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Natural Radioactivity Of Some Selected Economic Minerals From Quarry Sites In Igarra Area, Edo State, Nigeria

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ABSTRACT

Activity concentrations of radionuclides in rocks and minerals are of vital importance in geosciences and health physics especially that primordial radionuclides 226Ra, 232Th and 40K constitute the main source of radiation exposure risks externally in soil, rocks and minerals.In this study, activity concentrations of 226Ra, 232Th and 40K in three economic minerals were evaluated using gamma ray spectrometric technique. Mean activity concentrations of 226Ra, 232Th and 40K were 3.15, 1.85, 291.59Bq/kg in dolomite, 1.01, 0.78, 197.89Bq/kg in feldspar and 5.41, 4.02, 427.03Bq/kg in calcite respectively. Computed average absorbed dose rate at 1m above ground and annual effective dose equivalent were 14.73, 9.19, 22.73nGy/h and 0.02, 0.01, 0.03mSv/y respectively for dolomite, feldspar and calcite. Other computed hazard indices for the studied economic minerals were below their respective safety limits stipulated in the UNSCEAR report.

Keywords: Environment, Generator, Noise, Noise pollution

INTRODUCTION

The earth and the atmosphere contains various levels of radionuclides, but only those with half lives similar with the age of the earth and their corresponding decay products active in terrestrial materials, such as ^{40}K, ^{226}Ra and ^{232}Th are of great interest, since gamma radiation from these represents the major external source of human exposure. The level of natural radioactivity in soils, rocks and in the surrounding environments as well as the associated external exposure due to gamma radiation depends primarily on the geological and geophysical conditions of the region (UNSCEAR, 2000). Since these radionuclides are not uniformly distributed, the knowledge of their distribution in soils, rocks, minerals and their measurements is very important, not only to estimate the amount of change of the natural background activity with time, but also for radiation protection issues (Kolo *et al*, 2012). These elements are widely distributed through the environment, generally in a trace amount in sediment, air, soil and others (Dinh Chen et al, 2011; Fasae & Isinkaye, 2018). Natural occurring radionuclides are present in every human environment; earth materials, water, air, food and even our body contain natural occurring radioactive (Najeba, 2008). These economics minerals (dolomite, feldspar and calcite) taken from the environment are used as raw material and product for buildings road, playground and for land filling (Najeba, 2008). These rocks used

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for construction of building, road, playground and land filing is one possible way of exposure to radiation in the environment, radiation cannot be felt using our senses organs, hence it is very important that the total amount of radiation emitting NORMs in the quarry site area are accurately known and kept to a level as low as reasonably achievable, in other to safeguard human lives and ensure that the environment is free from radiation exposure (Aborisade *et al*, 2018). However, the environmental impacts, human health challenges and issues associated with mineral exploration and utilization demands for urgent attention (Kolo *et al*, 2016). Quarry site studies to access radionuclides has been reported in literatures (Aborisade *et al*, 2018; Essien & Akpan, 2016; Shittu *et al*, 2015), Nimat et al*,* 2017) but not so much has been reported from the study area even though quarry activities has been around the study for more than two decades. Therefore, this study seek to estimate the concentration level of the radionuclide at the quarry sites, to estimate the radiological hazards indices posed by the activities of the quarry and for this study to serve as baseline for the public.

METHODOLOGY

Sample Collections, Geology of the Area and Preparation

Five samples each of dolomite, feldspar and calcite, totally fifteen samples (15) were collected randomly from selected quarry sites in Igarra area. The samples collected were labelled and sealed at the point of collection (figure 1).

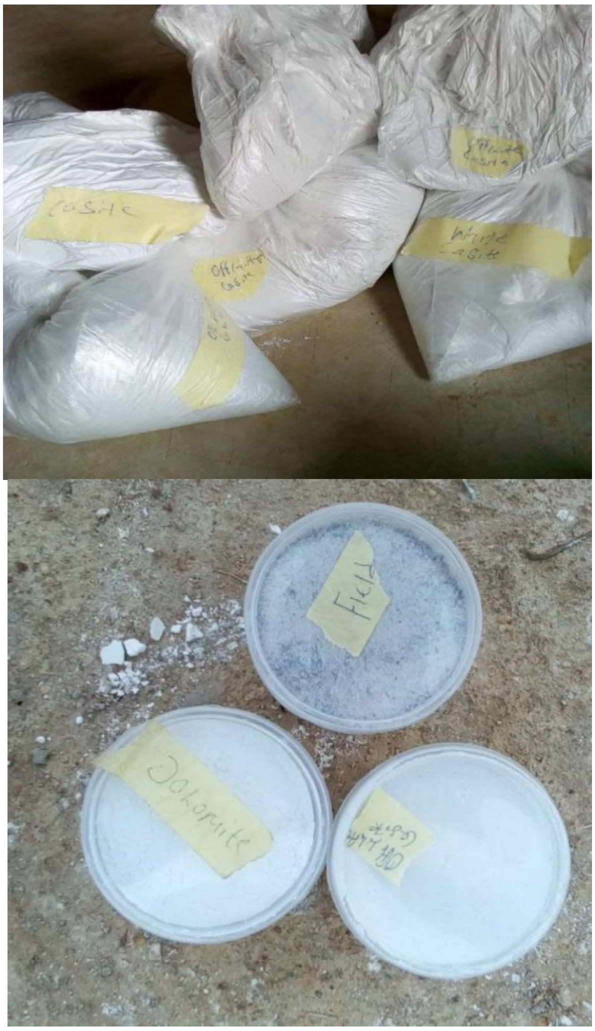

Figure 1: Samples of the collected minerals, labelled and packaged

The location of the study area is Igarra in Edo State of Nigeria (figure 2). The Igarra area lies within Latitudes 7^{o}24′5″N-7^{o}30′N and Longitudes 6^{o}00′E-6^{o}10′5″E at the northern fringe of Edo State, Nigeria and underlain in the north by Precambrian Basement Complex, and in the south by Cretaceous and Tertiary sediments. Igarra lies in the northern part of Edo State and is the headquarters of Akoko Edo Local Government Area .The major highway in the area runs from Auchi through, Sobe Ogbe, Ikpeshi, Igarra to Ibillo (Oloto & Anyanwu, 2013).

The collected was air dried and filtered before transmission to the Laboratory (figure 1).

The Study Area

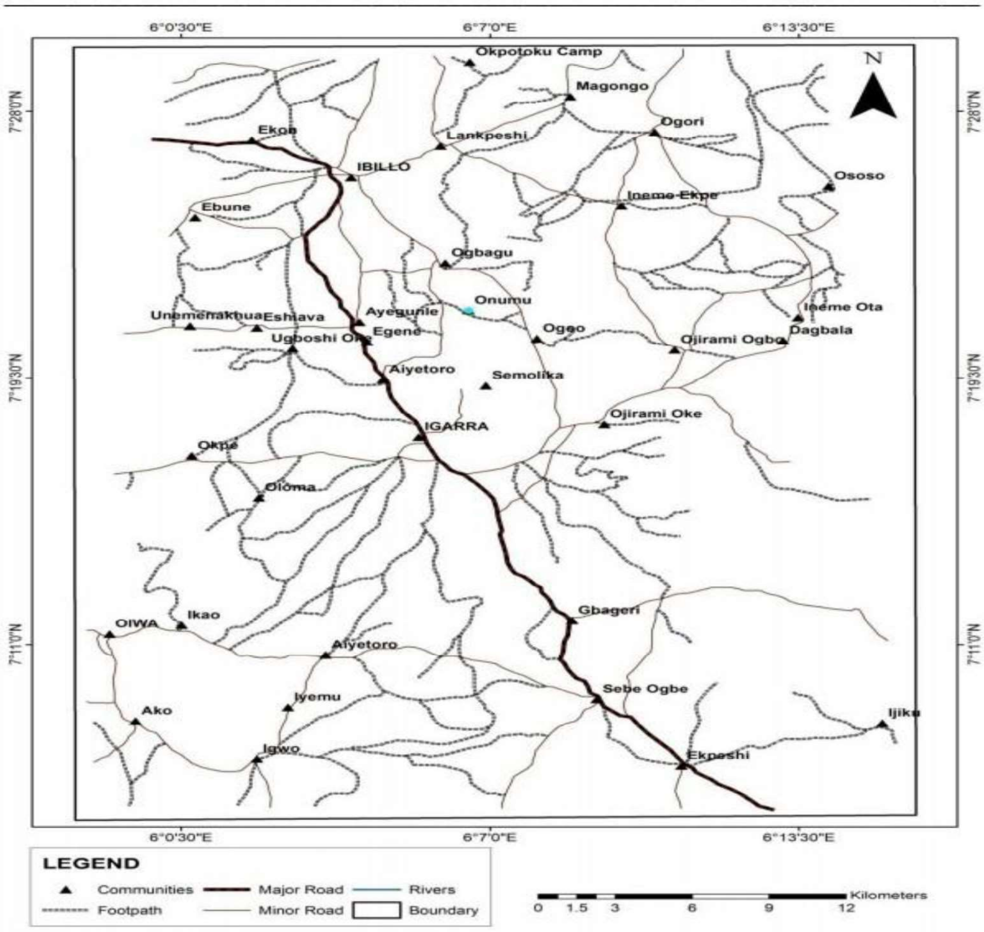

Figure 2: the map of the study area (Oloto& Anyanwu, 2013).

Radioactivity Measurement

The gamma ray spectrometry system used for the measurement consist of 3x3 inch NaI(Tl), detector by Scintillation Technologies USA located at Ladoke Akintola University of Science and Technology Ogbomosho (LAUTECH), Nigeria. The detector is housed in a 6cm thick lead shield so as to reduce the background radiation levels many times. The inside of the detector is also lined with cadmium and copper sheets, which according to El-Ayadarous (2007), help to absorb the emitted x-rays from lead which may contain radioactive impurities due to antimony impurities. The detector assemblage is coupled to a computer based multichannel analyzer (MCA) with ACCUSPEC computer program used for data acquisition and analysis of gamma spectra. The efficiency and energy calibration of the detector were done over energy range using 137Cs and 60Co standard isotopic sources over energy range of 200keV to 3MeV, being the energy range of radionuclides to be determined. Also, the IAEA gamma spectrometric reference materials, RGK-1, RGRa-1 and RGTh-1 were used to recalibrate the system for quantitative determination of ^{40}K, ^{226}Ra and ^{232}Th in the economic mineral samples. The activity concentration of ^{226}Ra was evaluated from 1764keVgamma line of 214Bi, while 2614keV gamma line of 208Tl was used to evaluate the activity concentration of ^{232}Th. The single 1460keV gamma line of ^{40}K was used for its content evaluation. Each sample was counted for 10hours

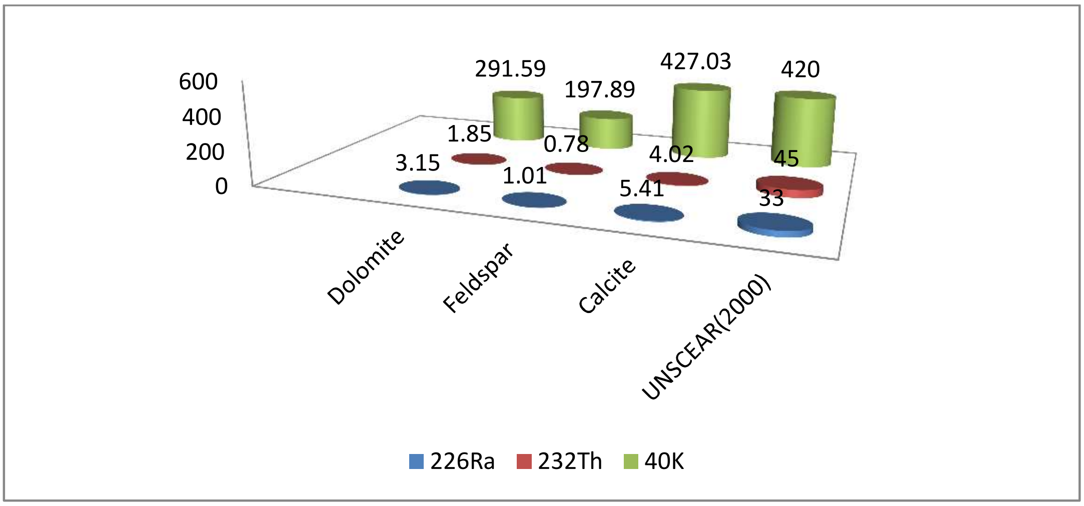

Figure 3; Mean activity concentrations of the economic minerals compared with UNSCEAR limits

RESULTS AND DISCUSSION

Activity Concentration

Descriptive statistical results of activity concentrations of ^{40}K, ^{226}Ra, and ^{232}Th, in the economic minerals from Igarra Area are given in Table 1. Mean activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K were 3.15, 1.85, 291.59Bq/kg in dolomite, 1.01, 0.78, 197.89Bq/kg in feldspar and 5.41, 4.02, 427.03Bq/kg in calcite respectively. The mean values were below their respective world medians of 30, 35 and 400Bq kg^{-1}(figure 3) except calcite which has its

^{40}K exceeded the recommended limit slightly as documented by UNSCEAR (2000).

Table 1. Mean activity concentrations and radiation hazard indices of three economic minerals from quarry sites in Igarra area, Edo State, Nigeria

	No of	Activity concentrations (Bq/kg)				D_R	AEDE	Hex	Iγr	ELCR
Minerals	samples	^{226}Ra	^{232}Th	^{40}K	Ra_{eq}	(nGy/h)	(mSv/y)	≤ 1	≤ 1	(× 10^{-3})
Dolomite	5	3.15	1.85	291.59	28.24	14.73	0.02	0.08	0.23	0.06
Feldspar	5	1.01	0.78	197.89	17.36	9.19	0.01	0.05	0.15	0.04
Calcite	5	5.41	4.02	427.03	44.04	22.73	0.03	0.12	0.36	0.10

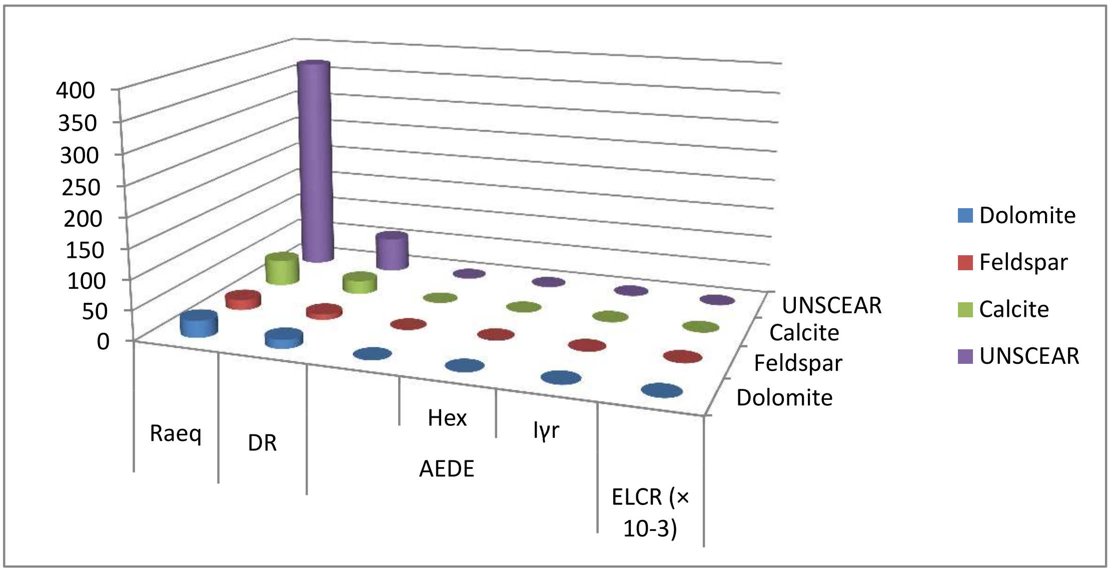

Figure 4: Hazard Indices compared with the UNSCEAR report

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Hazard Indices

Gamma Dose Rate

From the measured activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in the economic minerals samples, the external gamma absorbed dose rate in air 1m above ground level was estimated following the equation (UNSCEAR, 2000)

$$D\ (nGyh^{-1}) = 0.462C_{Ra} + 0.621C_{Th} + 0.417C_K \qquad (1)$$

Where D is the dose rate in $nGyh^{-1}$, C_{Ra}, C_{Th}, C_K (Bqkg-1), and 0.462, 0.621, and 0.417 ($ngyh^{-1}$ per $Bqkg^{-1}$) are the activity concentrations and dose conversion factors of ^{226}Ra,^{232}Th and ^{40}K respectively. In equation (1) above, it is assumed that all decay products of ^{226}Ra and ^{232}Th are in radioactive equilibrium with their precursors (UNSCEAR, 2000).

Radium Equivalent

A common index with respect to radiation exposure, called the radium equivalent activity (Ra_{eq}), is defined to represent the specific activities of ^{226}Ra, ^{232}Th and ^{40}K in different combinations in economic mineral samples. This index is calculated using the relation in these literatures as shown in equation (2) below (Beretka & Matthew, 1985; Yu et al, 1992; UNSCEAR, 2000).

$$Ra_{eq}\ (Bqkg^{-1}) = C_{Ra} + 1.43C_{Th} + 0.077C_K \qquad (2)$$

Where C_{Ra}, C_{Th}, and C_K are activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in $Bqkg^{-1}$ respectively. Ra_{eq} is defined according to equation (2) with the assumption that $1Bqkg^{-1}$ of ^{226}Ra, $0.7Bqkg^{-1}$of ^{232}Th or $13Bqkg^{-1}$ of ^{40}K yields the same gamma ray dose (Malanca et al, 1993; OECD, 1979).

Annual Effective Dose Equivalent

Annual effective dose equivalent for the studied economic minerals was evaluated from the absorbed gamma dose rate.

$$AEDE_{out}(mSvy^{-1}) = D_R \times 1.23 \times 10^{-3} \qquad (3)$$

outdoor occupancy factor of 0.2, and conversion coefficient of 0.7SvGy-1, provided in the UNSCEAR (2000) report was used in equation (3). AEDE was calculated from the equation (3): Average AEDE for the economic minerals samples were 0.02, 0.01, and 0.03mSvyear^{-1}respectively for dolomite, feldspar and Calcite (Table 1 and figure 4). These values were below the average annual effective dose of 0.460mSv year^{-1} from terrestrial radionuclides in normal background areas as acknowledged in UNSCEAR (2000) report.

External Radiation Hazard Index

The external hazard index (H_{ext}), which is an estimate of radiation risk resulting from exposure to gamma rays of the primordial nuclei is evaluated from the equation (UNSCEAR, 2000)

$$H_{ext} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_k}{4810} \leq 1 \qquad (4)$$

Where C_{Ra}, C_{Th} and C_K are activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K (Bqkg^{-1}) respectively. The maximum value for H_{ext} is equal to unity, which corresponds to 370Bqkg^{-1}, the upper limit of Ra_{eq}. As shown in table (1) H_{ext} for the studied minerals were 0.08, 0.05 and 0.12 for dolomite, feldspar and calcite respectively (figure 4). Hence the values of these indices are less than unity so the radiation hazard indices of the area are insignificant.

Gamma Index

Other key hazards that were considered in this study are gamma (Iγ) index. This index was estimated based on the European Commission standard. Gamma index (Iγ) is the factor that assesses the γ-radiation hazard(s) associated with the naturally occurring radionuclides in a material. The Iγ is determined based on Eq. (5) as given by (OEDC 1979; Bouhila et a*.,* 2017].

Iγ = 0.3333ACRa + 0.0050ACTh + 0.0003ACK (5)

Where AC_{Ra}, AC_{Th} and AC_K are the same as for other estimated hazards. The permissible range of the outdoor annual effective doses' contributions to the γ-radiation is 0.3 to 1mSv y^{-1}. Any material or sample that poses the AEDOutdoor> this range should be exempted from use as raw materials or finished products. If the $I\gamma \leq 1$, it corresponds to an outdoor dose of 1mSv y^{-1}. However, if the $I\gamma \leq 0.5$, it corresponds to an outdoor dose of 0.3mSvy^{-1}(Adagunodo et al*,* 2018)). From Table 3, the Iγ ranged from 0.42 to 0.61, with a mean of 0.48. These results correspond to $I\gamma \leq 0.5$, which gives the outdoor effective dose (Adagunodo et al, 2018).

Excess Life Cancer Rate

Excess lifetime cancer risk ELCR is defined as the probability that an individual will develop cancer over his lifetime of exposure to radiation and it is given as equation (5)

$$ELCR = AEDR \times DL \times RF \qquad (5)$$

Where DL is the average lifespan (70 years) and RF is risk factor (Sv−1) which is 0.057, for stochastic effects from low-dose background radiation ((Kolo et al, 2015; Kolo, 2014), from the studied minerals, ELCR fell below the standard level which shows that the quarry sites is safe.

Conclusion

In view of environmental and human health impacts of these economic minerals (dolomite, feldspar and calcite) quarry activities around the world and particularly the studied area, specific activities of ^{40}K, ^{226}Ra, and ^{232}Th in the economic minerals collected from selected quarry sites in Igarra Area, Nigeria, were measured and analyzed. Results of this studied indicated that mean activity concentrations of primordial radionuclides were far below their respective world average values. Calculated values for all radiation hazard parameters were below their respective recommended limits from radiation protection perspective. The results of this investigation showed that quarry activities in the selected Area of the Igarra do not constitute any immediate radiological risk to the workers, the environment, and the public in general (see Table 1, Figure 3 and Figure 4).

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Study of the Benthic Ecological Characteristics of Antau River Keffi, Nasarawa State

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ABSTRACT

Benthic ecology is the study of aquatic organisms and sediments that make up the bottom characteristics of an aquatic ecosystem, for the purpose of identifying environmental conditions and conduct ecological impact surveys. The research was conducted to study the grain size distribution and the benthic macrofauna present in Antau River in Keffi, Nigeria. Benthic sediment and macrofauna samples were collected from five stations from upstream towards downstream of the River to determine the grain size distribution and identify the Benthic macrofauna. Grain size distribution between stations showed slight variations; as station three contained the highest amount of gravel at 37%. All the stations had significant percentage of sand, with Station five having the highest percentage at 92.6%. Mud was present in all stations with station one with the highest Percentage at 7.8%. Station three showed the highest percentage of very fine gravel, very coarse sand and coarse sand at 37.4%, 16.2% and 18.1% respectively. Medium sand was at the highest percentage of 21.2% at Station four. Fine sand was at the highest percentage of 54.4 % at Station five and very fine sand was highest at 38.3% in Station one. The composition of macrofaunas comprises of; Arthropoda, Annelida and Chordata. Total number of species recorded was 4411. *Bufobufo* of the group of Anura had the highest number of individual species at 25.4% abundance. *Acroneuria sp* of the Plecoptera group yielded the smallest number of individual species of at 2.6% abundance. Other group are Diptera (16.6%), Coleoptera (6.2%),Trichoptera (8.3%), Ephemeroptera (4.3%), Hemiptera (9.2%), Odonata (13.9%) and Arhynchobdellida (3.9%) abundance. The relationship between some grain size distributions and benthic macrofauna showed significant correlation. The research however indicates that the river has high biodiversity and wide-raging grain size distribution.

Keywords: Benthic macrofauna, Benthic sediments, Grain size Distribution, Antau River

INTRODUCTION

Benthic ecology is the study of the of aquatic organisms and sediments that make up the bottom structure, communities and characteristics in an aquatic ecosystem, to determine environmental conditions and conduct ecological impact surveys (Babbe and Culter, 2010).

Benthic macrofaunas are invertebrates' aquatic animals that are generally visible with the naked eyes. They are benthic organisms, living underneath rocks and lower areas of Rivers and streams (Shailendra *et al.,* 2006). Benthic macro faunas are also referred to as macro benthos or macroinvertebrates (Obot *et al.,* 2014). They

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