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Assessment of Possible Radionuclides in Granites of North Peninsular Malaysia and Their Associated Hazards

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Abstract

High radiation above the Earth is mainly due to naturally occurring radioactive elements in the Earth's crust and are concentrated in granites.Granites on the other hand are widely used in the constructions of houses, buildings, and event as ornamental stones. This study investigates the possible radionuclides present in the granites of the northern Peninsular Malaysia and the potential hazard associated with them. Thirty nine samples were taken from random locations in Penang, Perak and Kedah to measure their alpha, beta and gamma radiations present. Eleven of them with significant radiation counts were taken for further analysis as to predict in more detail of the possible radionuclides present based on the alpha, beta and gamma radiations measured. The radionuclides predicted are based on the three prominent radioactive series of the natural radioactivity and Potassium-40. Most of the samples are predicted as to have Potassium-40 and several other radionuclides of the Uranium and Thorium Series of long half-life. The results then can be used to investigate the potential health hazard of the granite samples as of the radionuclides present. High activity of radiation is measured in the granites of Bayan Lepas Waterfall, Bukit Hijau, Hot Spring, Kampar, Kampung Raga, Kuala Woh, LataMengkuang and Shamrock Beach..

Keywords:Radionuclides; Natural radiations; Alpha particles; Beta decay; Gamma radiation, Radiation hazards.

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1. Introduction

"The greatest contribution to mankind exposure's comes from natural background radiation", United Nations Scientific Committee on Effects of Atomic Radiation was quoted as saying in its report [1]. As regarding another researcher, he simply put it as "Natural radioactive materials are the most important source of radiation exposure to humans" [2]. The contribution is so large that 97.7% of the total radiation exposure is actually from natural sources while the only remaining 2.3% is from man-made sources of radiation. For most individuals this exposure even exceeds that from all man made sources combined [3]. It is well-known that natural radioactivity is present in rocks, soil, sediment, water and fish. To describe only natural rocks, many of them were reported to contain ^{40}K, ^{232}Th, ^{238}U and ^{226}Ra and contribute to the background radiation levels [4]. This is in persistence with ^{238}U, ^{232}Th and their decay products and ^{40}K as the major sources of external gamma radiation in natural radioactivity [5,6,7,1].^{40}K which is a singly occurring radionuclide in the meantime is a gamma ray emitter in addition to beta decays and therefore contributes significantly to the gamma radiation exposure [8]. Other pure beta particle emitters such as ^{87}Rb may also occur in natural environment but do not increase the radiation dose to man to any significant value, as beta particles are locally absorbed [9]. External exposures to gamma radiation outdoors arise from terrestrial radionuclides occurring at trace levels in all ground formation [7]. Granites in general are characterized by their relatively high content of natural radionuclides such as uranium, thorium and potassium [10]. In terms of natural radioactivity, granites exhibit an enhanced elemental concentration of uranium (U) and thorium (Th) compared to the very low abundance of these elements observed in the mantle and the crust of the Earth [11,8]. U, Th and K are amongst the most incompatible elements [7]. Among all sources of radiation dose to man, inhalation of radon and its decay products contributed the most. It is the main contributor of the dose from the natural radiation [3].

2.0 Materials and Methods

2.1 Sample preparation

Thirty nine samples were collected from various random locations of granite outcrops scattered in three different states of Kedah, Penang and Perak. There is no specific pattern followed in deciding the locations of the samples. The samples were picked in such a way that its location were scattered as uniformly as possible when plotted in map. The table below shows the locations of the collected samples. These core samples were drilled by using a handheld core diamond-driller. The samples were taken at the surface to the 6 -10cm in depth of the granite rocks at the locations. They were prepared in the shape then crushed into small pieces by using a mechanical crusher before being ground to form fine powder. The powdered samples were sieved to a diameter range of less than 300 µm before being filled into polyethylene vials and sealed. The samples were labeled according to their location.

2.2 Radiations measurement condition

Measurement of the radiation include three ionizing radiations; alpha particles, beta particles and gamma radiation. The measurements of the radiations were taken simultaneously for each sample. Most of the radiation

measurements and radiation sources for laboratory works were kept in laboratory. Temperature of the measurements was of room temperature. The time of the experiment includes day and night ranging in six months.

2.3 Alpha particle counting

All samples were subjected to alpha particle counting with a counting time of 50 minutes. The size of each samples were set for 2/32" diameter x 3/8 thickness and were measured with ZnS(Ag) Scintillation Alpha Counter.

Table 1. Detector Specification

Sample size	2-1/32"diameter x 3/8" thickness, maximum.
Scintillation Phosphor	ZnS(Ag) powder on a plastic light pipe.
Photomultiplier Tube	2-inch diameter, 10 stages.
Efficiency	80% of 2π minimum from a 1 inch diameter Pu^{239} source.
Background	Less than 0.3 counts per minute.
Plateau	At least 200V long

2.4 Beta and Gamma Radiation Counting

Beta detector was used in this study to measure beta particles and consist of tube without photocathode. The beta particles were directly being detected by the dynodes in the photomultiplier tube for signal processing. Gamma scintillation detector was employed with adequate lead shielding which reduces the background by a factor about 95%. The detector consist of monocline crystal assembly which include high resolution NaI(TI) crystal, photomultiplier tube, internal magnetic/light shield, chrome plated aluminum housing high quantum efficiency, low dark current, good collection efficiency and gain stability.

Table 2. Gamma Detector Specification

Tube size	2 inches
Crystal size	1-1/2 inch × 1 inch
Resolution	approximately 8% at 662 keV of Cs-137
Window	0.02 inch aluminium, density 147.9 mg/cm^2
Reflector	oxide 1/16 in. thick, density 88mg/cm^2
Magnetic/Light shield	Conetic lined steel

2.5 Subsequent measurements

From the results obtained through alpha, beta and gamma counting, samples with significant radiation counts were taken for further measurement. The samples were again underwent alpha, beta and gamma measurement with exactly the same methods and apparatus but of different duration of time.

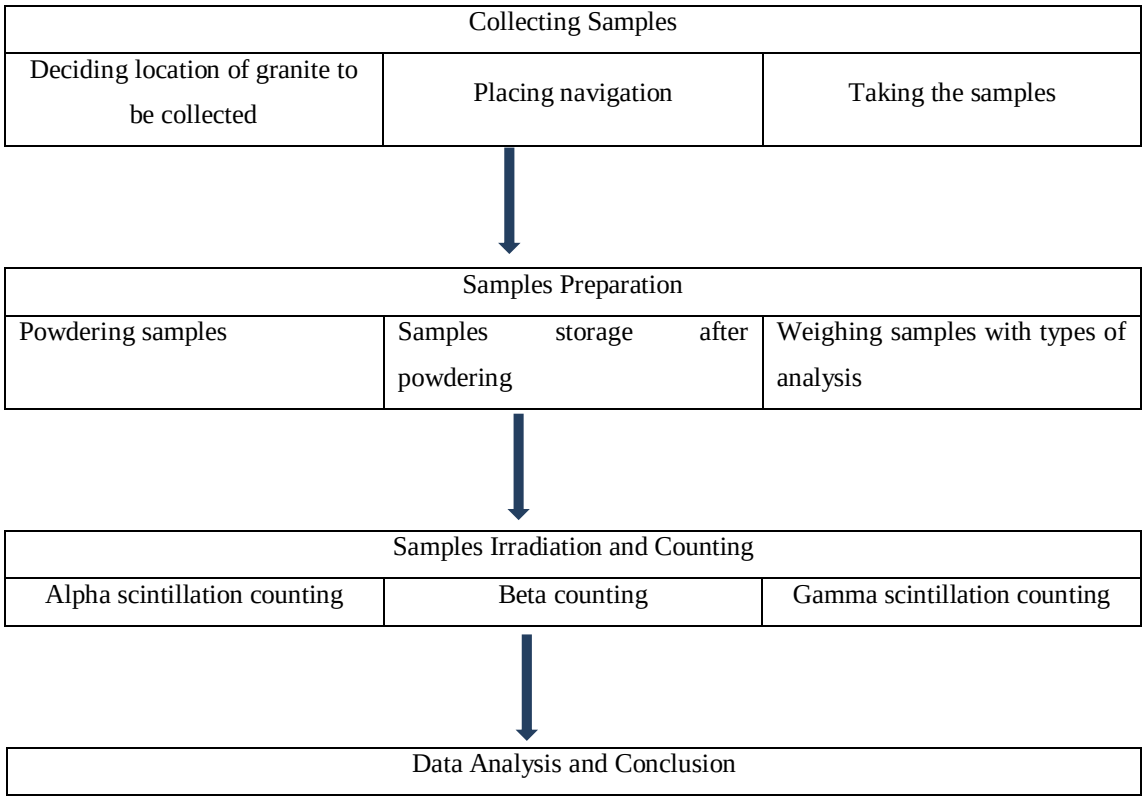

Fig 1. Flow Chart of Study Methodology

3. Result and Discussion

3.1Radiation count rate

Out of three radiations measured, gamma radiation shows the highest count (Fig. 2). Possible gamma radiation sources exist in the samples include ^{232}Th, ^{238}U and ^{40}K. The radionuclides were much quoted gamma radiation contributors of terrestrial radionuclides to the environment.

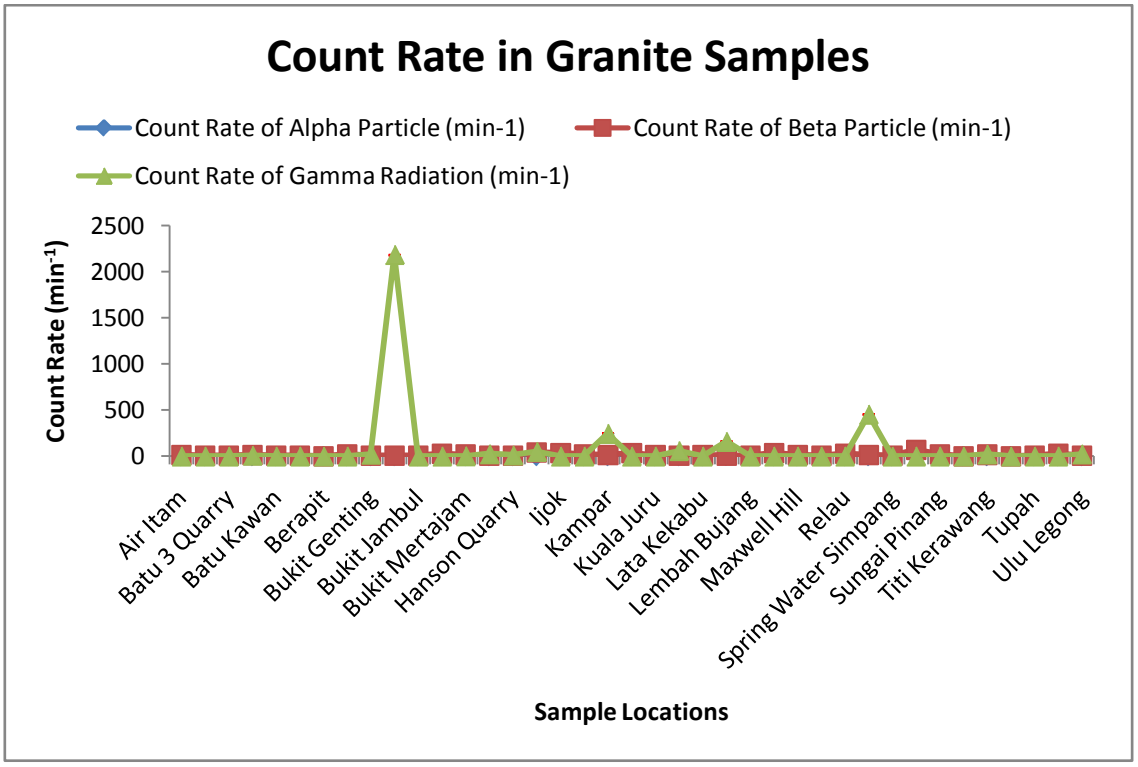

Fig. 2. Count Rate in Granite Samples

Gamma radiation may also be emitted following beta decay as most beta decay lead to excited state of the product nucleus. In some single beta decay processes, multiple gamma-ray photons were emitted per disintegration of the parent nucleus. Thus, although beta particles count were much lower, gamma radiation counts from their decay were possible. Evidences of beta particles beside gamma radiation show the possible occurrence of gamma radiation from beta emitters. Gamma radiation was also emitted due to annihilation process. Annihilation process occurred due to presence of positrons or positively-charged beta particles which interact with matter in the detector. This event proposed the occurrence of beta decay which therefore suggests the presence of also beta emitters in the samples. Beta particle count rate of the samples was far less recorded compared to gamma radiation but was relatively higher compared to alpha particles. The low count rates of beta particles in 50 minutes of time suggest the higher concentration of longer half-life radionuclides compared to the short ones. They include Thorium-234, Protactinium-234, Lead-210, Bismuth-210, Radium-228, Actinium-228, Lead-212 and Bismuth-212. These radionuclides have half-life longer than 50 minutes thus contribute very low beta particle counts to the measurement as the actual decay time may and may not be in the time of the

measurement. Alpha particle count rates although very low but was still of presence in some samples. In the context of time duration of experiment, the possible radionuclides exist in the samples may include Uranium-238, Uranium-234, Thorium-230, Radium-226, Radon-222, Lead-210, Bsimuth-210, Polonium-210, Thorium-232, Thorium-228 and Radium-224. These radionuclides also have half-life longer than 50 minutes. Overall, the possible radionuclides or of higher concentrations present in the samples consist of Thorium-228, Thorium-234, Thorium-230, Thorium-232, Protactinium-234, Lead-210, Bismuth-210, Bismuth-212, Radium-228, Radium-226, Radium-224, Radon-222, Actinium-228, Lead-212, Uranium-238, Uranium-234 and Polonium-210 beside Potassium-40.

3.2 Alpha particle count rates

The alpha counts measured in the range of 0 – 3 counts per minute. Relatively high alpha count rate in Sri Perigi can be associated with higher presence of alpha emitting radionuclides in the area and no alpha emitters as of the other area without any count of alpha particles.

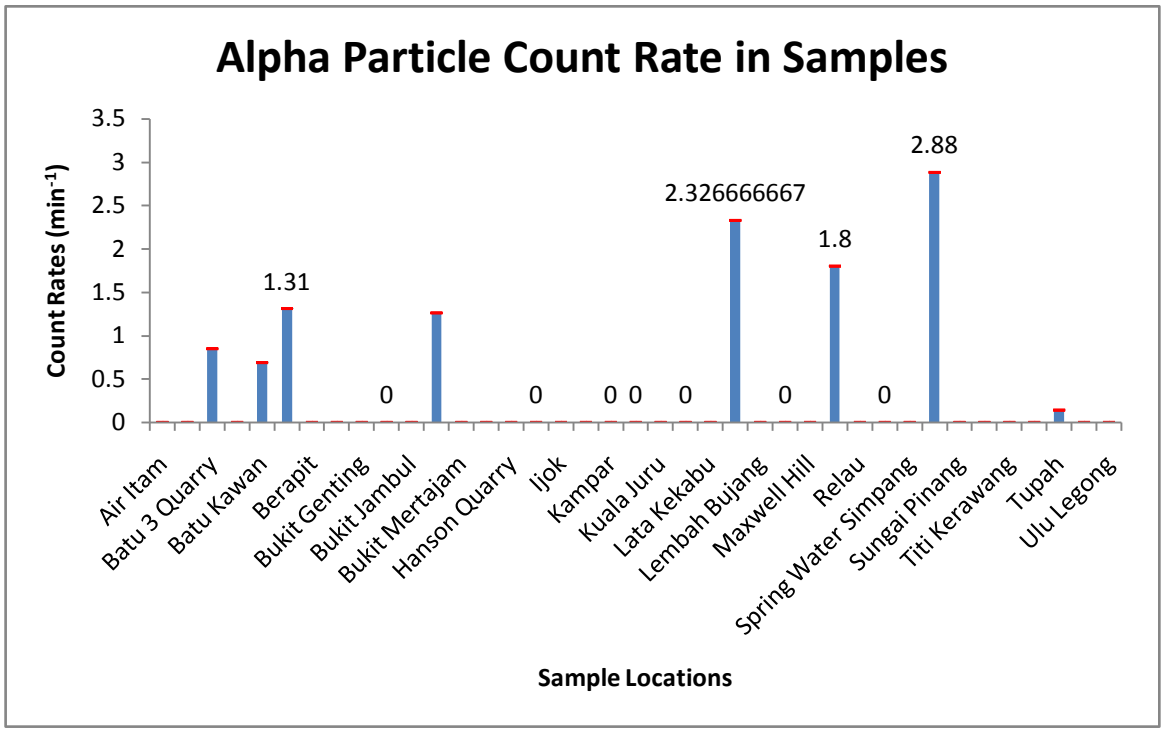

Fig. 3. Alpha Particles Count Rates

3.3 Beta particles count rates

Occurrence of beta counts for all samples except one suggests that beta emitters were prominent radionuclides in the granite and thus environment. It also suggest the presence of ^{40}K in most of the granite samples.

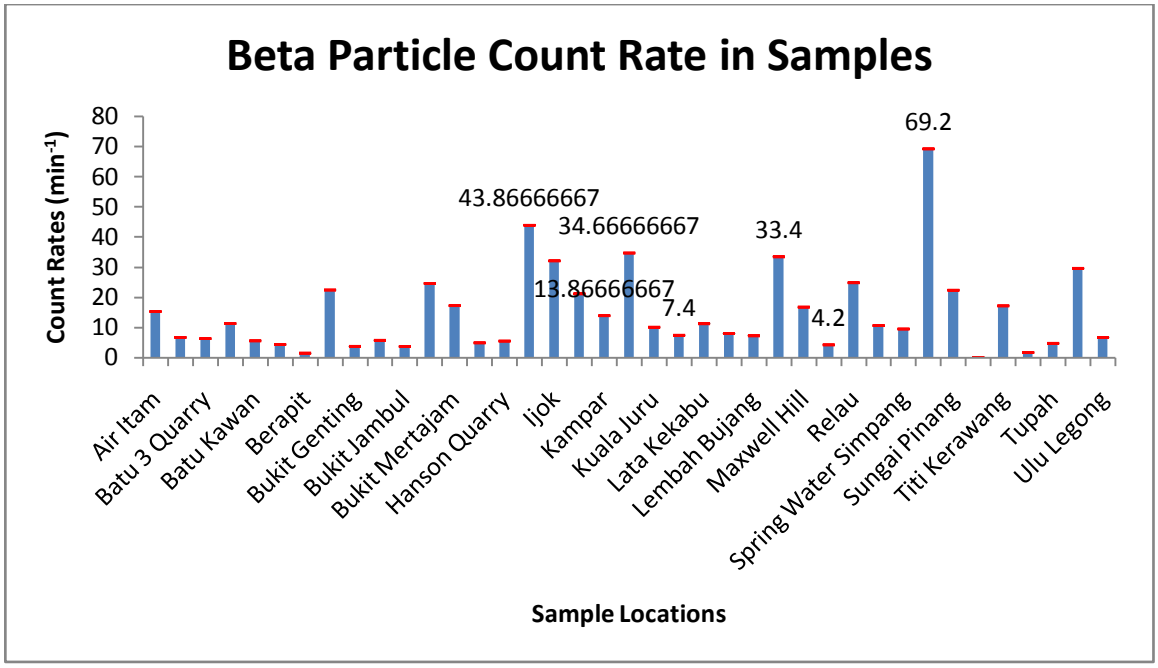

Fig. 4. Beta Particles Counts Rates

3.4 Gamma radiation count rates

A relatively very high gamma radiation as compared to the other samples was measured in Bukit Hijau. The range of gamma radiation measured was in 0 – 2200 counts per minute. Most exposure was associated with gamma radiation.

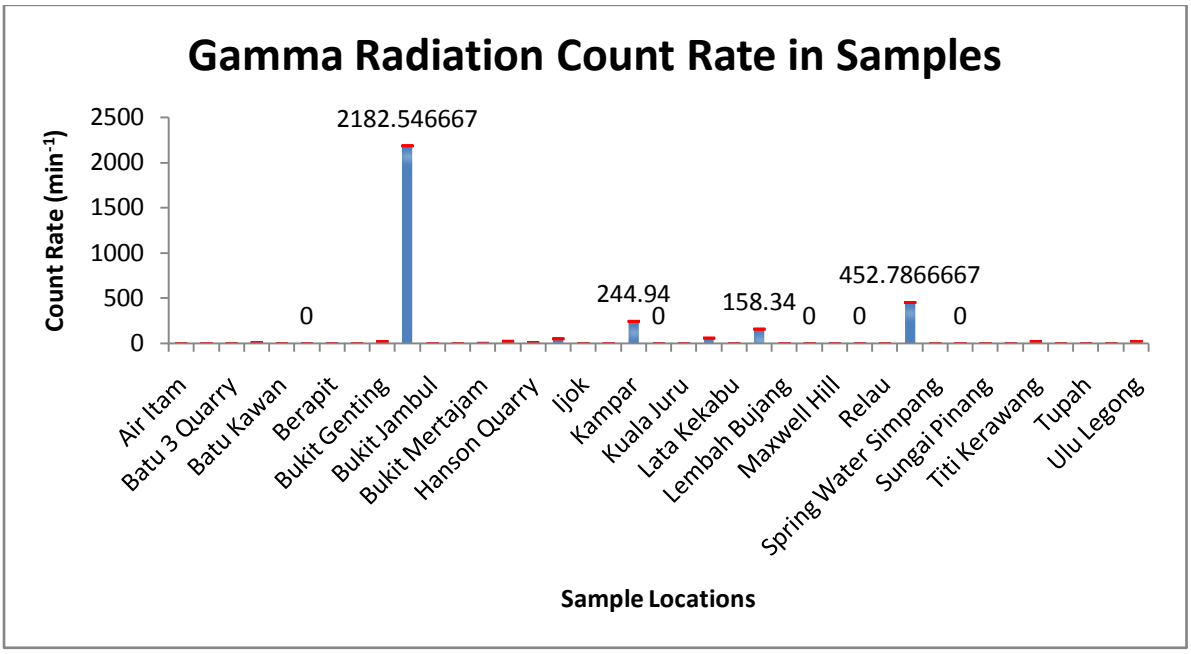

Fig. 5. Gamma Radiation Count Rates

3.5 Overall view of radiation activity

The granite samples chosen for further analysis were taken as to have natural radionuclides each. It was well-known that radioactivity were contained and enhanced in granites and these granites were not of exception. Granites with their low-level activity may prove fatal to health in a long duration of time. Each of the granites studied here showed present of radioactivity while some have a part of them were of significant counts of radioactivity. Potassium-40 as the most possible radionuclide exists in the granite samples emits both beta particles and gamma radiation. Beta particles though locally absorbed, may pose radiological risk in a long term if no precaution were taken. There were types of ionizing radiation too which can ionize the human living cells or tissue. However, the precautions needed were not of dire need although to have them was better. Beta activity was observed in 11 samples were taken for further analysis. Out of three ionizing radiations measured, gamma radiation and alpha particles were the most hazardous radiation to be taken precautionary measures with. Gamma radiation contributes significant exposure to man and also the environment whether indoor or outdoor atmosphere. In fact, most study on granite was specifically concerned with gamma radiation. Gamma radiation was of long range and can affect the living things although being far away from the living things itself. It has high penetration ability. Most of the radionuclides especially from Uranium and Thorium series and even Potassium-40 produce significant activity of gamma radiation. This researchshowed the present of the radiation although in short term duration thus showing that gamma radiation was almost always emitted in the samples. Alpha particles on the other hand were of short range. This nature also makes alpha particles especially of hazard to health upon inhalation. Among all sources of radiation dose to man, inhalation of radon and its decay products contributed high dose. In this case, radon was of present abundantly in natural environment. Other potential alpha emitting radionuclides which naturally occurs in environment and also in granites was Radium-224. Exposure to Radon-220 and Radium-224 represent a significant fraction of the total natural radiation dose to the general public indoor.

4. Conclusion

Gamma showed the highest activity and very high in relative to the other two radiations showing its high influence of its exposure to the public. Furthermore, gamma radiation was the radiation most associated with high exposure in the environment which most of them from terrestrial sources which include granites. Beta particles were deemed negligible to the radiation dose to mas as they were locally absorbed but as a type of ionizing radiation which can affect living tissues, some protective measures can be taken although not of great need. Thirty eight out of the all 39 samples showed present of beta particles which can conclude as the main particle exists in the granite themselves. Alpha particles on the other hand were present in just a part of the samples and of low activity. However, their low activity was still of important consideration as the particles upon inhalation were fatal to the living and they can accumulate in the bodies with time. The result obtained showed the present of radionuclides of Thorium and Uranium series and also Potassium-40. These radionuclides and their progeny emit alpha and beta particles and gamma radiation in their decay thus influence the radioactivity present in the granite samples.

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