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EXPOSURE TO BACKGROUND IONIZING RADIATION FROM QUARRIES AND PREMISES IN KISUMU COUNTY, KENYA

Environmental Science

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ABSTRACT

Introduction: Exposure to higher levels of ionizing radiation beyond the recommended threshold may cause DNA mutation thereby resulting in varying disease conditions including cancer. As such, determination of levels of ionizing background radiation from quarries and premises where humans live become critical to ensure health safety.

Materials and Methods: Background ionizing radiations were captured from quarries and premises in Kisumu County. A total of 427 premises were sampled and the data subjected to descriptive statistics as well as analysis of variance at 95% stringency level to reveal statistical significance among and within the variables.

Results: Neither quarries nor premises sampled had their annual ionizing radiation levels below the WHO recommended threshold of 1mSv. Majority of quarries (45%) and premises (52%) clustered between 101-200 and 201-300 categories, respectively. Lolwe revealed the highest level of ionizing radiation with a 296% deviation from WHO recommended standard while the lowest level of ionizing radiation of 179% was recorded in Kakwacha.

Conclusion: The results reported here indicate presence of higher levels of ionizing radiations in quarries and premises beyond the acceptable annual threshold thereby posing significant health risk to the public. These results form the basis for a nationwide research to determine the scope of the risk in order to guide the formulation of the national building code, related policies and mitigation interventions to safeguard the safety of the Kenyan public.

KEYWORDS

Quarries, Premises, ionizing radiation, cancer

INTRODUCTION

The rising global disease incidences, especially of cancer, in many low and middle income countries has provoked tremendous efforts towards the development of integrated interventions that focus on prevention, early detection, treatment and palliative care [1]. In Kenya for instance, cancer is ranked third among the main causes of death after infectious and cardiovascular or heart related diseases, and accounts for close to 20,000 deaths annually [2]. Of the many causes of cancer, ionizing radiations which naturally occur in rocks, are known to cause DNA mutation. Exposure to ionizing radiations such as x-rays and gamma rays, given off by radioactive materials such as alpha particles, beta particles, and neutrons, may cause genetic mutations in cells leading to several health hazards including cancer [3]. These ionizing radiations occur in trace levels in rocks as naturally occurring radioactive materials. Ionizing radiations comprise subatomic particles, ions or atoms and electromagnetic waves on the short wavelength end of the electromagnetic spectrum. They are highly energetic and when they pass through a material, they deposit enough energy that can lead to breakage of molecular bonds and displacement of electrons from atoms. The electron displacement results in ions that cause changes in human cells [4]. However, most permanent buildings, particularly in Kisumu county, Kenya, are constructed using underground stones mined from embedded rocks, yet the country is not adequately radio-profiled to determine whether these rocks contain radionuclides that emit ionizing radiations. World Health Organization recommends that the annual exposure to background ionizing for the general public should not exceed 1 mSv because the risk of cancer increases with the increase in the duration of radiation exposure. The objective of this study was to determine the levels of background ionizing radiation in quarries and premises in Kisumu County, Kenya, relative to the WHO recommended reference.

MATERIALS AND METHODS

Background ionizing radiation from quarries was recorded from Kedowa Kericho and Misori region. Fifteen different points were selected for measurement per quarry and the same procedure repeated in other quarries. Since the normal background radiation levels often vary at different locations within and among quarries a timed count was taken so as to establish the normal background radiation count rate for each point. An *in-situ* approach of background radiation measurement was preferred and adopted to enable sample maintain their original environmental characteristics. A total of 427 premises were sampled from 9 estates namely: Kakwacha, Kisumu CBD, Lolwe, Migosi, Milimani, Nyalenda, Polyview, Robert Ouko, Vundumba. Measurements of indoor radiation were taken in eight different points per premise and the same procedure repeated in other premises. The readings were captured in milliRoentgew per hour (mR/h).

At each point, a sample of four measurements were taken and the mean value calculated. The readings were recorded in a work sheet and entered in Microsoft excel spreadsheet for analysis. Radiation readings were converted from hours to years taking into account a maximum daily exposure of 24h. An occupancy factor (OF) of 0.8 outlined by UNSCEAR in 1988, which represents the proportion of the total time during which an individual is exposed to a radiation field was factored in the equation. When converting the indoor readings to annual equivalent doses in mSv/y for the premises, the following equation was used.

$$E_i = X \times 8760 \times 0.8 \times 0.01 \times 1.7$$

E_i is the annual equivalent dose rate in mSv/y.
X is the indoor meter reading in mR/h.
8760 is the annual conversion factor in hours/year.
0.8 is the indoor occupancy factor
0.01 is the conversion of mR to mSv
1.7 is the calibration factor.

Descriptive statistics was used to express the data as Means ± SEM. One way ANOVA was used to test the significance within the quarries and premise clusters at 95% confidence level. Data was further subjected to Turkey's post hoc for pairwise comparison and separation of means. Minitab version 17.0 was used to determine the significant relationships between the radiations from different premises. The findings were presented through tables that showed levels of mean radiation levels between quarries and premises, and their differences in statistical significance. The results were further computed relative to the recommended WHO annual dose reference of 1mSv. The percentage deviations was calculated by getting the percentage of the difference of the annual reading from the WHO threshold.

RESULTS AND DISCUSSION

Construction stones used for building permanent premises in Kisumu County are sourced from quarries located in either Kedowa Kericho or Misori. Stones from Misori showed statistically lower annual levels compared to those from Kedowa Kericho which revealed the highest levels taken for 24h ($p \leq 0.05$, Table 1).

Table 1: Annual exposure to ionizing radiation in quarries in Kisumu County computed using 24h daily working period.

Quarry	Annual Exposure 24h
Kedowa Kericho	3.987 ± 0.122^{a}
Misori	2.460 ± 0.124^{b}

Values are expressed as Mean±SEM. Values followed by the same superscript are not significantly different (p≤0.05; One way ANOVA followed by Tukey's post hoc test)

When quarries were clustered to determine the annual percentage deviation from the WHO recommended threshold of 1mSv, none of them was compliant with majority (45%) clustering between 101-200 category (Table 2).

Table 2: Percentage deviation from the recommended WHO standard of annual exposure to ionizing radiation in quarries in Kisumu.

Deviation cluster (%)	Number of quarries (%) (Annual 24h)
0<	0
1-100	11
101-200	45
201-300	20
301-400	20
401>	4

This study sampled 9 estates. Lolwe revealed the highest level of ionizing radiation with a 296% deviation from WHO recommended standard. This was followed by Vundumba and Milimani, 289% and 282.5%, respectively (Table 3). The lowest level of ionizing radiation was recorded in Kakwacha, which recorded a 179% deviation (Table 3). There was no statistical significance in levels of ionizing radiation between the Migosi and Milimani, Nyalenda and Ployview, and Lolwe and Vundumba (Table 3, $p \leq 0.05$).

Table 3: Annual exposure to ionizing radiation in premises in Kisumu County

Estates	Annual Indoor Reading	Deviation from WHO standard (%)
Kakwacha	2.792±0.079d	179.2%
Kisumu CBD	3.206±0.063cd	220.6%
Lolwe	3.961±0.096a	296.1%
Migosi	3.645±0.077ab	264.5%
Milimani	3.825±0.127ab	282.5%
Nyalenda	3.400±0.076bc	240.0%
Polyview	3.371±0.083bc	237.1%
Robert Ouko	3.587±0.137abc	258.7%
Vundumba	3.890±0.185a	289.0%

Values are expressed as Mean±SEM. Values followed by the same superscript are not significantly different (p≤0.05; One way ANOVA followed by Tukey's post hoc test)

Overall, when the ionizing radiations from the premises were clustered to determine the overall deviation from the recommended threshold, none of the premises showed percentage deviation less than zero with majority of the premises (52%) clustering between 201-300 category. In fact, 3% of the premises recorded a deviation above 400 (Table 4)

Table 4: Percentage annual deviation from WHO recommended standard of ionizing radiation in Kisumu County

Deviation cluster (%)	Number of units (%)
0<	0
1-100	1
101-200	25
201-300	52
301-400	19
400>	3

In this study, the levels of background ionizing radiations in quarries and premises were not only high but also varied. This portends a health risk given that the extent of cell damage - and therefore cancer - is directly related to the received dose of radiation [5, 6]. The variation in the radiation levels shown in this study is consistent with earlier studies which attribute such differences to the concentrations of naturally occurring radionuclides which become trapped in the earth's crust during the formation of the parent rocks [7] and end up in soils as part of rock cycle through weathering. The levels of background ionizing radiations recorded in this study is comparable to those previously reported by Ogola et al. [8]. Other factors such as geographical and local geology may determine the amount of radionuclides resulting in distinct variation in the radiation level in the environment [9].

CONCLUSIONS

These results indicate presence of higher levels of ionizing radiations in premises beyond the acceptable annual threshold thereby posing significant health risk to the public. Consequently, these results form the basis for a nationwide research to determine the scope of the risk so as to guide the formulation of the national building code and related policies to safeguard the safety of citizens in Kenyan.

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