DETERMINATION OF RADON-222 CONCENTRATION IN SOME SELECTED DRINKING WATER SOURCES AT GEIDAM TOWN, GEIDAM LOCAL GOVERNMENT AREA OF YOBE STATE, NIGERIA.

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Abstract

Exposure human to high doses of radon-222 through ingestion in water or inhalation as gas can lead to stomach or lung cancer. In this research, the concentrations of Radon-222 (^{222}Rn) were investigated from eleven (11) water samples collected at different locations within Geidam town, Geidam Local Government Area of Yobe state, using liquid vacuum degasification process and RD-35 device. From the results obtained, the minimum value of radon concentration is found in the main borehole of Low-Cost near Friday mosques to be 0.57 pCi/L, while the maximum value measured which was related to a water tank in the general hospital quarters recoded 1.89 pCi/L. The overall average radon concentration for all water samples is found to be (0.99 ± 0.14) pCi/L. According to the achieved results, the radon concentration from all the water samples was lower than the maximum allowable concentration set by EPA and WHO guidelines.

Key Words: *Radon-222, Natural Radioactive Sources, Effective Dose, Drinking Water*

Introduction

Radiation and radioactive isotopes constitute a natural part of our environment. High concentrations of these radioactive isotopes in the environment can be a threat to our health. The highest fraction of the natural radiation we receive comes from the radioactive gas radon (Irene et al., 2013). Radon is a chemically inert, radioactive gas that decays by alpha particle emission with a half-life of 3.82 days. Radon originates from the disintegration of radium and both elements are part of the ^{238}U decay series. Radon is omnipresent in soil and rocks in varying concentrations depending on the Radon concentration and several factors. Radon is soluble in water, and therefore, is present and able to travel in ground water. It is a colorless, odorless, tasteless, radioactive noble gas that generally lacks activity toward other chemical agents. However, it occasionally forms clathrate compounds with some organic compounds and may form ionic or covalent bonds with highly reactive elements such as oxygen or fluorine. Radon is the heaviest noble gas and exhibits the highest boiling point, melting point, critical temperature, and critical pressure of all noble gases. Radon's isotopes are radioactive; include mass numbers ranging from 200 – 226 (Irene et al., 2013).

Radon-222 (^{222}Rn) is a naturally occurring radioactive gas formed within the ^{238}U decay series. According to the U.S. Environmental Protection Agency (EPA, 1986), radon is a carcinogen and the second leading cause of lung cancer in the United State. It is estimated that 3,000 - 20,000 lung cancer deaths in the U.S. are associated with radon (NRC, 1999). On average, radon accounts for roughly 55% of one's annual radiation dose, with the remaining coming from medical (11%), internal (11%), terrestrial (8%), cosmic (8%), and other sources (NCR, 1999). Radon originates in the ground, where its radioactive parents are found. It can escape from the ground and build up in low concentrations in outside air and accumulate in basements and homes (Eisenbud and Gesell, 1997). The EPA has set an action level of 0.15 Bq/L (4 pCi/L) for indoor air (EPA, 1986).

A Becquerel (Bq) is a measure of activity equal to one disintegration per second. One curie (Ci) is equal to 3.7×10^{10} Bq.

Direct inhalation is probably the most likely mechanism that radon enters into our body, although other route such as dermal sorption is possible. Health implication of radon in drinking water (The source of drinking water such as well water, river water, boreholes are considered to be an important factor for limiting radon levels in drinking water) refers to ingestion of dissolved radon will result in a radiation dose to the lining of the stomach. Moreover, inhalation of radon gas that released from water sources will contribute to the radon content of indoor air and, if inhaled, will result in a radiation dose to the lung (Somlai, K., 2007). Long-term exposure to high concentrations of radon in indoor air increases the risk of lung cancer (Gilbert, J. 1998 and Zhou et al., 2001)

This research aimed to measure the levels of radon concentration in various boreholes and well water samples in Geidam local government area of Yobe state; also we aimed to determine the distribution of radon activity concentrations in some water samples in order to formulate database information for future researches in reviewing radon concentration levels in the Geidam metropolitan.

Material and Method

Study Area

Geidam is one of the seventeen local governments of Yobe State in Nigeria. Its headquarters is in the town of Geidam in the northwest of the area at 12°53′49″N 11°55′49″E. It has an area of 4,357 km^2 and a population of 157,295 at of 2006 census. The major climatic seasons are rainy season which begins in March or April and ends in October and the dry season which begins in November and ends in March or April. Farming is the main occupation of the people and groundwater is the main water source for both irrigation and domestic uses during dry seasons. The degradation of the water sources due to human activities does not cause any concern to the rural populace as they are hardly aware of the negative impacts of their actions on the sources of water supply.

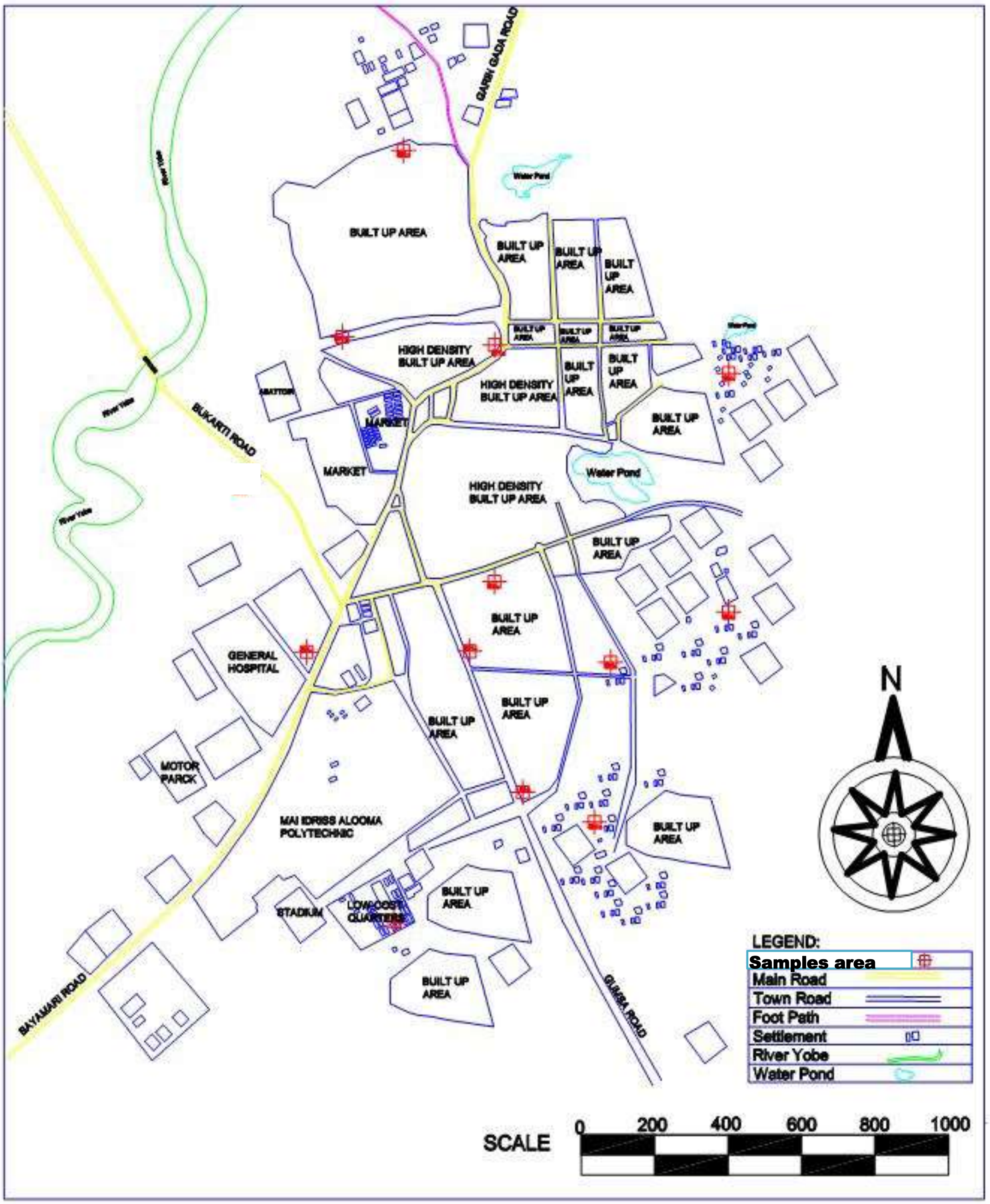

Figure 1. Sketch Map of Geidam Town showing the locations where the samples are been collected.

Sample Collection

A total numbers of 11 water samples were collected for analysis from the underground water sources (Boreholes) at different locations in Geidam town, Geidam local government area, Yobe State. The location coordinates, temperature, TDS and electric conductivity of water are measured in the sampling locations. The samples were collected using 200mL plastic vials. When collecting surface water samples, the vials are submerged in the water completely until filled and tightly capped before removing out of the water so as to avoid out gassing of radon-222 gas. Water from boreholes were been pumped and allow to flow for at least three (3) minutes before the samples was collected in order to ensure that fresh samples is obtained. Each collected sample is been properly label and the time of sample collection has carefully noted and recorded.

Sample Preparation

After sampling from water sources is conducted in conditions that had minimal contact with air and sampling container was filled with water with no empty space. The samples were then transferred to research laboratory of School of Science, Department Science Laboratory Technology Mai Idris Alooma Polytechnic Geidam Yobe state in order to measure radon concentration.

Sample Analysis

The water samples were analysed using water degassing procedure. The liquid vacuum degasification system was used in order to extract the radon in the water. Therefore, after the radon was extracted from the water in a closed space and portable radon detector (RD-35) was used directly in measuring the radon concentration from each sample. It take two hours to obtain the radon level from each sample, the result obtained was carefully recorded.

The following equation; $C = C_0 e^{(-0.693/T)t}$ was used to enforce half-life of radon according to the period of time between sampling and testing, where:

C= Rn-222 concentration at reading time pCi/L.

C_0= Rn-222 concentration at sampling time (actual concentration) pCi/L.

T= the half-life of Rn-222 equal to 3.8 days or 91.2 hours.

t= period of time between sampling and testing.

Results

Figure 1, shows sampling points of water sources in Geidam town. Coordinates of the sampling location, the radon concentration in water resources in (pCi/L), electrical conductivity of water (EC) according to μscm^{-1}, temperature in terms of degrees Celsius and total dissolved solids (TDS) in terms of ppm are presented in table 1.

The average radon concentration of the studied samples ranged from 0.57 to 1.89 pCi/L, which is lower than EPA permitted standard and WHO guidelines.

Table 1 Coordinates of the sampling location, radon concentration in water resources of Geidam town (pCi/L), electrical conductivity of water (EC) according to µscm^{-1}, temperature in terms of degrees Celsius and total dissolved solids (TDS) in terms of ppm.

S/N	Sample Location	Latitude (N)	Longitude (E)	The Radon Concentration (pCi/L)	EC (µscm^{-1})	TDS (ppm)	Temperature (°C)
1	Miapoly Hostel C	12°52'57.01	11°55'13.04	1.44	869	434	28.1
2	MiapolyLibrary	12°52'53.06	11°55'12.02	1.2	952	476	27.5
3	Lowcost	12°52'43.07	11°55'10.60	0.57	1226	613	24.9
4	General Hospital Lab.	12°53'15.96	11°55'2.46	0.66	1226	534	25.0
5	General Hospital Quarters	12°53'9.74	11°55'12.33	1.89	3825	1912	24.1
6	Diru	12°53'41.48	11°55'2.86	0.6	1437	718	23.2
7	Anguwan Kanti	12°53'42.97	11°55'34.99	0.81	703	351	25.0
8	Ajari	12°53'55.03	11°55'40.18	1.32	869	305	24.7
9	Ashekiri	12°53'47.79	11°55'33.64	1.11	2802	1401	26.7
10	Bololo	12°53'16.33	11°56'1.16	0.69	1249	624	27.0
11	Fulatari	12°53'16.62	11°56'11.78	0.71	851	425	26.5

Discussion

The minimum value of radon concentration of water samples from the selected location in Geidam local government is found to be 0.57 pCi/L, at the main borehole of Low-Cost near Friday mosques, while the EC and T.D.S values were found to be 1226 µscm^{-1} and 613 ppm respectively.

The overall average value of the radon concentration from all water samples of the selected locations in Geidam town is (0.99 ± 0.14) pCi/L, with EC value of 1438.45 µscm^{-1} and T.D.S. value of 708.45 ppm.

The general hospital quarters tap recorded the highest concentration with a value of 1.89 pCi/L, with EC value of 3825 µscm^{-1} and T.D.S. 1912 ppm respectively. The water is originated from the main over-head tank of the hospital borehole. The high radon concentration recorded may be linked to the soil type of the study area. While MIA poly hostel borehole has concentration value of 1.44pCi/L, with EC and T.D.S values of 869 µscm^{-1} and 434 ppm.

For the radon concentration of MIA poly library borehole is 1.2 pCi/L, with EC and T.D.S values of 952 μscm^{-1} and 476 ppm respectively.

Movement of groundwater, borehole depth, and its ability to leach radioactive materials from underlying bedrock during this movement water is one of the important factors to be considered in the variation of radon concentration in water (Faure G, 1977**).** General hospital laboratory borehole recorded the value of 0.66 pCi/L, with EC of 1040 μscm^{-1} and T.D.S. of 534 ppm, Diru has 0.60 pCi/L, with EC of 1437 μscm^{-1} and T.D.S. of 718 ppm while Anguwan Kanti has waters 0.81 pCi/L, with EC of 703 μscm^{-1} and T.D.S. of 351 ppm, Ajari has the value of 1.32 pCi/L, with EC of 869 μscm^{-1} and T.D.S of 305 ppm, Ashekiri has 1.11 pCi/L, with EC of 2802 μscm^{-1} and T.D.S of 1401 ppm.

For water sample collected from Bololo has radon concentration of 0.69 pCi/L, with EC of 1249 μscm^{-1} and T.D.S of 625 ppm and Fulatari which recorded the value of 0.70 pCi/L, with EC and T.D.S values of 851 μscm^{-1} and 425 ppm respectively.

In our study, we found that the value of total dissolved solids (T.D.S) recorded range from 305 ppm to 1912 ppm. The distribution of the total solids does not follow any pattern in the samples**.**

In some countries such as in Maine (U.S), the T.D.S values are slightly greater in water samples containing high-unsupported levels of radon. Such water might contribute to indoor radon levels. It was estimated that water supply containing 10,000 pCi/L of radon would result in 1 pCi/L of radon concentration in air. The ratio of radon concentration in air to that of water, however, it depends on water use and room ventilation.

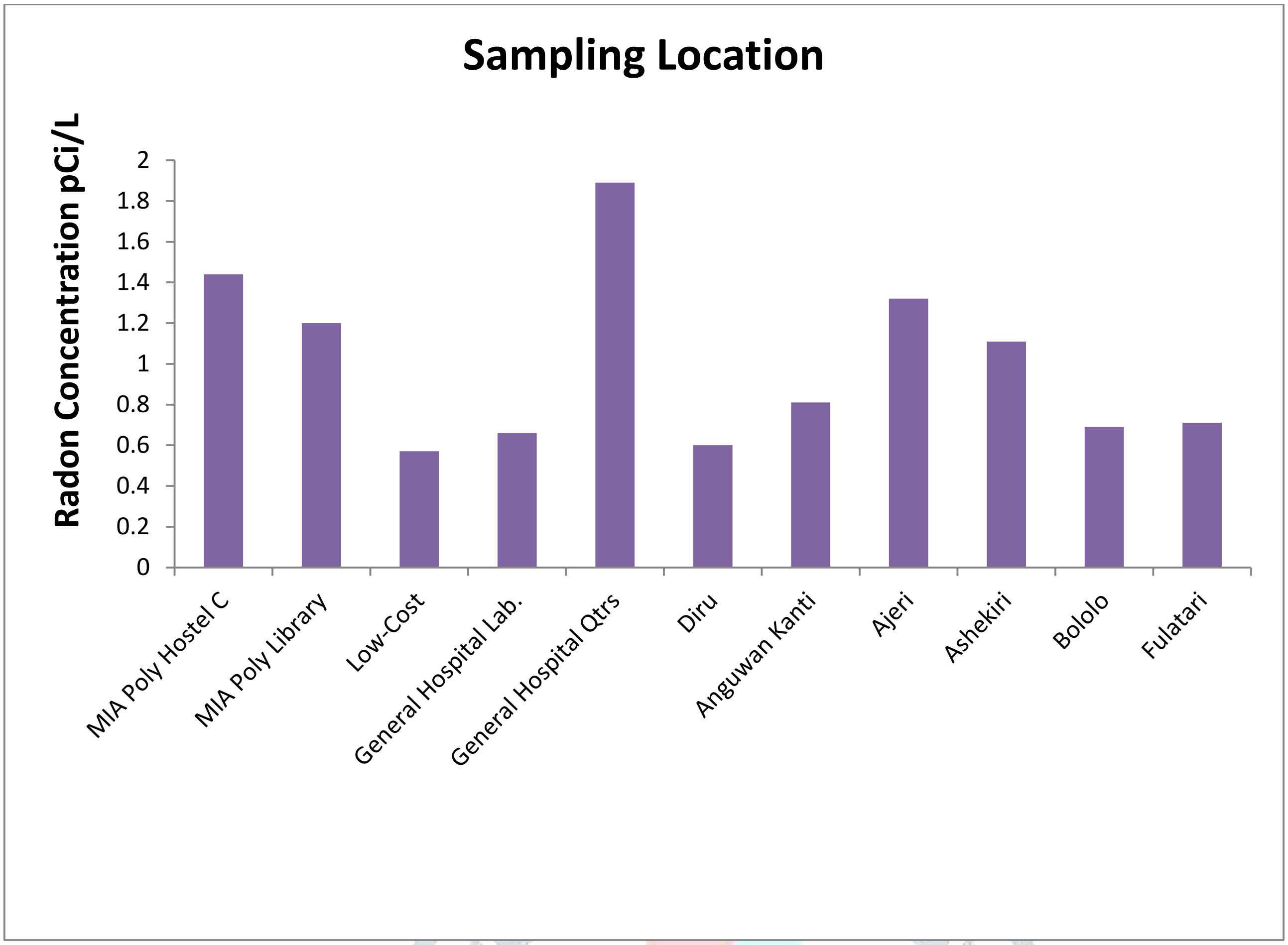

Fig. 2 Radon concentration from different water samples from different locations in Geidam town

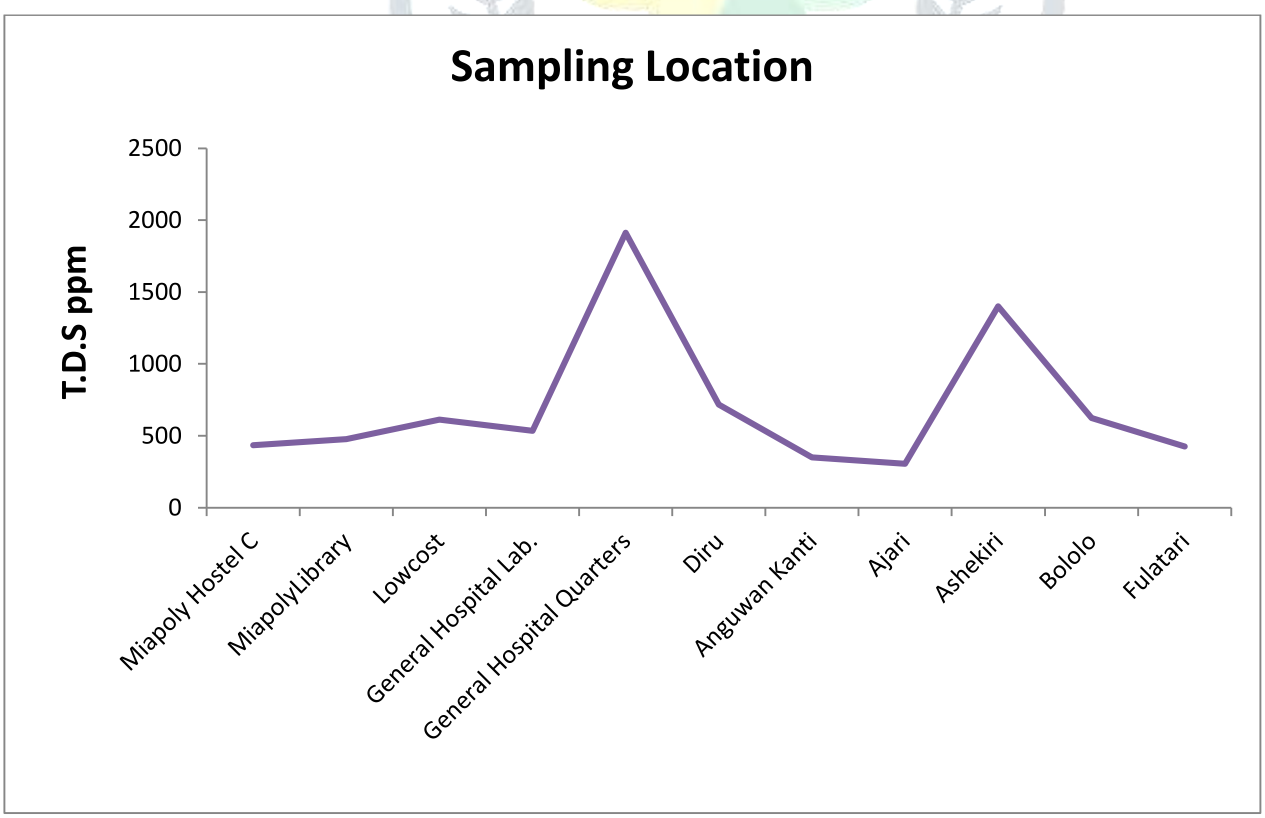

Fig. 3 The relation between T.D.S and the sampling locations in Geidam town

The distribution of Radon-222 concentrations of all the analyzed water samples collected at various locations of Geidam town, Geidam Local Government Area of Yobe State, as illustrated in figure 2 which revealed locations of higher concentrations and those of lower concentrations of radon as shown in a bar charts.

Conclusion

In order to protect people and reduce the consequences of exposure to radon gas, when the radon concentration is high, the water storage tanks should be used for aeration; and should be avoided as household water sources for using. Hence, having knowledge about radon values of household water resources is very important. In this study, the achieved values of radon concentration in all the water samples were lower than the maximum allowable concentration set by EPA and WHO. Therefore, in the current situation there is no any necessary action required to reduce the radon concentration in water resources of Geidam town, Geidam local government of Yobe state.

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