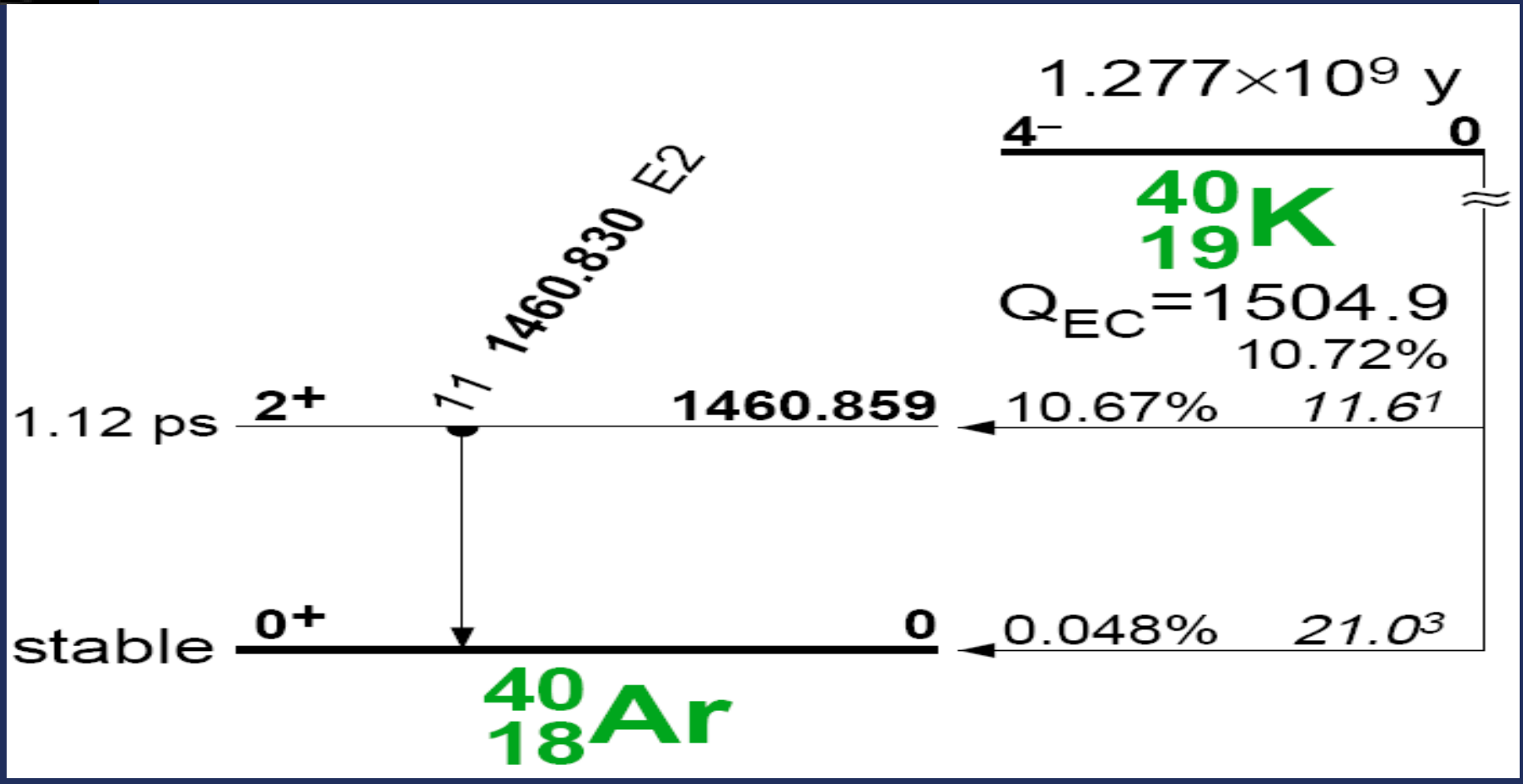

- K-40

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Recommended effective dose limits

Application	Dose limit	
	Occupational	Public
Whole body	20 mSv[a] per year, averaged over a period of 5 years[b]	1 mSv[a] in a year
Annual equivalent dose in		
Lens	150 mSv	15 mSv
Skin	500 mSv	50 mSv
Hand and feet	500 mSv	-

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How did we collect our samples

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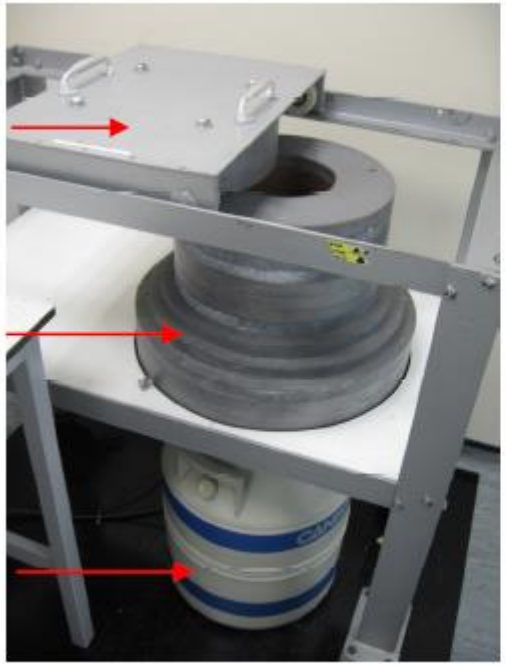
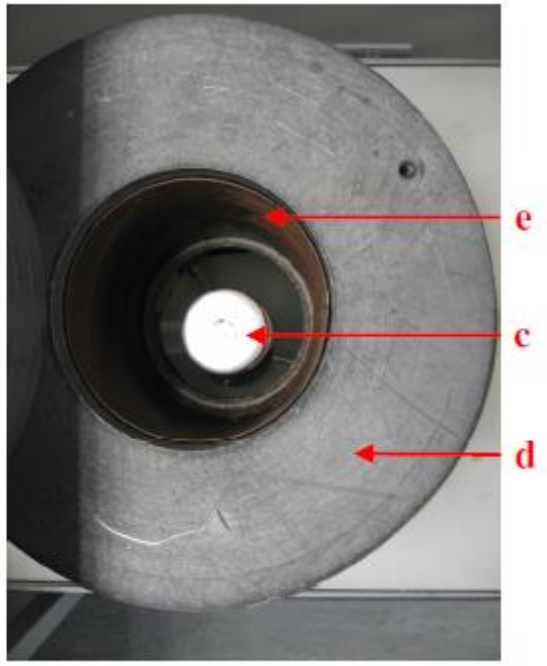
Sample counting





A coaxial hyper-pure germanium (*HPGe*) detector and a set of shielding

(a) door closed tightly against shield body
(b) liquid nitrogen cryostat
(c) detector located near centre of shield volume
(d) 10 cm thick cylindrical lead material and
(e) an inner layer of 0.1 cm thick copper.

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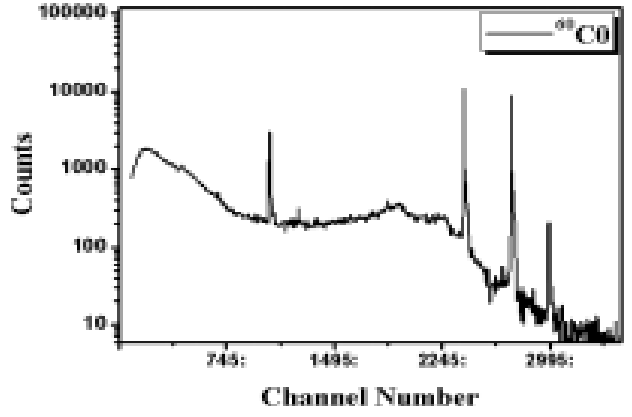
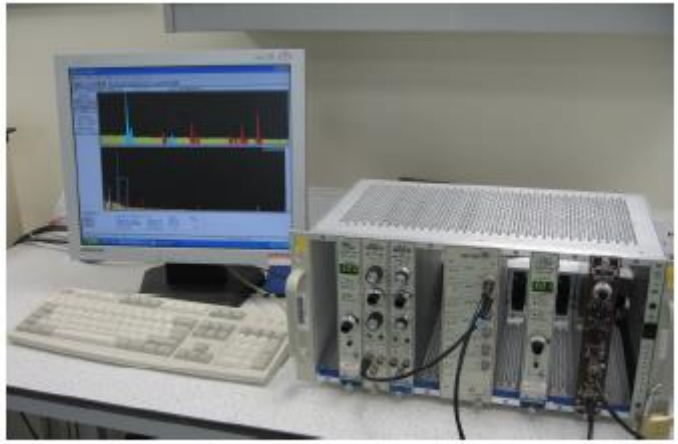
Sample counting

- The activity concentrations were calculated using the photo peaks corresponding to ^{226}Ra (186 keV), ^{214}Bi (1238 keV and 1378 keV), ^{214}Pb (295 keV and 351 keV) for ^{238}U; ^{208}Tl (860 keV), ^{228}Ac (338 keV, 911 keV) for ^{232}Th and 1460 keV for ^{40}K
- A typical ^{60}Co spectrum obtained in the current study is presented in the figure.





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Radiological Analysis

- The measured activity of ^{238}U, ^{232}Th and ^{40}K were converted into doses by applying the factors 0.462, 0.604 and 0.0417 for uranium, thorium and potassium respectively.

- These factors were used to calculate the external gamma dose rate (D) at 1.0 m above the ground level using the equation below

➢ Absorbed dose rate (D) ($nGyh^{-1}$) $= 0.0417C_k + 0.462C_u + 0.604C_{Th}$

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Radiological Analysis

- Other factor such as Annual Effective Dose Equivalent (AEDE), Radium Equivalent Activity (Ra_{eq}), Hazard index (HI) and Excess life cancer risk (ELCR) were evaluated on the basis of the following equations;

  - Annual Effective Dose Equivalent (AEDE)

    $$H_E = D \times T \times F$$

  - where H_E is the annual effective dose (mSv), D is the absorbed dose rate ($nGyh^{-1}$), T is the outdoor occupancy time (365 days x 24h x 0.2) and F conversion factor (0.7 x 10^3 mSv/10^9nGy).

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Radiological Analysis Cont.

- **Radium Equivalent Activity (Ra_{eq})**

The equation is based on the assumption that 259 Bq kg^{-1} of ^{232}Th, 370 Bq kg^{-1} of ^{226}Ra and 4810 Bq kg^{-1} of ^{40}K produce the same gamma –radiation dose rates.

$$\mathrm{Ra}_{eq}\,(Bqkg)^{-1} = A_{Ra} + 1.43_{Th} + 0.077A_k$$

- **Hazard index (HI) (Hin, Hex)**

- To ensure that the radiation exposure due to NORMs does not exceed the permissible dose equivalent of 1 mSv yr^{-1}, the external hazard index and internal hazard index have been introduced

$$H_{in} = \frac{C_U}{185} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \leq 1$$

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Radiological Analysis Cont.

$$H_{ex} = \frac{C_U}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \leq 1$$

- Excess life cancer risk (ELCR)

- The Excess life cancer risk (ELCR) deals with the probability of development of cancer over a lifetime at a given exposure level

- The ELCR is calculated from equation
  ELCR = AEDE x DL x RF

- where, AEDE is the Annual Effective Dose Equivalent, DL average Duration of Life (70 years), and RF is the Risk Factor, i.e. fatal cancer risk per Sievert.

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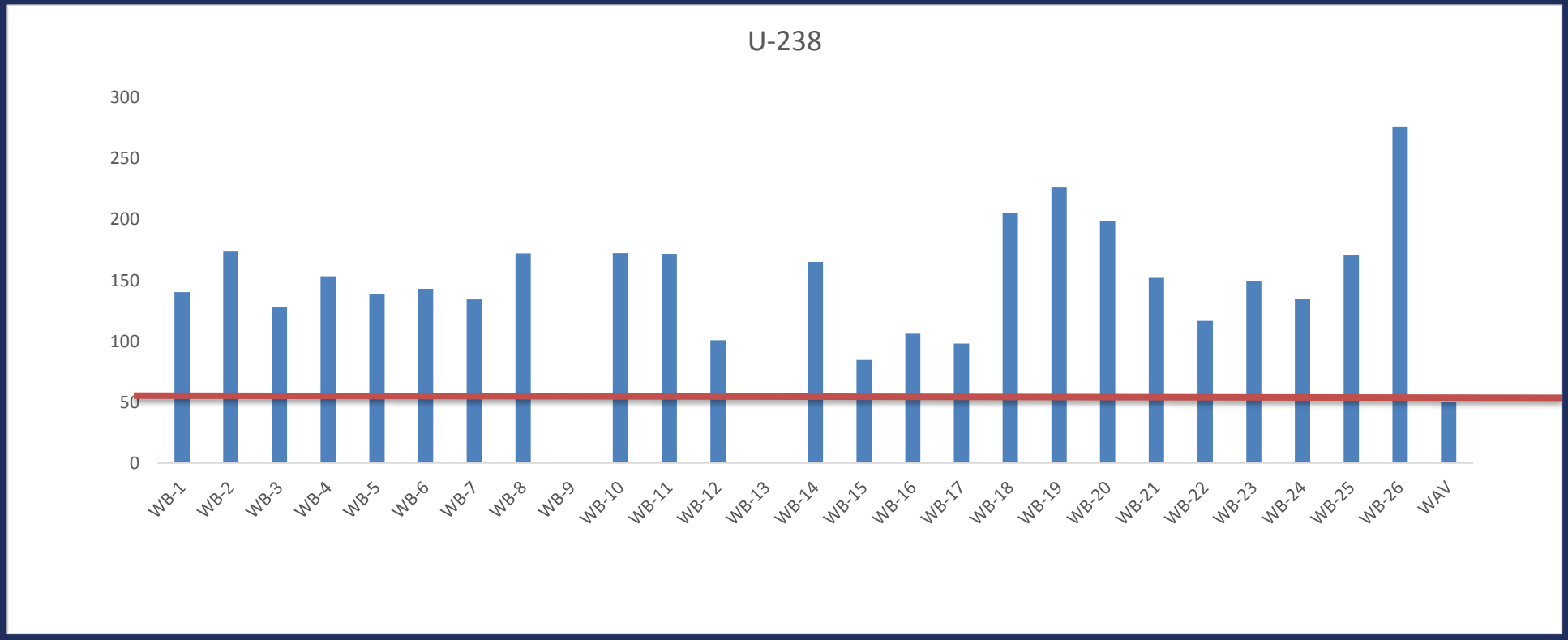
RESULTS AND DISCUSSION



The activity concentration ranges from BDL-276.39 Bq/kg with and average of 142.79 Bq/kg

WAV= 50 Bq/kg

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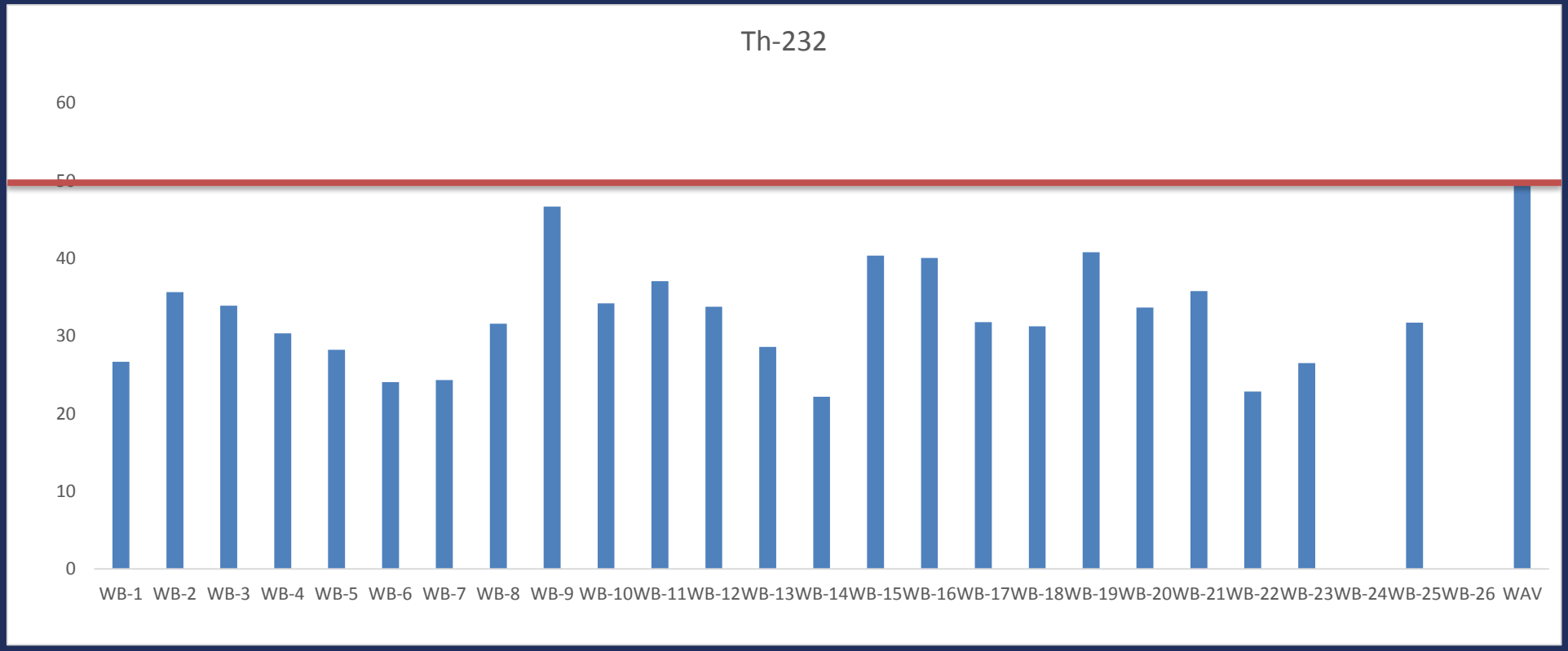
RESULTS AND DISCUSSION



The activity concentration ranges from BDL-40.80 Bq/kg with and average of 29.69 Bq/kg

WAV= 50 Bq/kg

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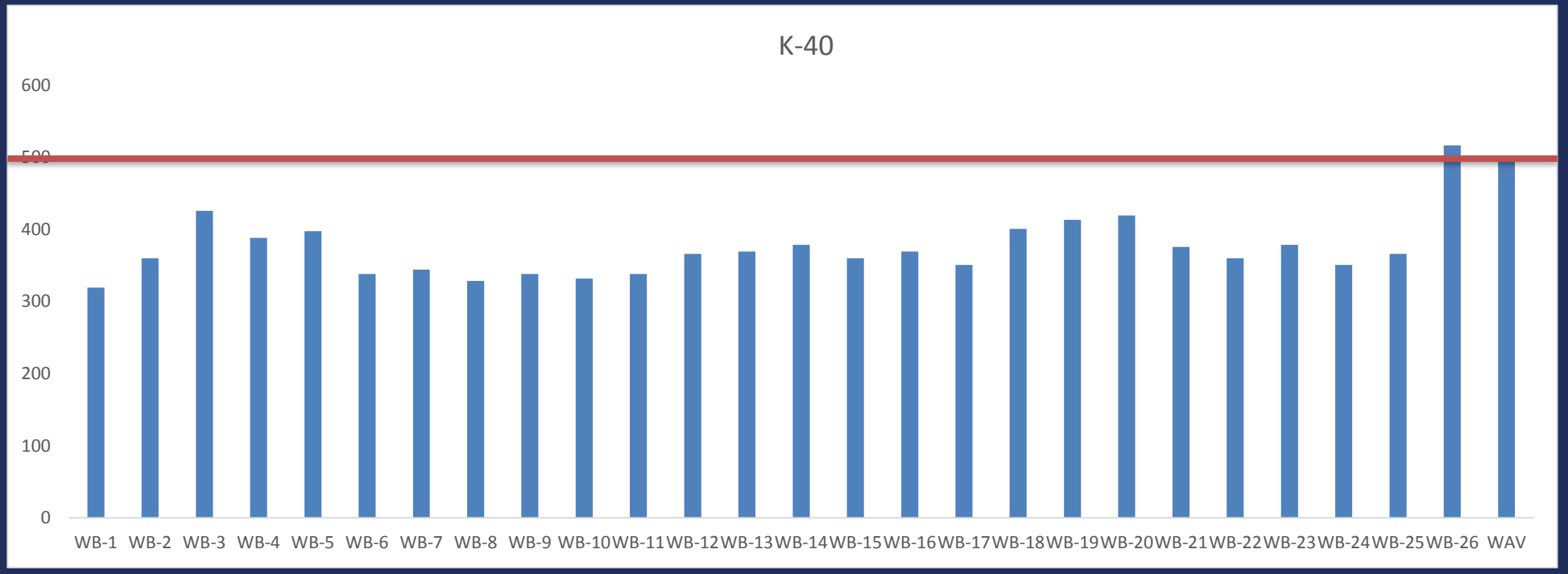
RESULTS AND DISCUSSION



The activity concentration ranges from 319-516.45 Bq/kg with and average of 359.78 Bq/kg

WAV= 500 Bq/kg

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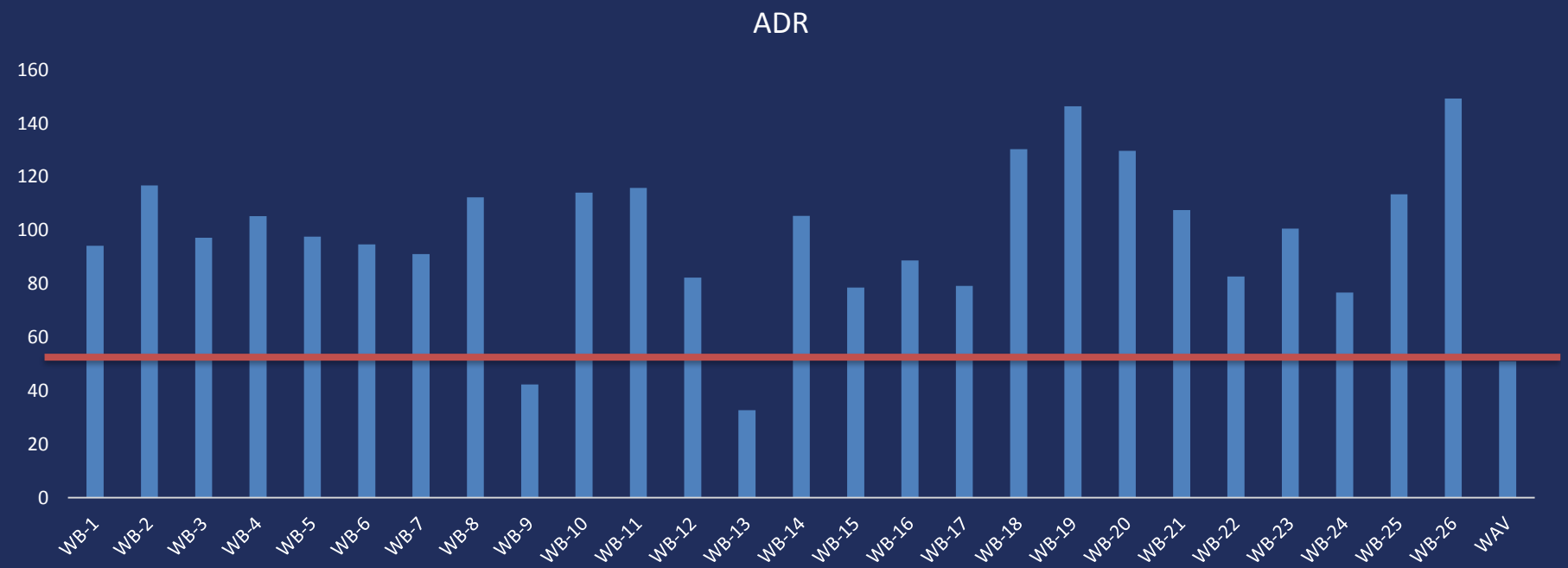
RESULTS AND DISCUSSION



- The absorbed gamma dose rates range from 32.66 to 149.23 nGy.h^{-1} with an average dose of 93.27 nGy.h^{-1}.
- WAV= 51 nGy.h^{-1}

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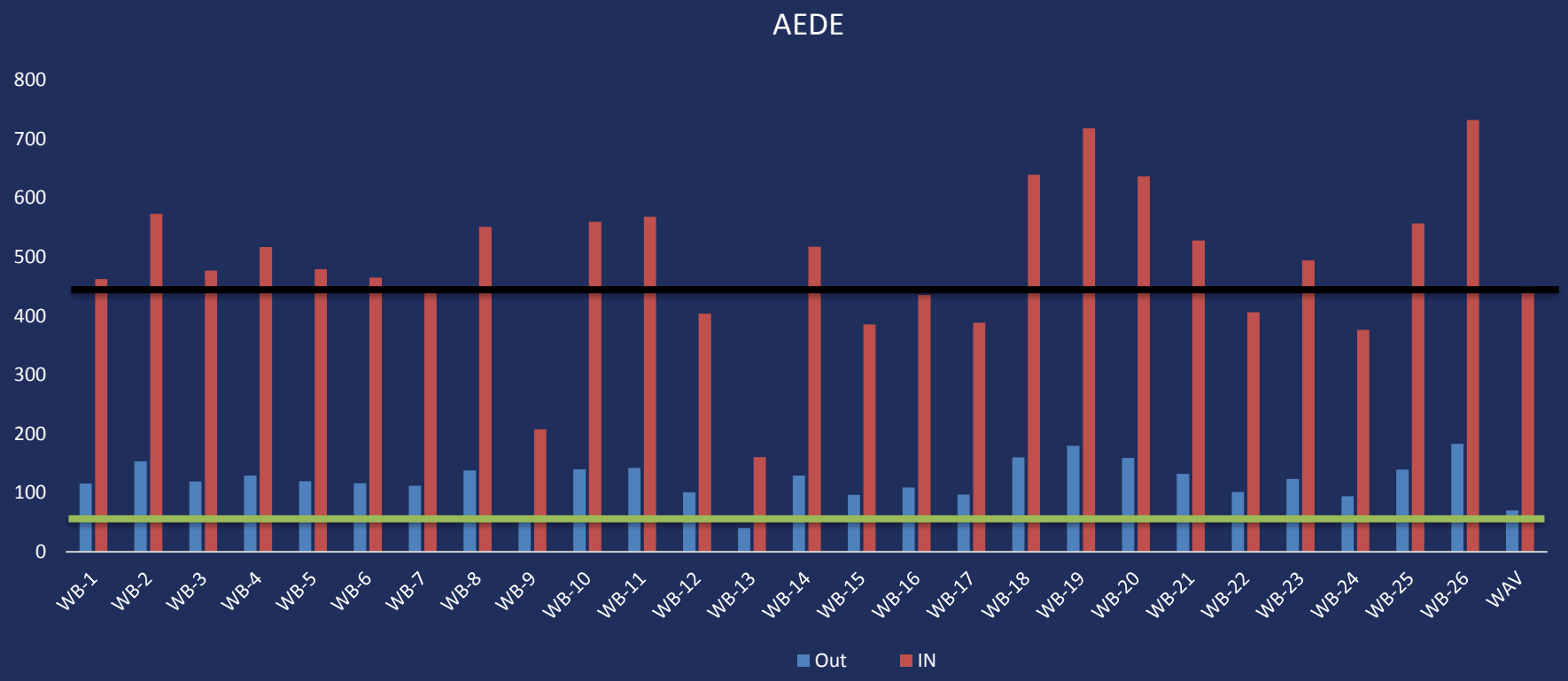
RESULTS AND DISCUSSION



AEDE was found to vary from 40.06 – 183.01µSv.y $^{-1}$ with an average value of 121.95 µSv.y $^{-1}$ for outdoor factor (WAV=70 µSv.y $^{-1}$) and 160.24 – 732.05 µSv.y $^{-1}$ with an average value of 487.79 µSv.y $^{-1}$ for indoor factor (WAV = 450 µSv.y $^{-1}$).

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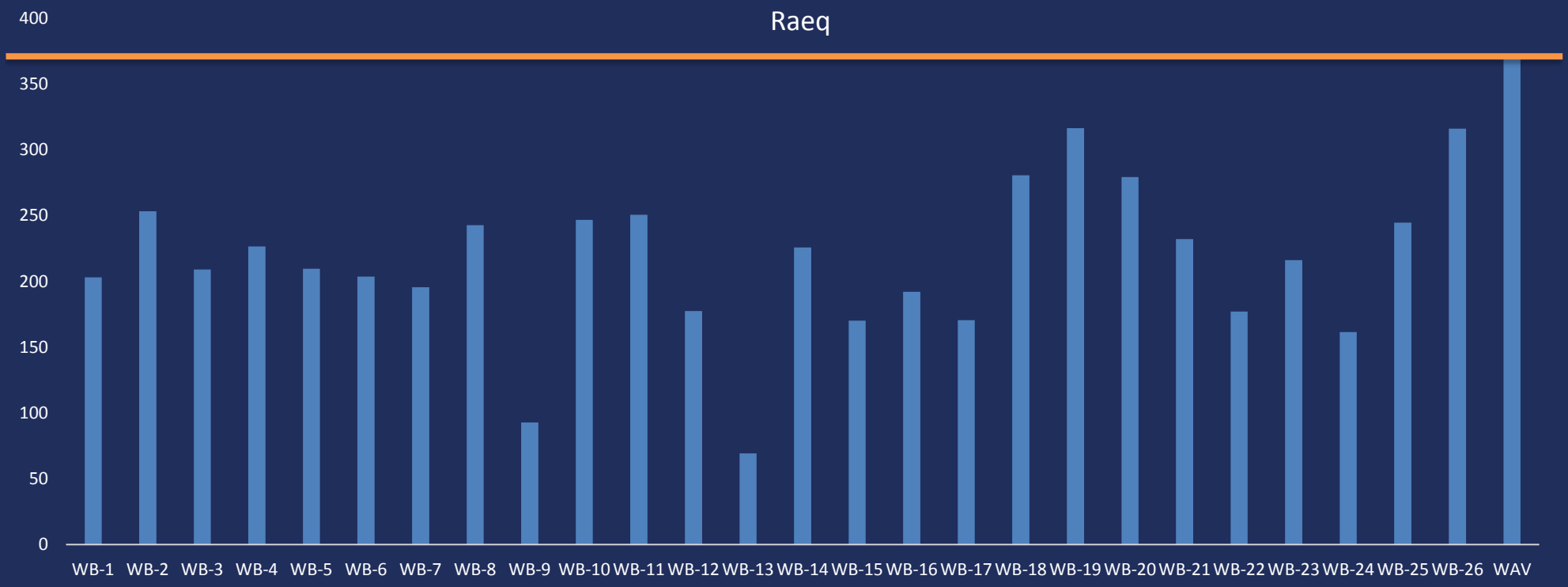
RESULTS AND DISCUSSION



The radium equivalent activity calculated ranged from 69.31 to 316.16 $Bq.kg^{-1}$. These values are lower than the recommended maximum value of 370 $Bq.kg^{-1}$.

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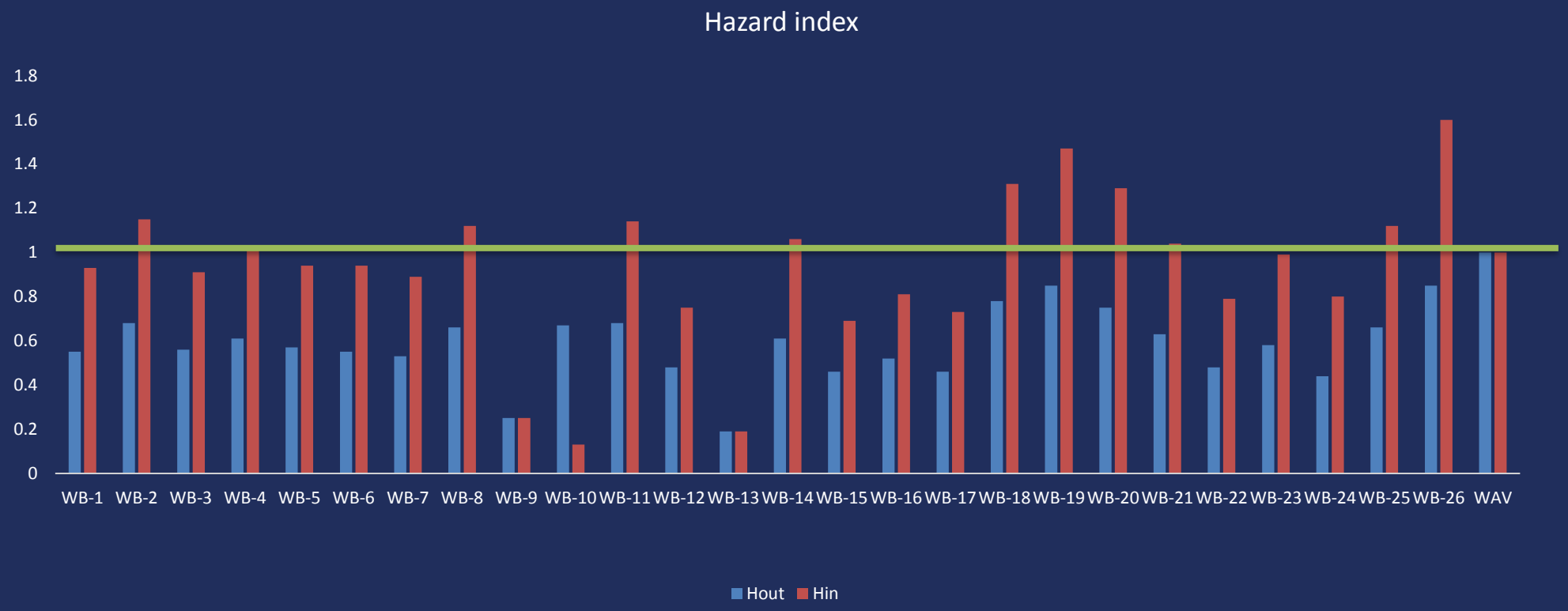
- The H_{ex} ranged between 0.19 – 0.85 with an average value of 0.58 and 0.19 – 1.60 with an average value of 1.96 for H_{in}
- The use of sediment for construction purposes may pose risk to internal exposure to carcinogenic radon and its short-lived progeny since the average value of H_{in} is more than unity



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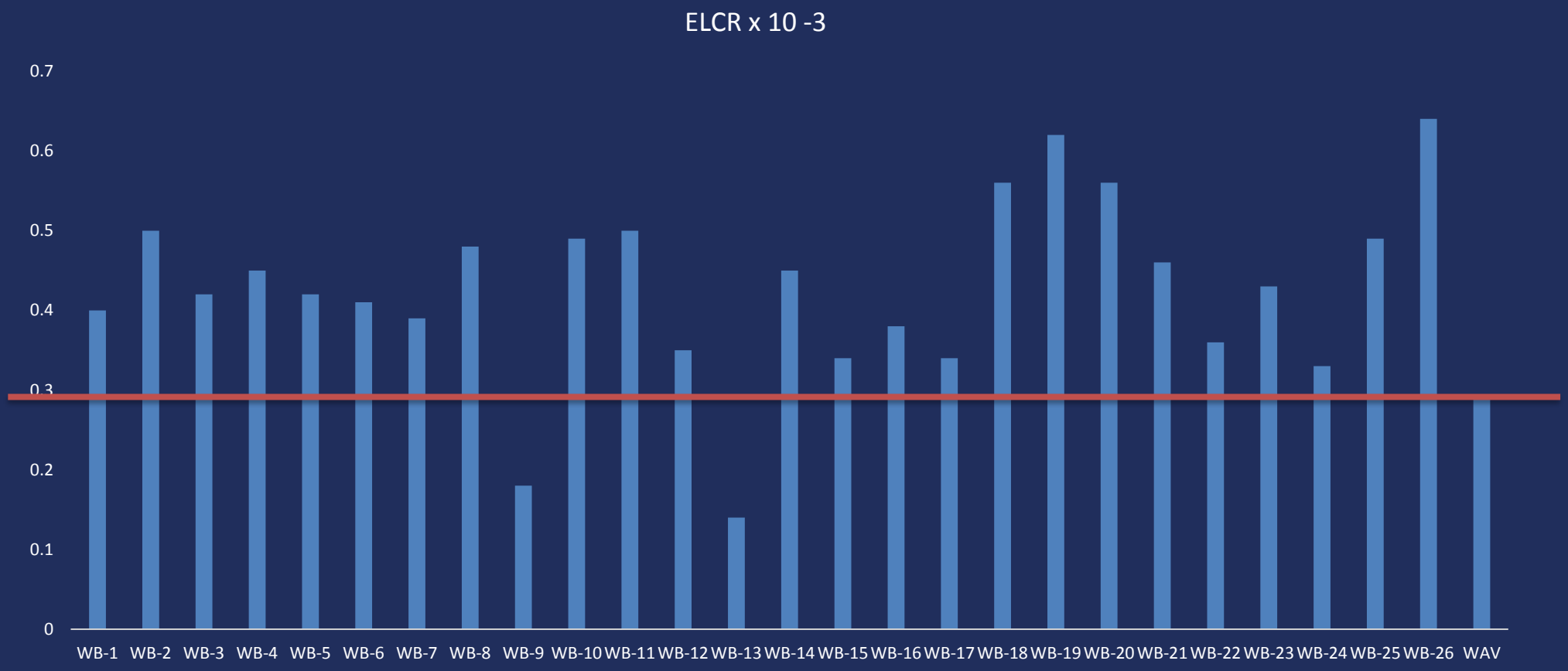
RESULTS AND DISCUSSION

- The ELCR values ranges from 0.14 – 0.64 with an average value of 0.43. The result showed that almost all the sites have values more than the world average (0.29×10^{-3}).



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CONCLUSION

- We have used the high resolution HPGe gamma detector to determine the activity concentration of ^{238}U, ^{232}Th and ^{40}K
- The average activity of ^{232}Th and ^{40}K are below the world admissible levels of 50 and 500 $Bq.Kg^{-1}$
- ^{238}U recorded an average level higher than the world accepted limits
- The absorbed dose and AEDE exceeded the world average of 51 $nGyh^{-1}$, 70 $\mu Sv.y^{-1}$ (outdoor) and 450 $\mu Sv.y^{-1}$ (indoor)

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CONCLUSION

- We found the R_{eq} values less than the world recommended value of 370 $Bq.kg^{-1}$.
- The evaluation of the health risk associated with the sediment use as building material clearly revealed H_{ex}, H_{in} and ELCR higher than the world allowed limit.
- The study provides a baseline for future investigation and the data obtained in this current study may be useful for natural radioactivity mapping and reference data for monitoring future possible radioactivity pollution in the region.

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Thank You.