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Assessment of Back Ground Radiation Dose rates Parameters and Potential Radiological Risks in Mining- Impacted Ponds in Nasarawa and Plateau State, Nigeria.

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Abstract:

The goal of the study is to assess radiation dose rates rate parameters and potential radiological risks in mining-Impacted ponds in Nasarawa and Plateau State Nigeria, Barikin Ladi, Riyom, and Jos South, as well as in Azara and Auta Balaifi, Nasarawa State. There is a history of heavy mining in these areas, which could be a factor in the high environmental concentrations of naturally occurring radionuclide.
At different locations surrounding the mining ponds, the dosage rates of alpha, beta and gamma radiation were measured using the Radionuclide Identifier, a sophisticated radiation detecting device.
The findings demonstrate a range of radiation levels, with dose rates in some places exceeding the global average for background radiation from natural sources. The study highlights the possible hazards to local inhabitants' and the environment's radiological health that could arise from extended exposure to high radiation levels.
It also emphasizes how crucial it is to keep an eye on these places constantly and to have radiation safety measures in place that work.
This study establishes baseline data for upcoming radiological evaluations and advances knowledge of the effects of mining operations on the environment.

Keywords: Background radiation, Alpha radiation, Alpha radiation, Beta radiation, Gamma radiation, Mining Ponds, Radiation Dose rate and environmental Monitoring.

1. Introduction

Naturally occurring radioactive materials (NORM) are widespread and broadly distributed among various environmental samples and in varying concentrations depending on the geological and geographical definitions of any given region. Coal, which is a naturally abundant fossil fuel, contains naturally occurring radioactive materials at varying activity levels. Human activities such as coal mining, redistributes and transports coal radioactivity to the surface thereby enhancing the radioactivity levels above background in the human environment. Long-lived radionuclide's particularly ^{238}U, ^{232}Th and their radioactive progenies, and ^{40}K are predominantly responsible for human radiation exposure.

Mining activities has impacted considerably on man and his environment. Mining operations involve the removal of huge amounts of topsoil and production of considerable amount of mining waste (tailings) with enhanced radioactivity. These large quantities of mine tailings are dumped haphazardly around the mine, where they are transported via atmospheric processes and finally concentrated in the soil environment. Leaching of the tailings can occur during wet climates and thus transfer the radionuclide's into surface and groundwater bodies.

Many atoms are unstable and would change naturally into atoms of another element accompanied by the emission of ionizing radiation, this process is called radioactivity, and the change is called radioactive decay. Unstable atoms that change through radioactive decay are called radionuclide, for example radon from decay of radium which in turn arises from the decay of uranium (^{238}U). Another radionuclide is Thorium from the decay of thorium (^{232}Th). The other principal geological source of radiation is terrestrial gamma radiation which originates from potassium nuclide (^{40}K). These elements are widely distributed in terrestrial materials including rocks, soils, and building materials extracted from beneath the earth surface and they are simply referred to as naturally occurring radioactive materials.

NORM is found in the biosphere including the air, soil, water, food and could equally be generated because of human activities such as oil, gas, and fertilizer productions. Natural sources still contribute almost 80% of the collective radiation exposure of the world's population. Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions and appear at different levels in the soils of each region in the world.

Health risks from exposure to low levels of NORM are low. However, activities involving the extraction, mining, processing, use, transfer, transport, storage, disposal, and/or recycling of NORM-containing or NORM-contaminated materials may increase exposure levels to workers and other individuals to levels of concern. Human activities such as mining, natural gas extraction, water treatment and petroleum refining, can alter the natural background radiation.

Human beings' exposure to naturally occurring radiation arises from two different sources. The first source comes from cosmic radiation from outer space. The interactions of cosmic-ray particles in the atmosphere can create several radioactive nuclei such as 3H, 7Be, and 14C. The other main contributor is the terrestrial radioactive materials which originate from the formation of the earth and are present everywhere in the earth's crust, and in the human body itself. Apart from the exposure from direct cosmic rays and Cosmo-genic radionuclide, natural exposures arise mainly from the primordial radionuclide's (NORM) which are spread widely and are present in almost all geological materials in the earth's environment.

Only very long-lived nuclides, with decay half-lives comparable to the age of the earth, and their decay products contribute to this natural radiation background in significant quantities.Radionuclides which emits either alpha or beta particles may be taken into the body by inhalation or ingestion and can give rise to internal exposures. Additionally, some of these nuclear species may emit gamma rays following their radioactive decay; these represent the main sources of external body exposures to humans.

A radiological mapping of the BarikinLadi town of Plateau State Aribaga, Ribi, Azara, Wuse/Maukin and Auta Balaifi Nasarawa State will provide data for NORM levels that will be useful to stakeholders. Soil contaminated with heavy metals may produce apparently normal crops but will be unsafe for human or animal consumption and this contamination with heavy metals is usually quite pertinent as reported by (Spycher, 2015). Soil is the main reservoir for artificial radionuclide emanating from precipitation and it acts as a medium of migration for transfer of elements to biological systems.

This study will provide data on NORM in soils of BarikinLadi, and Riyom town Jos South and Aribaga, Ribi, Azara, Wuse/Maukin and Auta Balaifi Nasarawa State. And it would be useful to the International Commission on Radiological Protection(ICRP, NIBIRRI, NNORM AND NUMPR) in the implementation of Environmental Impact Assessment (EIA) Decree No. 86 of 1992 (FEPA 1995) and also for the implementation of some agricultural policies for the general populace in the area as well as providing information for further studies on NORM.

2. The Study Area

The study area is situated in Plateau State. The states are within the Middle Benue Trough of Nigeria which lies between latitude 7^0 $45'$and $9^0 25'$N of the equator and between longitude 7^0 and $9^0 37'$N of the Greenwich Meridian. BarikinLadi mining site is in BarikinLadi Local Government Area of Plateau State. The geographical coordinates 8^o 221 North, 9^o 151 East and has an altitude of 181.5m above sea level (See Fig. 3.1). While Azara mining site is in Nasarawa Local Government Area of Nasarawa State, the geographical coordinates 8^o 22^1 North, 9^o 15^1 East and has an altitude of 181.5m above sea level.

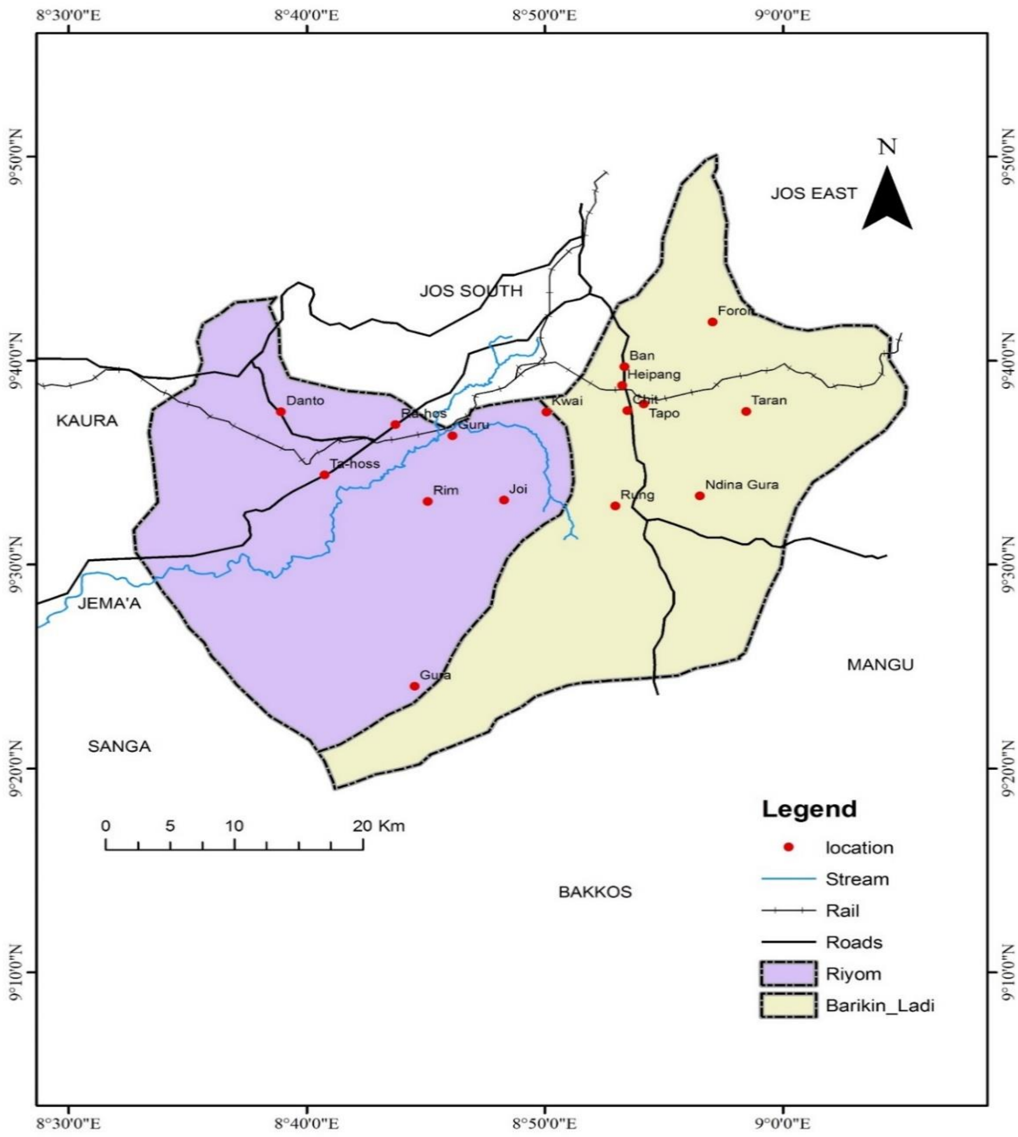
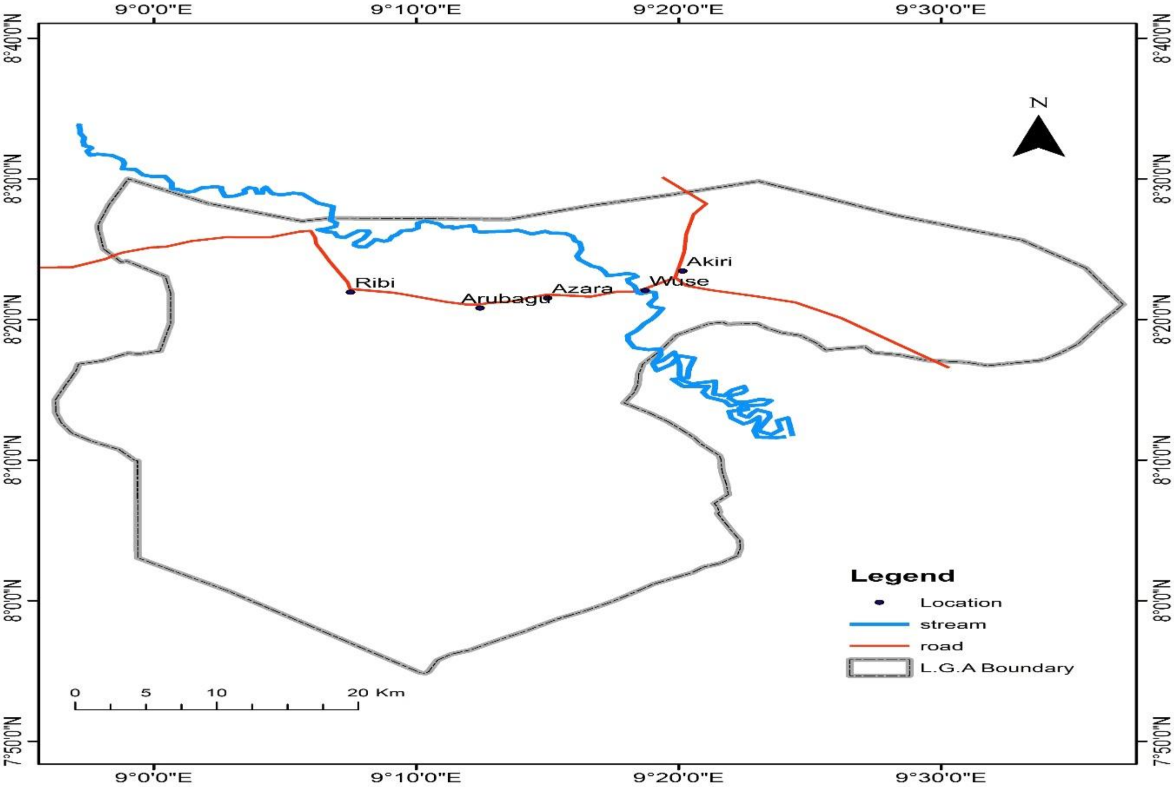


Figure 1.1: Map of Study Areas in Plateau



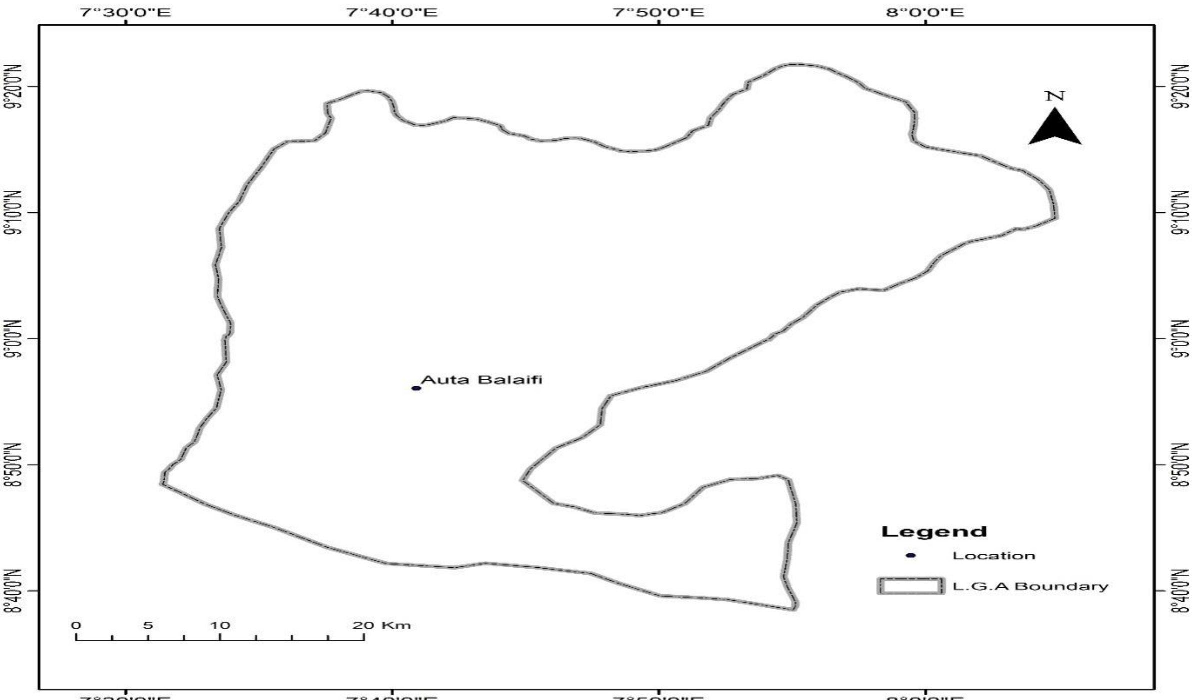


Figure 1.2: Map of Study Areas in Nasarawa State

The study area is geo-morphologically within the upward Awe formation which consists of transitional sandstone, shale, siltstone and limestone and the fluviatile sandstone of the Keana Formation. The Azara area forms part of the north-eastern limb of the Keana anticlinorium. The major barite mineralization is associated with the mineralized hydrothermal vein that is a consequence of the tectonic rifting that led to the emplacement of the Benue Trough which was in part controlled by trans-current fault activity. The barite deposit in Azara occurs as hydrothermal veins within the cretaceous Keana sandstone of the middle Benue Trough. The defunct Nigerian Mining Corporation identified eighteen hydrothermal veins.

Due to the location of the study area in the tropical sub-humid climatic belt, the mean annual temperature is high. The highest temperature is recorded from January to March. A single maximum temperature is achieved in the month of March when maximum temperatures can reach 390 C. Minimum temperature on the other hand can drop to as low as 170 C in December and January. The onset of rain begins in the month of April which brings about a noticeable decline in temperature in the study area. This is made possible by the blanket effect of cloud cover over the area. Rainfall ceases by the end of October when a further decline in temperature in the area is made possible in November/December by the coming of the harmattan winds.

The relative humidity in the study area rises from February to a maximum of about 88% in July. Steady rain commences in April, when the relative humidity will be at about 75%. During this period, the southern part of the state comes under the influence of the humid maritime air mass. The predominant soil parent materials in the area are derived from cretaceous sandstones, siltstone, shale, limestone, and ironstone of undifferentiated basement complex. These rocks are frequently overlain by gravely lateritic iron pans probably formed in the late tertiary era which is associated with concretion gravels and accumulation of alluvial deposits in “rivers flood plains”. The climatic phenomena and rock grade have yielded different soil types. In the study area, the vegetation type is dominantly characterized with southern guinea savanna and some elements of northern guinea savanna with interspersion of grassland, tree savanna, fringing woodland, or gallery forest along the valleys. The people in the study area are mainly farmers. The major crops they produce include yam, cassava, melon, guinea corn, and other grains in large quantities for both consumption and trade. Substantial numbers of nomads reside in the area and are the main suppliers of milk, eggs, butter, hides and skin. The indigenous people are mainly farmers, and the Hausas are petty traders. The Ibo and Yoruba are mainly traders in utensils, automobiles and building materials particularly in the local government headquarters and villages.

2.1. Economic Activities in the Study Area

Mining started in Plateau and Nasarawa State in the 18 centuries before the arrival of the Europeans. Its exploration was local and was marketed by the Arab’s caravan its 19th-century offshoot in the spotlight upon the British presence in the region.

Plateau State was at the time place under the ancient Bauchi Province in the Northern part of Nigeria. The equanimity of the weather and the high demand for tin make the area European commune. The Europeans have a lot of settlements in the area, and this motivated them to create a lot of routes which linked Jos (Plateau) to other areas of the then province.

Before the oil exploration began in Nigeria, the economy of the country was built with resource tapped from mining and agricultural produce and the inhabitant of these areas are now the victims of the aftermath. This can be seen in the form of environmental threats such as existence of numerous ponds, devastation of agricultural land and the insistence of crisis over who owned some certain areas and elective positions. The pattern of ruler ship introduced at the time has also contributed to the lingering crisis in the State. This has shown that the present ecological hazard and the persistence indigene-settler conflicts are products of tin extraction in the state.

2.2. Objectives

1. To gauge the Th-232 and Ra-226 activity concentrations in mining ponds.
2. To evaluate the possible health concerns related to radiation that may arise from the observed radiation levels.
3. To supply baseline data for the impacted areas' regulatory and remediation actions.

3. Materials and Methods

The measurement site was selected (built up area) based on the extent of the ten (10) geological formations, a geographical sampling of at least 200 meters apart within each formation, and the distribution of settlement. The measurement sites were located using a Global Positioning System compass, and data was collected throughout the study region using a Radionuclide Identification Device (R.I.D) and a mobile topographer to ascertain the distance.

Using the survey meter, the data was produced straight from the mining ponds. About 25 mining ponds and farmland were measured for the activity of naturally occurring radioactive materials (NORM) using the geology map of the area, about two hundred and forty (70) samples were measured depending upon the availability of the mining pond.

4. Results:

Table 4.1 Barikin Ladi

S/N	Sample Code	Ra-226 (Bq)	Th-232 (Bq)
1	X1	0.002049	0.007178
2	X2	0.002119	0.004213
3	X3	0.006244	0.002485
4	X4	0.007418	0.009323
5	X5	0.005091	0.008815
6	X6	0.004831	0.004741
7	X7	0.009013	0.008292
8	X8	0.006624	0.003218
9	X9	0.0073	0.006024
10	X10	0.006111	0.006105
	Mean	**0.00568**	**0.00682**

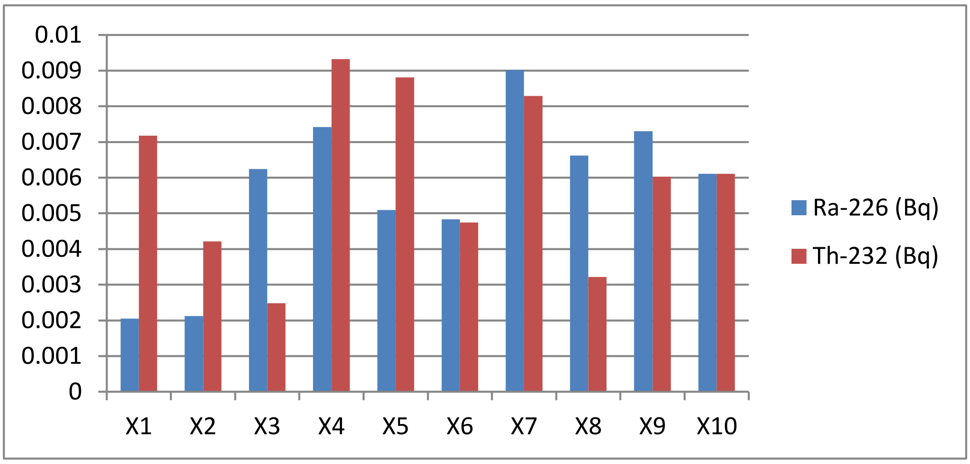


Table 4.2 Heipang Village

S/N	Sample Code	Ra-226 (Bq)	Th-232 (Bq)
1	X1	0.0055543	0.0400912
2	X2	0.040204	0.135622
3	X3	0.0096021	0.1016078
4	X4	0.0020333	0.1226081
5	X5	`0.056073	0.00804671
6	X6	0.0810461	0.0047414
7	X7	0.072481	0.106666
8	X8	0.0808241	0.149608
9	X9	0.122461	0.158462
10	X10	0.166624	0.0074714
	Mean	**0.06369**	**0.08319**

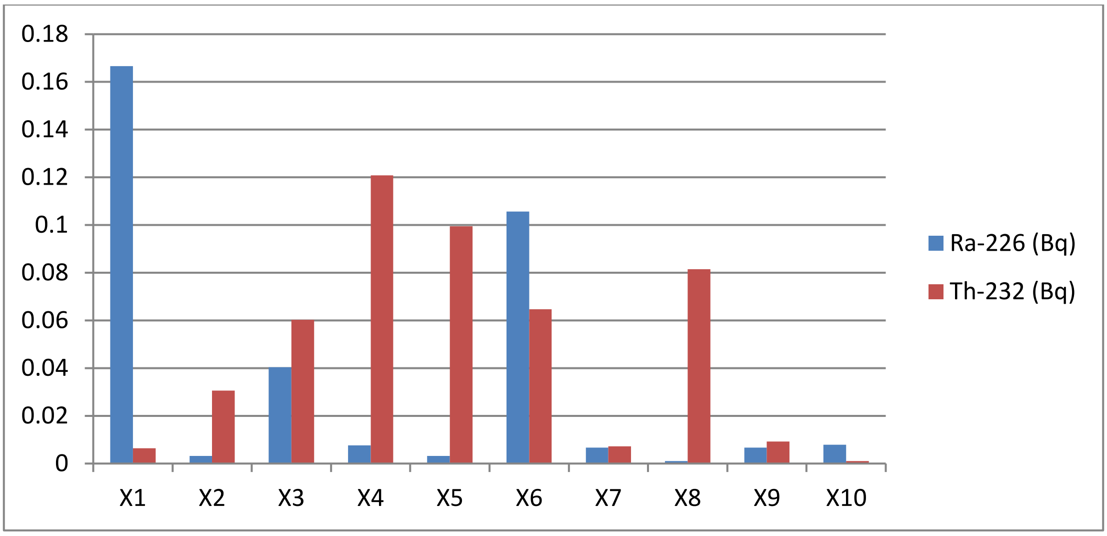


Table 4.3 Tofan Village

S/N	Sample Code	Ra-226 (Bq)	Th-232 (Bq)
1	X1	0.135098	0.0993966
2	X2	0.1096082	0.1212642
3	X3	0.143441	0.0494253
4	X4	0.0676942	0.1093821
5	X5	0.0055669	0.1121026
6	X6	0.1212643	0.0337041
7	X7	0.0066667	0.0992146
8	X8	0.0071765	0.142222
9	X9	0.043834	0.1202142
10	X10	0.0514319	0.0560678
	Mean	**0.069178**	**0.094299**

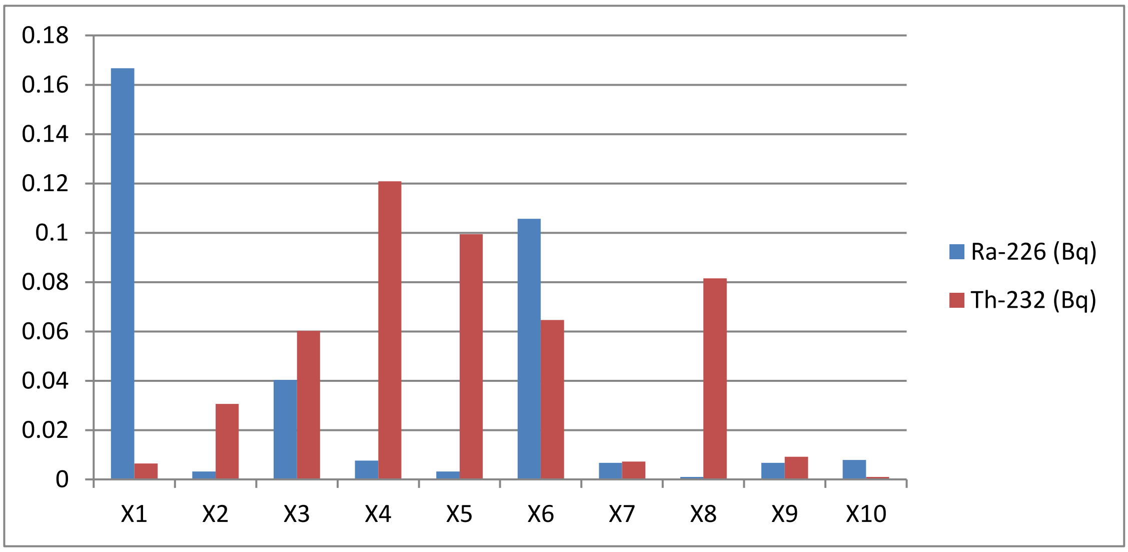


Table 4.4 Rung Village

S/N	Sample Code	Ra-226 (Bq)	Th-232 (Bq)
1	X1	0.005524	0.052
2	X2	0.0380211	0.128241
3	X3	0.17324	0.128241
4	X4	0.2112489	0.0542131
5	X5	0.0047241	0.035214
6	X6	0.0034221	0.141222
7	X7	0.118236	0.544412
8	X8	0.0666667	0.0524231
9	X9	0.0412221	0.0772142
10	X10	0.066178	0.0774132
	Mean	**0.072848**	**0.129859**

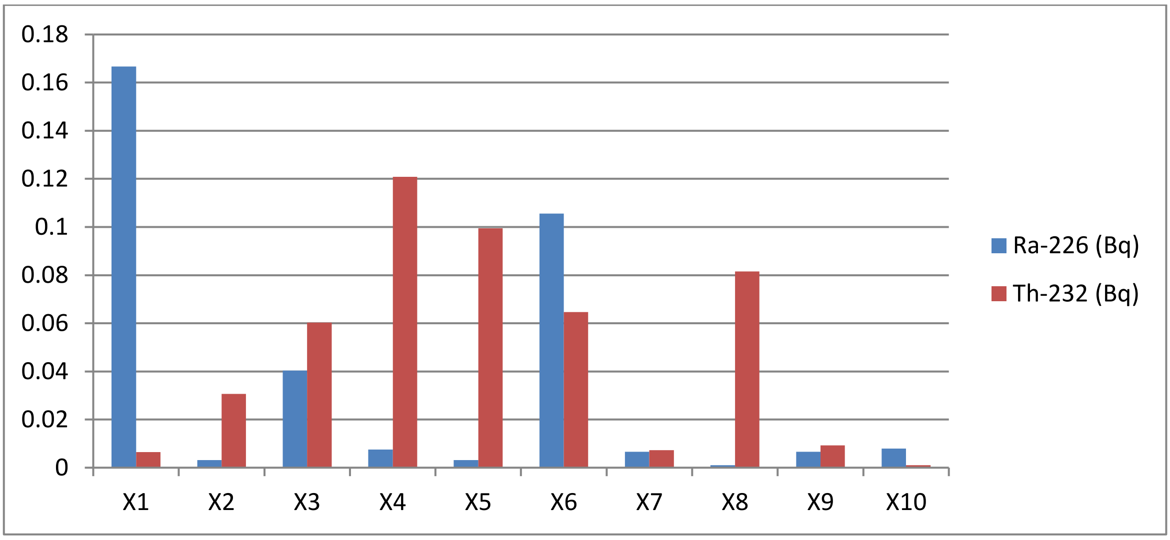


Table 4.5 Zakerek Village

S/N	Sample Code	Ra-226 (Bq)	Th-232 (Bq)
1	X1	0.18022	0.1822221
2	X2	0.165423	0.1824233
3	X3	0.029521	0.0380222
4	X4	0.032667	0.1757444
5	X5	0.0304222	0.1800221
6	X6	0.2124233	0.174214
7	X7	0.2027121	0.1652478
8	X8	0.0412022	0.1724778
9	X9	0.032522	0.1512222
10	X10	0.0331111	0.15047
	Mean	**0.096022**	**0.157806**

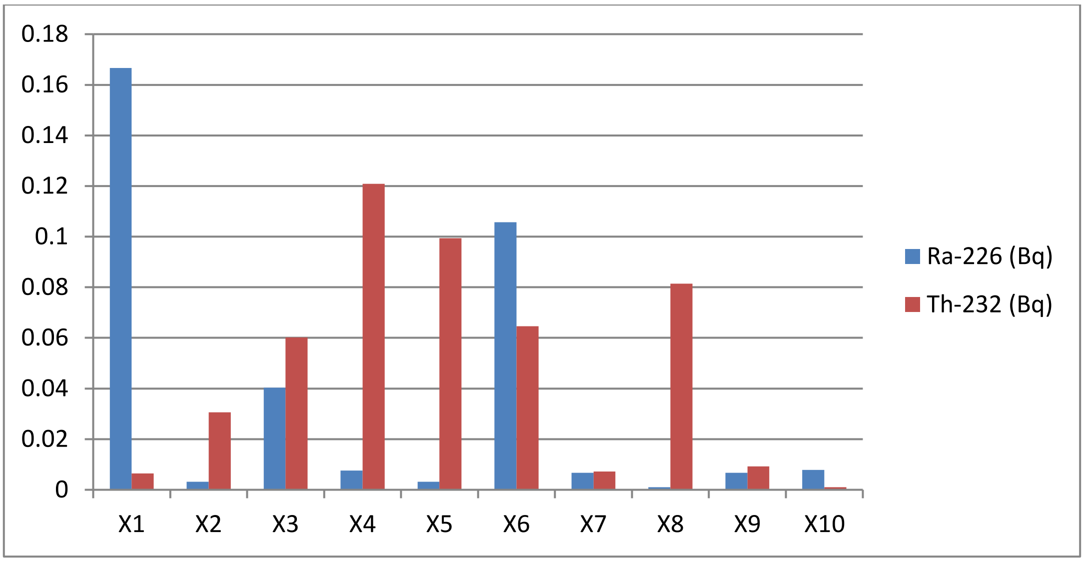


Table 4.6 Ban Village

S/N	Sample Code	Ra-226 (Bq)	Th-232 (Bq)
1	X1	0.13597	0.0622002
2	X2	0.0062741	0.1666222
3	X3	0.0882281	0.0064572
4	X4	0.0508422	0.0088241
5	X5	0.0434182	0.1252478
6	X6	0.024024	0.004018
7	X7	0.0762422	0.004314
8	X8	0.0074202	0.113382
9	X9	0.0136202	0.13122
10	X10	0.097374	0.123412
	Mean	**0.054142**	**0.074768**

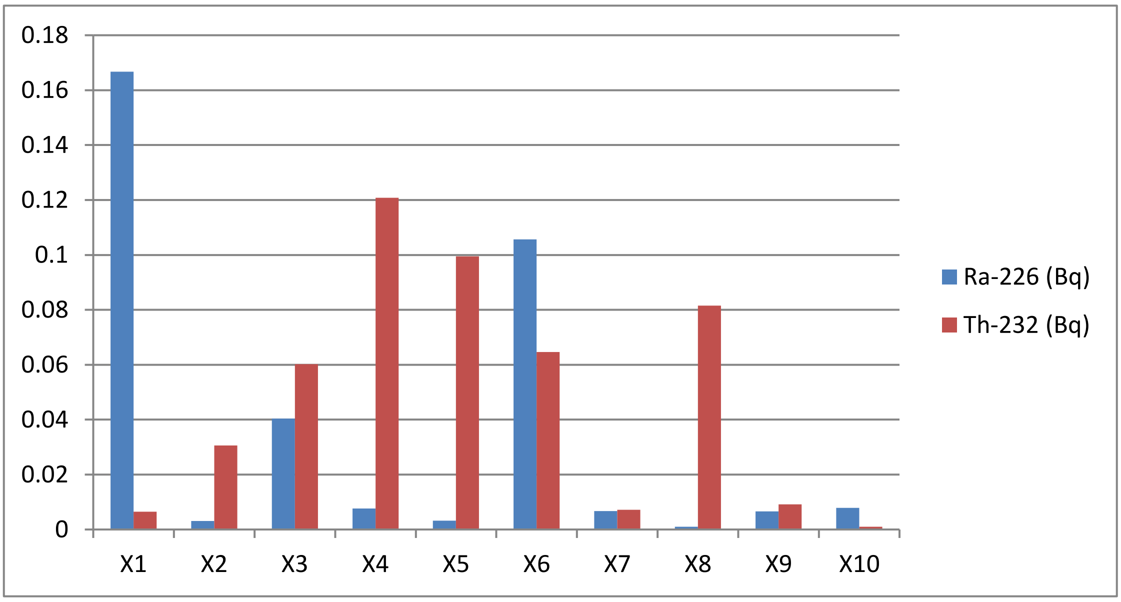
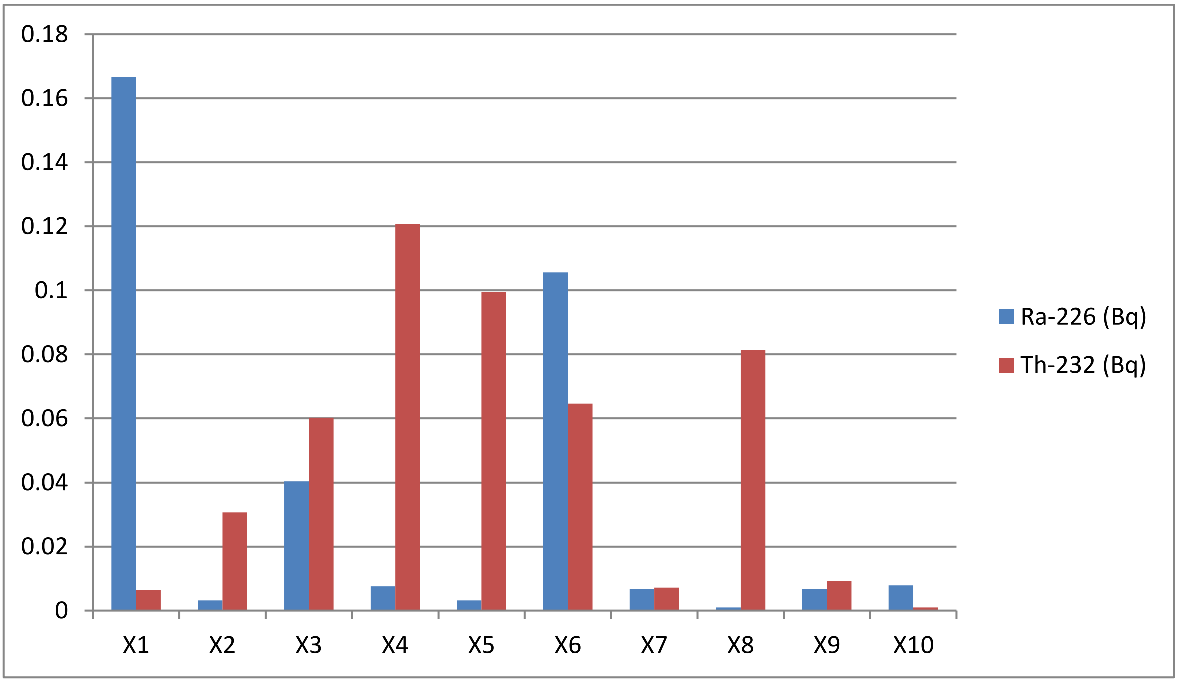


Table 4.7 Riyom Village

S/N	Sample Code	Ra-226 (Bq)	Th-232 (Bq)
1	X1	0.0512	0.0942
2	X2	0.0224	0.0598
3	X3	0.0088	0.0698
4	X4	0.034	0.0988
5	X5	0.0096	0.0544
6	X6	0.0768	0.0364
7	X7	0.0596	0.0956
8	X8	0.034	0.0678
9	X9	0.0678	0.078
10	X10	0.0546	0.0898
	Mean	**0.04168**	**0.07406**



5. Discussion

The findings indicate that the concentrations of Ra-226 and Th-232 activity varied throughout the mining ponds under investigation. An understanding of the possible threats to radiological health in these places can be gained from the mean values of these concentrations.

- **Barikin Ladi:** It was discovered that the mean activity concentrations of Th-232 and Ra-226 were 0.00682 and 0.00568 Bq, respectively. These are comparatively low levels in relation to other locations.

- **Heipang Village:** In comparison to Barikin Ladi, the mean concentrations for Ra-226 and Th-232 were 0.06369 Bq and 0.08319 Bq, respectively, suggesting increased radioactivity.
- **Tofan Village:** Demonstrated moderate amounts of radioactivity with mean activity values of 0.094299 Bq for Th-232 and 0.069178 Bq for Ra-226.
- **Rung Village:** Higher radioactivity was indicated by the mean amounts of 0.072848 Bq for Ra-226 and 0.129859 Bq for Th-232.
- **Zakerek Village:** The study yielded mean activity concentrations for Th-232 of 0.157806 Bq and Ra-226 of 0.096022 Bq, which are among the highest values observed.
- **Ban Village:** Showed comparatively low mean concentrations of Th-232 at 0.074768 Bq and Ra-226 at 0.054142 Bq.
- **Riyom Village**: Ra-226 and Th-232 have mean amounts of 0.04168 Bq and 0.07406 Bq, respectively, suggesting comparatively little radioactivity.

6. Radiological Health Implications

It is suggested that certain areas, especially the villages of Zakerek and Rung, may have higher levels of Ra-226 and Th-232, which could be associated with higher risks to radiological health. To reduce the potential health effects on the local population, ongoing monitoring and remediation efforts are advised.

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