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ASSESSMENT OF RADIOLOGICAL RISK OF RADON IN BOREHOLE WATER IN EDE AND ITS ENVIRONS

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Abstract

Provision of hand-pumped borehole water has been a way to ameliorate the hardship experienced due to the scarcity of portable Water in Ede and her environs. The awareness of the presence of radon, a carcinogenic radioactive gas in borehole is near zero in the study area. It is imperative to measure the concentration of the radon in the samples of water collected from the hand-pumped borehole water collected in Ede and her environs. The cancer risks associated with the ingestion of water from hand-pumped boreholes in the study area was estimated using radiation hazards indices and compares the measured values with the recommended unit by International Commission on Radiological Protection (ICPR) and World Health Organization (WHO).

Water samples were collected from fifteen hand-pumped operated boreholes and assayed for the radon concentration using RAD7, an active electronic radon detector manufactured by Durridge Company, USA. The concentration of the radon in the water samples translated to the radiological indices for quantifying the cancer risk.

The result showed that the radon concentration ranged between 28Bq/L and 598B/L, which was higher than (WHO) recommended value of 11.1Bq/L.

The annual effective dose equivalent ranged between 102.2μsvy$^{-1,}$ and 1467.3 μsvy^{-1}, annual gonadal effective dose ranged from 63.88 μsvy^{-1} to 1364 μsvy^{-1} while Excess Life Time Cancer risk (ELCR) ranged between 0.25x 10^{-3} and 5.44x10^{-3}. However, large number of water samples assayed presented a risk value higher than the limit of 0.29x10^{-3} recommended by (ICRP).

Keywords: Radon concentration, Annual effective dose equivalent, Gonadal effective dose, excess lifetime cancer risk and Radon.

1. INTRODUCTION

Water is life that forms an appreciable proportion of all living things including man. It constitutes about 80% of animal cells. About 70% of water constitutes the human body by weight and several body functions rely on water [1]. The importance of water to human cannot be over emphasized, it include drinking, washing, bathing etc. There are three main sources of water which include ground water, surface water and rain water

Increase in Nigeria population has consequently raised the demand for water in the last decades and enhanced the standard of living. Water supply in Nigeria countries and communities is still inadequate and does not commensurate with the demand. This result to a short falling water use and many suffer from this aberration [2].

Alternatively, on the global scale, borehole water had been gaining increasing attention as essential vital water resources. It is one of the sources of fresh water for many communities owning to its relatively low susceptibility to pollution in comparison to surface water, and its relatively large storage capacity. Borehole water may contain constituents such as Micro-organism, gases, radioactive particles, inorganic and organic materials. Scientist assesses the quality of water by measuring the amount of various consistent contained in water.

Deterioration of borehole water especially hand-pumped borehole water quality is considering one of the main problems that exert huge pressure on our economy and there is the need for urgent response because no serious investigation has been carried out. Exposures to radioactive material are one of the water quality problems that have not been considered extensively investigated [3]. Radioactive water also known as radiological contamination is the deposition of radioactive substances on surface or within solid, liquid or gases including human body, where their presence is undesirable. Radiation and radioactive isotopes constitutes a natural part of our environment, which if occur in a higher concentration pose a threat to human's health. The highest fraction of the natural radiation we receive comes from the radioactive gas radon. Radon can present health hazard by ingestion of freshly drawn radon contaminated ground water before radon degasses to indoor air and by in halation of radon emanated from tap water (4) the national research council (NRC) in the USA has estimated that 11% of stomach cancers may result from drinking radon contaminated water it also estimated that approximately 89% of the total cancer caused by radon in drinking water were due to radon inhalation from indoor air. A small percentage of the total radon in indoor air is from tape water, the greatest source is ground beneath the home. ^{226}Ra is ubiquitous in soil and rock in varying concentration. It is chemically inert radioactive gas that is formed by the decay of ^{238}U with half- life of 3.82 days with emission of alpha particle and production of daughter products polonium, lead and bismuth. It is soluble in water therefore present in borehole water [5]. Radon originates from the ground where its radioactive parents ^{238}U and ^{226}Ra are found. It can escape from the ground and introduced into ground water by diffusion along microcrystallines imperfection within the rock [6]. Certain rock types include; granites, dark shade, light colored volcanic rock, sedimentary rocks containing phosphate and metamorphic rocks recorded to have higher average Uranium [7].

Radon escape easily from rocks and soil into fractures and opening in rocks and pores spaces between grains of soil [8].The migration of radon through porous material of fractural rock is achieved primarily by transport. The migration and concentration of radon is dependent on bedrock type, the physical condition in the rock (fracture, joints and porosity), the aquifer parameters and aquifer geo chemistry. Drinking water containing radon presents a risk of developing internal organ cancers, primarily stomach and lung cancer from radon inhaled in the air during domestic use as it diffuses into air.

For over decades now, drinking water in south- western Nigeria is predominantly underground with deep wells, hand-pumped borehole and boreholes as sources of drinking water in homes, hospitals, schools and public places. As a result of radon migration from underground rock of different concentration there exists a possibility of high concentration level or radon in drinking water in southwestern Nigeria.

For this reason, it is very important to assess the level of naturally occurring radon from hand-pumped borehole water. This is so important especially in an area such as Ede in Osun State, Nigeria where several environmental problems are seriously threatening the inhabitants. As a result of inadequate sanitation, disease such as diarrhea and cholera are spread in Ede environs. Residences are forced to resorts to borehole for those that were able to afford as an alternative source of water.

Moreover, in public places and public school hand-pumped borehole water were in place through government assistance in the study area.

This study determined the level of radon in the hand- pumped borehole water using RAD7 monitoring system. The date obtained was used to assess the possible radiological risk by evaluating doses and relative doses.

2. Materials and Methods

2.1Geology of the study area

The study was carried out in Ede, North and south western Nigeria local government, Osun state, southwestern Nigeria. Ede is a town in Osun State, Nigeria that a lies at $7^0 44^1 20^0$N $4^0 26^1 10^0$E/7.73.889^{0}N 4.43611^{0}E with an elevation 269m and approximately population of 159,866. The study areas underlined by different rock types which include, Schist, pegmatite gneiss, charrockitic metal instructive , quartzite and quartz- chits. The rock types are widely known as to contain high uranium content which is responsible for higher radon concentration in water [9].

2.2 Sample collection and preparation

Samples were collected randomly from selected hand pumped borehole locations with 5 samples from Ede South and 10 samples Ede North local Government areas. The bore-hole water samples were collected directly from the source at different places in the study areas and poured in a clean 1.5 liters bottle previously rinsed with distilled water. Conscious effort was taken to prevent bubbling of the water not to allow escape of dissolved radon gas in the water during water collection. The total sample collected was fifteen from the random selected, locations.

2.3 Radon measurement

Within the closed loop of RAD7 is a desiccant to dry the air within it before entering the detector for radon concentration measurement. The detector was connected with a bubbling kit which enabled it to degas radon concentration from the water sample. Each of the water samples was assayed for 45minutes as it took a minute for each run and five runs were taken for each sample. This is shown in table 1.

2.4 Statistical Analysis

To identity the level of Radon concentration in the borehole water, samples mean standard deviation (S.D) and corrected mean analysis have been used to treat the radon concentration. The sample means $\bar{X}$ presented in equation (1)

$$\bar{X} = \frac{\varepsilon x_{¿}}{n} \qquad 1$$

Where n is the number of each sample run Ɛx¿ is the total mean of each sample

Standard deviation analysis is presented in equation 2

- $S.D = \sum_{¿}^{n} \frac{(X_{¿} - X)2}{n-1}$ 2

2.5 Radiation Hazard Indices Calculation

2.5.1 The annual effective dose equivalent to an individual due to consumption of radon gas from water sample were estimated using equation.

$$AEDE = MA \times IW \times IDEF \qquad 3$$

AEDE is the annual effective dose equivalent, MA is the measure activity in Bq/L, IW is the intake water in litres and IDEF is the ingestion dose equivalent factor given as $5.00x10^{-9}$ msv/Bq. The annual water consumption for teenagers / adults is 730 litres / years [14].

2.5.2 The annual Gonadal Equivalent Dose (AGED)which is the measure of the threat and stomach risk from exposure to a particular level of radiation was evaluated. The AGED for members of the public for a given activity (radon concentration) is given by equation4

$$AGED = \frac{AEDE}{WRXWT} \quad 4$$

Where

WR is the radiation weighting for alpha activity which is equal to 20

W_T is the tissue weighting factor for gonads is equals to 0.08

2.5.3 The excess lifetime cancer risk [ELCR] was evaluated using equation 5.This deals with the probability of developing cancer over a life time at a given exposure level, consider 70years as the average duration of life for human beings

$$ELCR = AGEDXDLXRF \quad 5$$

DL is the average duration of life (70years) RF is the risk factor (μsvy^{-1}) for stochastic as effect ICRP used RF as 0.57 for public.

3.0 Result and discussion

3.1 Radon concentrates in water samples

Table 1 Present the radon concentration in hand pumped borehole water of some randomly Selectedare areas in Ede and its environs. Tables 2 and 3 presents the

AEDE, AGED and ELCR respectively. The radon concentration ranged from 28Bq/L to 598Bq/L .The values are higher than the world health organization (WHO) Limit of 11Bq/L This observation showed similar trend in [10][11] and[12]. it has been report that geological structure of an area is a predominant factor for high radon concentration and the saturated zone of the earth crust contains high radon [13]. This implies that the depth of the soil is also a predominant further of high radon concentration: Moreover, human activities such as mining, milling and processing of uranium ore, mineral sands, smelting metal: ferrous ores, drilling, transportation processing and burning of fossil fuels/dump sites of large amount of waste material without adequate protection enhanced the levels of naturally occurring radiluchiles presence in the soil as well as surface and ground water in areas that are rich in natural radionuclide [14]Graph of the radon concentration it shown in figure 1

The annual effective dose equivalent to an individual due to consumption of radon gas, from water samples and the gonadal dose equivalent were estimated to be between 63.88µsvy^{-1}and 102.3µsvy^{-1} 1364.18µsvy and 2182.7µsvy^{-1} respectively. Their values were both higher man the global recommended limit

TABLE OF RESULTS

LOCATION	1ST Bq/m^3	2ND Bq/m^3	3RD Bq/m^3	4TH Bq/m^3	5TH Bq/m^3
ISEKI	166K±8230	192K±9030	231K±10K1	253K±10K9	269K±11K4
ASUNMO	86K5 ±5630	146K±7630	192±9040	230K±10K1	250K±10K8
ONISO	79K4±5730	95K6±6210	118K±7020	132K±7420	132K±7310
BEPO	146K±8400	125K±7590	122±7460	129±7650	135K±7810
BABA NLA OBA	192K±9760	180K±9470	195K±10K0	224K±10K9	220K±10K7

AGO	293K±11K9	217K±9990	229K±10K6	229K±10K8	242K±11K2
ILORI	92K4±460	415K±13K6	711K±2K7	850K±25K7	922K±28K0
ATAPARA	6280±1060	19K1±1830	32K6±2440	38K7±2700	43K5±2870
AGBALE	138Kv8350	168K±9430	197K±10K4	226±11K2	241K±11K7
AGIP	382K±15K8	267K±12K7	223K±11K3	194K±10K3	192K±10K3
ARINAGO	121K±7560	306K±13K4	465K±17K9	531K±19K8	587K±21K4
ADI-AGBO	73K6±4000	76K5±4160	94K±v4760	99K6±4980	102K±5120
AGBANGUDU	236K±11K1	171K±9340	178K±9580	178K±9580	168K±9250
GAA FULANI	437K±15K6	380K±14K3	400±15K1	398K±15K4	427K±16K5
OLUOBINU	111K±5460	328K±11K6	496K±16K4	566K±18K5	589K±19K3

Table 1: Radon concentration in the sample per location of five runs.

Location	**Mean (x) Bq/m^3**	**Mean (x) Bq/L**	**Standard deviation Bq/m3**	**Corrected mean Bq/m^3**
ISEKI	222K	222	42K6	19K8
ASUNMO	181K	181	66K	17K3
ONISO	111K	111	23K2	13K4
BEPO	131K	131	9513	15K6

BABA NLA OBA	202K	202	189K9	20K3
AGO	242K	242	29K8	21K7
ILORI	598K	598	342K9	28K
ATAPARA	28	28	15K2	4K2
AGBALE	194K0	194	41K9	16K8
AGIP	252	252	78K9	24K2
ARINAGO	402	402	189K	32K
ADI-AGBO	89K2	89.2	13K2	9K55
AGBANGUDU	186K	186	28K2	19K5
GAA FULANI	408K	408	23K1	30K8
OLUOBINU	418K	418	200K	28K5

The table2: Standard deviation and corrected means of radon 222 concentration per location

Location	**Activity concentration of radon Bq/L**	**Annual effective dose equivalent AEDE**	**Annual gonadal equivalent dose (AGED) µsvy**	**Ecess life time cancer risk (ELCR) x10^{-3}**
ISEKI	222	810.3	506.44	2.02
ASUNMO	181	660.65	412.91	1.65
ONISO	111	405.15	253.22	1.01

BEPO	131	478.15	298.84	1.19
BABA NLA OBA	202	737.3	460.81	1.84
AGO	242	883.3	552.06	2.20
ILORI	598	2182.7	1364.18	5.44
ATAPARA	28	102.2	63.88	0.25
AGBALE	194	708.1	442.56	1.77
AGIP	252	919.8	574.56	2.29
ARINAGO	402	1467.3	917.06	3.66
ADI-AGBO	89.2	325.58	203.48	0.81
AGBANGUDU	186	678.9	423.48	1.69
GAA FULANI	408	1489.42	930.75	3.71
OLUOBINU	418	1525.7	953.56	3.80

Table 3: Estimated value of ELCR, AEDE and AGED for a given concentration of radon gas insesterinwater.

of radon ingested in water of 70 µsvy^{-1}[15]. This result is also similar to awork carried out in ekiti south western Nigeria [10].The excess life time cancer risk was estimated range from $0.25x10^{-3}$to$5.44x\ 10^{-3}$.These values obtained from Atapara and ILori location respectively These showed a higher values than the global recommended limit of $0.29x10^{-3}$ if consumer over and average period of 70years [16]. Resultwas higher value than one obtained in [17]which has an excess life time cancer risk lower than the maximum permissible limit of the ICRP.

Annual effective dose equivalent (AEDE) and annual gonadal equivalent (AGED) and the ICRP limit is presented in figure 2 also the excess life care risk (ELCR) and the world average value is presented in figure 3.

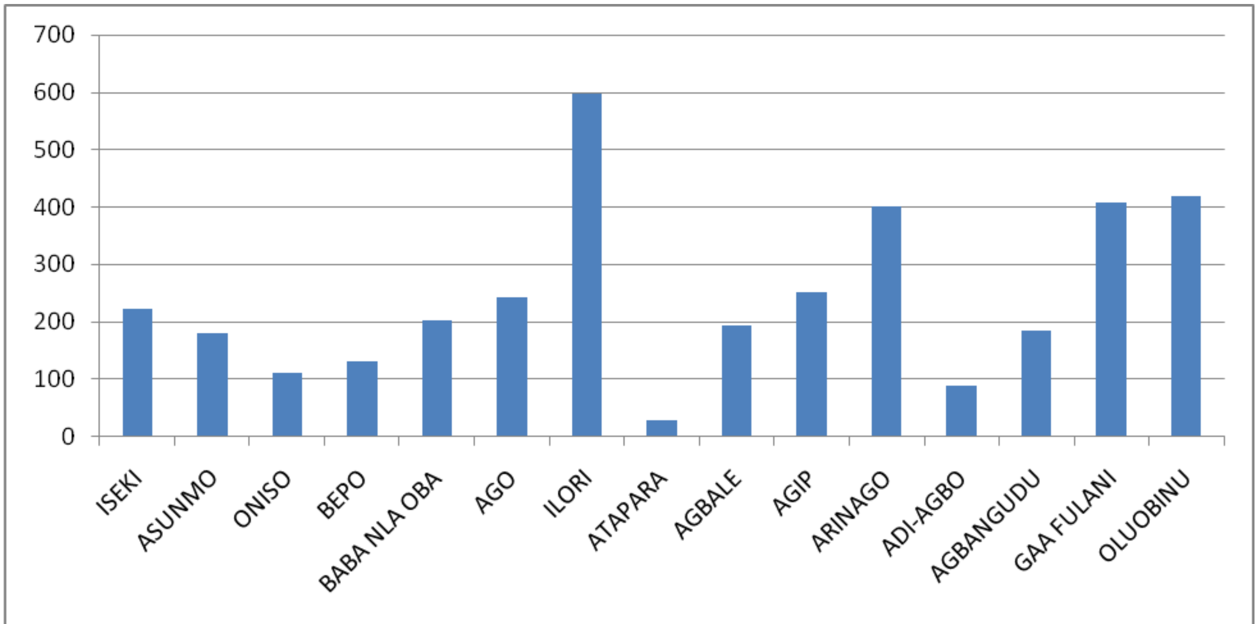

FIG 1: ACTIVITY CONCENYRATION OF RADON PER LOCATION.

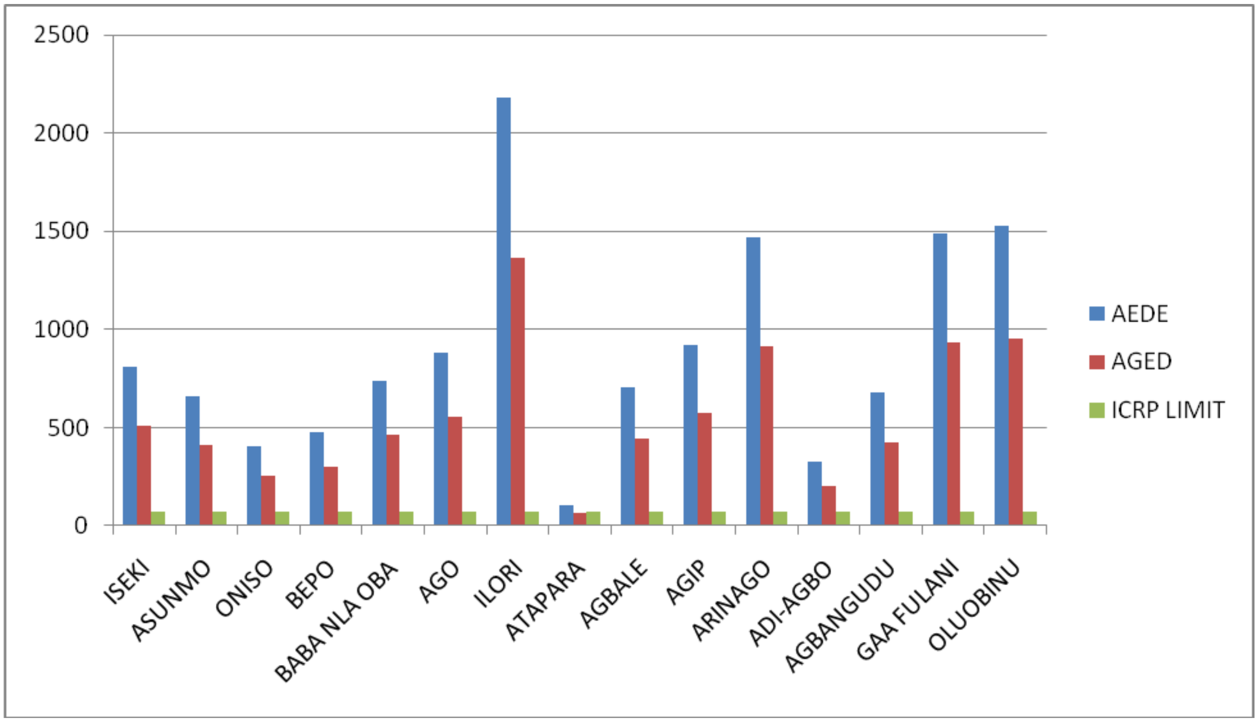

FIG 2: ANNUAL EFFECTIVE DOSE EQUIVALENT, ANNUAL GONADAL EQUIVALENT AND ICRP LIMIT.

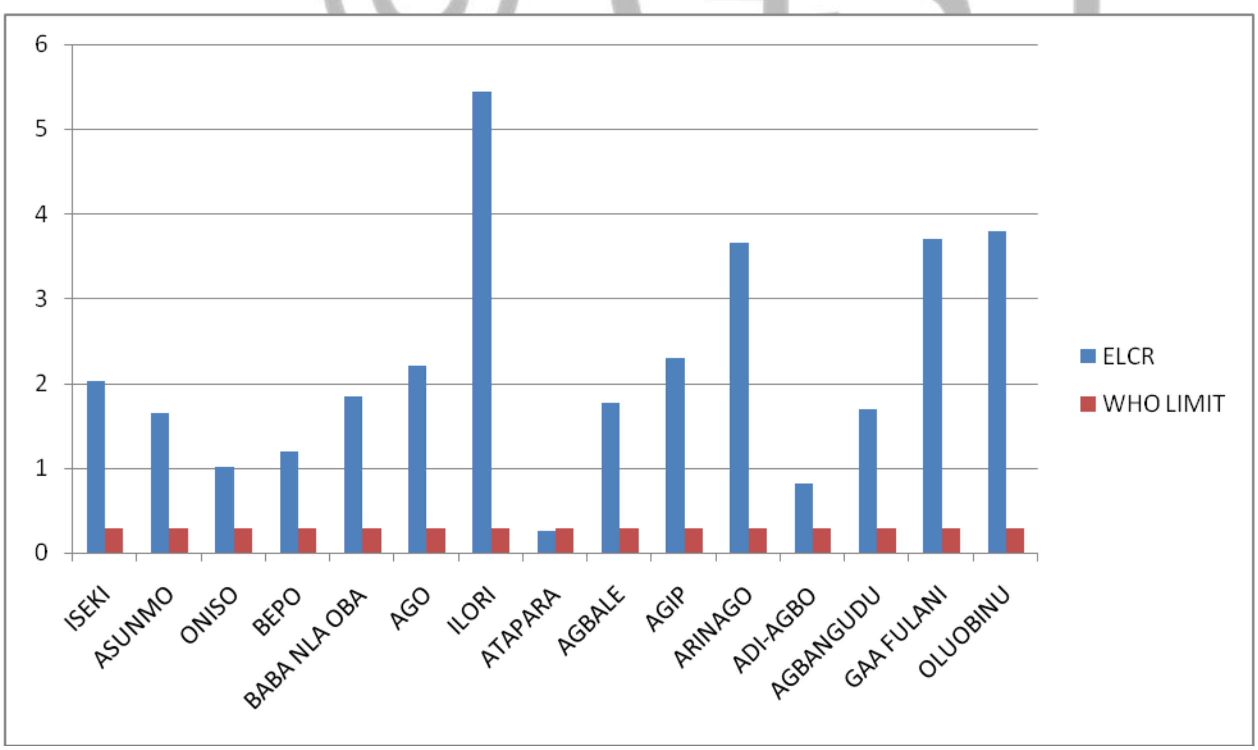

FIG 3: EXCESS LIFETIME CANCER RISK AND THE WORLD AVERAGE VALUE

4.0 Conclusion

Radioactivity concentration, annual effective dose equivalent and radiation hazard in hand-pumped borehole water due to intake of radionuclide had been evaluated using RAD 7 monitor system of Durridge Company, USA. Result obtained showed that radon levels in hand pumped borehole water varied from one sample to the other in different areas. The variations in radon concentration level could be mainly due to the difference in rock types, soil types area, depth of the bore hole and the geology of the area. In the study areas, the minimum radon concentration was found to be 28Bq/L while the maximum was 598Bq/L These were obtained in Atapara and Ilori respectively and these values were higher than the global recommended limit. The radiation hazard indices due to radon consumption in water were estimated and varied from 63.88 µsvy^{-1} to 102.3 µsvy^{-1}and 1364.18 µsvy^{-1}to 2182.7 µsvy^{-1}for AEDE and AGED respectively. Further investigation was carried out to determine the excess lifetime cancer risk (ELCR). The result obtained due to radon consumption from borehole water ranged from 0.25×10^{-3} to 5.44×10^{-3} for Atapara and Ilori respectively. Observations obtained from radiation hazard indices were higher than the maximum permissible limit set by UNSCEAR of 70µsvy^{-1}for AEDE and AGED. Moreover the excess life time cancer risk result obtained in all samples was higher than the world limit of 0.29×10^{-3}, although Atapara had equivalent value of 0.25×10^{-3}.Therfore, it could be concluded that hand pumped borehole water in the study area has high radiological risk over a period of time and further investigation to be carried out to ensure the safety of the populace in the study area especially Ilori.

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