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Estimation of Excess Life Time Cancer Risk Due to Occupational Exposure To Ionizing Radiation in Marble Mining Sites in Igbeti, Olorunsogo, Oyo State

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Abstract

The research work is aimed at estimating the excess life time cancer risk due to occupational exposure to ionizing radiation in selected marble mining sites in Igbeti, Oyo State. The work scenario at the sites results to both internal and external exposure to ionizing radiation at the sites. In-situ measurement of the dose rate in the pits, grinding sites and other locations in the sites was carried out using Gamma RAE II and LK3600 dosimeters placed at one meter above the ground level for a stipulated period of time. Radiation dose to risk converter software designed by World Information Service on Energy (WISE) was used to estimate the excessive life time cancer risk for artisan miners in the sites for a period of 10 years. The dose rate ranges from the sites ranges from 8nGy/hr-140 nGy/hr. The estimated annual Dose rates range between 20µSv/yr-170 µSv/yr. The estimated excess life time cancer risk for 10 years ranges between 0.003%-0.019% at workers' risk factor of 0.04 per Sv and conversion factor of 0.7Sv/Gy Conclusively, there is no significant risk of cancer for all the workers at the mining sites. More workers may be employed to improve the efficiency of the companies mining marbles thereby attempting to meet the national and the global needs for marbles.

Keywords: Excessive Life Time Caner Risk, Occupational Exposure and Ionizing Radiation.

1.0 Introduction

Soil contains radioactivity derived from the rocks which it originated. However, the majority of radioactive element is chemically bound in the earth crust and is not a source of radiation exposure on the surface unless released through natural phenomenon (e.g earthquake or volcanic activities) or human activities (e.g mining or construction). Mining of marbles can result in external gamma irradiation and inadvertent ingestion of dust at the mining and grinding sites. These activities may therefore increase radiation levels above background at the sites. The increased radiation level will consequently lead to increase of radiation exposure of workers in the area. There is therefore the need to measure the radiation levels around the sites for activities that can cause the enhancement of radiation levels in order to assess workers radiation exposure. This is important in order to ensure that workers do not exceed regulatory radiation dose limit recommended by ICRP (20msv/yr) [1]. Inhalation of radon and its decay products is responsible of about half of the annual average effective dose received by the human due to natural sources of radiation [2]. Outdoor radon does not represent a significant health hazard because high concentrations are never reached. However, it becomes a problem when released into a closed or poorly ventilated enclosures like dwellings, buildings and also caves and mines. Radon and its decay products are found in variable concentrations indoors, outdoors, and in mining environments. Epidemiology studies have shown a direct link between intake of high concentration of radon and the incidence of cancer [3-8].Inhalation of radon and its decay progeny (daughters) is responsible for half of the annual average effective dose received by humans due to natural sources of radiation [9] and this is peculiar to cave and underground mines .When radon decays after inhalation or ingestion, it releases energy that can damage cells of sensitive organs like lungs and stomach and can cause cancer. Two of the α-emitting daughters of ^{222}Rn (^{218}Po and ^{214}Po) contribute to over 90% of the total radiation dose attributed to exposure to Radon [10].Many of the artisan miners in the business of exploring God endowed natural resources are aware of the risk involved when mines collapse but are not aware of the level of the risk involved due to exposure to high level of radon concentration from the natural decay of radionuclide from rocks and soil during the work scenario at mining sites with open pits compared to caves or underground

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mines . Work activities at the mining site involves external irradiation by gamma rays during digging of pits, carrying slurries from the pit, internal dose due to inhalation of air contaminated with marble dust at the mining and grinding site and inadvertent ingestion of radionuclide during their work activities. Many unemployed youths are afraid of taking up jobs with mining sites because they are not well informed of the difference in level of exposure to high level of ionizing radiation from caves and underground mines when compared with low level ionizing radiation from open pits as the case study for the research. This has resulted in many youths shunning any involvement in the lucrative business of artisan mining spread across the country. Sequel to the dwindling price of crude oil, an expert in the Mining Industry, Abdullahi Usman, popularly called "Dan China", has called on President Muhammad Buhari to ensure the inclusion of the Mining and Minerals sector in his developmental agenda, saying if properly harnessed, the sector will generate five times what the Nigeria is getting from crude oil [11].The result of the research work if favorable can be a useful tool in achieving the dream of the present administration by giving a sense of direction on where to employ more of the teeming unemployed youth. Additionally, it can also serve as base-line for future radiological study of the selected mining sites. Finally, the result will also contribute to the existing body of knowledge in this area of research.
The purpose of the study is to estimate the excess life time cancer risk due to occupational exposure to ionizing radiation in selected marble mining sites in Igbeti, Oyo State using radiation dose to risk converter software [12]. The following are the specific objectives of the work:

i. In-situ measurement of the dose rate in the open pits and outside the pit.
ii. Estimation of annual dose rate at the mining sites.
iii. Estimate the excess life time cancer risk due to occupational exposure to ionizing radiation from open mine in marble mining site for a period of 10 years.
iv. Alleviate the fear in the minds of unemployed youth (if possible) in working with open pit mining sites such as the mining sites in Igbeti, Olorunsogo local government of Oyo State, Nigeria.

2.0 Methodology

In-situ measurement of the dose rate in the pits, grinding sites and other locations in the sites was carried out using Gamma RAE II and LK3600 placed at one meter above the ground level per locations of consideration at the sites for a stipulated period of time (300sec). Gamma RAE II R uses CsI (TI) as detector and CsI with combined with TI makes the device a good scintillator. It has in-built daily calibration capacity and factory calibration is not required. Energy range is 0.06MeV-3.0MeV. LK3600 dosimeter use G.M tube in detecting and measuring radiation. G-M counter compensation improves the low-energy response of the dosimeter and it has high sensitivity and will respond to radiation in the natural environment. It's Measuring range for dose rate: 0.000usv/h—5msv/h and accumulated dose up to 6-digit LCD display of the range 000.000—999.999msv and energy response: <±30% (50KeV—1.3MeV).
Radiation Dose to risk software designed by World Information Service on Energy (WISE) [12] was used to estimate the excessive life time cancer risk of the workers in the sites for a period of 10 years. The use of two dosimeters in the work is to cater for low and high level of radiation dose that workers may be exposed to during the work activities at the site.
The annual effective dose rate to the population, H_e was calculated by the formula:

$$H_e = DTF_O \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where D is the average values of the in- situ values of the (dose rate μSv/hr) measures at the sites, T is the occupancy time (T=f X 24 X 365.25h year $^{-1}$) f is the occupancy factor with value of 0.2 and 0.8 for outdoor and indoor measurements respectively and F_o is the conversion factor
(0.7 SvGy-1) [13]. Radiation Dose to Risk Converter calculator determines the health risk from a given radiation dose supplied to the software input interface as shown in Table 7. The dose or the dose rate is entered as input parameters and appropriate units of μSv/hr was used for the work since in-situ dose rate measured with the dosimeters is in μSv/hr. The occupancy determines the time in a year a person is exposed at the given rate. It can be entered in hours per year, or in percentage of total time, or continuous exposure as selected from the software interface shown in Table 7 . Typical work time is 2920 hours per year was used since the artisan miners spend 8hrs per day for 6 days in a week at the site. The number of years entered allows for cumulative dose calculation over the whole work life or lifetime. The fatal cancer risk factor per Sievert for stochastic effect uses 0.04 for workers and 0.05 for the public recommends 0.7Sv/Gy for adults,0.8 for children and 0.9 for infants for dose factor for gamma radiation[1,2]

3.0 Results and Discussion

This section presents the result of the research work and appropriate pictorial representation of the results.

Table 1: Measured Dose-Rate At Mining Site A

	GAMMA RAE II R (μSv/h)					**LK3600(μSv/h)**			
INSIDE PITS (μSv/h)	0.01	0.01	0.01	0.01		0.062	0.047	0.109	0.015
OUTSIDE PITS (μSv/h)	0.01	0.01	0.01	0.01		0.062	0.015	0.031	0.047
LOADING/ UNLOADING SITE (μSv/h)	0.02	0.02	0.02	0.02		0.078	0.047	0.031	0.047
SUMMARY	Peak Dose rate: 0.02μSv/h Minimum Dose Rate: 0.00μSv/h Average Dose Rate inside Pit:0.01μSv/h Average Dose Rate inside Pit:0.01μSv/h Average Dose Rate at loading site:0.02μSv/h					Loading Site:Mean Dose rate=(0.051±0.017) μSv/hr Inside Pit: (0.058±0.034)μSv/h Outside pit: (0.039±0.018)μSv/h			

From Table 1,usingGamma RAE II R, the peak dose rate is 0.02μSv/h(20.0nGy/hr),the dose rate inside the pit and outside the pit are the same with a value of 0.01**μ**Sv/h(10.0nGy/hr).This may due to the fact that large open pit may be at the same atmospheric condition as outside the pit. The dose rate at the loading and unloading site is higher than inside and outside this pit with a value of 0.02μSv/h (20.0nGy/hr).This may be caused by the increased dust load at the site as a result of the work scenario there which involves carrying the bagged marbles into the truck and unloading the bagged marbles carried from mining sites by the truck. The estimated annual dose rate is 24.5μSv/yr using the software. The estimated excess life time cancer risk for 10 years is 0.002% at workers' risk factor of 0.04 per Sv and conversion factor of 0.7Sv/Gy [1,2] using the highest dose rate of 0,02**μSv/h** as the input dose rate for the software. Similarly, with the use of LK3600 dosimeter the mean dose rate for loading site A is 0.051μSv/h(51nGy/h) while the dose rate inside and outside the pits are 0.058μSv/hr(58nGy/hr) and 0.039μSv/hr(39.0nGy/hr) respectively.The estimated annual dose rate is 71.2μSv/yr using the highest value of dose rate of 58nGy/hr. The values of the annual dose rate is quite lower than the world wide permissible limit of occupational exposure of 20mSv/yr. Using the radiation dose to risk software [12], the estimated excess life time cancer risk for 10 years is 0.007% at workers' risk factor of 0.04 per Sv, conversion factor of 0.7Sv/Gy and the highest dose rate of 58nGy/hr [1,2].

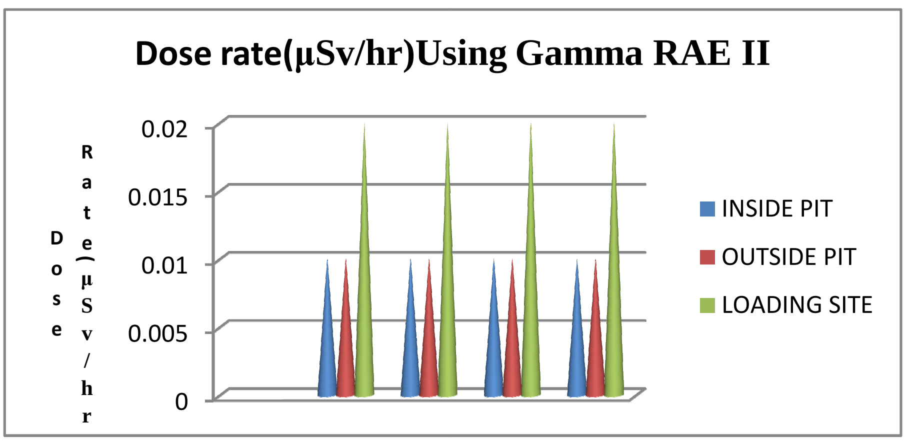

Fig 1: Dose Rate (μSv/hr) at Mining Site A Using Gamma RAE IIDosimeter

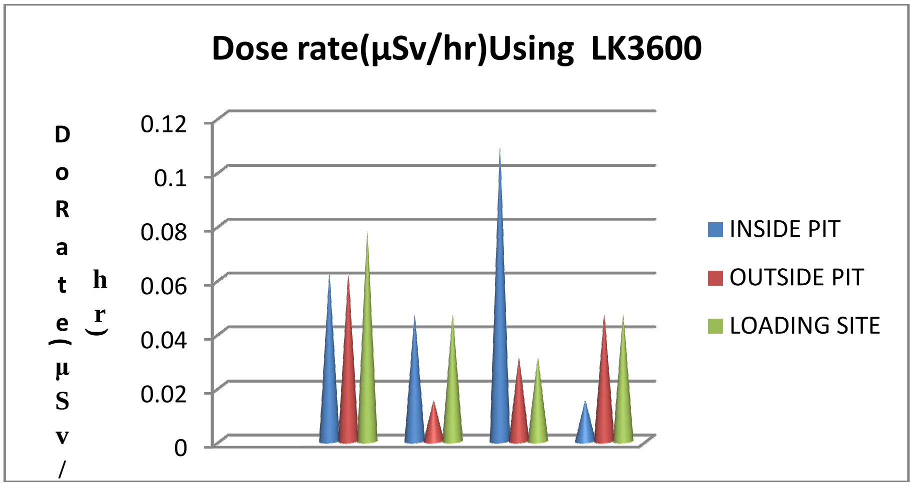

Fig 2: Dose Rate (µSv/hr) at Mining Site A Using LK3600 Dosimeter

Table 2: Measured Dose-Rate at Grinding Site A

	LK3600 (μSv/h)				**GAMMA RAE II R(μSv/h)**				
GRINDING SITE	0.078	0.031	0.047	0.015		0.01	0.01	0.01	0.01
RESTING/ EATING SITE	0.00	0.031	0.109	0.094		0.04	0.04	0.04	0.04
SUMMARY	Grinding Site:Mean Dose rate=(0.043±0.023) µSv/hr	Resting point at Grinding Site: (0.059±0.045)µSv/hr			Peak Dose Rate: 0.04μSv/h Mini. Dose Rate: 0.00μSv/h				

From Table 2, using Gamma RAE II R, the peak dose rate is 0.04μSv/h (40nGy/hr), the dose rate at the grinding site where the machines are installed in the open is 0.01μSv/h(10.0nGy/hr).This may due to the fact that work activities at the site takes place in open field with very good air circulation. The dose rate at the resting spot is 0.04µSv/hr (40nGy/hr).This may be due to background radiation or any other unnoticed source of radiation in the spot. The estimated annual dose rate using the radiation dose to risk converter software is 49.1µSv/yr. The estimated excess life time cancer risk for 10 years is 0.005% at workers' risk factor of 0.04 per Sv and conversion factor of 0.7Sv/Gy using the highest dose rate of 0.04 **μSv/h** [1,2].Similarly, with the use of LK3600 dosimeter the mean dose rate for grinding site A is 0.043µSv/h(43nGy/h).The estimated annual dose rate is 72.4µSv/yr using the highest dose rate value of 59nGy/h. The value of the annual dose rate is quite lower than the world wide permissible limit of occupational exposure of 20mSv/yr. Again, the estimated excess life time cancer risk for 10 years is 0.009% using the software at workers' risk factor of 0.04 per Sv, conversion factor of 0.7Sv/Gy and the highest dose rate value 0.059µSv/hr [1,2].

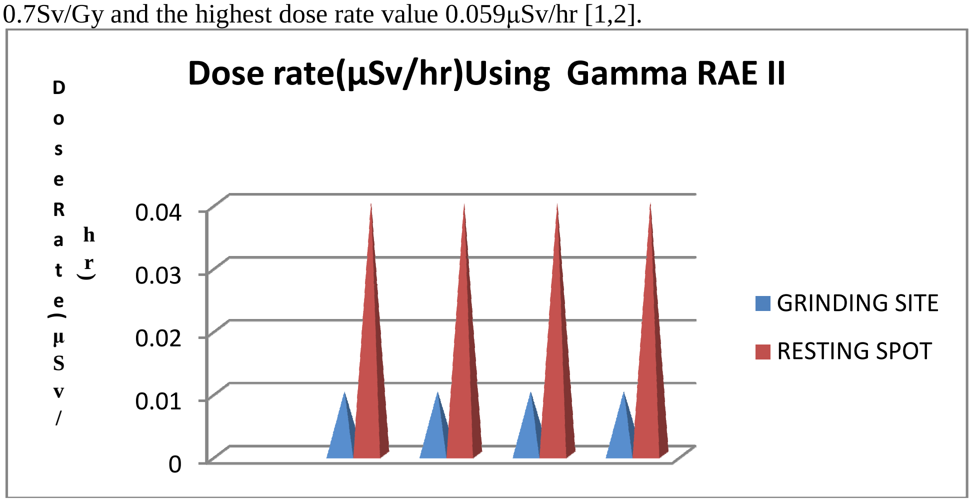

Fig 3: Dose Rate (µSv/hr) at Grinding Site A Using Gamma RAE IIDosimeter

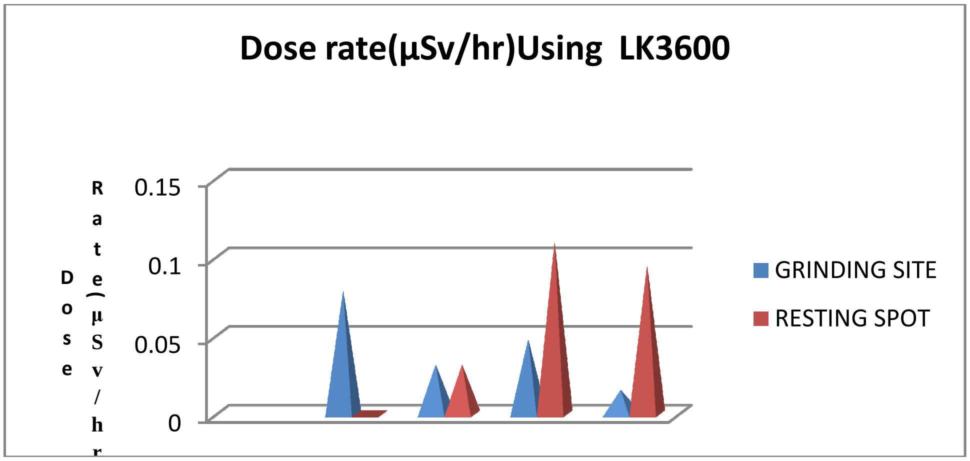

Fig 4: Dose Rate (µSv/hr) at Grinding Site A Using LK3600Dosimeter

Table 3: Measured Dose-Rate At Mining Site B

	LK3600 (μSv/h)						**GAMMA RAE II R (μSv/h)**					
OUTSIDE PIT	0.195		0.156	0.117	0.078			0.04	0.04	0.04	0.05	
INSIDE PIT	0.039		0.078	0.010	0.009			0.03	0.03	0.03	0.02	
LOADING SITE	0.039		0.078	0.156	0.117			0.04	0.05	0.05	0.05	
SUMMARY	L/Site:Mean Dose rate=(0.098±0.043) µSv/hr	Outside Pit:(0.137±0.044) µSv/hr Inside Pit:(0.034±0.028)µSv/hr					Peak Dose Rate:0.05μSv/h Mini. Dose Rate: 0.00μSv/h Average Dose rate Inside Pit:0.043μSv/h Average dose rate outside Pit:0.048μSv/h Average dose Rare at Loading site:0.048μSv/h					

From Table 3, using Gamma RAE II R, the peak dose rate is 0.05μSv/h (50.0nGy/hr), the average dose rate inside the pit and outside the pit are the same with a value of 0.043μSv/h(43.0nGy/hr) and 0.048µSv/hr(48.0nGy/hr) respectively.This may due to the fact that large open pit may be at the slightly different atmospheric condition as compared to outside the pit and there may be other sources of radiation. The dose rate at the loading and unloading site is higher than inside and outside this pit with a value of 0.048μSv/h(48.0nGy/hr).This may be caused by dust load at the site as a result of the work scenario there which involves carrying the bagged marbles into the truck and unloading the bagged marbles carried from mining sites by the truck. The estimated annual dose rate using the software is 61.36µSv/yr with the highest dose rate of 50nGy/hr. The estimated excess life time cancer risk using the software for 10 years is 0.07% at workers' risk factor of 0.04 per Sv , conversion factor of 0.7Sv/Gy and using the highest dose rate [1,2]. With the use of LK3600 dosimeter the mean dose rate for mining site B loading site is 0.098µSv/h(98.0nGy/h) while the dose rate inside and outside the pits are 0.034µSv/hr(34.0nGy/hr) and 0.137µSv/hr(137.0nGy/hr).The value may be due to background radiation or any other unnoticed source of radiation. The estimated annual dose rate is 168.1µSv/yr using the highest dose rate value for outside the pit. The values of the annual dose rate are quite lower than the world wide permissible limit of occupational exposure of 20mSv/yr. The estimated excess life time cancer risk for 10 years ranges is 0.016% at workers' risk factor of 0.04 per Sv, conversion factor of 0.7Sv/Gy and the highest dose rate value (0.137µSv/hr) [1,2].

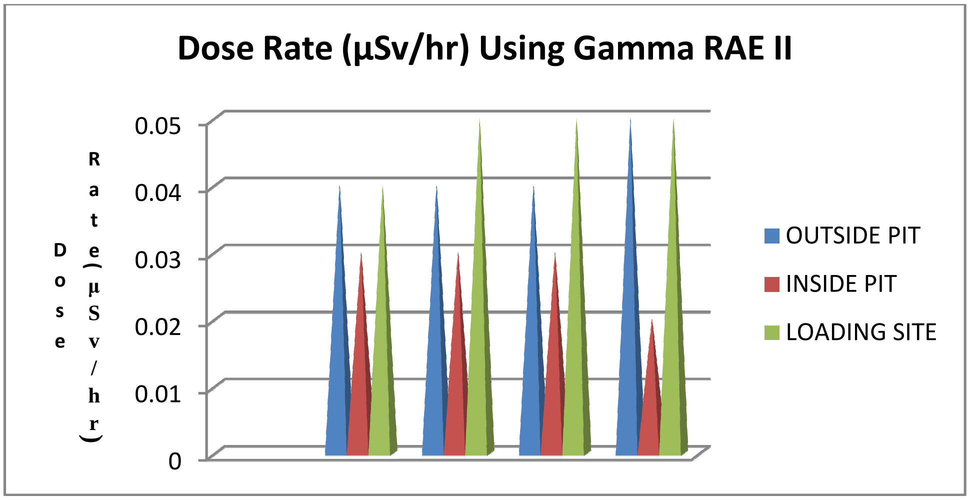

Fig 5: Dose Rate (µSv/hr) at Grinding Site A Using Gamma RAE IIDosimeter

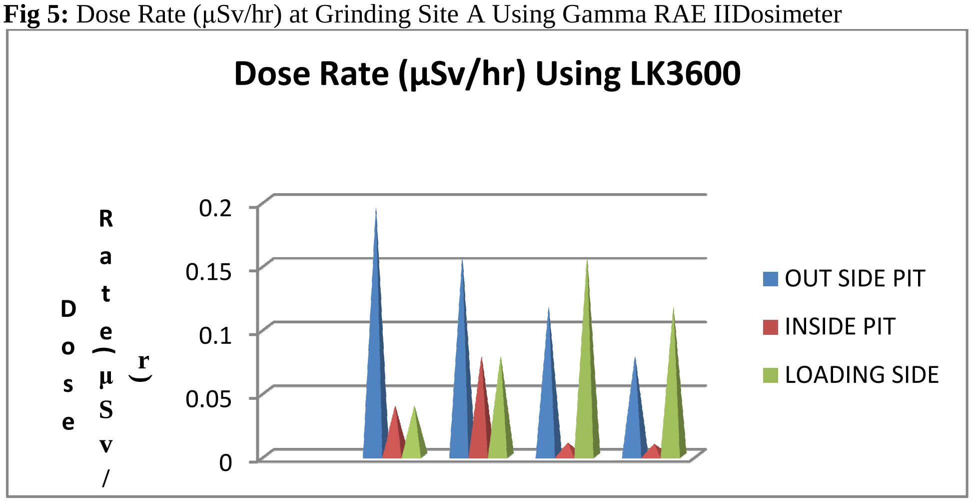

Fig 6: Dose Rate (µSv/hr) at Mining Site A Using LK3600 Dosimeter

Table 4: Measured Dose-Rate At Grinding Site B

	LK3600 (μSv/h)								**GAMMA RAE II R (μSv/h)**			
GRINDING SITE			0.062	0.109	0.235	0.015			0.03	0.03	0.04	0.05
RESTING/ EATING SITE			0.047	0.094	0.078	0.109			0.04	0.04	0.04	0.04
SUMMARY	Grinding Site:Mean Dose rate=(0.105±0.082) µSv/hr	Resting point at Grinding Site: (0.082±0.023)µSv/hr							Peak Dose Rate:0.05μSv/h Mini. Dose Rate: 0.00μSv/h			

From Table 4, using Gamma RAE II R, the peak dose rate is 0.05μSv/h (50nGy/hr), the dose rate at the grinding site where the machines are installed inside the factory is 0.03μSv/h(30.0nGy/hr).This may due to the fact that work activities in the factory such as heavy duties machine crushing and grinding the marbles takes place inside with not very good air circulation when compared with the grinding site at A. The dose rate at the resting spot is 0.04µSv/hr(40.0nGy/hr).The estimated annual dose rate is 61.4µSv/yr using the software. The estimated excess life time cancer risk for 10 years is 0.007% at workers' risk factor of 0.04 per Sv and conversion factor of 0.7Sv/Gy [1, 2].With the use of LK3600 dosimeter the mean dose rate for site B grinding site is 0.105µSv/h(105.0nGy/h).The estimated annual dose rate is 128.7µSv/yr using the highest dose rate value of 105nGy/h. The value of the annual dose rate is quite lower than the world wide permissible limit of occupational exposure of 20mSv/yr. The estimated excess life time cancer risk for 10 years is 0.015% at workers' risk factor of 0.04 per Sv, conversion factor of 0.7Sv/Gy and the highest dose rate value 0.105µSv/hr [1,2].